Expandierende Energiesysteme am Beispiel Perus

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von
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Vorwort und Dank

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Auflistung Publikationen

Publikationen

Israel, A. & Jehling, M. (2019). How modern are renewables? The misrecognition of traditional solar thermal energy in Peru's energy transition. Energy Policy, 133(110905), 1-8. https://doi.org/10.1016/j.enpol.2019.110905

- Beitrag A. de Freitas nach CRediT Contributor Roles Taxonomy[1]:
    - Conzeptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Visualization, Writing – original draft (all, except chapter 2.2.), Writing – review & editing
- Beitrag J. Mathias nach CRediT Contributor Roles Taxonomy[1]:
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Israel, A. & Herrera, R. J. (2020). The governance of Peruvian energy transitions: Path dependence, alternative ideas and change in national hydropower expansion. Energy Research & Social Science, 69(101608), 1-12. https://doi.org/10.1016/j.erss.2020.101608

- Beitrag A. de Freitas nach CRediT Contributor Roles Taxonomy[1]:
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- Beitrag R. Herrera nach CRediT Contributor Roles Taxonomy[1]:
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Fernandes de Freitas (geb. Israel), A. & Jehling, M. (2023). Change and path dependency in expanding energy systems: Explaining Peru's energy transition beyond a North-South divide. Energy Research & Social Science. https://doi.org/10.1016/j.erss.2023.103039

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- Beitrag J. Mathias nach CRediT Contributor Roles Taxonomy[1]:
    - Resources, Visualization, Writing – original draft: *Chapter 2.2. A neo-institutionalist framework for analysing expanding energy systems*, Writing – review & editing

Zusätzliche Publikation

Israel, A. & Hitzeroth, M. (2018). How do micro- and small-scale enterprises respond to global competition? An example of the textile survival cluster Gamarra in Lima. International Development Planning Review, 40(2), 203-222. https://doi.org/10.3828/idpr.2018.9

[1] https://credit.niso.org/

Kurzfassung

Globale Bestrebungen zur Transition von Energiesystemen haben weitreichende Auswirkungen auf technische und gesellschaftliche Strukturen. Die in der Forschung und Praxis übliche Differenzierung von Energiesystemen des Globalen Nordens und des Globalen Südens sowie die Übertragung von Konzepten und Politiken geraten zunehmend in Kritik, da sie die Diversität von Energiepraktiken nicht anerkennen und die Reproduktion von Ungleichheiten riskieren.

Vor diesem Hintergrund befasst sich diese Arbeit mit der empirischen Analyse des sozio-technischen Energiesystem Perus und seiner Transition. Hierfür werden Methoden qualitativer empirischer Sozialforschung angewandt und empirisches Material aus drei Feldforschungsaufenthalten zwischen 2016 und 2018 ausgewertet. Die empirischen Ergebnisse zeigen Akteure, Institutionen und Technologien ausgewählter Expansions- und Transitionsprozesse des peruanischen Energiesystems und dienen als Grundlage für die Formulierung von Handlungsempfehlungen.

Darüber hinaus wird eine alternative Kategorie zur Differenzierung von Energiesystemen vorgeschlagen. Die Kategorie expandierender Energiesysteme hat den Vorteil, dass sie anhand relevanter Merkmale des Energiesystems selbst anstatt entwicklungspolitisch motivierter Länderkategorien erfolgt und spezifische energiebezogene Bedingungen für Transitionen berücksichtigt.

Die Vorgehensweise und die Ergebnisse werden in Form einer kumulativen Arbeit, bestehend aus drei Beiträgen, vorgestellt und in Zusammenhang gebracht. Hierfür werden zuerst die einrahmende Problem- und Fragestellung der Arbeit vorgestellt. Darauf folgen die theoretischen Grundlagen sozio-technischer Energiesysteme und eine Einführung in die ausgewählten Analysekonzepte *energy governance*, *energy justice* und *historischer Institutionalismus*. Anschließend werden die der gesamten Arbeit zugrundeliegenden Methoden der Datenerhebung und -auswertung zusammengefasst. Der kumulative Teil der Dissertation stellt die zentralen Ergebnisse der einzelnen Beiträge und ihre Bedeutung für die Arbeit vor. Der erste Beitrag zeigt am Beispiel der Verdrängung eines historisch verankerten solarthermischen Clusters in Arequipa die Problematik modernistischer Diskurse und top-down Entscheidungsprozesse auf. Der zweite Beitrag verdeutlicht am Beispiel des geplanten Ausbaus der Wasserkraft im Fluss Marañón, die Relevanz von Expansionsprozessen für Wandel und Kontinuität im Energiesystem. Der dritte Beitrag konzeptualisiert sozio-technische Expansionsprozesse und vergleicht die Ergebnisse der drei empirisch untersuchten Fälle in Peru sowie ihre Wirkung auf Wandel und Kontinuität im Energiesystem. Abschließend werden Schlussfolgerungen für die *energy governance* Perus und für die Eignung der verwendeten analytischen Konzepte gezogen sowie ein Ausblick für weiterführende Forschungen gegeben.

Abstract

Global efforts for the transition of energy systems have far-reaching implications for technical and social structures. The common differentiation of energy systems of the Global North and the Global South in research and practice, as well as the transfer of concepts and policies, are increasingly criticized for neglecting the diversity of energy practices and risking the reproduction of inequalities.

In the light of this, this thesis deals with the empirical analysis of Peru's socio-technical energy system and its transition. For this purpose, methods of qualitative empirical social research are applied and empirical material from three field research stays between 2016 and 2018 is analyzed. The empirical results show actors, institutions and technologies of selected expansion and transition processes of the Peruvian energy system and provide a basis for the formulation of recommendations.

Beyond that, an alternative category for differentiating energy systems is proposed. The category of expanding energy systems has the advantage of being based on relevant characteristics of the energy system itself rather than developmentally motivated country categories and takes into account specific energy-related conditions for transitions.

The approach and the results are presented and synthesized in the form of a cumulative paper consisting of three contributions. Therefore, the framing problem and question of the work are presented first. This is followed by the theoretical foundations of socio-technical energy systems and an introduction to the selected analytical concepts of energy governance, energy justice and historical institutionalism. Subsequently, the data collection and analysis methods underlying the entire thesis are summarized. The cumulative part of the dissertation presents the key findings of the individual contributions and their significance to the thesis. The first contribution uses the example of the displacement of a historically embedded solar thermal cluster in Arequipa to illustrate the problematic nature of modernist discourses and top-down decision-making processes. The second contribution uses the example of the planned expansion of hydropower in the Marañón River to illustrate the relevance of expansion processes for change and continuity in the energy system. The third paper conceptualizes socio-technical expansion processes and compares the results of the three empirically studied cases in Peru and their effect on change and continuity in the energy system. Finally, conclusions are drawn for Peru's energy governance and for the suitability of the analytical concepts used, and an outlook for further research is given.

1. Rahmenschrift

1.1. Problemstellung

Zu den größten globalen Herausforderungen dieses Jahrhunderts zählen die weltweite Befriedigung von Energiebedürfnissen sowie die Transition fossiler Energiesysteme. Weltweit hatten im Jahr 2020 ca. 750 Millionen Menschen keinen Zugang zu Elektrizität (The World Bank, 2022a). Die UN zählt das Sichern eines „Zugangs zu bezahlbarer, verlässlicher, nachhaltiger und moderner Energie für alle“ zu den 17 *Sustainable Development Goals* (UNDP, 2015). Mit dem Zugang zu Elektrizität wird eine Steigerung der Lebensqualität assoziiert, verursacht durch Verbesserungen in Gesundheit und Bildung, einen erhöhten Zugang zu Informationen, den Abbau von gender-spezifischen Belastungen und wirtschaftlichen Vorteilen (Bhattacharyya, 2012; Fuso Nerini et al., 2018).

Gleichzeitig sind unsere heutigen Energiesysteme mitverantwortlich für den globalen Klimawandel. Über 73 % der weltweiten Treibhausgasemissionen wurden 2016 dem Energiesektor zugerechnet. 2021 erreichten energiebezogene CO_2 Emissionen ein neues Rekordhoch und verzeichneten den höchsten jemals gemessenen globalen Jahreswert (IEA, 2020). Laut dem aktuellen IPCC Bericht ist die Transition des Energiesektors eine der zentralen Möglichkeiten, Klimarisiken zu reduzieren (IPCC, 2022). Neben der Klimakrise zeigt auch die aktuelle globale Energiekrise im Kontext des Angriffskriegs Russlands in der Ukraine die Grenzen des fossilen Energieregimes auf und betont die Dringlichkeit der Transition von Energiesystemen (Baev, Marsh & Tzimitras, 2022; Berahab, 2022).

Dies stellt Gesellschaften vor große Herausforderungen. Denn Energiesysteme sind komplexe Systeme, die sich aus materiellen wie auch immateriellen Elementen zusammensetzen. Sie sind tief mit ökonomischen Produktionsweisen, Ökosystemen und sozio-kulturellen Aspekten verwoben. Dies erklärt auch die große Vielfalt nationaler Energiesysteme (Kosmadakis, Karellas & Kakaras, 2013). Somit sind auch die Bedingungen für und die Ergebnisse von Energietransitionen weltweit sehr unterschiedlich (Jianchao, Ruoyu, Pingkuo & Lyuyang, 2021; Kuzemko, Lockwood, Mitchell & Hoggett, 2016). Die sozialwissenschaftliche Energieforschung setzt sich damit auseinander und betrachtet die Funktionsweise sozio-technischer Energiesysteme und ihrer Transitionen (B. K. Sovacool et al., 2015; Benjamin K. Sovacool, Axsen & Sorrell, 2018).

Eine in der Literatur und Praxis häufig vorkommende Differenzierung der vielfältigen Energiesysteme ist die zwischen Systemen des Globalen Südens und des Globalen Nordens (Asif, 2021; Goldthau, Eicke & Weko, 2020; U. E. Hansen et al., 2018; Kaygusuz, 2012; Liao & Agrawal, 2022; Radley & Lehmann-Grube, 2022; Vanegas Cantarero, 2020; Wieczorek,

2018). Diese Unterscheidung wird mit unterschiedlichen politischen, sozialen und wirtschaftlichen Kontexten begründet (Iychettira, 2021). Laut Araújo (2014, S. 114) ist diese Unterscheidung “reif für eine sozialwissenschaftliche Überprüfung”, da sie „eine sehr subjektive Bedeutung haben [kann], die für Energie wenig relevant ist“. Problematisch ist darüber hinaus, dass prominente Theorien und Konzepte der sozialwissenschaftlichen Energieforschung überwiegend auf Grundlage der Energiesysteme im Globalen Norden entstanden und somit nur begrenzt auf den Globalen Süden übertragbar sind (Becker & Naumann, 2017; Furlong, 2014; Lawhon & Murphy, 2012; Loorbach, Frantzeskaki & Avelino, 2017; Schlaile & Urmetzer, 2018). Lawhon et al. (2012) argumentieren bezüglich der Multilevel-Perspektive (MLP), dass "eine intensivere Auseinandersetzung mit dem Globalen Süden erforderlich ist, um die breitere Anwendbarkeit und Stringenz der Theorie zu verbessern" (Lawhon & Murphy, 2012, S. 363). Eine ähnliche Kritik wird von Apfel et al. (2021) am Konzept der Energiegerechtigkeit geäußert. Sie stellen in Frage, inwieweit das Konzept „an die Realitäten im Globalen Süden angepasst werden müsste, da dieses eurozentrische Vorstellungen beinhaltet" (Apfel et al., 2021, S. 12).

Literatur, die sich spezifisch mit Energiesystemen im Globalen Süden sowie deren Transition auseinandersetzt, hat in den letzten Jahren stark zugenommen. Es wurden entscheidende Fortschritte bei der Integration lokaler Perspektiven gemacht (Becker & Naumann, 2017; Broto et al., 2017; Castán Broto, Baptista, Kirshner, Smith & Neves Alves, 2018; Cloke, Mohr & Brown, 2017; P. Munro, van der Horst & Healy, 2017; Power et al., 2016). Kritisiert wird allerdings, dass bestehende Forschungen weiterhin überwiegend aus Fallstudien bestehen, oftmals mit einem techno-ökonomischen Fokus, während Konzeptualisierung und Theoriebildung oder Analysen zu Institutionen und Macht seltener sind (Apfel et al., 2021). Hierin liegt ein grundlegendes Problem: Konzepte und Theorien nehmen Energiesysteme und Transitionen von des Globalen Nordens implizit zur Norm. Energiesysteme des Globalen Südens stellen eine Abweichung der Norm da und ihre Strukturen und Prozesse können nur unzureichend verstanden werden (Israel & Jehling, 2019; P. Munro et al., 2017). In der Praxis führt das Übertragen von Idealen und Konzepten ferner dazu, dass bereits existierende Praktiken der Energieversorgung im Streben nach einer modernen Energieversorgung negativ konnotiert und verdrängt werden (Israel & Jehling, 2019; P. Munro et al., 2017). Die Verdrängung soziokulturell verankerter Praktiken der Energieversorgung durch fremdbestimmte Modelle reproduziert strukturelle Ungleichheiten.

1.2. Fragestellung und Zielsetzung

„Demokratische Governance mit territorialer Perspektive - hierin liegt […] die zentrale Herausforderung für das Energie- und Ressourcenmanagement im 21. Jahrhundert."

(Monge, 2016)

Transitionen von Energiesystemen verändern gesellschaftliche Verhältnisse. Die Dringlichkeit der globalen Klimakrise zwingt zu raschem Handeln auf globaler Ebene, um im Sinne einer politisch motivierten Transition von Energiesystemen negative Klimafolgen abzumildern. Inwiefern Transitionen Ungleichheiten innerhalb und zwischen Gesellschaften vertiefen oder ihnen entgegenwirken hängt auch davon ab, wie wir unterschiedliche Energiesysteme wahrnehmen und verstehen. Die Anerkennung der Diversität von Energiesystemen und das Verstehen der Systeme und ihrer Transitionen aus sich heraus ist Voraussetzung dafür, endogene Potentiale zu erkennen, kontextualisierte Lösungen zu finden und ungleiche Machtverhältnisse nicht zu verschärfen.

Das Ziel dieser Arbeit ist es, das peruanische Energiesystem, als Beispiel für ein System aus dem Globalen Süden, empirisch zu untersuchen und zu überprüfen, welche spezifischen Bedingungen für und Ergebnisse von Transitionen identifiziert werden können.

Darüber hinaus strebt diese Arbeit an, eine alternative Kategorie von Energiesystemen vorzuschlagen, die auf systemimmanenten energiebezogenen Merkmalen beruht und so die normative Dichotomie zwischen Energiesystemen des Globalen Südens und des Globalen Nordens zu überwinden. Dafür werden folgende Fragen bearbeitet:

I. Aus welchen Bestandteilen bestehen Energiesysteme und wie wirken sich diese auf ihre Systemstabilität aus?
II. Welches systemimmanente Merkmal von Energiesystemen eignet sich für die Bildung einer Kategorie?
III. Inwiefern entspricht das peruanische Energiesystem einem expandierenden Energiesystem und welche Besonderheiten bringt dies für seine Transition mit?
    a. In welcher Form findet Expansion im peruanischen Energiesystem statt?
    b. Welche Akteure, Institutionen und Technologien prägen die Expansionsprozesse?
    c. Welche Wechselbeziehungen zwischen Expansion und Transition können in Peru erkannt werden?
    d. Welche kontextualisierten Governance-Empfehlungen können ausgesprochen werden?
IV. Inwiefern trägt das Konzept expandierender Energiesysteme dem Verständnis von Transitionen bei?

1.3. Theoretische Einführung und Definition einer alternativen Kategorie von Energiesystemen

1.3.1. Sozio-technische Energiesysteme und ihre Transition

In diesem Abschnitt soll geklärt werden, aus welchen Bestandteilen sich sozio-technische Energiesysteme zusammensetzen und wie sich diese auf Transitionen auswirken.

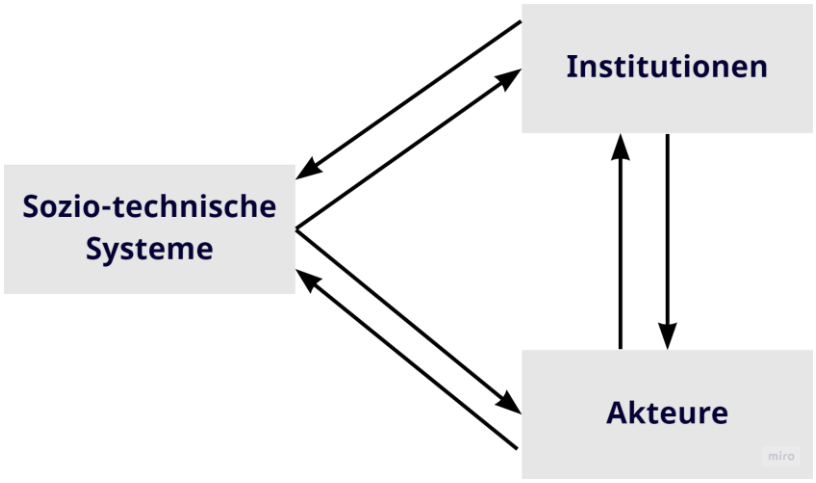
Energiesysteme sind komplexe Systeme, die sich aus einer Vielzahl von Erzeugungsanlagen, Verteilungsinfrastrukturen aber auch Versorgungsunternehmen, Lobbygruppen, Verbraucher:Innen, umfassenden Regulationen sowie auch Traditionen und Verbrauchsmuster zusammensetzen. Die komplexe Gestalt von Energiesystemen spiegelt sich auch in der Vielfalt wissenschaftlicher Ansätze zu ihrer Analyse wider. Im Bereich der sozialwissenschaftlichen Energieforschung befassen sich unterschiedliche Disziplinen mit den Herausforderungen der Transition von Energiesystemen. Forschungen der Energiegeographie befassen sich vor allem mit der Raumwirksamkeit von Energietransitionen auf verschiedenen Skalen sowie dem Verständnis von Mensch-Umwelt Beziehungen (T. Hansen & Coenen, 2015). Politikwissenschaftliche Zugänge betonen die Bedeutung von Machtverhältnissen, wie beispielsweise die *political economy of energy transition* (Baker, Newell & Phillips, 2014; Kuzemko, Lawrence & Watson, 2019). Ethnographisch und anthropologische Ansätze gehen der Frage nach wie Menschen Energie erleben, konzeptualisieren und bewerten sowie was Ethik dazu beitragen kann, wie wir aktuelle Entscheidungen über Energie treffen (Benjamin K. Sovacool, 2013). Insbesondere Fragen nach Gerechtigkeit in Energiesystemen rücken hier zunehmend in den Fokus (Jenkins, McCauley, Heffron, Stephan & Rehner, 2016). Die Transitionsforschung befasst sich mit umfassenden gesellschaftlichen Transformationen und schlägt vielfältige Strategien und Instrumente für eine nachhaltige Transformation verschiedener sozio-technischer Systeme vor (Loorbach et al., 2017; Markard, Raven & Truffer, 2012). *Energy Governance* Ansätze befassen sich mit den spezifischen Herausforderungen für kollektive Handlungsweisen in Energiesystemen (Goldthau, 2014; Lockwood, Kuzemko, Mitchell & Hoggett) und *political ecology of energy transitions* untersucht gesellschaftliche Naturverhältnisse im Kontext von Energiesystemen (P. G. Munro, 2021; Benjamin K. Sovacool, 2021).

Grundlegend für sozialwissenschaftliche Perspektiven auf Energiesysteme ist die Berücksichtigung technischer und sozialer Elemente sowie deren Wechselwirkungen. Die zugrundeliegende Theorie sozio-technischer Systeme geht ursprünglich auf Forschungen im Minensektor des *Tavistock Institute* in der Nachkriegszeit zurück. Hier werden erstmals die Interdependenzen von technischen und sozialen Aspekten systematisch betrachtet (Trist, 1981). Seitdem hat sich die STS-Theorie stetig weiterentwickelt und wurde auf verschiedene Sektoren angewendet, insbesondere auch auf den Energiesektor (Fox, 1995). Nach Geels et

al. (2007) besteht ein sozio-technisches System aus einem Cluster von Elementen, darunter Technologie, Wissenschaft, Regulation, Nutzerpraktiken, Märkte, kulturelle Bedeutung, Infrastruktur, Produktions- und Angebotsnetzwerke. Diese werden den folgenden drei Dimensionen zugeordnet: Systeme (Ressourcen, materielle Aspekte), Akteure und Institutionen (Geels, 2004). Zusammen bilden sie ein ganzes System von Verbrauch und Produktion, das darüber hinaus mit weiteren Wirtschaftssektoren wie Verkehr und energieintensiven Industrien verflochten ist (Goldthau, 2014; Kuzemko et al., 2016).

Die Stabilität eines sozio-technischen Systems hängt von diesen materiellen und immateriellen Bestandteilen und ihren Interdependenzen ab. Materielle Bestandteile sind zum Beispiel gebaute Infrastrukturen, in die große Summen an Arbeit, Kapital und Ressourcen investiert wurden (Benjamin K. Sovacool, 2016, S. 21). Diese sind im System versunken und lähmen eine Transformation (Benjamin K. Sovacool, 2016, S. 21). Immaterielle Bestandteile, die stabilitätsfördernd wirken, sind etablierte Routinen, Rollen, Denk- und Handlungsweisen oder Verträge, also die Anpassung von Lebensstilen, Erwartungen und sozialen Beziehungen (Geels & Kemp, 2007). Abbildung 1 zeigt die dynamischen Interaktionen zwischen den Dimensionen eines sozio-technischen Systems auf.

Abbildung 1: Dimensionen eines sozio-technischen Systems



Quelle: Darstellung nach Geels (2004)

Sozio-technische Transitionen sind konzeptualisiert als eine "groß angelegte Transformation innerhalb der Gesellschaft, während derer sich die Struktur des sozio-technischen Systems grundlegend ändert" (Kuzemko et al., 2016, S. 97). Sie umfassen weitreichende Veränderungen in verschiedenen Dimensionen: „technologisch, materiell, organisatorisch, institutionell, politisch, wirtschaftlich und soziokulturell" (Markard et al., 2012, S. 956). Die größten Hindernisse für die Transition von Energiesystemen sind laut Sovacool (2011) sozio-technischer Natur und betreffen nicht nur die "technische Machbarkeit und Leistung, sondern auch Fragen im Zusammenhang mit Marktversagen, Verbraucherwerten und -akzeptanz, Regulierungsstrukturen, Geschäftspraktiken und Kulturen" (Benjamin K. Sovacool, 2011,

S. 3834). Aufgrund der Komplexität von Energiesystemen und ihrer Stabilität vollziehen sich Transitionen über beträchtliche Zeiträume. Sovacool (2016) diskutiert Zeitspannen von Transitionen und kommt zu dem Schluss, dass "die meisten Energietransitionen eher pfadabhängig als revolutionär [und] eher kumulativ als vollständig substituierend waren und wahrscheinlich auch weiterhin sein werden" (Benjamin K. Sovacool, 2016, S. 32).

Transitionsforscher:innen stützen sich für die Konzeptualisierung von Transitionen sozio-technischer Systeme auf die MLP (Bhattarai, Maraseni & Apan, 2022; Burke & Stephens, 2018; Cherp, Vinichenko, Jewell, Brutschin & Sovacool, 2018; Dewald, Grunwald, Poganietz & Schippl, 2019; Geels, Sovacool, Schwanen & Sorrell, 2017; Benjamin K. Sovacool & Brisbois, 2019; Benjamin K. Sovacool et al., 2020). Ihre Ursprünge aus der evolutorischen Ökonomik sind im Fokus auf das technologische Regime und auf Innovationsmuster entlang bestehender Trajektorien zu erkennen (Dewald et al., 2019). Die MLP erweitert diese durch die Landschaftsebene, die den strukturellen Rahmen abbildet und Akteure wie Nutzer:innen, Zivilgesellschaft und Politiker:innen berücksichtigt. Transitionen finden in diesem Rahmen statt, wenn das vorherrschende Regime destabilisiert wird und Durchbrüche in Nischen ermöglicht werden (Araújo, 2014). An der MLP wird kritisiert, dass unterschiedlichen Bedingungen für Energietransitionen nicht ausreichend berücksichtigt werden (Furlong, 2014; Kuzemko et al., 2016). Furlong (2014) zeigt, inwiefern die in der Nachkriegszeit in Europa entstandene MLP, die infrastrukturellen Bedingungen von sozio-technischen Systemen im Globalen Süden unzureichend berücksichtigt. Denn im Gegensatz zur universellen und uniformen Versorgung durch ein einziges Netzwerk, erfolgt die Versorgung mit Wasser oder Energie im Globalen Süden häufig durch hybride und disaggregierte Systeme. Dies wird laut Furlong (2014) von der MLP nicht ausreichend berücksichtigt. Darüber hinaus kritisieren Kuzemko et al. (2016) die Betonung der Rolle von aufkommenden technologischen Innovationen und die Fokussierung auf politische Interventionen zu deren Förderung (Kuzemko et al., 2016). Sie empfehlen eine stärkere Berücksichtigung der politischen und institutionellen Bedingungen für Transitionen und betonen die Rolle von alternativen Ideen, die konkrete regionale Probleme aufzeigen und neue Lösungen anbieten können (Kuzemko et al., 2016). Der Wandel des Energiesystems wird hier als "Kampf der Ideen" beschrieben. Er erfolgt durch die erfolgreiche Anfechtung etablierter "Governance-Orthodoxien" durch gut artikulierte, alternative Narrative (Kuzemko et al., 2016, S. 100).

Diese Einführung in sozio-technische Systeme zeigt Bestandteile von Energiesystemen auf, die der Bildung einer alternativen Kategorie dienen können. Sie betont darüber hinaus die Notwendigkeit die Eignung von Analysekonzepten für die spezifischen Kontexte zu überprüfen und politische und institutionelle Faktoren für Transitionen stärker zu berücksichtigen.

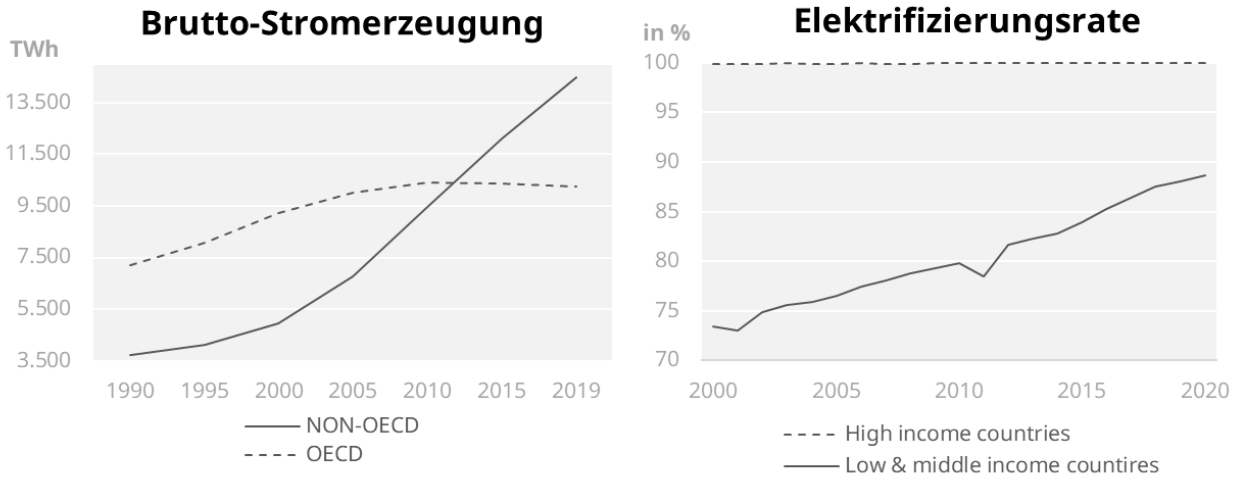
1.3.2. Alternative Kategorie: Expandierende Energiesysteme

Das Ziel dieser Arbeit ist, eine alternative Kategorie von Energiesystemen zu entwickeln und dabei unterschiedliche Bedingungen für Transitionen aufzuzeigen, ohne diese entwicklungspolitischen Bewertungen zu unterziehen. Die Grundlage für die Differenzierung von Energiesystemen anhand systemimmanenter Merkmale, bilden dabei theoretische Überlegungen zur Transition sozio-technischer Systeme. Wie in Abschnitt 1.3.1. beschrieben, ist ein bedeutender Faktor für die Trägheit sozio-technischer Systeme die in der materiellen Infrastruktur versunkene Arbeit, Ressourcen und Kapital. Hier existiert ein für Transitionen relevanter, systemimmanenter Unterschied, der die Differenzierung in konsolidierte und expandierende Energiesysteme erlaubt.

In diesem Sinne sind expandierende Energiesysteme Systeme, die eine Erweiterung der materiellen Infrastruktur erfahren. Das bedeutet sowohl einen Ausbau der Erzeugungskapazität wie auch eine territoriale Ausdehnung von Erzeugungs- und Verteilungsinfrastruktur. Im Gegensatz dazu weisen konsolidierte Energiesysteme eine relativ konstante Energieerzeugung auf. Im Rahmen der Transition erfahren konsolidierte Energiesysteme eine Substitution bestehender materieller Infrastruktur, wie beispielsweise in Deutschland beim sogenannten Atomausstieg zu beobachten ist (Löhr, 2018).

Abbildung 2 veranschaulicht die Unterschiede zwischen expandierenden und konsolidierten Energiesystemen anhand der zwei Merkmale des Ausbaus der Gewinnungskapazität und der räumlichen Ausdehnung. Die linke Grafik zeigt die Bruttostromerzeugung von OECD und nicht-OECD Länder zwischen 1990 und 2019, wobei deutlich wird, dass die OECD-Länder in den letzten 20 Jahren ein beschränktes Wachstum aufweisen, wohingegen das Wachstum der nicht-OECD Länder stark ansteigend ist. Die rechte Grafik zeigt sie die stark ansteigende Elektrifizierungsrate von sogenannten *low-&middle-income countries,* die einer räumliche Ausdehnung der Gewinnungs- und Verteilungsinfrastruktur gleichkommt. Diese Schaubilder dienen nicht einer länderspezifischen Abgrenzung expandierender und konsolidierter Energiesysteme. Sie zeigen aber auf, dass es mit dem Beginn des Aufschwungs globaler Transformationsbemühungen zu Beginn des 21. Jahrhunderts (Solomon & Krishna, 2011; Benjamin K. Sovacool, 2016), unterschiedliche Entwicklungen der Bruttostromerzeugung und der Elektrifizierungsraten von Energiesystemen gibt.

Abbildung 2: Unterschiedliche Entwicklung der Brutto-Stromerzeugung und Elektrifizierungsrate



Quelle: Eigene Darstellungen basierend auf IEA (2021) und The World Bank (2022b)

Dieser Unterschied eignet sich dafür, eine deskriptive und energiebezogene Differenzierung mit weitreichenden Implikationen für Transitionen vorzunehmen und empirisch zu überprüfen. Es stellt sich die Frage, inwiefern physische Expansionen, d.h. der Bau zusätzlicher Erzeugungs- und Verteilungsinfrastrukturen, den Einsatz neuer Technologien erleichtern und kumulativen Wandel im Energiesystem einleiten oder inwiefern immateriellen Komponenten wie Ideen, Institutionen und politische Macht Wandel verhindern.

Die Wechselwirkungen zwischen den überlagerten Prozessen der Expansion und der Transition sind bisher nicht ausreichend konzeptualisiert. Ihre Untersuchung ist Ziel der empirischen Forschung.

1.3.3. Konzepte zur Analyse expandierender Energiesysteme

Für die Analyse von Energietransitionen –im Globalen Süden wie auch im Globalen Norden- werden zunehmend Forderungen laut, politische und institutionelle Bedingungen stärker zu berücksichtigen (Kuzemko et al., 2016; Lockwood, Kuzemko, Mitchell & Hoggett, 2017). Der Fokus rückt stärker auf die Rolle verschiedener Akteure und Akteursgruppen sowie ihre Ermächtigung oder Einschränkung durch formelle und informelle Institutionen. Hier eignen sich Konzepte der Governanceforschung, Erkenntnisse aus dem Institutionalismus und das Konzept der *energy justice*, die im Folgenden erläutert werden.

Energy Governance

Der allgemeine Begriff der Governance wird in zahlreichen wissenschaftlichen Disziplinen sowie in der politischen Praxis verwendet und ist mit unterschiedlichen Bedeutungen verbunden. Laut Gailing (2018) hat sich die Governance-Forschung in den letzten Jahren von einer eher normativen Perspektive der Reform hierarchischer Politikgestaltung hin zu einer deskriptiven analytischen Perspektive gewandelt, die sich auf die Analyse kollektiver

Handlungsweisen konzentriert (Gailing, 2018). Diese neuere Perspektive in der Governance-Forschung befasst sich mit verschiedenen Formen der sozialen Koordination und dem Zusammenspiel von öffentlichen und privaten Institutionen auf verschiedenen Ebenen und für verschiedene kollektive Handlungsfelder.

Wissenschaftler:Innen, die sich mit der *energy governance* befassen, haben die spezifischen Herausforderungen der Governance im Energiesektor herausgearbeitet. Diese sind erstens die starke vertikale Komplexität, die durch die Interdependenz mit anderen Sektoren wie Industrie, Landwirtschaft, Gebäude, Umwelt oder Gesundheit verursacht wird und den Energiesektor zu einem "Nest oder Netz anderer globaler Systeme macht, die übereinandergeschichtet sind" (Goldthau & Sovacool, 2012, S. 232; Goldthau, 2014). Zweitens sind am Energiesektor Akteure auf verschiedenen Ebenen beteiligt, von der lokalen, regionalen, nationalen bis zur globalen Ebene (Bazilian, Nakhooda & van de Graaf, 2014). Goldthau und Sovacool klassifizieren drei Ebenen, nämlich die Makroebene, die sich auf trans- oder supranationales Engagement bezieht, die Mesoebene, die sich auf den Einfluss der mittleren Ebene auf Energiesysteme und spezifische Technologien" bezieht, und die Mikroebene, die sich auf Aktivitäten auf Haushaltsebene bezieht (Goldthau & Sovacool, 2012). Auf jeder Skala und auch dazwischen gibt es zahlreiche heterogene Akteure mit unterschiedlichen Interessen und Ressourcen. Drittens gibt es komplexe und vielschichtige Institutionen, Gesetze und Vorschriften, um kollektive Maßnahmen im Energiesektor zu koordinieren. Um diesen Herausforderungen gerecht zu werden, werden polyzentrische Governance Konfigurationen vorgeschlagen (Goldthau, 2014; Ostrom, 2010).

Institutionalismus

Als Antwort auf die wachsende Anerkennung der Bedeutung von Institutionen für Energietransitionen wurden für deren Analyse in den letzten Jahren zunehmend Erkenntnisse aus dem Institutionalismus integriert (Andrews-Speed, 2016; Hitzeroth, Jehling & Brueckner, 2017; Israel & Jehling, 2019; Jehling, Hitzeroth & Brueckner, 2019; Lockwood et al., 2017). Dabei gibt es verschiedene Ansätze des Institutionalismus, denen unterschiedliche Paradigmen zugrunde liegen und die sich auf unterschiedliche Ebenen fokussieren. Diese warden unterschieden in *sociological institutionalism, rational-choice institutionalism, organizational institutionalism* und *historical institutionalism* (Lowndes & Roberts, 2013).

Einen Überblick über empirische Anwendungen dieser Ansätze auf Energietransitionen gibt Andrews-Speed (2016). Er ordnet den einzelnen Ansätzen unterschiedliche Erkenntnismöglichkeiten zu (Andrews-Speed, 2016). Demnach ist *rational-choice institutionalism* besonders für Erkenntnisse über Eigentumsrechte, Transaktionskosten und Verträge geeignet und befasst sich auf der Mikroebene mit dem Handeln individueller Akteure. *Sociological institutionalism* eignet sich für einen Fokus auf die Rolle soziokultureller Systeme

und befasst sich mit der organisatorischen Ebene und der Historische Institutionalismus (HI) legt einen besonderen Fokus auf Machtverteilungen und betont die Pfadabhängigkeit von Energiesystemen.

Analysen des HI betrachten, wie Akteure Institutionen gestalten und nutzen, um ihre eigenen Interessen zu verfolgen und um durch sie Macht auszuüben oder inwiefern sie durch sie behindert werden. Er eignet sich für Erkenntnisse über Machtverteilungen und ist an großen geographischen Skalen über längere Zeiträume interessiert (Andrews-Speed, 2016; Lowndes & Roberts, 2013). HI ist der Versuch zu zeigen wie politische Kämpfe in ihrem institutionellen Gefüge verhandelt werden und wie Institutionen die Versuche von Akteuren beeinflussen, ihre Interessen zu verfolgen (Lockwood et al., 2017). Dabei werden sowohl formelle wie auch informelle Regeln in Form von Normen, Routinen und Ideen mit einbezogen (Lockwood et al., 2017). Diese institutionellen Zwänge, durch die Akteure eingeschränkt werden oder Macht ausüben werden in *regulation*, *practice*, und s*tory telling* unterteilt (Lowndes & Roberts, 2013). *Regulation* erfolgt über den institutionellen Zwang durch schriftliche Regeln, also formell festgehaltene Gesetze oder Vorschriften (Jehling et al., 2019; Lowndes & Roberts, 2013). *Practice* erfolgt furch informelle Praktiken, also Verhaltensmuster, die durch Demonstration vermittelt werden. Macht durch s*tory telling* erfolgt über Ideen und Überzeugungen, die durch Narrative zwischen Akteuren übermittelt werden (Lowndes & Roberts, 2013). Diese diskursive Macht entsteht durch die Fähigkeit Diskurse effektiv zu nutzen sowie diskursive Koalitionen zu bilden. So können auch alternative Ideen an Macht gewinnen und etablierte Interessen herausfordern (Kuzemko et al., 2016; Lowndes & Roberts, 2013). Akteure können in unterschiedliche Regulierungsebenen gegliedert werden und sind entweder *rule-makers*, die Regeln setzen, oder *rule-takers*, die Regeln auf ihre spezifischen Interessen und lokalen Gegebenheiten anwenden (Goldthau, 2014; Lowndes & Roberts, 2013). Beide Gruppen stehen in einer dynamischen Beziehung, durch die die Praktiken der *rule-takers* in Regeln umgewandelt werden können und neue (d. h. gemachte) Regeln an etablierte Praktiken angepasst werden.

Wandel wird im HI als inkrementell und stark pfadabhängig verstanden (Andrews-Speed, 2016; Lockwood et al., 2017; Lowndes & Roberts, 2013; Pierson, 2004). Der HI zeigt dabei, inwiefern Institutionen Wandel behindern, aber andererseits auch inwiefern Institutionen selbst resistent gegenüber Wandel sind (Andrews-Speed, 2016). Laut Lockwood et al. (2017) ist der HI für die Analyse von Energietransitionen in verschiedenen Kontexten und auch im Globalen Süden gut geeignet (Israel & Jehling, 2019; Lockwood et al., 2017). Ein Kritikpunkt bei der Anwendung auf Energiesysteme ist die mangelnde Berücksichtigung materieller Aspekte (Lockwood et al., 2017).

Energy Justice

Energy Justice ist ein Konzept, das in den letzten Jahren rasant an Bedeutung gewonnen hat (Jenkins et al., 2016; Benjamin K. Sovacool, 2013). Im Unterschied zu den analytischen Governanceansätzen und dem Institutionalismus handelt es sich hier um ein normatives Konzept, das Grundsätze der sozialen Gerechtigkeit auf den Energiesektor anwendet und Gerechtigkeitsaspekte von der Energieerzeugung, des Energieverbrauchs und der Energiesicherheit bis hin zum Klimawandel untersucht (D. McCauley, R. Heffron, Hannes R. Stephan & Kirsten E H Jenkins, 2013; Jenkins et al., 2016). Die theoretische Grundlage des Konzepts der Energiegerechtigkeit geht auf die Umweltgerechtigkeit (Schlosberg, 2004) und in jüngerer Zeit auf die Klimagerechtigkeit (Dawson, 2010) zurück. Betont werden Wechselbeziehungen zwischen ökologischen und gesellschaftlichen Dynamiken, die häufig zu einer Reproduktion von Benachteiligung und Ungerechtigkeit führen (P. Munro et al., 2017).

Konzeptionell wird Gerechtigkeit hier in drei Dimensionen unterteilt: Verteilungs-, Verfahrens- und Anerkennungsgerechtigkeit (Jenkins et al., 2016; Schlosberg, 2004). Die Dimension der Verteilungsgerechtigkeit bezieht sich auf eine "gleichmäßige Verteilung von Vorteilen und Nachteilen auf alle Mitglieder der Gesellschaft", während die Dimension der Verfahrensgerechtigkeit den Zugang zu und die Beteiligung an Entscheidungsprozessen umfasst (Jenkins et al., 2016, S. 176). Die Dimension der Anerkennungsgerechtigkeit ist "ein epistemologischer Fokus auf die Art und das Ausmaß, in dem unterschiedliche Formen von Wissen und Werten einbezogen werden" (P. Munro et al., 2017, S. 636) und stellt die Frage: "wer wird ignoriert?" (Jenkins et al., 2016, S. 175). Die Anerkennungsgerechtigkeit ist von grundlegender Bedeutung und ist Voraussetzung für das Erreichen von Verteilungs- und Verfahrensgerechtigkeit (Schlosberg, 2004). Sie "stellt die institutionalisierte Ausgrenzung in Frage", die häufig der Grund hinter Ungleichverteilung ist (Fraser, 2000; Schlosberg, 2004, S. 519). Nach Castán Broto et al. (2018, S. 647) ermöglicht sie pluralistische Ansätze und ist "eine Feier des Besonderen".

In jüngster Zeit haben sich mehrere Studien mit der Anwendbarkeit des Konzepts der Energiegerechtigkeit im Kontext spezifischer Rahmenbedingungen im Globalen Süden befasst (Castán Broto et al., 2018; Kruger & McCauley, 2020; Lacey-Barnacle, Robison & Foulds, 2020; P. Munro et al., 2017; van der Horst, Grant, Montero & Garneviciene, 2021). Munro et al. (2017) analysieren die globale Energiepolitik für den Zugang zu „moderner Energie“ und ihre lokalen Auswirkungen auf die "traditionelle" Energieversorgung mit Brennholz in Sierra Leone. Die Analyse zeigt, dass "Lösungen für Energiearmut" wahrscheinlich "Formen der Entmachtung und Ungerechtigkeit" reproduzieren und paternalistische Ansätze in Bezug auf Energiesysteme im globalen Süden verstärken (P. Munro et al., 2017, S. 639).

Andere Autor:Innen argumentieren, dass das Konzept der Energiegerechtigkeit nicht ohne Anpassung auf den Globalen Süden übertragen werden kann (Apfel et al., 2021; Castán Broto et al., 2018; Monyei, Jenkins, Serestina & Adewumi, 2018). Castán Broto et al. (2018) ergänzen daher das Konzept der *energy justice* durch emanzipatorische Forderungen, die sie im globalen Süden für besonders relevant halten und stützen sich auf postkoloniale Perspektiven. Die postkoloniale Theorie betont strukturelle Ungleichheiten als historisches Erbe von Unterdrückung und Ausgrenzung und fordert eine historische Betrachtung (Anderson, 2002; Baptista, 2018; Castán Broto et al., 2018). Sie findet durch die Dimension der Energiesouveränität Einklang in das Konzept der *energy justice*. Energiesouveränität betont den emanzipatorischen Charakter der Energieversorgung und die Notwendigkeit der Selbstbestimmung. Sie wirkt als weiteres Korrektiv, indem sie die spezifischen historischen und kulturellen Kontexte der Energiesysteme sowie ungerechte Systeme der Wissensproduktion, die asymmetrische Machtverhältnisse reproduzieren, hervorhebt. Sie fordert lokalisierte Modelle der Energieversorgung und die Anerkennung "kontextuell erzeugter Innovation“ (Castán Broto et al., 2018, S. 648).

Die hier vorgestellten Konzepte der sozialwissenschaftlichen Energieforschung, *energy governance*, historischer Institutionalismus und *energy justice* wurden jeweils in einem oder mehreren Beiträgen angewendet und ihre Eignung für die Analyse eines expandierenden Energiesystems betrachtet.

1.4. Methoden und Untersuchungsgebiet Peru

Das peruanische Energiesystem eignet sich als Fallbeispiel für diese Arbeit, da es in den letzten drei Jahrzehnten eine starke Expansion in Bezug auf die Erzeugungs- und Verteilungsinfrastrukturen erfahren hat (Gamio, 2018). Von 1999 bis 2019 hat sich die gesamte Bruttostromerzeugung Perus von 20,3 TWh auf 57 TWh mehr als verdoppelt (International Energy Agency, 2022). Auch die Elektrifizierungsrate stieg in diesem Zeitraum rapide an. Während Peru in den 1990er Jahren mit einer Elektrifizierungsrate von weniger als 70% weit hinter dem lateinamerikanischen Durchschnitt zurücklag, haben heute, je nach Quelle, 97 % (International Energy Agency, 2022) bis 99 % (World Bank, 2022) der Bevölkerung Zugang zu Elektrizität. Der Ausbau des peruanischen Energiesystems wurde von einer Vielzahl von Akteuren vorangetrieben, durch verschiedene Energietechnologien umgesetzt und von unterschiedlichen institutionellen Rahmenbedingungen begleitet.

Um die Wechselwirkung zwischen Akteuren, Institutionen und Technologien in Expansionsprozessen zu verstehen wurden in diesem Forschungsvorhaben qualitative Methoden empirischer Sozialforschung angewandt. Das ermöglicht "Meinungen, Einstellungen, Wahrnehmungen und Verständnisse von Menschen und Gruppen in

verschiedenen Kontexten" (Benjamin K. Sovacool et al., 2018, S. 18) zu untersuchen. Die Erhebung und Analyse qualitativer Daten in Form von Sekundärdaten wie Gesetzen, Plänen, Nachrichten, Berichten und in Form von teilstrukturierten qualitativen Interviews ist für die Analyse des Zusammenspiels von Akteuren und Institutionen vorherrschend (Harrington; Leiren & Reimer, 2018; Lis & Szymanowski, 2022). Sie erlaubt Rückschlüsse darüber, wie Akteure Institutionen nutzen, um ihre eigenen Interessen zu verfolgen, inwiefern sie durch sie Macht ausüben oder durch sie behindert werden (Fernandes de Freitas & Jehling, 2023).

Die Erhebung des Datenmaterials erfolgte in einem zweistufigen Verfahren. In einem ersten Schritt wurden, im Jahr 2016, 13 teilstrukturierte Interviews mit Entscheidungsträgern, Wissenschaftlern, Vertretern von Energie- und Bergbauunternehmen, NGOs, Interessengruppen und einer internationalen politischen Stiftung geführt. Die Interviews konzentrierten sich auf Akteure, Institutionen und Technologien der Expansionsprozesse des peruanischen Energiesystems. Auf Grundlage der Interviews wurden verschiedene Typen sozio-technischer Expansionen identifiziert und drei empirische Beispiele ausgewählt.

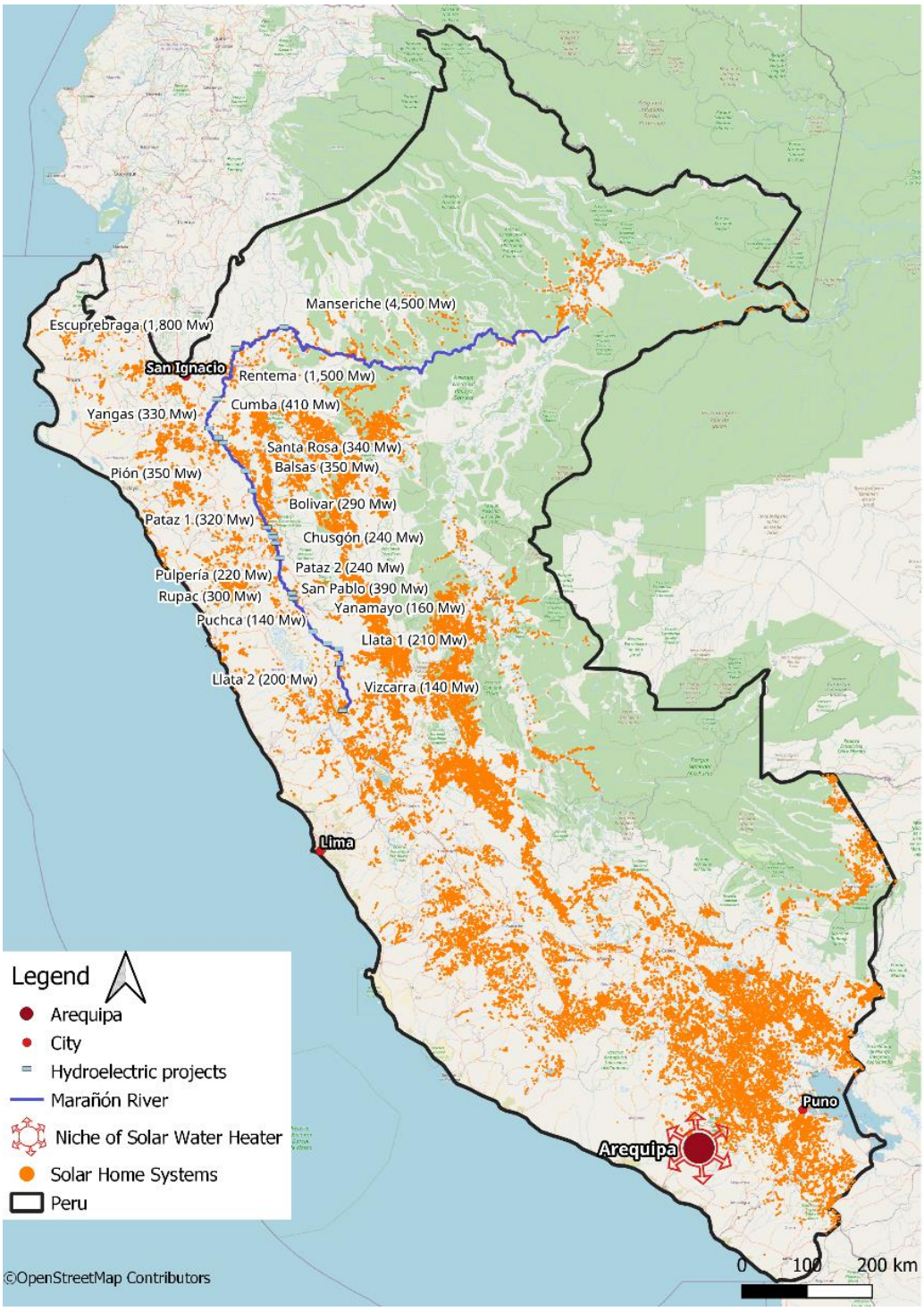
Die zweite Stufe der Datenerhebung beschäftigte sich mit der weiterführenden Analyse der drei ausgewählten sozio-technischen Expansionsprozesse. Hierfür wurden 2017 und 2018 weitere Feldforschungen durchgeführt. Der Vergleich von "Stichproben aus verschiedenen Fällen, Regionen oder Settings [kann] häufig nützlichere Ergebnisse liefern" (Benjamin K. Sovacool et al., 2018, S. 29).

Das gesamte empirische Material der drei Feldforschungsstudien umfasst mehr als 40 teilstrukturierte Interviews, die in Lima, Arequipa, Puno und San Ignacio durchgeführt wurden; Feldbesuche in den südlichen und nördlichen Anden (Puno, Arequipa, und Cajamarca); und Sekundärdaten wie Gesetze, Pläne, Nachrichten, Berichte und geocodierte Daten. Die Liste der Interviews befindet sich im Anhang.

Die Interviews wurden mit Hilfe der qualitativen Inhaltsanalyse (Dresing & Pehl, 2018; Mayring, 2010) ausgewertet. Die Kategorien resultierten aus einem mehrstufigen Prozess, der induktive und deduktive Verfahren kombiniert (Kuckartz, 2016). Nach Prüfung und Anpassung der Kategorien, wurden die transkribierten Interviews kodiert. Die ausgewählten Zitate aus den Interviews sind aus dem Spanischen, Deutschen oder Portugiesischen ins Englische übersetzt.

Abbildung 3 zeigt die drei untersuchten Expansionen im nationalen Kontext Perus: Die landesweite Verteilung von Solar Home Systems, der geplante Bau von 20 Wasserkraftwerken im Marañón-Fluss und die wachsende Nische von Solarwarmwasserbereiterns (SWH) in Arequipa.

Abbildung 3: Empirisch untersuchte Expansionen in Peru



Quelle: eigene Darstellung, basierend auf Arana Cardó (2012) und García Pérez (2011), sowie vom MINEM bereitgestellten Daten über die Standorte der installierten Solar Home Systems

1.5. Kumulativer Teil der Dissertation

Im folgenden Teil werden die Ergebnisse der einzelnen Beiträge kurz zusammengefasst und ihre Bedeutung für die Dissertation aufgezeigt. Die ersten beiden Beiträge zeigen jeweils die Ergebnisse zu einem spezifischen Expansionsprozess, während der dritte Beitrag eine Synthese der insgesamt drei untersuchten Prozesse darstellt.

1.5.1. Wie modern sind erneuerbare Energien? Traditionelle Solarthermie in Arequipa und seine Marginalisierung in Perus Energietransition

> **'it is not about promoting the products where nobody measures the quality'**
> (interviewter Vertreter einer Organisation für internationale Entwicklungszusammenarbeit)

Die Untersuchung des lokalen Clusters für solarthermische Energie in Arequipa zeigt die Gründe für die Marginalisierung lokal produzierter erneuerbarer Energietechnologien im Zusammenhang von Bestrebungen nach „moderner Energie" auf. Die Nutzung solarthermischer Energie hat in der in den Anden gelegenen Stadt Arequipa, begünstigt durch die hohen Strahlenwerte, eine lange Tradition. Bereits in den 1930er Jahren baute ein Universitätsprofessor das erste Modell eines solarthermischen Warmwasserbereiters in Arequipa. In den 1980er Jahren griff die staatliche Behörde INDECOPI in Lima (Nationales Institut für die Verteidigung des Wettbewerbs und den Schutz des geistigen Eigentums) die Erfahrung verschiedener peruanischer Universitäten zur Herstellung von Solarwarmwasserbereitern auf und entwickelte die Technologie weiter. Sie erstellte eine Lizenz zur Produktion sogenannter *Sistemas de Calentamiento de Agua con Energía Solar* (Systeme zur Wassererwärmung mit Solarenergie) und stellte diese exemplarisch in verschiedenen Städten Perus aus. Ein Unternehmen in Arequipa kaufte eine Lizenz und fing an die Technologie vor Ort zu produzieren und zu vertreiben. Was daraufhin geschah wird von einem interviewten Wissenschaftler als eine spontane, marktbasierte Diffusion der Technologie in Arequipa beschrieben:

> '[the first enterprise] starts to produce, and as it is such a simple technology, so other persons watch and start to copy […] so everybody starts, enterprises start to appear, they start to produce and start to grow, the enterprises, and the technology starts to spread'

Der wirtschaftliche Vorteil der SWH gegenüber elektrischen Warmwasserbereitern sowie die lange Tradition der Nutzung von Solarenergie erklären den Erfolg der Technologie. Nach Schätzungen verfügen aktuell ca. 55.000 Haushalte Arequipas über einen SWH. Neben privaten Haushalten werden die SWH auch in kleinen industriellen Betrieben, Hotels und öffentlichen Einrichtungen eingesetzt. Geschätzte 50 Kleinunternehmen produzieren und vertreiben die Technologie in Arequipa, der zweitgrößten Stadt Perus. Nach und nach erweiterten die Unternehmen ihre Aktivitäten und vertreiben die Technologie nun auch in peripheren urbanen Räumen Arequipas und anderen Regionen Perus.

Von staatlichen Akteuren auf lokaler, regionaler und nationaler Ebene wird die Verbreitung der Technologie nicht wahrgenommen. Sie erfährt weder staatliche Förderung noch wird sie reguliert. Die fehlende Regulierung wird von befragten Unternehmen als Problem dargestellt, da es zunehmend zu einem aggressiven Wettbewerb und kritischen Wettbewerbsstrategien kommt, die das Vertrauen in die Technologie gefährden.

Während staatliche Akteure aus Peru unbeteiligt bleiben, erscheinen im Zusammenhang der globalen Bemühungen für einen universellen „Zugang zu bezahlbarer, verlässlicher, nachhaltiger und moderner Energie für alle“ (UNRIC - Regionales Informationszentrum der Vereinten Nationen) internationale Akteure der Entwicklungszusammenarbeit (EZ) in Arequipa und verändern den lokalen Markt. Das Projekt eines Konsortiums von internationalen EZ-Agenturen, mit Hauptsitz in Arequipa, verfolgt das Ziel der Dynamisierung des Marktes für Solarthermen im ländlichen Raum. Hierfür fördert es den Einsatz von SWH, wobei ausschließlich importierte SWH gefördert werden. Dies wird mit fehlenden Qualitätsstandards der lokalen Produkte begründet: ‘*it is not about promoting the products where nobody measures the quality’* (Vertreter internationale Entwicklungsagentur). Das Programm ziele darüber hinaus nicht auf die Förderung der nationalen Industrie, sondern auf die Dynamisierung des Marktes moderner erneuerbarer Energietechnologien ab. Dies führt zu einer wahrgenommenen Veränderung des lokalen Clusters: Produzierende Unternehmen verkaufen nun neben der Eigenproduktion oftmals auch importierte Thermen und die lokal produzierte Technologie läuft Gefahr verdrängt zu werden.

Dieser Beitrag zeigt die Entstehung und Verbreitung von lokalen Praktiken der Nutzung erneuerbarer Energie, die von staatlichen Akteuren nicht wahrgenommen und durch die ausbleibende Regulierung gefährdet werden. Die Perspektive des hier angewendeten historischen Institutionalismus zeigt die pfadabhängige Entwicklung der institutionellen Konfiguration und verdeutlicht eine persistente Marginalisierung der lokalen Praktiken im Kontext der Forderungen nach einem universellen Zugang zu „moderner Energie“. In Hinblick auf das hier angewendete Konzept der *energy justice,* bestätigt dieses Beispiel die zentrale Funktion der Anerkennungsgerechtigkeit. Das Fehlen derselbigen geht mit einer Beeinträchtigung der weiteren Gerechtigkeitsdimensionen einher.

In Bezug auf die Ziele dieser Dissertation konnte dieser erste Beitrag die Problematik modernistischer Diskurse an einem konkreten Beispiel aufzeigen. Die Marginalisierung lokaler Energiepraktiken in Arequipa ist besonders eindrücklich, da es sich hier um vermeintlich nachhaltige erneuerbare Energietechnologien handelt. Die ausführliche Untersuchung der Akteure und Institutionen über einen längeren Zeitraum verdeutlicht die Problematik von global anwendbaren Top-Down Strategien, die lokale Kontexte nicht ausreichend berücksichtigen und deren techno-ökonomischer Fokus die sozio-ökonomische und kulturelle Bedeutung von

existierenden Energiepraktiken nicht anerkennt. Dies betont die Notwendigkeit alternative Diskurse anzustoßen und entwicklungspolitisch motivierte Kategorien durch energiebezogene zu ersetzen.

1.5.2. Governance der peruanischen Energietransition: Pfadabhängigkeit, alternative Ideen und Wandel in der nationalen Expansion von Wasserkraft

'…the problem is not that there is an increasing demand, the problem is that there is a potential that wants to be exploited'
(Vertreter einer peruanischen NGO)

Die empirische Untersuchung des geplanten Ausbaus der Wasserkraft im Fluss Marañón in Peru ging der Frage nach, inwiefern sich Expansionen auf die Pfadabhängigkeit von Energiesystemen auswirken. Dafür wurden, unter Bezugnahme auf analytische Governance-Perspektiven, Institutionen und Akteure identifiziert, die die Expansion vorantreiben oder sich derer entgegensetzen. Anschließend wurde überprüft inwiefern dieser Expansionsprozess Wandel im Energiesystem einleitete oder Kontinuität verstärkte.

Der geplante Ausbau der Wasserkraft im Fluss Marañón, einem Hauptzufluss des Amazonas, wurde formal durch ein Präsidialdekret initiiert. Dieses erklärt den Fluss zur Energiearterie des Landes und deklariert den Bau von 20 Großwasserkraftwerken zum sozialen und nationalen Interesse. Die angestrebte Menge zusätzlich erzeugter Energie entspricht mehr als dem doppelten der gesamten Kapazität des peruanischen Energiesystems zu diesem Zeitpunkt. Neben dem Präsidialdekret spielt ein bilaterales Energieabkommen zwischen Brasilien und Peru eine zentrale Rolle für den geplanten Ausbau. Dieses bestimmt den Bau von Großwasserkraftwerken im peruanischen Amazonasgebiet, mit dem Ziel, einen Teil der gewonnenen Energie nach Brasilien zu exportieren. Es setzt darüber hinaus fest, dass der Bau der Wasserkraftwerke durch die Brasilianische Entwicklungsbank finanziert und von brasilianischen Baukonzernen realisiert werden. Fünf der geplanten Wasserkraftwerke im Flusslauf des Marañóns stehen in direktem Zusammenhang mit dem bilateralen Abkommen. Die Verhandlungen darüber fanden ohne der Beteiligung betroffener sektoraler und regionaler Behörden oder der Zivilgesellschaft auf peruanischer Seite statt. Ein wichtiger Treiber des Ausbaus der Wasserkraft in Peru ist der energieintensive Bergbausektor, der auf eine günstige und verlässliche Energieversorgung angewiesen ist. Auch in räumlicher Nähe der geplanten Wasserkraftwerke des Marañóns befinden sich existierende und geplante Bergbaudistrikte, was einen Zusammenhang vermuten lässt. Interviewte Berfürworter:Innen des Ausbaus propagieren die Idee, dass der Fluss energetisch genutzt werden müsse, da das Wasser sonst verloren ginge, ohne dass daraus monetärer Wert geschöpft würde. Ausschlaggebend für den Ausbau ist, in dieser Argumentation, nicht eine unbefriedigte Nachfrage nach Energie, sondern ein Potenzial, das inwertgesetzt werden soll.

Dem geplanten Ausbau der Wasserkraft im Marañón setzt sich eine breite Opposition entgegen. Diese umfasst sowohl Teile der betroffenen Bevölkerung wie auch staatliche Behörden und die organisierten Zivilgesellschaft. Angeprangert werden die umfangreichen sozialen und ökologischen Auswirkungen des massiven geplanten Eingriffs sowie eine unzureichende Analyse derselbigen. Darüber hinaus wird der Umfang des Ausbaus und der Verkauf nationaler Ressourcen kritisiert. Ein weiterer zentraler Kritikpunkt ist die mangelnde Transparenz und fehlende Beteiligung relevanter Akteure. Der Idee des Flusses als Ressource und ökonomisches Potential werden Wahrnehmungen des Flusses als Ökosystem und Lebensraum entgegengesetzt. Das bilaterale Abkommen mit Brasilien wurde in Folge der Proteste dem Kongress zum Entscheid vorgelegt und mehrheitlich abgelehnt. Ein internationaler Korruptionsskandal, um den am Abkommen beteiligten brasilianischen Baukonzern Odebrecht, der Peru in eine fortwährende politische Krise auslöste, stoppte letztendlich den geplanten Ausbau. Laut eines Interviews hat sich die öffentliche Wahrnehmung von Großwasserkraft infolge der Auseinandersetzung verändert, sodass sie nun nicht mehr als „beste Energiequelle“ angesehen werde.

Die empirischen Ergebnisse dienen als Grundlage für die Formulierung von Governance Empfehlungen. Sie zeigen auch, dass in der Auseinandersetzung über Energieexpansionen grundlegende Natur- und Gesellschaftsverhältnisse verhandelt werden. Die Ergebnisse zeigen darüber hinaus, dass Expansionen des Energiesystems zur Veränderung von Institutionen führen können. Formale Institutionen wie das bilaterale Abkommen wurden aufgelöst und auch die Wahrnehmung von Wasserkraft hat sich verändert. Der Beitrag zeigt somit, dass die Expansion eines Energiesystems institutionellen Wandel einleiten kann.

In Bezug auf die Ziele dieser Dissertation ist mit diesem Beitrag ein wichtiger Fortschritt gelungen. Die Kategorie expandierender Energiesysteme konnte in einer renommierten Zeitschrift eingeführt und definiert werden:

> “We agree that a differentiation based on the characteristics of the energy system itself is required and suggest the concept of expanding energy systems, which are characterised by overall energy generation being increased and territorial coverage being extended. Such systems are in contrast to consolidated energy systems, where energy generation is constant or decreasing (IEA, 2019). We argue that the expansion of energy systems has implications for energy transitions.”

Der Beitrag zeigt, dass die Analyse von Expansionsprozessen einen wichtigen Beitrag zum Verständnis von Energietransitionen liefern kann. Er zeigt ferner Fragen auf, die spezifisch für expandierende Energiesysteme relevant sind: wieviel zusätzliche Energie soll generiert werden? Wer profitiert von der Expansion und wer trägt die Kosten? Wie werden Entscheidungen über das Ausmaß der Expansion getroffen? Abschließend konnte dieser Beitrag die Kategorie expandierender Energiesysteme in die aktuelle wissenschaftliche Debatte einfließen lassen.

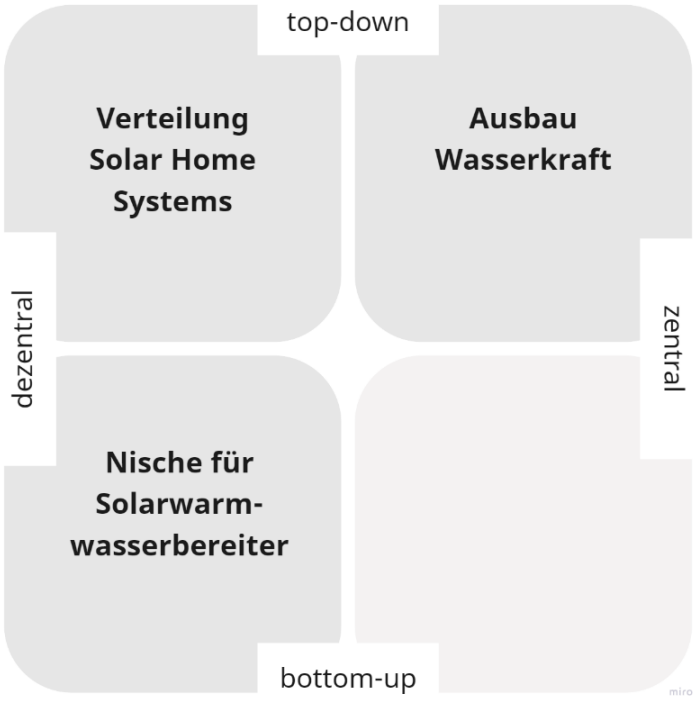
1.5.3. Wandel und Pfadabhängigkeit in expandierenden Energiesystemen: Die Erklärung der Energiewende in Peru jenseits der Nord-Süd-Dichotomie

'we could show that the conceptualisation of expanding energy systems is suitable for contributing to an enhanced understanding of different conditions for and outcomes of energy transitions'
(Auszug aus Beitrag III)

Der dritte Beitrag stellt eine Synthese der empirischen Ergebnisse dar und entwickelt das Konzept expandierender Energiesysteme. In einem ersten Schritt werden in diesem Beitrag das peruanische Energiesystem und seine Expansionen vorgestellt. Dabei werden sowohl materielle Aspekte wie der Ausbau der Erzeugungsinfrastruktur und der Verteilungsinfrastruktur als auch immaterielle Aspekte wie der regulatorische Rahmen der Expansionen vorgestellt.

Anschließend werden vier verschiedene Typen sozio-technischer Expansionsprozesse abgleitet. Die technische Dimension bezieht sich dabei auf die Zentralität der Energieerzeugung, also darauf, ob die zusätzliche Energie über das zentrale Netz verteilt oder durch dezentrale, netzunabhängige Technologien erfolgt. Die soziale Dimension bezieht sich auf die zugrundeliegenden Entscheidungsprozesse und unterscheidet zwischen *top-down* Prozessen, die durch *rule-maker* bestimmt werden und *bottom-up* Prozessen, die durch *rule-taker* bestimmt werden. Insgesamt konnten 3 verschiedene Typen sozio-technischer Expansionsprozesse in Peru identifiziert und empirisch analysiert werden. Diese sind in Abbildung 4 dargestellt.

Abbildung 4: Vier Typen sozio-technischer Expansionsprozesse und empirische Beispiele aus Peru



Quelle: Eigene Darstellung

Der Beitrag stellt für jeden der drei identifizierten Prozesse die relevanten Akteure, Institutionen und Technologien vor. An dieser Stelle wird nur auf die Verteilung von Solar Home Systems (SHS) eingegangen, da die Ergebnisse zur Nische bzw. zum Cluster der SWH bereits in Abschnitt 1.5.1. und der Ausbau der Wasserkraft in Abschnitt 1.5.2. zusammengefasst wurden. s

Das empirische Fallbeispiel bezieht sich auf ein Programm zur landesweiten Verteilung von alleinstehenden Photovoltaiksystemen, sogenannten SHS. Der Anstoß für dieses nationale Programm kam laut Aussagen eines ministeriellen Beamten von „ganz oben“ (Fernandes de Freitas & Jehling, 2023). Das Ziel des Programmes ist es, bis zum 200. Unabhängigkeitsjubiläum Perus, eine 100% Elektrifizierungsrate zu erreichen. Dezentrale erneuerbare Energietechnologien wurden von Entscheidungsträger als einzige technische Option für dieses ehrgeizige politische Ziel angesehen. Um die regulatorischen Rahmenbedingungen hierfür zu schaffen, wurde ein Präsidialdekret erlassen. Die Ausschreibung zu dem sogenannten „Massiven Photovoltaikprogramm“ gewann ein Tochterunternehmen des italienischen Konzerns Tozzi Green. Eine Beteiligung von staatlichen Behörden unterhalb der nationalen Ebene, sektoralen Behörden außerhalb des Energiesektors oder der Bevölkerung hat nicht stattgefunden. Zwischen 2017 und 2020 installierte das Unternehmen landesweit 205.000 SHS in ländlichen Haushalten, 2.400 SHS in staatlichen Bildungseinrichtungen und 640 SHS in Gesundheitsstationen. Dabei wurden dem Unternehmen weitreichende Entscheidungsbefugnisse wie die Auswahl der begünstigten Haushalte und Einrichtungen überlassen. Die Nutzer:Innen der Technologien sind zur Zahlung eines monatlichen Energiebeitrags verpflichtet. Kritisiert wurde an dem Programm die fehlende Anpassung der Technologie sowie der Regulationen an die jeweiligen sozio-ökonomischen und ökologischen Kontexte. Die Untersuchungen in den südlichen und nördlichen Anden haben gezeigt, dass die einheitliche Technologie den unterschiedlichen Energiebedürfnissen nicht gerecht wird. Während halbnomadische Viehhirten in den südlichen Anden bemängelten, dass sie mobile Geräte bräuchten, bemängelten Kaffeebauern der nördlichen Anden, dass die Geräte nicht ausreichten, um die Maschinen der Kaffeeverarbeitung zu betreiben. Auch der Zahlungsausfall des Nutzertarifs, der in 90% der Haushalte vermerkt wird, zeigt eine fehlende Anpassung der formalen Regulationen an die sozio-ökonomischen Bedingungen der Haushalte und die dezentrale Eigenschaft der Technologie. Diese Probleme werden auf eine mangelnde Kenntnis zentraler Akteure des Nationalstaats über die Lebensbedingungen in ländlichen Gebieten und eine mangelnde Bereitschaft für Beteiligungsprozesse zurückgeführt.

Der Vergleich der drei Expansionsprozesse aus Abbildung 4 zeigt schließlich Gemeinsamkeiten in Bezug auf Entscheidungsprozesse und die Rolle privater Unternehmen in Peru auf. Der heutige regulatorische Rahmen, ein Ergebnis neoliberaler Reformen und

späterer Anpassungen, überlässt weitreichende Entscheidungen über Energieexpansionen mächtigen Einzelakteuren des Zentralstaates, ohne einer Beteiligung nachgeordneter Ebenen oder weiterer sektoraler Behörden. Die Ergebnisse zur Bedeutung privater Unternehmen in Expansionsprozessen stimmen mit Kuzemko et al. (2016) überein, die argumentieren, dass das neoliberale Paradigma in Energiesystemen zu einer kritischen Rolle von Energieunternehmen und einer Koevolution der Energiepolitik führt.

Abschließend zeigt dieser Beitrag, welche Wirkung Energieexpansionen auf Wandel und Kontinuität im Energiesystem haben. In Bezug auf immaterielle Faktoren konnte gezeigt werden, dass der Einfluss von historisch verankerten Akteuren und Institutionen auf Expansionen eine verstärkende Wirkung auf Kontinuität im Energiesystem hat. Die Ergebnisse zeigen jedoch auch, dass die Expansionsdynamiken institutionellen Wandel anstoßen können. Mit anderen Worten: Wenn die Energiewende „ein Kampf der Ideen" (Kuzemko et al., 2016, S. 100), ist der Ausbau der Energiesysteme der Boxring. In Bezug auf materielle Faktoren konnte gezeigt werden, dass die Ablehnung von neuen dezentralen Technologien, wie SHS oder SWH gering ist. Die Ergebnisse bestätigen also, dass bei Expansionen ein geringes *capital sunk* besteht und die Ablehnung von dezentralen erneuerbaren Energietechnologien gering ist. Ein anderes Bild ergab sich für den zentralisierten Ausbau von erneuerbaren Energietechnologien. Wie im dritten Beitrag dargelegt, wirken etablierte Energieunternehmen dem Ausbau der netzgebundenen erneuerbaren Energien entgegen (Fernandes de Freitas & Jehling, 2023). Dies deutet darauf hin, dass die etablierten Energieunternehmen beim Ausbau zentraler netzgebundener Energietechnologie zwar nicht von *sunk capital* betroffen sind, aber bei Ausschreibungen konkurrieren und somit mit *lost profits* konfrontiert sind.

In Bezug auf die Ziele dieser Dissertation ist dies der zentrale Beitrag, der eine Synthese der empirischen Ergebnisse darstellt und das Konzept expandierender Energiesysteme in die wissenschaftliche Debatte einbringt. Es ist gelungen sozio-technischer Expansionsprozesse in verschiedene Typen zu gliedern und die Bedeutung von Expansionen für die Transition von Energiesystemen aufzuzeigen.

1.6. Zusammenfassung und Schlussfolgerung

1.6.1. Zusammenfassung

Die globalen Bemühungen dem Klimawandel entgegenzuwirken, zielen auch auf unsere Energiesysteme ab und führen zu umfassenden gesellschaftlichen Veränderungen. Neben der technischen Herausforderung unsere Energiesysteme zunehmend klimaneutral zu gestalten, stellt sich uns auch die Herausforderungen soziale Gerechtigkeitsaspekte zu berücksichtigen (Jenkins et al., 2016). Diese Arbeit argumentiert, dass die dichotome Betrachtung von Energiesystemen des Globalen Südens und Energiesystemen des Globalen Nordens zu einer

defizitären Perspektive auf letztere führt, diese marginalisiert und letztendlich globale Ungleichheiten perpetuiert. Das daraus abgeleitete Ziel dieser Arbeit war es, eine alternative Kategorie zur Differenzierung von Energiesystemen zu entwickeln, die als energiebezogene Kategorie einen Beitrag zum Verständnis verschiedener Bedingungen für und Ergebnisse von Transitionen liefert.

Unter Bezugnahme auf die Theorie sozio-technischer Systeme (Geels, 2004; Geels & Kemp, 2007) wurde die Kategorie expandierender Energiesysteme vorgeschlagen. Diese zeichnet sich durch den Ausbau der Erzeugungskapazitäten und die räumliche Ausdehnung der Verteilungsinfrastruktur aus und unterscheidet sich dadurch von konsolidierten Energiesystemen. Anschließend wurde am Fall des peruanischen Energiesystems, das in den vergangenen 20 Jahren eine starke Expansion erfahren hat, untersucht, welche Akteure, Institutionen und Technologien die Expansionen prägen und welche Bedeutung die Expansionen für Wandel und Kontinuität im Energiesystem haben. Dafür wurde auf Erkenntnisse der Governanceforschung (Gailing, 2018; Goldthau, 2014), des Historischen Institutionalismus (Andrews-Speed, 2016; Lockwood et al., 2017) und des Konzepts der *energy justice* (Jenkins et al., 2016; P. Munro et al., 2017) zurückgegriffen. Im Rahmen von drei Feldforschungsaufenthalten zwischen 2016 und 2018 wurden mehr als 40 teilstrukturierte Interviews mit ausgewählten Akteuren geführt und Sekundärdaten gesammelt. Die Auswertung der Interviews erfolgte mithilfe der qualitativen Inhaltsanalyse (Mayring, 2010).

Die drei entstandenen Beiträge bilden den Entwicklungspfad des Konzepts expandierender Energiesysteme ab. Der erste Beitrag zeigt am Beispiel eines lokalen Clusters von Solarwarmwasserbereitern in Arequipa, wie lokale Praktiken der Energieversorgung mit erneuerbaren Energietechnologien durch globale Diskurse über den Zugang zu „moderner Energie für alle“ marginalisiert und verdrängt werden. Er verdeutlicht die Notwendigkeit modernistische Diskurse zu überwinden, um kontextualisierte Lösungen zu ermöglichen. Im zweiten Beitrag wird die Kategorie expandierender Energiesysteme definiert und in den wissenschaftlichen Diskurs eingebracht. Am Beispiel des massiven Ausbaus der Wasserkraft im Fluss Marañón, wird gezeigt, welche Akteure und Institutionen sich für den Ausbau einsetzen und durch welche Akteure und alternative Ideen sie herausgefordert werden. Dieses Beispiel veranschaulicht, dass Expansionen institutionellen Wandel anstoßen können und ihre Analyse einen wichtigen Beitrag für das Verständnis von Transitionen liefern kann. Der dritte Beitrag stellt eine Synthese der empirischen Untersuchungen und die Konzeptualisierung expandierender Energiesysteme dar. Diese zeichnen sich durch Expansionsprozesse aus, die vier verschiedenen Typen zugeordnet werden. Diese Typen sozio-technischer Expansionsprozesse berücksichtigen die soziale Dimension bottom-up oder top-down und die technische Dimension dezentral oder zentral. Der Vergleich der drei empirisch untersuchten

Fälle in Peru ermöglichte Rückschlüsse auf die Governance der Expansionsprozesse Perus und diente der Formulierung von Empfehlungen. Daneben wurde die Bedeutung von Expansionen für technischen und institutionellen Wandel dargestellt.

1.6.2. Schlussfolgerung

Im Folgenden werden die Schlussfolgerungen dieser Dissertation in Bezug auf die Governance des expandierenden Energiesystem Perus, in Bezug auf die Eignung der verwendeten Konzepte und auf das Erreichen der in 1.2. genannten Ziele vorgestellt.

Governance Herausforderungen für die Energietransition in Peru

Die empirische Analyse von Akteuren, Institutionen und Technologien ausgewählter Expansionen des peruanischen Energiesystems zeigte den regulatorischen Kontext und die Entscheidungsprozesse um Expansionen auf. Sie verdeutlichte wie die neoliberalen Reformen des Energiesektors und seine späteren Anpassungen, weitreichende Entscheidungen zum Energieausbau mächtigen Einzelakteuren des Zentralstaates überlässt. Regionale und lokale Entscheidungsträger:Innen und sektorale Behörden außerhalb des Energieministeriums und die Zivilgesellschaft werden an den Entscheidungsprozessen nicht beteiligt. Dies wird im Fall des „Massiven Photovoltaikprogramms“, bei dem die Entscheidung von „ganz oben" kam und formal durch ein Präsidialdekret bzw. eine Auktion umgesetzt wurde, ersichtlich. Die hierarchische und zentralisierte Entscheidungsfindung führte zu einer Programmgestaltung, die nicht an die lokalen Energiepraktiken angepasst war und die der Vielfalt der Energiebedürfnisse nicht gerecht wurde. Ein ähnliches Muster der Entscheidungsfindung zeigte sich im Fall des geplanten Ausbaus der Wasserkraft im Fluss Marañón. In ähnlicher Weise erließ der ehemalige Präsident ein Dekret und unterzeichnete ein bilaterales Energieabkommen, ohne der Beteiligung nachgeordneter Ebenen oder weiterer sektoraler Behörden. Anders ist hier, dass die Größenordnung des zentralen Energieausbaus zu Widerstand führte und eine breite Allianz von Gegnern zum Stillstand des Ausbaus führte. Auch der Fall des marginalisierten solarthermischen Clusters in Arequipa ist ein Beispiel für hierarchische und zentralisierte Entscheidungsprozesse, die hier in der Nichtannerkennung der lokalen Energiepraktiken resultieren. Die Ergebnisse zeigen also, dass in allen drei Fällen eine Abkopplung zwischen den Praktiken der *rule-maker* und der *rule-taker* die Nachhaltigkeit der Energieexpansionen beeinträchtigt.

Die Ergebnisse verdeutlichen auch die zentrale Rolle privater Unternehmen in Entscheidungsprozessen über den Ausbau der Energieversorgung in Peru. Im Fall des Ausbaus der Wasserkraft im Marañón-Fluss waren private Bauunternehmen an den Verhandlungen über das bilaterale Energieabkommen beteiligt, während betroffene staatliche Behörden ausgeschlossen blieben. Interessant ist, dass Unternehmen und Entscheidungsträger, die sich für den Ausbau der Wasserkraft im Marañón einsetzen, das

gleiche Narrativ von einem zu inwertsetzenden Wasserkraftpotenzial teilen. Auch beim Fall des „Massiven Photovoltaiprogramms“ werden dem Privatsektor weitreichende Entscheidungsbefugnisse, wie die Auswahl der zu elektrifizierenden Haushalte, überlassen.

Die Ergebnisse widersprechen der, von der *energy goverance* postulierten, polyzentrischen Governance Konfiguration. Diese bedeutet "die Skalen zu mischen und multiple Akteursgruppen einzubeziehen", um ein System zu schaffen, das "gleichzeitig mehrere Ebenen und Entscheidungsträger umfasst“ (Goldthau, 2014, S. 138). In Peru konnte beobachtet werden, dass verschiedene Akteure, darunter die organisierte Zivilgesellschaft und staatliche Behörden auf verschiedenen Ebenen, bereit sind, eine aktive Rolle bei der Entscheidungsfindung über das zukünftige Energiesystem zu übernehmen. Voraussetzung für die Beteiligung verschiedener sektoraler Behörden an Entscheidungen über Energieexpansionen ist eine Erweiterung des techno-ökonomischen Fokus und die Anerkennung der weitreichenden ökologischen und sozialen Implikationen. Es erfordert insbesondere auch einen Zentralstaat, der bereit ist, zu intervenieren und gleichzeitig die Macht mit anderen Akteuren zu teilen (Benjamin K. Sovacool, 2011). Das Konzept expandierender Energiesysteme zeigt, dass der Moment der Expansion einen Anstoß dazu geben kann, etablierte Ideen zu hinterfragen, anzufechten und etablierte „Governance-Orthodoxien" in Frage zu stellen (Kuzemko et al., 2016, S. 100).

Eignung und Anpassung der analytischen Konzepte

In Bezug auf die Eignung der verwendeten Konzepte können folgende Rückschlüsse gezogen werden. Die Arbeit zeigt, dass analytische Governance-Ansätze geeignet sind, um die kollektive Handlungskoordination zu einem spezifischen Problem abzubilden und einen wichtigen Beitrag zum Verständnis der Rolle verschiedener Akteure und Institutionen in Expansionsprozessen liefern können. Sie zeigt darüber hinaus, dass Erkenntnisse der *energy governance* hilfreich sind um spezifische Herausforderungen des Energiesektors, wie die starke horizontale und vertikale Verflechtung aufzuzeigen. Es wurde aber auch deutlich, dass allgemeine Governance-Empfehlungen wie die Forderung nach *multilevel* bzw. polyzentrischen Governance-Formen die spezifischen sozio-kulturellen und politischen Kontexte unzureichend berücksichtigen (Israel & Herrera, 2020). Insbesondere die „Blindheit für Macht und Verteilungsfragen“ (Offe, 2008) stellt ein Problem für die Analyse von Expansionsprozessen dar. Eine mögliche Anpassung wäre eine stärkere Bezugnahme auf die Gouvernementalitätsforschung im Kontext von expandierenden Energiesystemen. Denn im Gegensatz zu Governance-Ansätzen, bei denen davon ausgegangen wird, „dass es mehr oder weniger dringliche Probleme gibt“ (Leibenath & Lintz, 2018, S. 98) werden Problemformulierungen in der Gouvernementalitätsforschung „ihrer Selbstverständlichkeit entledigt“ (Leibenath & Lintz, 2018, S. 98). Übertragen auf das Beispiel expandierender

Energiesysteme ermöglicht die Gouvernementalitätsforschung somit nicht nur die Frage nach der Art und Weise wie eine Expansion des Energiesystems verhandelt wird, sondern auch ob und in welchem Ausmaß eine Expansion nötig ist und wer dies definiert.

Neben den Governance Konzepten wurde in dieser Arbeit auch das Konzept der *energy justice* vorgestellt und seine Eignung für die Anwendung auf expandierende Energiesysteme getestet. Dabei konnte festgestellt werden, dass das Konzept das Aufzeigen von Ungerechtigkeiten in expandierenden Energiesystemen sowie die Zuordnung zu verschiedenen Gerechtigkeitsdimensionen ermöglicht. Die Anwendung auf das Beispiel Arequipas zeigte, dass globale modernistische Diskurse lokale Energiepraktiken nicht anerkennen und letztendlich verdrängen. Sie bestätigt also die grundlegende Bedeutung der Anerkennungsgerechtigkeit für die Verteilungs- und Prozessgerechtigkeit (Fraser, 2000). Problematisch ist allerdings, dass sich das Konzept auf das Aufzeigen von Ungerechtigkeiten beschränkt ohne diese ausreichend zu erklären.

Abschließend lässt sich feststellen, dass sich der historische Institutionalismus als am besten geeignetes Instrument der Analyse von expandierenden Energiesystemen herauskristallisiert hat. Für expandierende Energiesysteme zeigt der historische Institutionalismus, wie sich Institutionen und Akteure gegenseitig beeinflussen und so Expansionen strukturieren (Andrews-Speed, 2016; Jehling et al., 2019). Er berücksichtigt Aspekte der Macht und wie Akteure Macht durch Institutionen entfalten oder durch sie eingeschränkt werden. Er ermöglicht es, längere Zeiträume zu betrachtet und pfadabhängige Entwicklungen aufzuzeigen. Narrative, wie das über „traditionelle“ oder „moderne“ Energiepraktiken, können aufgedeckt und ihre strukturierende Wirkung verdeutlicht werden. Er kann somit die identifizierten Ungerechtigkeiten historisch kontextualisieren und erklären. In Bezug auf Wandel und Kontinuität in expandierenden Energiesystemen, kann der HI aufzeigen, inwiefern bestehende Institutionen Expansionsprozesse beeinflussen und somit für Kontinuität sorgen oder inwiefern Expansionsprozesse institutionellen Wandel anstoßen können (Fernandes de Freitas & Jehling, 2023). Der Kritik einer fehlenden Berücksichtigung von Materialität durch den HI (Lockwood et al., 2017) konnte durch die Berücksichtigung von sozialen und technischen Dimensionen von Expansionsprozessen entgegnet werden. Dies zeigte wie die Trägheit von Institutionen und ihre fehlende Anpassung an neuartige Technologien, wie im Falle der fehlenden Anpassung an die Dezentralität der SHS, zu Problemen führen können.

Fortschritte und Grenzen des Konzepts expandierender Energiesysteme

In Bezug auf die formulierten Ziele und Fragestellungen können erste Fortschritte in der Entwicklung und Positionierung des Konzepts expandierender Energiesysteme verzeichnet werden. Mit dem ersten Beitrag wurde aufgezeigt, welche negativen Auswirkungen modernistische Diskurse und die defizitäre Betrachtung von Energiesystemen im Globalen

Süden mit sich bringen. Dies betont die Notwendigkeit alternativer Analysekategorien für Energiesysteme. Mit dem zweiten Beitrag wurde die Kategorie expandierender Energiesysteme in den Wissenschaftsdiskurs eingeführt und die Bedeutung des differenzierenden Merkmals der Expansion für Wandel und Kontinuität verdeutlicht. Im dritten Beitrag erfolgte die Konzeptualisierung expandierender Energiesysteme durch die Typisierung verschiedener sozio-technischer Expansionsprozesse und ihrer Wirkung auf Wandel und Kontinuität im Energiesystem.

Zu berücksichtigen bleibt, dass in dieser Arbeit ein Beispiel eines expandierenden Energiesystems betrachtet wurde und im Rahmen dessen eine Auswahl an Expansionsprozessen untersucht wurde. Für die Weiterentwicklung des Konzepts ist es notwendig, weitere Beispiele aus Peru sowie aus anderen nationalen Kontexten zu analysieren und zu vergleichen. Denn schon das Energiesystem des Nachbarlands Ecuador weist große Unterschiede in seiner Governance-Konfiguration auf. Hier wäre es interessant zu untersuchen, inwiefern sich abweichende politische und sozio-ökonomische Kontexte auf die Expansionsprozesse auswirken. Ein weiterer interessanter Schritt wäre der Vergleich von Transitionsprozessen expandierender Energiesysteme mit denen konsolidierter Energiesysteme. Schlussendlich ist das Konzept expandierender Energiesysteme nicht dazu in der Lage Transitionen erklären. Es bietet aber im Vergleich zur gängigen Differenzierung zwei wichtige Vorteile. Erstens trägt es dem Verständnis von Energietransitionen bei, indem es spezifische Bedingungen für Wandel und Kontinuität aufzeigt. Zweites überwindet die Kategorie expandierender Energiesysteme normative Entwicklungskonzeptionen und kann so, zumindest diskursiv, einer Marginalisierung dieser Energiesysteme entgegenwirken.

Literaturverzeichnis

Anderson, W. (2002). Introduction: Postcolonial Technoscience. *Social studies of science*, *32*(5/6), 643–658. Verfügbar unter: http://www.jstor.org/stable/3183050

Andrews-Speed, P. (2016). Applying institutional theory to the low-carbon energy transition. *Energy Research & Social Science*, *13*, 216–225. https://doi.org/10.1016/j.erss.2015.12.011

Apfel, D., Haag, S. & Herbes, C. (2021). Research agendas on renewable energies in the Global South: A systematic literature review. *Renewable and Sustainable Energy Reviews*, *148*, 1–16. https://doi.org/10.1016/j.rser.2021.111228

Arana Cardó, M. (2012). *Proyectos hidroeléctricos en la cuenca del Río Marañon. Serie de Cuadernos de Integración.* Lima: Forum Solidaridad Perú, SER. Zugriff am 08.06.2022. Verfügbar unter: http://www.psf.org.pe/institucional/wp-content/uploads/2014/05/cuadernos-integracion-003.pdf

Araújo, K. (2014). The emerging field of energy transitions: Progress, challenges, and opportunities. *Energy Research & Social Science*, *1*, 112–121. https://doi.org/10.1016/j.erss.2014.03.002

Asif, M. (2021). *Energy and Environmental Security in Developing Countries*. Cham: Springer International Publishing. https://doi.org/10.1007/978-3-030-63654-8

Baev, P. K., Marsh, N. & Tzimitras, H. (2022, April). *The Energy Crisis Hits Europe. Resonances for the Global South and Climate Change* (PRIO, Hrsg.) (Prio Policy Brief). Oslo. Zugriff am 25.10.2022. Verfügbar unter: https://www.prio.org/publications/13176

Baker, L., Newell, P. & Phillips, J. (2014). The Political Economy of Energy Transitions: The Case of South Africa. *New Political Economy*, *19*(6), 791–818. https://doi.org/10.1080/13563467.2013.849674

Baptista, I. (2018). Space and energy transitions in sub-Saharan Africa: Understated historical connections. *Energy Research & Social Science*, *36*, 30–35. https://doi.org/10.1016/j.erss.2017.09.029

Bazilian, M., Nakhooda, S. & van de Graaf, T. (2014). Energy governance and poverty. *Energy Research & Social Science*, *1*, 217–225. https://doi.org/10.1016/j.erss.2014.03.006

Becker, S. & Naumann, M. (2017). Energy democracy: Mapping the debate on energy alternatives. *Geography Compass*, *11*(8), e12321. https://doi.org/10.1111/gec3.12321

Berahab, R. (2022, Februar). *The Energy Crisis of 2021 and its Implications for Africa* (Policy Center For The New South, Hrsg.) (06). Zugriff am 25.10.2022. Verfügbar unter: https://www.policycenter.ma/sites/default/files/2022-02/PB_06-22_Berrahab%20(1).pdf

Bhattacharyya, S. C. (2012). Energy access programmes and sustainable development: A critical review and analysis. *Energy for Sustainable Development*, *16*(3), 260–271. https://doi.org/10.1016/j.esd.2012.05.002

Bhattarai, U., Maraseni, T. & Apan, A. (2022). Assay of renewable energy transition: A systematic literature review. *The Science of the Total Environment*, *833*, 155159. https://doi.org/10.1016/j.scitotenv.2022.155159

Broto, V. C., Stevens, L., Ackom, E., Tomei, J., Parikh, P., Bisaga, I. et al. (2017). A research agenda for a people-centred approach to energy access in the urbanizing global south. *Nature Energy*, *2*(10), 776–779. https://doi.org/10.1038/s41560-017-0007-x

Burke, M. J. & Stephens, J. C. (2018). Political power and renewable energy futures: A critical review. *Energy Research & Social Science*, *35*, 78–93. https://doi.org/10.1016/j.erss.2017.10.018

Castán Broto, V., Baptista, I., Kirshner, J., Smith, S. & Neves Alves, S. (2018). Energy justice and sustainability transitions in Mozambique. *Applied Energy*, *228*, 645–655. https://doi.org/10.1016/j.apenergy.2018.06.057

Cherp, A., Vinichenko, V., Jewell, J., Brutschin, E. & Sovacool, B. (2018). Integrating techno-economic, socio-technical and political perspectives on national energy transitions: A meta-theoretical framework. *Energy Research & Social Science*, *37*, 175–190. https://doi.org/10.1016/j.erss.2017.09.015

Cloke, J., Mohr, A. & Brown, E. (2017). Imagining renewable energy: Towards a Social Energy Systems approach to community renewable energy projects in the Global South. *Energy Research & Social Science*, *31*, 263–272. https://doi.org/10.1016/j.erss.2017.06.023

D. McCauley, R. Heffron, Hannes R. Stephan & Kirsten E H Jenkins. (2013). Advancing energy justice: The triumvirate of tenets. *International Energy Law Review*, *32*(3), 107–110.

Dawson, A. (2010). Climate Justice: The Emerging Movement against Green Capitalism. *South Atlantic Quarterly*, *109*(2), 313–338. https://doi.org/10.1215/00382876-2009-036

Dewald, U., Grunwald, A., Poganietz, W.-R. & Schippl, J. (2019). Die Energiewende als sozio-technische Transformation – Von der Analyse zur Gestaltung. In J. Radtke & W. Canzler (Hrsg.), *Energiewende* (S. 319–352). Wiesbaden: Springer Fachmedien Wiesbaden. https://doi.org/10.1007/978-3-658-26327-0_11

Dresing, T. & Pehl, T. (2018). *Praxisbuch Interview, Transkription & Analyse. Anleitungen und Regelsysteme für qualitativ Forschende* (8. Auflage). Marburg: Eigenverlag.

Fernandes de Freitas, A. & Jehling, M. (2023). Change and path dependency in expanding energy systems: Explaining Peru's energy transition beyond a North–South divide. *Energy Research & Social Science*, *99*, 103039. https://doi.org/10.1016/j.erss.2023.103039

Fox, W. M. (1995). Sociotechnical System Principles and Guidelines: Past and Present. *The Journal of Applied Behavioral Science*, *31*(1), 91–105. https://doi.org/10.1177/0021886395311009

Fraser, N. (2000). Rethinking Recognition. *New Left Review*, *3*, 107. Verfügbar unter: https://www.proquest.com/scholarly-journals/rethinking-recognition/docview/1301918978/se-2?accountid=11793

Furlong, K. (2014). STS beyond the “modern infrastructure ideal”: Extending theory by engaging with infrastructure challenges in the South. *Technology in Society*, *38*, 139–147. https://doi.org/10.1016/j.techsoc.2014.04.001

Fuso Nerini, F., Tomei, J., To, L. S., Bisaga, I., Parikh, P., Black, M. et al. (2018). Mapping synergies and trade-offs between energy and the Sustainable Development Goals. *Nature Energy*, *3*(1), 10–15. https://doi.org/10.1038/s41560-017-0036-5

Gailing, L. (2018). Die räumliche Governance der Energiewende: Eine Systematisierung der relevanten Governance-Formen. In O. Kühne & F. Weber (Hrsg.), *Bausteine der Energiewende* (S. 75–90). Wiesbaden: Springer Fachmedien Wiesbaden. https://doi.org/10.1007/978-3-658-19509-0_4

Gamio, A. P. (2018). Transición energética: un cambio necesario en el Perú. *pluriversidad*, *1*(1), 179–191. Verfügbar unter: https://www.scopus.com/inward/record.uri?eid=2-s2.0-85085380716&partnerID=40&md5=b684f791b00f2bde1a705835b25959b4

García Pérez, A. (2011). *Declaran de interés nacional y social la construcción de veinte (20) centrales hidroeléctricas en la Cuenca del Río Marañón. D.S. Nº 020-2011-EM*. Zugriff am 08.06.2022. Verfügbar unter: http://www.minem.gob.pe/archivos/legislacion-n47b81u0zwf06-D_S_N%C2%BA_020-2011-EM.pdf

Geels, F. W. (2004). From sectoral systems of innovation to socio-technical systems. *Research Policy*, *33*(6-7), 897–920. https://doi.org/10.1016/j.respol.2004.01.015

Geels, F. W. & Kemp, R. (2007). Dynamics in socio-technical systems: Typology of change processes and contrasting case studies. *Technology in Society*, *29*(4), 441–455. https://doi.org/10.1016/j.techsoc.2007.08.009

Geels, F. W., Sovacool, B. K., Schwanen, T. & Sorrell, S. (2017). Sociotechnical transitions for deep decarbonization. *Science (New York, N.Y.)*, *357*(6357), 1242–1244. https://doi.org/10.1126/science.aao3760

Goldthau, A. (2014). Rethinking the governance of energy infrastructure: Scale, decentralization and polycentrism. *Energy Research & Social Science*, *1*, 134–140. https://doi.org/10.1016/j.erss.2014.02.009

Goldthau, A., Eicke, L. & Weko, S. (2020). The Global Energy Transition and the Global South. In M. Hafner & S. Tagliapietra (Hrsg.), *The Geopolitics of the Global Energy Transition* (Lecture Notes in Energy, Bd. 73, S. 319–339). Cham: Springer International Publishing. https://doi.org/10.1007/978-3-030-39066-2_14

Goldthau, A. & Sovacool, B. K. (2012). The uniqueness of the energy security, justice, and governance problem. *Energy Policy*, *41*, 232–240. https://doi.org/10.1016/j.enpol.2011.10.042

Hansen, T. & Coenen, L. (2015). The geography of sustainability transitions: Review, synthesis and reflections on an emergent research field. *Environmental Innovation and Societal Transitions*, *17*, 92–109. https://doi.org/10.1016/j.eist.2014.11.001

Hansen, U. E., Nygaard, I., Romijn, H., Wieczorek, A., Kamp, L. M. & Klerkx, L. (2018). Sustainability transitions in developing countries: Stocktaking, new contributions and a research agenda. *Environmental Science & Policy*, *84*, 198–203. https://doi.org/10.1016/j.envsci.2017.11.009

Harrington, T.. *Accountability and regulatory governance in a cross-jurisdictional market : a case study of the all-island energy market (Ireland). Ph.D*. Queen's University Belfast; School of Law. Retrieved from https://ethos.bl.uk/OrderDetails.do?uin=uk.bl.ethos.706970

Hitzeroth, M., Jehling, M. & Brueckner, M. (2017). Apples and oranges? A multi-level approach explaining social acceptance of renewable energy in Germany and Australia. *International Journal of Global Energy Issues*, *40*(3/4), 141. https://doi.org/10.1504/IJGEI.2017.086617

IEA. (2019). *World Energy Outlook 2019. Flagship report November 2019,* International Energy Agency. Zugriff am 17.11.2022. Verfügbar unter: https://www.iea.org/reports/world-energy-outlook-2019

IEA. (2020, März). *Global Energy Review: CO2 Emissions in 2021. Part of Global Energy Review - Flagship report* (International Energy Agency, Hrsg.). Zugriff am 25.08.2022. Verfügbar unter: https://www.iea.org/reports/global-energy-review-co2-emissions-in-2021-2

IEA. (2021, August). *Total gross electricity production, 1974-2019* (International Energy Agency, Hrsg.). Paris. Zugriff am 25.08.2022. Verfügbar unter: https://www.iea.org/data-and-statistics/charts/total-gross-electricity-production-1974-2019

International Energy Agency. (2022). *IEA World Energy Balances. Peru: Key energy statistics*. Zugriff am 08.06.2022. Verfügbar unter: https://www.iea.org/data-and-statistics/data-product/world-energy-statistics-and-balances

IPCC. (2022). *Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* (H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.), Hrsg.). Cambridge University Press. Zugriff am 25.08.2022. Verfügbar unter: https://www.ipcc.ch/report/ar6/wg2/

Israel, A. & Herrera, R. J. (2020). The governance of Peruvian energy transitions: Path dependence, alternative ideas and change in national hydropower expansion. *Energy Research & Social Science*, *69*(101608), 1–12. https://doi.org/10.1016/j.erss.2020.101608

Israel, A. & Jehling, M. (2019). How modern are renewables? The misrecognition of traditional solar thermal energy in Peru's energy transition. *Energy Policy*, *133*(110905), 1–8. https://doi.org/10.1016/j.enpol.2019.110905

Iychettira, K. K. (2021). Lessons for renewable integration in developing countries: The importance of cost recovery and distributional justice. *Energy Research & Social Science*, *77*, 1–15. https://doi.org/10.1016/j.erss.2021.102069

Jehling, M., Hitzeroth, M. & Brueckner, M. (2019). Applying institutional theory to the analysis of energy transitions: From local agency to multi-scale configurations in Australia and Germany. *Energy Research & Social Science*, *53*, 110–120. https://doi.org/10.1016/j.erss.2019.01.018

Jenkins, K. [Kirsten], McCauley, D., Heffron, R., Stephan, H. & Rehner, R. (2016). Energy justice: A conceptual review. *Energy Research & Social Science*, *11*, 174–182. https://doi.org/10.1016/j.erss.2015.10.004

Jianchao, H., Ruoyu, Z., Pingkuo, L. & Lyuyang, Z. (2021). A review and comparative analysis on energy transition in major industrialized countries. *International Journal of Energy Research*, *45*(2), 1246–1268. https://doi.org/10.1002/er.5866

Kaygusuz, K. (2012). Energy for sustainable development: A case of developing countries. *Renewable and Sustainable Energy Reviews*, *16*(2), 1116–1126. https://doi.org/10.1016/j.rser.2011.11.013

Kosmadakis, G., Karellas, S. & Kakaras, E. (2013). Renewable and Conventional Electricity Generation Systems: Technologies and Diversity of Energy Systems. In E. Michalena & J. M. Hills (Hrsg.), *Renewable Energy Governance* (Lecture Notes in Energy, Bd. 23, S. 9–30). London: Springer London. https://doi.org/10.1007/978-1-4471-5595-9_2

Kruger, R. & McCauley, D. (2020). Energy Justice, Hydropower and Grid Systems in the Global South. In G. Bombaerts, K. Jenkins, Y. A. Sanusi & W. Guoyu (Eds.), *Energy Justice Across Borders* (Springer eBooks Religion and Philosophy, 1st ed., S. 91–109). Cham: Springer. https://doi.org/10.1007/978-3-030-24021-9_5

Kuckartz, U. (2016). *Qualitative Inhaltsanalyse. Methoden, Praxis, Computerunterstützung* (Grundlagentexte Methoden, 3., durchgesehene Aufl.). Weinheim, Bergstr: Beltz Juventa. Verfügbar unter: http://katalog.ub.uni-heidelberg.de/titel/67972788

Kuzemko, C., Lawrence, A. & Watson, M. (2019). New directions in the international political economy of energy. *Review of International Political Economy*, *26*(1), 1–24. https://doi.org/10.1080/09692290.2018.1553796

Kuzemko, C., Lockwood, M., Mitchell, C. & Hoggett, R. (2016). Governing for sustainable energy system change: Politics, contexts and contingency. *Energy Research & Social Science*, *12*, 96–105. https://doi.org/10.1016/j.erss.2015.12.022

Lacey-Barnacle, M., Robison, R. & Foulds, C. (2020). Energy justice in the developing world: a review of theoretical frameworks, key research themes and policy implications. *Energy for Sustainable Development*, *55*, 122–138. https://doi.org/10.1016/j.esd.2020.01.010

Lawhon, M. & Murphy, J. T. (2012). Socio-technical regimes and sustainability transitions. *Progress in Human Geography*, *36*(3), 354–378. https://doi.org/10.1177/0309132511427960

Leibenath, M. & Lintz, G. (2018). Streifzug mit Michel Foucault durch die Landschaften der Energiewende: Zwischen Government, Governance und Gouvernementalität. In O. Kühne & F. Weber (Hrsg.), *Bausteine der Energiewende* (S. 91–107). Wiesbaden: Springer Fachmedien Wiesbaden. https://doi.org/10.1007/978-3-658-19509-0_5

Leiren, M. D. & Reimer, I. (2018). Historical institutionalist perspective on the shift from feed-in tariffs towards auctioning in German renewable energy policy. *Energy Research & Social Science*, *43*, 33–40. https://doi.org/10.1016/j.erss.2018.05.022

Liao, C. & Agrawal, A. (2022). Sustainable and just energy transition in the Global South. *World Development*, *152*, 105798. https://doi.org/10.1016/j.worlddev.2021.105798

Lis, A. & Szymanowski, R. (2022). Greening Polish transportation? Untangling the nexus between electric mobility and a carbon-based regime. *Energy Research & Social Science*, *83*, 102336. https://doi.org/10.1016/j.erss.2021.102336

Lockwood, Kuzemko, Mitchell & Hoggett.. *Theorising governance and innovation in sustainable energy transitions*.
Lockwood, M., Kuzemko, C., Mitchell, C. & Hoggett, R. (2017). Historical institutionalism and the politics of sustainable energy transitions: A research agenda. *Environment and Planning C: Politics and Space*, *35*(2), 312–333. https://doi.org/10.1177/0263774X16660561
Löhr, M. (2018). Grüne Umstellung, Energiewandel und Energiewende – Akteure in den Energiesystemtransformationsprozessen in Dänemark, Frankreich und Deutschland. In J. Radtke & N. Kersting (Hrsg.), *Energiewende* (Energietransformation, S. 79–129). Wiesbaden: Springer Fachmedien Wiesbaden. https://doi.org/10.1007/978-3-658-21561-3_4
Loorbach, D., Frantzeskaki, N. & Avelino, F. (2017). Sustainability Transitions Research: Transforming Science and Practice for Societal Change. *Annual Review of Environment and Resources*, *42*(1), 599–626. https://doi.org/10.1146/annurev-environ-102014-021340
Lowndes, V. & Roberts, M. (2013). *Why institutions matter. The new institutionalism in political science* (Political Analysis). Basingstoke, Hampshire, New York: Palgrave Macmillan. Retrieved from https://ebookcentral.proquest.com/lib/kxp/detail.action?docID=4763046
Markard, J., Raven, R. & Truffer, B. (2012). Sustainability transitions: An emerging field of research and its prospects. *Research Policy*, *41*(6), 955–967. https://doi.org/10.1016/j.respol.2012.02.013
Mayring, P. (2010). *Qualitative Inhaltsanalyse. Grundlagen und Techniken* (Pädagogik, 11., aktual. u. überarb. Aufl.). Weinheim: Beltz.
Monge, C. (2016). *Zwischen Wasserkraft und Petrodollar: Energie-Governance in Peru* (Heinrich Böll Stiftung, Hrsg.). Zugriff am 19.11.2022. Verfügbar unter: https://www.boell.de/de/2016/03/02/zwischen-wasserkraft-und-petrodollar-demokratische-energie-governance-peru
Monyei, C. G., Jenkins, K. [K.], Serestina, V. & Adewumi, A. O. (2018). Examining energy sufficiency and energy mobility in the global south through the energy justice framework. *Energy Policy*, *119*, 68–76. https://doi.org/10.1016/j.enpol.2018.04.026
Munro, P., van der Horst, G. & Healy, S. (2017). Energy justice for all? Rethinking Sustainable Development Goal 7 through struggles over traditional energy practices in Sierra Leone. *Energy Policy*, *105*, 635–641. https://doi.org/10.1016/j.enpol.2017.01.038
Munro, P. G. (2021). Energy political ecologies in the South Pacific: the politics of energy transitions in Vanuatu. *Cambridge Journal of Regions, Economy and Society*, *14*(2), 361–378. https://doi.org/10.1093/cjres/rsab006
Offe, C. (2008). Governance — „Empty signifier“ oder sozialwissenschaftliches Forschungsprogramm? In G. F. Schuppert & M. Zürn (Hrsg.), *Governance in einer sich wandelnden Welt* (S. 61–76). Wiesbaden: VS Verlag für Sozialwissenschaften. https://doi.org/10.1007/978-3-531-91066-6_3
Ostrom, E. (2010). Polycentric systems for coping with collective action and global environmental change. *Global Environmental Change*, *20*(4), 550–557. https://doi.org/10.1016/j.gloenvcha.2010.07.004
Pierson, P. (2004). *Politics in Time. History, Institutions, and Social Analysis*. Princeton: Princeton University Press.
Power, M., Newell, P., Baker, L., Bulkeley, H., Kirshner, J. & Smith, A. (2016). The political economy of energy transitions in Mozambique and South Africa: The role of the Rising Powers. *Energy Research & Social Science*, *17*, 10–19. https://doi.org/10.1016/j.erss.2016.03.007
Radley, B. & Lehmann-Grube, P. (2022). Off-grid solar expansion and economic development in the global South: A critical review and research agenda. *Energy Research & Social Science*, *89*, 102673. https://doi.org/10.1016/j.erss.2022.102673

Schlaile, M. P. & Urmetzer, S. (2018). Transitions to Sustainable Development. In W. Leal Filho, T. Wall, U. Azeiteiro, A. M. Azul, L. Brandli & P. G. Özuyar (Hrsg.), *Good Health and Well-Being* (Encyclopedia of the UN Sustainable Development Goals, S. 1–16). Cham: Springer International Publishing. https://doi.org/10.1007/978-3-319-71058-7_52-1

Schlosberg, D. (2004). Reconceiving Environmental Justice: Global Movements And Political Theories. *Environmental Politics*, *13*(3), 517–540. https://doi.org/10.1080/0964401042000229025

Solomon, B. D. & Krishna, K. (2011). The coming sustainable energy transition: History, strategies, and outlook. *Energy Policy*, *39*(11), 7422–7431. https://doi.org/10.1016/j.enpol.2011.09.009

Sovacool, B. K. [B. K.], Ryan, S. E., Stern, P. C., Janda, K., Rochlin, G., Spreng, D. et al. (2015). Integrating social science in energy research. *Energy Research & Social Science*, *6*, 95–99. https://doi.org/10.1016/j.erss.2014.12.005

Sovacool, B. K. (2011). An international comparison of four polycentric approaches to climate and energy governance. *Energy Policy*, *39*(6), 3832–3844. https://doi.org/10.1016/j.enpol.2011.04.014

Sovacool, B. K. (2013). *Energy & Ethics. Justice and the Global Energy Challenge* (Energy, Climate and the Environment Ser). New York: Palgrave Macmillan. Retrieved from https://ebookcentral.proquest.com/lib/kxp/detail.action?docID=1330950

Sovacool, B. K. (2016). *The history and politics of energy transitions: Comparing contested views and finding common ground* (Bd. 2016). UNU-WIDER. https://doi.org/10.1093/oso/9780198802242.003.0002

Sovacool, B. K. (2021). Who are the victims of low-carbon transitions? Towards a political ecology of climate change mitigation. *Energy Research & Social Science*, *73*, 101916. https://doi.org/10.1016/j.erss.2021.101916

Sovacool, B. K., Axsen, J. & Sorrell, S. (2018). Promoting novelty, rigor, and style in energy social science: Towards codes of practice for appropriate methods and research design. *Energy Research & Social Science*, *45*, 12–42. https://doi.org/10.1016/j.erss.2018.07.007

Sovacool, B. K. & Brisbois, M.-C. (2019). Elite power in low-carbon transitions: A critical and interdisciplinary review. *Energy Research & Social Science*, *57*, 101242. https://doi.org/10.1016/j.erss.2019.101242

Sovacool, B. K., Hess, D. J., Amir, S., Geels, F. W., Hirsh, R., Rodriguez Medina, L. et al. (2020). Sociotechnical agendas: Reviewing future directions for energy and climate research. *Energy Research & Social Science*, *70*, 101617. https://doi.org/10.1016/j.erss.2020.101617

Trist, E. L. (1981). *The evolution of socio-technical systems. A conceptual framework and an action research program* (Occasional paper, no. 2). Toronto: Ontario Ministry of Labour, Ontario Quality of Working Life Centre.

UNDP. (2015). *Human development report 2015: Work for human development*. Zugriff am 22.08.2022. Verfügbar unter: www.undp.org/publications/human-development-report-2015

UNRIC - Regionales Informationszentrum der Vereinten Nationen.. *Ziel 7: Zugang zu bezahlbarer, verlässlicher, nachhaltiger und moderner Energie für alle sichern,* UNRIC - Regionales Informationszentrum der Vereinten Nationen. Zugriff am 17.11.2022. Verfügbar unter: https://unric.org/de/17ziele/sdg-7/

Van der Horst, D., Grant, R., Montero, A. M. & Garneviciene, A. (2021). Energy Justice and Social Acceptance of Renewable Energy Projects in the Global South. In S. Batel & D. Rudolph (Eds.), *A critical approach to the social acceptance of renewable energy infrastructures. Going beyond green growth and sustainability* (Springer eBook Collection, 1st ed., S. 217–234). Cham: Springer International Publishing; Imprint Palgrave Macmillan. https://doi.org/10.1007/978-3-030-73699-6_12

Vanegas Cantarero, M. M. (2020). Of renewable energy, energy democracy, and sustainable development: A roadmap to accelerate the energy transition in developing countries.

Energy Research & Social Science, *70*, 101716. https://doi.org/10.1016/j.erss.2020.101716

Wieczorek, A. J. (2018). Sustainability transitions in developing countries: Major insights and their implications for research and policy. *Environmental Science & Policy*, *84*, 204–216. https://doi.org/10.1016/j.envsci.2017.08.008

The World Bank. (2022a). *Access to electricity,* The World Bank. Zugriff am 16.11.2022. Verfügbar unter: https://data.worldbank.org/indicator/EG.ELC.ACCS.ZS

The World Bank (The World Bank, Hrsg.). (2022b). *Access to electricity (% of population) - High income, Low & middle income*. Zugriff am 17.11.2022. Verfügbar unter: https://data.worldbank.org/indicator/EG.ELC.ACCS.ZS?end=2020&locations=XD-XO&start=1990&view=chart

World Bank (International Energy Agency (IEA), International Renewable Energy Agency (IRENA), United Nations Statisctics Devision (UNSD), World Bank & World Health Organization (WHO), Hrsg.). (2022). *World Bank Global Electrification Database. Access to electricity, rural (% of rural population) - Peru*. Zugriff am 15.03.2022. Verfügbar unter: https://data.worldbank.org/indicator/EG.ELC.ACCS.RU.ZS?locations=PE

2. Beitrag I

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How modern are renewables? The misrecognition of traditional solar thermal energy in Peru's energy transition

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ABSTRACT

The ubiquitous claim for 'modern' energy access leads to profound transformative dynamics in energy systems in the global South. However, the policies' effects on existing socio-technical forms of energy provision must be considered. In this paper, we highlight the case of Peru, where the 'modernisation' of the energy systems endangers an established practice of renewable energy use. In the city of Arequipa, households widely rely on solar water heaters that have been manufactured locally since the 1930s. Applying an institutionalist approach, we analyse actors and institutions of this local energy system. We identify a disconnection of existing renewable energy practices from national policies and their marginalisation by international cooperation agencies. We show how the misrecognition jeopardises the livelihood of people involved and provokes the loss of contextualised innovation potentials. Thus, we discover a dichotomy of 'modern' energy policies and 'traditional' practices of solar thermal energy. Based on this case study, we therefore stress the need to include local energy practices into the energy policy framework for ensuring technological and social gains. We also emphasise the need to generally shift away from a top-down approach with generalised globally applicable solutions to more inclusive governance and policy formulation.

1. Introduction

At least since 'access to affordable, reliable, sustainable, and modern energy for all' was added to the United Nations Sustainable Development Goals, *'modern'* energy access has shaped global energy debates (UNDP, 2015, p. 15). Successive policies have led to profound transformative dynamics in many energy systems, especially in the global South (Purcell and Martinez, 2018). A 'modernist' perspective on energy policy, however, entails the risk of devaluating established energy practices as 'not-modern' or simply 'traditional' (Gupta, 1998). Indeed, the transformation of energy systems has substantial social consequences for those who rely on existing energy systems and who are not considered by discourses on 'modern' energy transitions (Munro et al., 2017). Moreover, established energy practices contain possible innovation potentials that - if taken into account - can contribute to a sustainable transformation of the energy system. We therefore agree with (Munro et al., 2017) that the debate about 'modern' energy systems needs to extend beyond a mere techno-bureaucratic perspective and include social and ethical dimensions of policies, especially when it comes to transition processes in the global South. Here, social aspects of the justice of energy provision and its transition are addressed from a normative point of view to inform energy policy-making (Jenkins et al., 2016).

Peru, and the Southern Peruvian city of Arequipa in particular, is an informative case to study these challenges. In this paper, we thus analyse the local energy system in Arequipa to show its evolution in the context of 'modern' energy access policies. As an example, we show the disconnection of 'modernist' energy policies from long-standing, well-established local practices of energy provision. National energy policies in Peru focus on a market-driven expansion of the energy system to reliably provide electricity for industry and households (OLADE, 2013). Renewable energies are increasingly promoted, mainly relying on centralised electricity generation that is mostly based on imported technologies (IRENA, 2013; Ministerio de Energía y Minas, 2008). In addition, numerous programmes of international cooperation agencies exist to promote 'modern' energy access in rural or semi-rural areas (ARE, 2014).

In contrast to this modernisation agenda, the energy system of Arequipa is characterised by the widespread use of solar thermal energy. The first solar water heater (SWH) was locally manufactured and installed in the 1930s - long before today's global demand for 'modern' energy access (Tinajeros Salcedo and Morante Trigoso, 2011). Today,

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SWH are manufactured by a cluster of micro- and small-scale enterprises and used in 55,000 urban households according to estimates (Pedro Gamio Aita, 2014). These SWH provide renewable and affordable energy, substituting electric water heating, and cover a substantial share of urban energy demand. However, Arequipa also is an example of a long-standing renewable energy system being marginalised on the agenda of 'modern' and renewable energy policies. As a result, its inherent potentials to contribute to the energy transition are hampered and put at risk.

To identify the causes of this situation and provide further insight into this case, we analyse the evolution of the solar thermal energy system from its beginning to date (Frigo, 2017). For analysis, we apply an historical institutionalist approach (Lockwood et al., 2017; Lowndes and Roberts, 2013) that focuses on the development path of local actors and their agency within an evolving institutional setting as well as its dialectical transformation. We then evaluate the findings based on the energy justice concept emphasising the role of recognition justice (Jenkins et al., 2016; Lockwood et al., 2017). We argue that, especially in the context of 'modern' energy access policies in the global South, it is necessary to address forms of disempowerment through structural inequalities and the resulting reinforcement of the latter (Castán Broto et al., 2018).

This paper first presents the analytical approach and the methodology of the empirical research. We then describe the development path of the local solar thermal energy system in Arequipa based on identified phases of relative institutional stability. Next, we discuss the evolution of the energy system, addressing injustices and the implications for an emancipatory energy provision. Finally, explicit policy recommendations for the promotion of the localized renewable energy systems are developed as are general requirements to re-think 'modern' energy governance.

2. Analytical framework and empirical application

2.1. Energy justice as conceptual framework

Energy justice, a fast growing strand in social science energy research, aims at applying social justice principles to energy policy (McCauley et al., 2013). Research in this field reaches from justice concerns in energy production, energy consumption, energy systems, energy security, and energy policy to climate change (Jenkins et al., 2016). Research is conducted in diverse local and regional contexts. The theoretical grounding of the energy justice concept draws back on environmental justice (Schlosberg, 2004) and, more recently, climate justice (Dawson, 2010). It emphasises the interrelation of environmental and social dynamics that frequently cause a reproduction of disempowerment and injustices (Munro et al., 2017).

Conceptually, justice is divided into three dimensions: distributional, procedural, and recognition justice (Schlosberg, 2004; Castán Broto et al., 2018). The distributional dimension demands an 'even distribution of benefits and ills on all members of society' whereas procedural justice entails the access to and participation in decision-making processes that govern the distribution (Jenkins et al., 2016, p. 176). The recognition dimension is 'an epistemological focus on the ways and extents to which disparate forms of knowledges and values are incorporated' (McCauley et al., 2013; Munro et al., 2017, p. 636) and poses the question 'who is ignored?' (Jenkins et al., 2016, p. 175). Recognition justice is fundamental to energy justice, as it is conditional to distributive and procedural justice (Schlosberg, 2004). It 'challenge (s) institutionalised exclusion' and is often the reason behind maldistribution (Fraser, 2000; Schlosberg, 2004, p. 519). According to Castán Broto et al. (2018, p. 647), it allows pluralist approaches and is 'a celebration of the particular'.

Most recently, several studies covered the applicability of the energy justice concept in the context of specific settings in the global South (Castán Broto et al., 2018; Islar et al., 2017; LaBelle, 2017; Munro et al., 2017). Munro et al. (2017) analyse globalised 'modern' energy policies and their local implications on justice in the context of 'traditional' fuelwood-based energy provision in Sierra Leone. The analysis shows that 'energy poverty solutions' are likely to reproduce 'forms of disempowerment and inequity' and to reinforce paternalist approaches regarding energy systems in the global South (Munro et al., 2017, p. 639).

Castán Broto et al. (2018) complement the energy justice framework by emancipatory claims that are especially relevant in the global South drawing on postcolonial perspectives. Postcolonial theory stresses structural inequalities as historical legacy of oppression and exclusion and, hence, calls for historical readings (Anderson, 2002; Baptista, 2018; Castán Broto et al., 2018). The postcolonial perspective is linked to energy justice by the dimension of energy sovereignty. Energy sovereignty emphasises the emancipatory character of energy provision and the need of self-determination. It acts as another corrective, stressing specific historical and cultural contexts in energy systems as well as unjust systems of knowledge production that reproduces unequal power relations. It calls for localized models of energy provision and, hence, is fundamental to the recognition of 'contextually generated innovation' (Castán Broto et al., 2018, p. 648).

2.2. Historical institutionalism as analytical tool

But how does non-recognition in the context of energy provision in the global South emerge and persist, and how is it sustained? In order to analyse this, we apply an institutionalist framework to address the structural causes of energy injustices.

We agree with Bazilian et al. (2014 in Munro et al., 2017) that research on energy access should go beyond technological solutions and give a broader relevance to actors, institutions, and processes that shape energy decisions and their outcomes. Institutionalist theory is therefore more and more applied as a tool to analyse energy systems (Andrews-Speed, 2016; Jehling et al., 2019). It highlights that energy transitions are shaped through the structuring effects of institutions and actors, which both form dialectic relationships and influence each other (Becker et al., 2016; Kuzemko et al., 2016; Lowndes and Roberts, 2013). Within this strand of thought, the field of historical institutionalism is well suited to show the evolution of energy transitions. Historical institutionalism emphasises how action or the articulation of individual and collective interests is constrained and affected by institutions. However, it also is interested in how these institutions are formed and path-dependently evolve over time, also paying attention to unintended consequences of institutional settings (Lockwood et al., 2017; Pierson, 2004). It thus allows the explanation of non-recognition, as it helps to identify how institutions 'shape political outcomes by facilitating the organisation of certain groups while actively disarticulating others' (Thelen, 2002: 92 in Lockwood et al., 2017).

With regard to the institutional settings and dynamics, Lowndes and Roberts (2013) distinguish three different modes of constraints, which are applied to deconstruct complex institutional configurations of socio-technical energy systems (Jehling et al., 2019). These modes are written rules, practices, and narratives. Rules, such as standards and regulations, are *formally recorded.* Practices are patterns of behaviour which are transmitted through demonstration. Narratives are processes of explanation and persuasion, which, through repetition, build up rationalities (Pierson, 2004) that put action into a *meaningful whole* (Feldman, 2004). That these three modes have different levels of explicitness does not mean they are unequally powerful in their constraining effects. While the conformity to rules is officially sanctioned, narratives in contrast enfold effects on actor's agency through a subtle, socially sustained way, such as attributions of being 'modern' or 'traditional' (Munro et al., 2017). With regard to the global South, this understanding of institutional configuration prevents a-priori categorisation into formality and informality and helps to scrutinise what determines the development path of an energy transition.

Actors, while seen as pursuing their own interests, gain or exercise power through institutions or are hampered by them. Depending on their activities on different regulatory levels (Goldthau, 2014), we distinguish between actors who are rule-makers setting up rules, and rule takers, who apply rules to their specific interests and local circumstances (Lowndes and Roberts, 2013). Via path dependant institutional changes, both form a dynamic relationship through which practices can be transformed into rules and rules are adapted to established practices. This notion of interlinkage becomes important for analysing recognition justice (Fraser, 2000; Schlosberg, 2004), as the institutional configurations that implicitly or explicitly empower specific actors to advocate for changes while dis-empowering others can be made visible.

2.3. Empirical application (methodology)

Our empirical work is based on Blatter and Haverland (2014) approach of Causal Process Tracing. In order to explain the development path of the Arequipa cluster, the case study is designed to develop a *relatively* complete explanation, thus identifying relevant explanatory factors in a comprehensive way. For the case study, we focus on the actors involved in the development and production of SWH in Arequipa and discern how the integration of SWH into the local energy systems evolves. On the regulatory level, we analyse the development of rules with regard to the energy system's expansion and integration of renewable energy. In order to structure the analysis, the depicted development path of the local system is subdivided into phases of relative institutional stability, which are separated by more or less abrupt changes (Hitzeroth et al., 2017).

In two field research phases in 2016 and 2017, a total of 21 semi-structured interviews were conducted with manufacturing enterprises as well as with decision-makers and experts from academia and NGOs at different scales (see Figure 1). The interviews were recorded, transcribed, and subjected to a qualitative content analysis (Mayring, 2010). The study relies on qualitative data, as quantitative information about the use of solar thermal energy in Arequipa is very limited due to the lack of regulation and monitoring. According to estimates, there are about 55,000 installed SWH and about 50 manufacturing enterprises in Arequipa (Pedro Gamio Aita, 2014; A4).

3. Analytical results: three phases of the solar thermal energy cluster in Arequipa

Clusters are 'local concentrations of certain economic activities' that are often characterised by a strong sociocultural identity (Altenburg and Meyer-Stamer, 1999, p. 1694). The empirical analysis of the solar thermal energy cluster in Arequipa reveals three development phases with relative institutional stability. In the first phase, the formation phase, a pioneer enterprise introduces a solar thermal collector and numerous enterprises follow spontaneously. In the next phase, the consolidation phase, the production and use of the technology are widely disseminated and specific local practices arise around the solar thermal energy cluster. In the current phase, the opening phase, local production of SWH in Arequipa is challenged by imported devices that are promoted by external actors in the context of 'modern' energy access policies. (see Fig. 1)

3.1. Cluster formation

3.1.1. Traditional practice of solar energy use

The use of solar thermal energy has a long tradition in Arequipa. It goes back to pre-Inca cultures, when sunlight was used to heat water in clay and stone bowls or to dry agricultural products, such as fish, meat, and some sorts of vegetables (B9). The extremely high and constant solar irradiation in the region allowed for the direct use of solar thermal energy and facilitated the diffusion of these practices. The practice of direct solar thermal energy use was deeply rooted in the local culture when the first prototype of a SWH was installed in Arequipa in the 1930s. A small enterprise managed by a professor of electrical engineering installed these early models of flat-plate collectors (Tinajeros Salcedo and Morante Trigoso, 2011).

3.1.2. Public promotion programme

The SWH remained a niche technology until the 1980s when the national government issued a one-time promotion programme that kicked off local production of the technology in Arequipa. The military government at that time pursued an import substitution strategy aimed at promoting key industrial sectors in order to enhance national industrialisation and to increase the country's independence. In this context, the INTINTEC, the public Institute for Industrial Technology Research and Technical Norms, was created. The INTINTEC incorporates the experiences of Peruvian universities that advanced research relating to SWH in the 1970s and developed the so-called *Sistemas de Calentamiento de Agua con Energía Solar* (Systems for Water Heating with Solar Energy) (Tinajeros Salcedo and Morante Trigoso, 2011). These systems are designed for domestic and small-scale industry use and consist of a simple technology based on a solar flat-plate collector connected to an insulated storage tank.

3.1.3. Spontaneous market-driven diffusion

The promotion programme induced the installation of prototypes in various regions of the country (Tinajeros Salcedo and Morante Trigoso, 2011). An enterprise from Arequipa purchased the licence to produce and commercialise the SWH system. Subsequent diffusion of the SWH technology and the formation of the cluster in Arequipa can be described as a spontaneous process without any further intervention of the public sector. An interviewed expert describes this process as follows:

'[the first enterprise] starts to produce, and as it is such a simple technology, so other persons watch and start to copy […] so everybody starts, enterprises start to appear, they start to produce and start to grow, the enterprises, and the technology starts to spread' (B9, own translation).

According to the interviews, the dissemination of the new technology was facilitated by the already existing culture of solar energy use in Arequipa.

To sum up, rapid dissemination of the technology was kicked off by public actors from the national scale who incorporated research conducted by national universities with respect to the technology of SWH and promoted its commercialisation. Arequipa - characterised by strong local practices of solar energy use - was a fertile ground for the national impulse and the SWH business started to flourish spontaneously and in a market-driven way. This unique process led to the spontaneous formation of the only solar thermal cluster in Peru.

3.2. Cluster consolidation

3.2.1. Local population's awareness of economic profitability of SWH

This phase was characterised by the consolidation of the SWH technology in urban Arequipa. The population of Arequipa was widely aware of the SWH technology and its economic profitability. An interviewed entrepreneur emphasised the widespread knowledge about the technology and its benefits: 'everybody knows it; an Arequipa citizen has to have his solar thermal collector because he knows that he saves money' (A3, own translation). Despite the high initial cost, the long-term costs of water heating with SWH were substantially lower than those of electric water heating devices. The economic benefit, together with the deeply rooted culture of solar thermal energy use, facilitated consolidation of the technology. According to (B4), SWH became a standard feature for many new buildings or residential areas in Arequipa. The main users of SWH were private households. To a lesser extent, small-scale industries and commercial businesses, such as hotels, used solar thermal energy for water heating purposes as well.

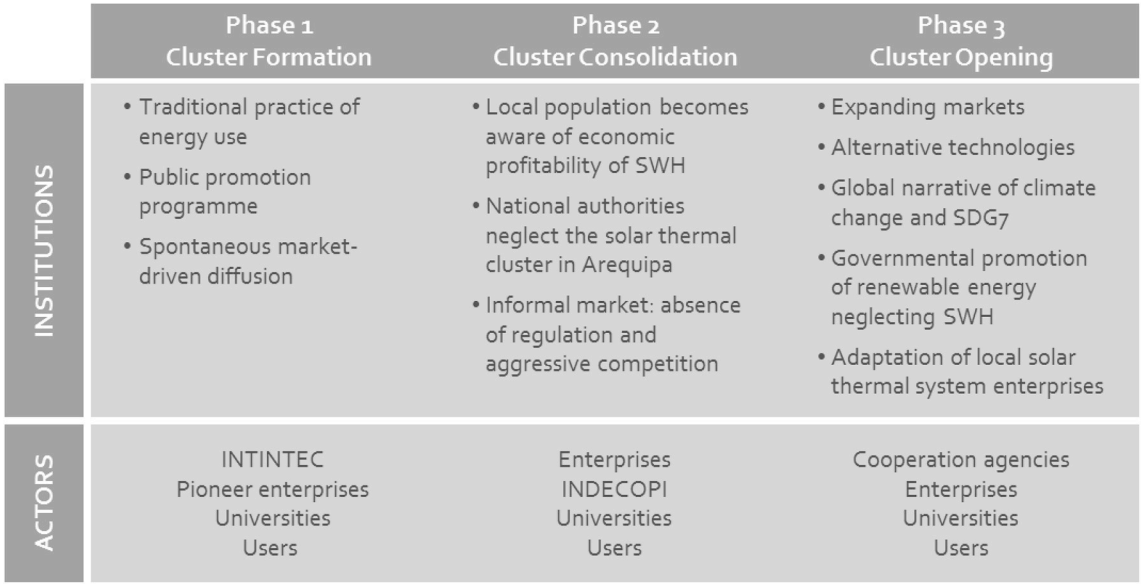

Fig. 1. Development phases of the solar thermal cluster in ArequipaSource: own elaboration.

According to the interviews, the main motivation for the use of SWH was the financial benefit in the long run compared to electric water heating devices.

3.2.2. *National authorities neglect the solar thermal cluster in Arequipa*

However, the use of SWH remained a local phenomenon limited to urban Arequipa and was not given any attention by national or regional energy authorities. According to the interviews, the MINEM (Ministry for Energy and Mining) first recognized the potential of solar thermal systems for the reduction of electricity consumption in the context of acute electricity shortages in 1994 and organised sporadic information seminars about SWH. As soon as the shortage was over, interest declined. Only after 15 years, in 2009, did the interest of national energy authorities in energy efficiency and the use of SWH re-emerge. The 'Referential Plan for the Efficient Use of Energy,' issued by the MINEM aimed at replacing electric water heating systems by SWH. The plan projected the introduction of 100,000 SWH in order to save 1200 TJ of electricity per year (Ministerio de Energía y Minas, 2009, p. 38). However, the policy and its potential implementation were weak (Bautista Guevara, 2013, p. 82f) and interviewed producers and academic experts did not know anything about the existence of the programme. The de facto neglect of solar thermal energy by national authorities became further manifest in the statement of an executive of the MINEM, who answered the question about the use of SWH in Peru by 'no, this has not yet been developed' (B6, own translation). The number of SWH installed in Arequipa provided another picture. According to estimates, 55,000 of 200,000 households were equipped with SWH (Pedro Gamio Aita, 2014). In the interview, however, two executive representatives of the MINEM pointed out that there was no public promotion of solar thermal energy for water heating in Peru.

3.3. *Informal market: absence of regulation and aggressive competition*

As outlined above, the solar thermal cluster in Arequipa was based on a spontaneous and market-driven development. Similar to other manufacturing clusters in Peru, the solar thermal cluster in Arequipa was described by the interviewed actors to be very informal (Israel and Hitzeroth, 2018). They stressed that there are no formal regulations for solar thermal technology production and use, except for some facultative technical norms issued by the National Institute for the Defence of Competition and Intellectual Property (INDECOPI). However, the standards are not mandatory and therefore not subject to controls. Furthermore, the statement of an entrepreneur depicts the lack of trust in formal certifications: 'as everything in Peru is corrupt, you pay and it's done' (B2, own translation). As Sánchez and Lehnert (2018, p. 127) confirm in their study on Mexico and Peru, 'emerging market firms often face corruption and institutional weakness in their environment' which limit the development of small- and medium-sized enterprises. An interviewed entrepreneur said that the municipality or the regional government could play an important role in the regulation of the market and the quality of the products, but that currently no efforts are being undertaken (B5).

Production of SWH mostly requires simple welding work and minor mechanical endowment. Consequently, the entry barriers are low and new producers constantly enter the market. This leads to very strong competition that is described by an expert as 'aggressive' (B9). The aggressive competition, in combination with an absence of formal regulations, induces illicit practices, such as fraud concerning the quality of the solar thermal collectors. Interviewees complain about the practice of some enterprises who advertise tanks as being made of durable stainless steel, whereas they are actually made of low-quality iron painted silver. Fraud concerning the quality goes hand in hand with fraud concerning the documents of the product. According to interviews, legal action against fraud is not possible due to manipulated documents.

The aggressive competition and the absence of formal regulations also affect relations between the enterprises. A producer states that he does not have any contact with other producers, because 'all are very distrustful' (B2, own translation) and according to an expert (B9), the only initiative to create an association of producers of solar thermal systems in Arequipa failed due to internal conflicts. Hence, the cluster does not have any joint voice that could represent common interests towards public actors.

In the absence of effective formal regulations, informal practices regulate the market. Producers offering cheap and low-quality products or having a bad administration cannot survive the competition in the long run, an expert says: 'one is born, another dies, it's like that' (A4, own translation). Because of fraud concerning the quality producers 'get denounced and disappear' from the market (B2, own translation). In this context, the age of an enterprise is an important indicator of its reliability and even justifies higher product prices.

Summing up, the phase of consolidation of the SWH cluster is characterised by the absence of public promotion and regulation on local, regional, and national scales. The low market entry barriers lead

to an aggressive competition on the partly informal market and induce illicit strategies. The mistrust between entrepreneurs inhibits cooperation and the common representation of interests towards public actors.

3.4. Cluster opening

3.4.1. Expanding markets

The consolidation of the cluster led to increasing market saturation in urban Arequipa. Estimations of installed devices in Arequipa by interviewed experts centre around a total of 55,000 systems installed in 200,000 households (Pedro Gamio Aita, 2014). Phase three is marked by a territorial expansion of the use of SWH. Producing enterprises from Arequipa have started to expand their selling activities into new markets, specifically the urban periphery and zones with lower socio-economic level in Arequipa. At the same time, entrepreneurs are opening selling points in other regions in Peru, especially the southern, central, and northern Andean regions, where solar radiation reaches its highest values. Interviewed experts emphasise that the Arequipan enterprises take their philosophy of solar thermal energy use with them and thus enable diffusion of the technology in the country.

3.4.2. Alternative technologies

A further innovation in this phase is the import of solar thermal systems. The imported technology consists of evacuated tube collectors that differ from the locally manufactured flat-plate collectors. According to the interviews, the first imported evacuated tube collectors were bought from China and reached Arequipa in 2000, but due to very high prices compared to local models, the technology was not widely disseminated. By 2009, prices of the imported technology had fallen drastically and a local entrepreneur started to import evacuated tube collectors produced in China and to advertise the imported products as '*British technology*' distinguished with '*industrial production and quality control certifications*'.[1] The imported evacuated tube collectors have a higher efficiency in the use of solar thermal energy for water heating. Compared to the locally produced flat-plate collectors, they are suited for use at higher altitudes with extreme intra-day temperature variations ranging from highly negative to highly positive values. According to the interviewed experts, the two technologies also differ in life expectancy. Imported technology is therefore offered with a shorter guarantee period than locally produced technology (B4). The production of evacuated tube collectors is technologically more complex and according to the interviews, attempts to produce this technology in Arequipa failed.

3.4.3. Global narrative of climate change and sustainable development goal 7

In this phase, global promotion of 'sustainable energy for all' (UNDP, 2015) has reached the cluster, which had been a market-driven phenomenon in the shadow of public promotion until then. A conglomerate of different European cooperation agencies have started to implement an energy development programme in Peru that aims at providing access to sustainable energy and poverty reduction.[2] Part of the programme managed by a project office in Arequipa is the promotion of SWH for water heating in rural areas. Different international, national, and local partners, such as microfinance agencies, participate in the implementation of the projects. Being aware of the local manufacturing cluster, it is striking that the programme exclusively promotes the installation of imported evacuated tube collectors in areas outside of Arequipa. According to an interviewed representative, one of the reasons is that imported evacuated tube collector systems work in all height zones in contrast to locally produced flat-plate devices that can only be applied in the altitudinal zones below 3000 m above sea level. For reasons of standardisation, promotion only covers the imported evacuated tube collectors. The local producers' criticism of lack of promotion of local products was countered by an interviewed official of the programme, who said 'it is not about promoting the products where nobody measures the quality' (B7, own translation). Practices of external actors based on formalised standards, such as quality certifications, obviously collide with the informal practices of the local market. The interviewee added that the programme is about promoting neither the 'technological development' nor 'the national industry.'

3.4.4. Governmental promotion of renewable energy neglecting SWH

In the context of the global promotion of sustainable energy, the Peruvian government formally began pushing renewable energy in 2008 with a decree promoting the investment in the generation of electricity with the use of renewable energies (Ministerio de Energía y Minas, 2008). This policy focused on electricity generation by renewable energy technologies, whereas the promotion of solar thermal energy was neglected by public actors on the national scale. The lack of information about the SWH and its use in Arequipa becomes evident in the interview with an executive of the MINEM, who erroneously argued that SWH are not yet used in Peru.

Also on the regional scale, solar thermal energy was neglected by public actors. A representative of the Regional Government for Energy and Mining of Arequipa, the capital of solar thermal energy use in Peru, presented the regional energy system in the interview. He explained the different types of energy used in the region, including a large-scale PV plant. However, he did not mention solar thermal energy and its use in Arequipa at all.

3.4.5. Adaptation of local solar thermal system enterprises

Local SWH enterprises adapted to the changing market and started to offer imported devices in addition to the locally manufactured technologies. Local enterprises now sell locally produced flat-plate solar thermal collectors as well as imported evacuated tube collectors. Other interviewed enterprises stated that they had to reduce the staff in order to compete with the cheaper imported technology. An interviewed expert summarised 'it started with the flat-plate technology and now it is changing to a heat pipe technology' (B9, own translation).

To sum up, the enterprises from the local cluster entered new markets and, spread the technology. New actors with disparate practices appeared in the cluster and jeopardised local production.

4. Discussion

4.1. Misrecognition of long-standing energy practices

The results of the analysis show that the evolution of local energy practices is disconnected from the national energy system. After a one-time promotion in the 1980s, the evolution of the solar thermal energy cluster in Arequipa shows an emergence of practices resulting from the manufacturers' and clients' agency. No further rules were imposed or developed to foster or frame practices of the solar thermal energy market. The unregulated market, characterised by the prevalence of informal or illicit practices, has persisted until today. This compromised the development of the cluster and caused mistrust by clients as well as between manufacturing enterprises. The mistrust inhibited entrepreneurial cooperation and, consequently, also the joint representation of common interests towards decision-makers. Decision-makers overlooked the established practices and focused on the

[1] http://termasdsol.com/nosotros.html, last access:18.10.2018, own translation.

[2] In 2009, a multi-donor partnership started to implement the *Energía, Desarrollo y Vida - EnDev* project in Peru that is part of the Energising Development Agreement. The main objective of the Energising Development Programme is 'facilitating sustainable access to modern energy services' and the project's evaluation relies on the indicator 'number of people provided with sustainable access to modern energy services per allocated euro' (https://energypedia.info/wiki/Energising_Development_(EnDev), latest access: 11.05.2019).

promotion of large-scale centralised electricity generation, such as the newly inaugurated photovoltaic plant *Rubi*.[3]

From the vantage point of historic institutionalism (Lockwood et al., 2017), the current disconnection of local practices from state-level regulation can be traced back to a path-dependent evolution of the institutional configuration (Jehling et al., 2019). We show how modes of constraints and agency evolved during the identified phases (Lowndes and Roberts, 2013) and lead to ongoing and sustained misrecognition. Due to lack of regulation in the past, the solar thermal cluster cannot gain access to the regulated energy system promoted by the state today. Furthermore, the self-regulated and established institutional configuration in Arequipa is now challenged by the introduction of imported solar thermal technology. The changes within the institutional configuration and the depicted phases of relative stability show a persistent marginalisation, which can be linked to narratives of 'modern' energy practices (Munro et al., 2017). A vicious cycle results: missing regulation impedes product standardisation and quality control. Subsequently the unreliable quality legitimates marginalisation of the technology and the manufacturing cluster, including exclusion from regulation. The narrative of a domestic technology that is inferior to an imported technology is perpetuated.

Analysing the process of energy transition in Arequipa through the institutional lens, we develop a basis for applying the conception of energy justice and clearly reveal the misrecognition of local practices (Jenkins et al., 2016). In theory, practices that emerged from implicit mechanisms can be turned into formal rules later. However, this cannot be observed in the case of Arequipa. Here, the misrecognition of local actors goes hand in hand with a lack of access to and participation in decision-making processes. In this setting, local actors lack agency to initiate a process within which local practices are recognized and turned into formal rules.

This underlines the fundamental role of recognition justice for the energy justice framework (Schlosberg, 2004). Only when recognising local actors and practices can procedural and distributional justice issues be addressed.

4.2. 'Modern' energy access programmes and disempowerment implications

Apart from the disconnection of national policies from local energy practices, the analysis also reveals their marginalisation by 'modern' energy access programmes launched by international actors, which is also referred to as energy bullying (Monyei et al., 2018). Involvement of external actors was found to endanger a localized model of renewable energy provision and its contextualised innovations. The techno-bureaucratic perspective of international cooperation agencies focuses on the narrow aim of creating access to 'modern' energy in rural areas and thereby neglects the socio-economic weight of established energy practices. In Arequipa, an existing cluster of 50 enterprises has successfully produced renewable energy technology for decades, and in this way provided the urban population with clean and affordable energy. Despite the misrecognition of the cluster by public actors, the technology is disseminated on the market due to its economic profitability and the existing local culture of solar thermal energy use. Use of solar thermal energy, which previously had been limited to urban Arequipa, has been extended to other regions in Peru by those enterprises. However, international cooperation agencies focusing on the creation of energy access in rural areas exclusively promoted imported SWH and, hence, endangered the local manufacturing cluster.

The disappearance of the cluster threatens the livelihood of the actors involved and causes the loss of contextualised innovations. It provokes the shift from an autonomous and socio-culturally rooted model of renewable energy provision to an externally determined one, thereby reproducing structural inequalities. Trotter and Abdullah (2018, p. 140) similarly show for the energy sector in sub-Saharan Africa that the current mechanisms of foreign involvement 'focus on creating market opportunities for non-African rather than domestic companies' and criticize the resulting aid dependency.

4.3. Conceptual implications

We combine an institutionalist perspective with the concept of recognition justice to develop an analytical framework to investigate the role of renewable energy in energy transition in the global South. By applying the framework to the case of Arequipa, we can also draw conclusions on the conceptual implications of this approach. Using modes of constraints, i.e. rules, practices and narratives (Jehling et al., 2019), proved to be very helpful in identifying mechanisms of misrecognition and disempowerment and empirically applying the concept of energy justice (Jenkins et al., 2016). The approach, thus, enriches the theoretical basis for analysing energy transitions in the global South (Lockwood et al., 2017; Munro et al., 2017). It especially helps to circumvent analytical categorisation of traditional or modern and formal or informal and allows for identifying the structuring effects of these dichotomies as narratives. In this study, we focus on the social dimension of the interaction between the institutional configuration and the actors of the production cluster. Further thoughts might more closely explore the question of materiality and its connection to technological changes in the respective field of solar thermal energy (Fuenfschilling and Truffer, 2014).

5. Conclusion and policy implications

In this paper, we analyse and discuss a case study which depicts the market-based development of a local cluster of solar thermal energy in Arequipa since the 1930s. Despite the success of local manufacturing enterprises in delivering renewable energy technology to a high share of households in the region, the cluster as well as the technology remain in the shadow of public regulation and promotion. In the context of global efforts for 'modern' energy access, international cooperation agencies promote the use of solar thermal energy in rural areas of Arequipa. However, they exclusively promote imported technology characterised by higher efficiency and quality certifications, as a result of which the local manufacturing cluster is marginalised and in danger of disappearing. The analysis is based on an institutionalist framework, by means of which we depict rules, practices, and narratives that constrain and empower actors within the energy system. We then apply the conception of energy justice to evaluate the analytical results and find a striking misrecognition of local energy practices. The reproduction of structural inequalities is addressed, drawing back on post-colonial perspectives and energy sovereignty. Based on the case study, explicit and general policy recommendations are derived.

First, in this specific case, it is fundamental to efficiently regulate the production and the use of solar thermal technology. Regulation is demanded by both interviewed entrepreneurs and experts. In order to integrate local practices and national rules, it is crucial to include local actors in the decision-making process. Once regulated, adequate cluster promotion policies can enhance the competitiveness of local manufacturers (Altenburg and Meyer-Stamer, 1999; Israel and Hitzeroth, 2018). Recognising the local cluster and creating an environment that stimulates and supports learning and innovation is the first step towards building a renewable energy system based on inherent innovation potentials (Altenburg and Meyer-Stamer, 1999). At the same time, incentive programmes for the use of the technology facilitate the diffusion of the renewable energy technology into previously unreached areas and sectors. Especially economic and financial incentives that allow for reducing the barrier of a high initial payment, together with an information campaign, may have drastic effects on the popularisation of solar water heaters (Chang et al., 2008). This joint conception of energy

[3] https://renewablesnow.com/news/enel-switches-on-180-mw-solar-pv-plant-in-peru-605894/(29.11.2018).

provision and energy use then contributes to both a sustainable transformation of the energy system and local economic development.

Second, external actors, such as international cooperation agencies, which currently promote the import of alternative solar thermal technologies, need to critically reflect upon the implicit socio-economic effects on local manufacturers and consider these in the development of their strategies.

In general, the analysis shows that the simplistic technological view of energy must be readjusted towards a more inclusive understanding of energy systems and their socio-cultural implications. It is necessary to re-think energy governance and shift away from a top-down approach with generalised globally applicable solutions to more inclusive governance and policy formulation. To enhance recognition justice, it is crucial to move away from epistemological modernism and recognise the diversity of energy outcomes as well as the value of existing local or regional solutions. Voices of different actors in the energy system need to be included in knowledge production to reach a broader debate about energy futures. This allows revealing and recognising innovation potentials of existing energy systems and their promotion through diversified policies. The legal and regulatory framework needs to be readjusted, giving voice to different actors, whose livelihood is based on existing energy systems.

However, a process of improved regulation only seems to be appropriate if sustained by changing narratives. Established energy practices and technologies have to be analysed and recognized as potentials for innovation instead of simply being devaluating as 'not-modern'. This enables an emancipatory perspective on self-determined energy systems in contrast to 'modern' energy policies that are likely to reproduce disempowerment and structural inequality within socio-technical energy systems in the global South. Only when the complexity of existing energy practices and its socio-cultural implications are understood can policies to promote a ‘modern’ and just energy system be developed.

Annex

Group	N°	Name	Location	N° Persons	Year
Private Sector	B1, B2, B3, B4, B5	Solar thermal enterprises	Arequipa	1-2	2017
Public Sector	B6	MINEM - General Directorate for Electricity	Lima	2	2017
	A6	MINEM - General Directorate for Rural Electrification	Lima	1	2016
	A1	Regional Directorate for Energy and Mining	Arequipa	1	2016
International Cooperation	B7	Program Office- International Cooperation Agency	Arequipa	1	2017
Financial Institutes	B8	Regional Microfinance Agency	Arequipa	1	2017
NGO	A5	National NGO for sustainable urban development	Lima	1	2016
Academics	B9, A4	National University of Saint Augustine	Arequipa	2/1	2017/2016
	A2	National University of Engineering – Centre of renewable energies	Lima	1	2016
	A3	Pontifical Catholic	Lima	1	2016
		University of Peru – Group for support of rural sector			

Fig. 1. Sample field research 2016 / 2017

References

Altenburg, T., Meyer-Stamer, J., 1999. How to promote clusters: policy experiences from Latin America. World Dev. 27, 1693–1713. https://doi.org/10.1016/S0305-750X(99)00081-9.

Anderson, W., 2002. Introduction: postcolonial technoscience. Soc. Stud. Sci. 32, 643–658.

Andrews-Speed, P., 2016. Applying institutional theory to the low-carbon energy transition. Energy Research & Social Science 13, 216–225. https://doi.org/10.1016/j.erss.2015.12.011.

ARE, B., 2014. The Peru Off-Grid Market in 12 Pages Players and Business Opportunities.

Baptista, I., 2018. Space and energy transitions in sub-Saharan Africa: understated historical connections. Energy Research & Social Science 36, 30–35. https://doi.org/10.1016/j.erss.2017.09.029.

Bautista Guevara, F., 2013. Eficiencia energética y conservación de la energía: perspectiva para un desarrollo sostenible. Revista Peruana de Energía 57–85.

Bazilian, M., Nakhooda, S., van de Graaf, T., 2014. Energy governance and poverty. Energy Research & Social Science 1, 217–225. https://doi.org/10.1016/j.erss.2014.03.006.

Becker, S., Beveridge, R., Röhring, A., 2016. Energy transitions and institutional change: between structure and agency. In: Gailing, L., Moss, T. (Eds.), Conceptualizing Germany's Energy Transition: Institutions, Materiality, Power, Space. Palgrave Macmillan, London, pp. 21–41.

Blatter, J., Haverland, M., 2014. Designing Case Studies, second ed. Palgrave Macmillan UK, London. https://doi.org/10.1057/9781137016669.

Castán Broto, V., Baptista, I., Kirshner, J., Smith, S., Neves Alves, S., 2018. Energy justice and sustainability transitions in Mozambique. Appl. Energy 228, 645–655. https://doi.org/10.1016/j.apenergy.2018.06.057.

Chang, K.-C., Lee, T.-S., Lin, W.-M., Chung, K.-M., 2008. Outlook for solar water heaters in Taiwan. Energy Policy 36, 66–72. https://doi.org/10.1016/j.enpol.2007.07.030.

Dawson, A., 2010. Climate justice: the emerging movement against green capitalism. South Atl. Q. 109, 313–338. https://doi.org/10.1215/00382876-2009-036.

Feldman, M.S., 2004. Making sense of stories: a rhetorical approach to narrative analysis. J. Public Adm. Res. Theory 14, 147–170. https://doi.org/10.1093/jopart/muh010.

Fraser, N., 2000. Rethinking Recognition. NLR, II 107–120.

Frigo, G., 2017. Energy ethics, homogenization, and hegemony: a reflection on the traditional energy paradigm. Energy Research & Social Science 30, 7–17. https://doi.org/10.1016/j.erss.2017.06.030.

Fuenfschilling, L., Truffer, B., 2014. The structuration of socio-technical regimes—conceptual foundations from institutional theory. Res. Policy 43, 772–791. https://doi.org/10.1016/j.respol.2013.10.010.

Goldthau, A., 2014. Rethinking the governance of energy infrastructure: scale, decentralization and polycentrism. Energy Research & Social Science 1, 134–140. https://doi.org/10.1016/j.erss.2014.02.009.

Gupta, A., 1998. Postcolonial Developments: Agriculture in the Making of Modern India. Duke University Press, Durham.

Hitzeroth, M., Jehling, M., Brueckner, M., 2017. Apples and oranges? A multi-level approach explaining social acceptance of renewable energy in Germany and Australia. Int. J. Glob. Energy Issues 40, 141. https://doi.org/10.1504/IJGEI.2017.086617.

IRENA, 2013. Renewable Energy Auctions in Developing Countries.

Islar, M., Brogaard, S., Lemberg-Pedersen, M., 2017. Feasibility of energy justice: exploring national and local efforts for energy development in Nepal. Energy Policy 105, 668–676. https://doi.org/10.1016/j.enpol.2017.03.004.

Israel, A., Hitzeroth, M., 2018. How do micro- and small-scale enterprises respond to global competition? An example of the textile survival cluster Gamarra in Lima. Int. Dev. Plan. Rev. 40, 203–222. https://doi.org/10.3828/idpr.2018.9.

Jehling, M., Hitzeroth, M., Brueckner, M., 2019. Applying institutional theory to the analysis of energy transitions: from local agency to multi-scale configurations in Australia and Germany. Energy Research & Social Science 53, 110–120. https://doi.org/10.1016/j.erss.2019.01.018.

Jenkins, K., McCauley, D., Heffron, R., Stephan, H., Rehner, R., 2016. Energy justice: a conceptual review. Energy Research & Social Science 11, 174–182. https://doi.org/10.1016/j.erss.2015.10.004.

Kuzemko, C., Lockwood, M., Mitchell, C., Hoggett, R., 2016. Governing for sustainable energy system change: politics, contexts and contingency. Energy Research & Social Science 12, 96–105. https://doi.org/10.1016/j.erss.2015.12.022.

LaBelle, M.C., 2017. In pursuit of energy justice. Energy Policy 107, 615–620. https://doi.org/10.1016/j.enpol.2017.03.054.

Lockwood, M., Kuzemko, C., Mitchell, C., Hoggett, R., 2017. Historical institutionalism and the politics of sustainable energy transitions: a research agenda. Environment and Planning C: Politics and Space 35, 312–333. https://doi.org/10.1177/0263774X16660561.

Lowndes, V., Roberts, M., 2013. Why Institutions Matter: the New Institutionalism in Political Science, 1. Publ. ed, Political Analysis. Palgrave Macmillan, Basingstoke.

Mayring, P., 2010. Qualitative Inhaltsanalyse: Grundlagen und Techniken, 11., aktualisierte und überarb. Aufl. Beltz Pädagogik. Beltz, Weinheim.

McCauley, D., Heffron, R., Stephan, H., Jenkins, K.E.H., 2013. Advancing energy justice: the triumvirate of tenets and systems thinking. International Energy Law Review 32, 107–116.

Ministerio de Energía y Minas, 2009. Plan Referencial del Uso Eficiente de la Energía - 2018.

Ministerio de Energía y Minas, 2008. Decreto Legislativo de Promoción de la Inversión para la Generación de Electricidad con el Uso de Energías Renovables: Nº 1002.

Monyei, C.G., Jenkins, K., Serestina, V., Adewumi, A.O., 2018. Examining energy sufficiency and energy mobility in the global south through the energy justice framework. Energy Policy 119, 68–76. https://doi.org/10.1016/j.enpol.2018.04.026.

Munro, P., van der Horst, G., Healy, S., 2017. Energy justice for all? Rethinking Sustainable Development Goal 7 through struggles over traditional energy practices in Sierra Leone. Energy Policy 105, 635–641. https://doi.org/10.1016/j.enpol.2017.01.038.

OLADE, 2013. Modelos de Mercado, Regulación Económica y Tarifas del Sector Eléctrico en América Latina y el Caribe - Perú.

Pedro Gamio Aita, 2014. Energías Renovables y Cambio Climático: 7 Proyectos demonstrativos de un desarrollo sustentable, 1000th ed. (Lima).

Pierson, P., 2004. Politics in Time: History, Institutions, and Social Analysis. Princeton University Press, Princeton. https://doi.org/10.2307/j.ctt7sgkg.

Purcell, T.F., Martinez, E., 2018. Post-neoliberal energy modernity and the political economy of the landlord state in Ecuador. Energy Research & Social Science. https://doi.org/10.1016/j.erss.2018.04.003.

Sánchez, C.M., Lehnert, K., 2018. Firm-level trust in emerging markets: the moderating effect on the institutional strength- corruption relationship in Mexico and Peru. estud.gerenc. 127–138. https://doi.org/10.18046/j.estger.2018.147.2656.

Schlosberg, D., 2004. Reconceiving environmental justice: global movements and political theories. Environ. Pol. 13, 517–540. https://doi.org/10.1080/0964401042000229025.

Tinajeros Salcedo, M., Morante Trigoso, F. (Eds.), 2011. Sistemas de calentamiento de agua con energía solar en la ciudad de Arequipa.

Trotter, P., Abdullah, S., 2018. Data for: Re-focusing Foreign Involvement in Sub-saharan Africa's Power Sector on Sustainable Development. https://doi.org/10.17632/9t7m2xt2s2.1.

UNDP, 2015. Human Development Report 2015: Work for Human Development. (New York).

3. Beitrag II

Israel, A. & Herrera, R. J. (2020)

The governance of Peruvian energy transitions: Path dependence, alternative ideas and change in national hydropower expansion

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The governance of Peruvian energy transitions: Path dependence, alternative ideas and change in national hydropower expansion

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ABSTRACT

Drawing from work on governance, this article stresses the role of different contexts for energy transitions and focuses on the particular conditions in expanding energy systems. The definition of expanding energy systems is introduced to avoid short-hand classifications such as developed and developing countries, and instead to differentiate based on the characteristics of the energy system itself. Furthermore, this article explores the implications of energy expansion for change and continuity in energy systems using the example of large-scale hydropower development in the Marañón River, Peru. Based on qualitative social research, this article shows that the analysed expansion of hydropower relies on the consolidated extractivist development model and stands for continuity; however, it also evinces that a diverse opposition of state authorities and civil society is willing to take an active part in decisions on the future energy system causing change. The article concludes that the expansion of energy generation is a window of opportunity for change in energy systems and provides suggestions on how to rethink governance. Finally, the article recommends further advancing the conceptualisation of transitions in expanding energy systems.

1. Introduction

Access to reliable energy can contribute to development and improve quality of life, whereas a lack of energy perpetuates poverty and socioeconomic inequalities [1–3]. Despite increasing electrification rates, households and the private sector still lack reliable access to energy in many regions worldwide. According to the International Energy Agency, an estimated 1.1 billion people did not have access to electricity in 2017 [4]. Enhancing energy access is hence recognised as a major global challenge and, since 2015, has been part of the United Nations Sustainable Development Goals [2,3,5]. Creating access to energy is not only a tremendous technical challenge but also one of governance. According to Bazilian et al., there are no 'easy fix' solutions because creating access is entangled with country-specific societal complexities [1,3]. Short-hand classifications of countries facing different challenges, such as developed and developing countries, however, should be avoided, as they 'can have a highly subjective meaning with little relevance for energy' [6]. We agree that a differentiation based on the characteristics of the energy system itself is required and suggest the concept of expanding energy systems, which are characterised by overall energy generation being increased and territorial coverage being extended. Such systems are in contrast to consolidated energy systems, where energy generation is constant or decreasing [7]. We argue that the expansion of energy systems has implications for energy transitions.

A growing consensus exists that current energy systems, consolidated as well as expanding ones, must undergo a severe transition to address climate change and its associated risks, because the energy sector is currently the largest source of greenhouse gas (GHG) emissions worldwide and the sector with the strongest growth rates [8]. Generally, energy transitions are defined by O'Connor as a 'significant set of changes to the patterns of energy use in a society' [9]. However, today's low-carbon transitions differ from previous ones in that they are purposive or 'problem-driven' rather than 'opportunity-driven', and therefore require the active engagement of policymakers and civil society [10,11]. The recent upswing of social science research on energy transitions reflects the substantial social implications of low-carbon energy transitions [12]. One strand of literature focuses on the resulting governance configurations [12–18]. In particular, transitions of consolidated energy systems, such as in the case of Germany's Energiewende, have been widely studied [14,19–23]. Kuzemko et al. emphasise that usually, multiple objectives and political drivers build the complex context for energy transitions, and Sovacool and Walter refer to the pernicious tradeoffs that result from the simultaneous dynamics of expanding access to electricity while minimising environmental degradation [10,24].

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We argue that expanding energy systems present a context in which energy transitions are subject to contradictory dynamics. The simultaneous challenge of expansion and transition might cause conflicts as well as release synergies that enable transition. Relevant literature is lacking, and a conceptualisation is required. Hence, the aim of this paper is to initiate a debate on the governance of energy systems undergoing simultaneous transition and expansion and to explore potential synergies and conflicts. We suggest a framework to analyse the interplay of these processes and further apply it to empirically analyse an example of hydropower expansion in Peru and its implications for energy transition. The focus on Peru was chosen because the country faces the simultaneous challenge of creating energy access and transforming the energy system [25]. Furthermore, a variety of different options for the future energy system are possible due to the diverse energy potential [26]. This leads to three key questions for analysis: first, which actors, institutions, and ideas drive and constrain the expansion of hydropower in Peru? Second, what implications does this have on change and continuity in the Peruvian energy system? Third, which synergies and conflicts could arise in energy systems with the simultaneous challenges of expansion and transition?

The remainder of this article is organised as follows. Section 2 begins with a theoretical reflection and the analytical framework. Section 3 introduces the case of energy expansion in Peru and describes the applied methods. Section 4 presents the results on the governance of large-scale hydropower expansion in the Marañón River, identifying key drivers and constraints. Section 5 discusses the implications on change and continuity in the energy system and provides suggestions for rethinking the existing energy governance configuration. Finally, section 6 concludes on conflicts and synergies of simultaneous energy expansion and transition.

2. Energy systems in the interplay of expansion and transition

2.1. Integration of concepts

Energy systems are commonly understood as socio-technical systems consisting of a cluster of elements, involving technical components, institutions, and actors [27]. Socio-technical transitions (STS) are conceptualised as a 'large-scale transformation within society during which the structure of the socio-technical system fundamentally changes' [10]. The co-evolution of material and intangible factors in socio-technical systems, such as built infrastructures as well as established routines, practices, expectations, and lifestyles, leads to system stability and causes path dependence [27]. As Sovacool argues, the greatest obstacles to energy transitions are thus of a socio-technical nature, relating not only to 'technical feasibility and performance but also issues relating to market failures, consumer values and acceptance, regulatory structures, business practices, and cultures', causing a significant inertia [28]. STS scholars often rely on the multi-level perspective (MLP) to conceptualise transitions of socio-technical energy systems, understood as '"regimes" that interact in practice across and between two levels: the "socio-technical landscape" and "niche innovations"' [10]. The niche level is where innovations emerge, whereas the landscape level is the structural context of the regime. Transitions occur in this framework when the prevailing regime is destabilised and allows for breakthroughs in niches [6].

Kuzemko et al. criticise the emphasis on the role of emergent technological innovations and the focus on political interventions for its promotion [10]; they recommend a stronger consideration of political and institutional conditions for transition and stress the role of ideas, which can establish problems and provide new solutions [10]. Energy system change is here described as a 'battle of ideas' and driven by successfully contesting established 'governance orthodoxies' through well-articulated, alternative narratives [10].

Understanding energy systems as socio-technical systems and considering the specific conditions of today's energy transitions as purposive, requiring the commitment of policymakers and civil society, we focus on energy governance approaches. The general concept of governance is used in multiple scientific disciplines as well as in political practice and is associated with different meanings. According to Gailing, in the last few years, governance research has experienced a shift from a more normative perspective of reforming hierarchical policymaking to a descriptive analytical one focusing on the analysis of collective action modes [29]. This new perspective in governance research allows for the analysis of complex structures of collective action and can refer to specific collective action fields on different scales [29]. It deals with different forms of social coordination and the interplay of public and private institutions on different scales. Applied to the field of energy, it thus allows us to analyse the particularities of the structures of collective action in the energy sector.

Energy governance scholars have unfolded general governance challenges inherent to the energy sector. These are, first, the strong vertical complexity caused by the interdependence with other sectors such as industry, agriculture, buildings, environment, or health, which makes energy a 'nest or mesh of other global systems layered on top of each other' [30,31]. Second, the energy sector involves actors on different scales from the individual to the local, regional, national, and global scales [3]. Goldthau and Sovacool classify three scales, namely the macro scale, referring to trans- or supranational engagement; the meso scale, referring to 'mid-level influence to energy systems and specific technologies'; and the micro scale, referring to activities at the household level [31]. On each scale as well as between them, numerous heterogeneous actors exist with different contrasting interests and resources involved. Third, complex and multi-layered institutions, laws, and regulations exist to coordinate collective action in the energy sector. Three different modes of institutional constraints can be differentiated in energy systems: formal written rules such as formally recorded standards and regulations; informal practices, which are patterns of behaviours transmitted through demonstration; and narratives, which are processes of explanation and persuasion that build up rationalities [32]. To address these governance challenges, Goldthau suggests a polycentric approach to energy governance [30]. This means to 'blend scales and engage multiple stakeholder groups' towards a system that 'simultaneously comprises multiple levels and decision-making bodies' [30].

2.2. Analytical framework

The analytical framework of this study was designed to analyse energy governance in the interplay of expansion and transition, and thus to explore conflicts and synergies. We argue that transition in expanding energy systems might be facilitated by lower system inertia because newly built infrastructure is not meant to replace existing infrastructure, as is the case in consolidated energy systems. However, the established governance context of the expansion – the intangible elements of the socio-technical system – might yet cause path dependence and foster continuity instead of change.

Analysing a specific example of hydropower expansion with an analytical governance perspective, we focus on the roles of different actors such as policymakers, firms, social movements, and scientific communities, and also on the roles of institutions and ideas. The entanglements of actors, institutions, and ideas are presented as key drivers and key constraints of the hydropower expansion. An analysis of the formal governance structure alone is not able to fully capture how governance arrangements, especially concerning hydropower, are negotiated [33,34]. We emphasise the need to look beyond formal regulations and agree with Kuzemko et al. on the importance of ideas to explain policymaking processes, because 'ideas can become embedded within institutions and institutions, in the form of regularized practices, rules and norms, influence decision-making processes' [10]. Furthermore, ideas 'influence which voices are "heard" in political debates and which are not', and once they are so embedded that they are taken for

granted, they are difficult to challenge and lead to path dependence [10].

We argue that analysing actors, institutions, and ideas shaping the governance of energy expansion subsequently allows the identification of change and continuity in the energy system and drawing of conclusions on energy transition. The focus on hydropower expansion provides insights into a particular governance configuration that differs from other examples of energy expansion in Peru [35]. However, it allows conclusions to be drawn on the interplay of expansion and transition in energy systems and initiates a debate on its conceptualisation.

3. Methods and context

3.1. Methods

As argued in 2.2., we explore the role of different actors, institutions, and ideas in shaping a specific example of energy expansion to provide insights into the interplay with transition. Two-step field research based on qualitative social research was designed and applied in Peru in 2016 and 2017.

As a first step, explorative field research was conducted in 2016 to identify and select a suitable example of energy expansion. Therefore, 13 semistructured interviews with a total duration of 11 h were conducted with decision-makers, actors from academia, nongovernmental organisations (NGOs), and the private sector at national, international, and regional scales. Fig. 1 presents the sample for the interviews.

The analysis of the interviews revealed a frequent problematisation of hydropower expansion in general and in particular the example of the Marañón River. We argue that it represents a suitable case because hydropower, often wrongly referred to as being emission-free [36,37], has experienced a renaissance in the context of the climate change debate and energy transitions [36–39]. The long history of the project, which involves 20 large-scale hydropower plants in the Marañón River, reaches from the first inventory in the 1970s through the upswing in the 2010s to the recent paralysation, and hence allows energy expansion and its implications for change and continuity to be explored.

To reinforce the analysis of this specific example, a second field research was conducted in 2017, focusing on the case of hydropower in the Marañón River. With the aim of investigating the governance context, including actors, institutions, and ideas, the focus was on the meso- and macro-scales. Interviews at the micro level with households were not conducted. Semistructured interviews do not aim to be representative but rather emphasise the individual opinions, attitudes, and experiences of interviewed actors [40].

Year	Institution	Description
2016	UNI/CER - *National University of Engineering / Centre for Renewable Energies (Energy Expert)*	academic
2016	PUCP/CIGA - *Pontifical Catholic University of Peru / Research Centre in Applied Geography (Energy Expert)*	
2016	UNI - *National University of Engineering (Energy Expert)*	
2016	UNSA - *National University of Saint Augustine / Centre for Renewable Energies and Energy Efficiency (Energy Expert)*	
2016	PUCP/INTE - *Pontifical Catholic University of Peru / Institute for the Sciences of Nature, Territory and Renewable Energies (Energy Expert)*	
2016	PUCP/GRUPO - *Pontifical Catholic University of Peru / Support Group for the Rural Sector (Energy Expert)*	
2016	KAS - *Konrad Adenauer Foundation / Regional Programme Energy Security and Climate Change in Latin America*	civil society (not-for-profit)
2016	CENERGIA* - *Centre for Energy and Environment Conservation Centro*	
2016	*Forum cities for life***	
2016	*Duke Energy Peru****	private sector (for-profit)
2016	*Duke Energy Peru****	
2016	GRA - *Regional Office of Energy and Mining Arequipa*	state
2016	MINEM/DGER - *Ministry of Energy and Mining / General Directorate of Rural Electrification*	

* members are private companies and public institutions from the energy sector
** members are local governments, universities, NGOs, entrepreneurial associations
*** interviews with staff from different sections that are not specified due to anonymity requirements

Fig. 1. Sample for the interviews conducted in 2016.

Year	Institution	Description
2017	MOCICC -*The Citizen's Movement against Climate Change*	civil society (not-for-profit)
2017	DAR - *Law, Environment and Natural Resources*	
2017	SPDA - *Peruvian Society for Environmental Law*	
2017	CSF - *Conservation Strategy Fund*	
2017	FONAM* - *The National Environmental Fund*	private sector (for-profit)
2017	SNMPE - *National Society of Mining, Petroleum and Energy*	
2017	*Compañía de Minas Buenaventura S.A.A. (Peruvian minig company)*	
2017	COES** - *Economic Operation Commitee of the National Interconnected System*	state
2017	SERNANP - *System of Protected Natural Areas of Peru*	
2017	MINEM/DGE -*Ministry of Energy and Mining/General Directorate of Electricity*	
2017	ANA - *National Water Authority*	
2017	ProInversión - *Agency of Promotion of Private Investment in Peru*	
2017	MINAM- *Former executive of the Ministry of Environment*	
2017	*Embassy of Brazil in Lima*	

* private institution created by Law N° 26793. The directive council is composed of ministries, representatives from NGOs, academia and the private sector
** private company of public interest

Fig. 2. Sample for the interviews conducted in 2017.

The selection of interviewees followed a nonprobability sampling strategy with the aim of creating an ideographic and in-depth understanding [41]. Information on governance actors gathered on the first field research trip in 2016 supported the purposive sampling, facilitating coverage of a broad range of perspectives and ensuring that actors with different perspectives were interviewed. Because data saturation was difficult to guarantee, we followed the criteria of diminishing returns, which means that considering the resources available we argue that there were sufficient data to answer the research question and that strongly diverging perspectives are unlikely [40]. Fig. 2 presents the sample of the 14 interviews with actors from civil society, the state, and the private sector. Further interviews were intended with representatives of the Ministry of Environment, the Brazilian construction company Odebrecht, and an involved commission of the Congress, but we did not succeed in obtaining them.

The guidelines for the semistructured interviews were divided into the six topics depicted in Fig. 3.

The order of the topics underwent slight adjustments according to the course of each interview. All interviews – except for one – were recorded with informed consent and added up to a duration of more than 10 h. The interviews were transcribed according to Dresing and Pehl and subsequently analysed using qualitative content analysis [42,43]. The categories were developed in a multistep process combining inductive and deductive proceedings, and hence consider both the empirical data as well as theory [44]. Thus, the interviews were first

N°	Topic and Subtopic
I	Introduction and consent
II	Expansion of Peruvian energy system
III	Hydropower expansion in Peru *Actors, institutions, challenges*
IV	Hydropower expansion in the Marañón River *Actors, institutions, challenges*
V	Own role in hydropower expansion in Peru and the Marañón River *Aims, strategies, relation to other stakeholder*
VI	Prospects of hydropower expansion in the Marañón River

Fig. 3. Six topics of the semistructured interviews.

all read and notes were taken; subsequently, the notes were classified into themes and translated into categories according to the analytical framework. To improve the validity of the categories, 30% of the interviews were coded and the resulting adjustments were made to the categories. Lastly, all transcribed interviews were coded in accordance with the final categories. In addition, relevant literature and a variety of secondary data such as laws, plans, news, and reports were collected and analysed. Citations of the interviews were translated from Spanish or Portuguese into English.

Neglect of the micro scale is perceived by the authors to be the main limitation of the methods. Interviews were conducted with actors who are actively engaged in energy governance. It could be enriching to further explore perceptions and expectations of affected – yet not consciously acting – actors, such as energy consumers.

3.2. Peruvian energy system and hydropower in the Marañón River

To explore the research questions, it is crucial to first understand the Peruvian energy system and its regulatory framework. The current energy matrix is described as 'hydrothermal', being composed mostly of hydroelectric and thermal power generation [26]. The long dominance of hydropower in the electricity sector was balanced by a strong increase in the use of natural gas following the launch of the national exploitation project Camisea in 2004 [26]. Today, electricity generation based on natural gas has reached 46% of overall electricity generation, whereas hydropower still accounts for 48% [26]. The electricity infrastructure is strongly centralised, favouring the large cities of the coast [25].

The current regulation of the Peruvian electricity sector has its origins in the early 1990s, a period marked by extensive neo-liberal market reforms. The role of the state was redefined under these conditions and the electricity sector, a typically state-driven sector, was at the centre of the reforms [45]. The Electrical Concessions Law [46] introduced in 1992 was the starting point of the privatisation process in the energy sector and, with slight modifications, has regulated the sector until today. Fundamental changes were the reliance on market forces for the sector's development, the privatisation of state-owned companies, and the introduction of competition [47]. The regulation of investments since then has been shared between three main institutions of the energy sector: the Ministry of Energy and Mining (MEM), the Supervisory Agency for Investment in Energy and Mining of Peru (OSINERGMIN), and the Committee for the Economic Operation of the National Interconnected System (COES). Institutional representations from other sectors, such as the environmental sector, are not included [48].

A slight modification to this reliance on market forces is the introduction in 2006 of tenders for the sector's development [49]. According to a representative of the MEM, the aim was to increase the insufficient private investment in energy generation and later on to balance the energy matrix that had become increasingly dependent on natural gas [49,50]. In addition to the instrument of tenders, interventions in the energy sector are conducted through individual actions such as supreme decrees.

According to the National Energy Plan 2014–2025, which is the guiding document of the energy sector, the principal aims of energy policy in Peru are competitive energy provision, energy security, and universal access, as well as low carbon emissions and minimal environmental impact [51]. A main challenge for the Peruvian energy system is the expansion of the energy supply to support the economic growth of the country, to alleviate energy poverty and improve rural energisation [26]. Over the past two decades, the electricity demand has experienced yearly growth rates of around 7% which were covered mainly by the development of large hydroelectric power plants and, lately, by natural gas-fired power plants [50]. Simultaneously, rural electrification has progressed significantly. The access to electricity of the rural population increased from 22% in 1997 [52] to approximately 80% or 90% in 2017 depending on the source [52,53]. However, approximately 3 million people still lack access to modern energy [25].

In addition to the expansion of the energy system, Peru has started shaping its own energy transition and slowly exploiting its vast renewable energy potential [25]. The first step towards the development of nonconventional renewable energy (NCRE) generation was marked by the establishment of a regulative framework in 2008 [26]. The corresponding legislative decree N°1002 followed the tender policy introduced in 2006, this time for electricity generated by NCRE sources, including biomass, wind, solar, geothermal, tidal, and small hydropower below 20 MW [50]. The tenders guarantee contracts for electricity provision for periods of 20 to 30 years at allocated prices [50]. The results after four rounds of tenders were 64 projects of NCRE generation adding 1274 MW of installed capacity, which is an increase in the NCRE share of 4.8% [26]. However, there is a temporal ceiling of 5% of NCRE participation and tenders have slowed [26]. According to Mitma Ramírez and Gamio Aita, no clear direction exists for the future of renewable energies and continuity of public policies is missing [25,50]. Despite the progress in laws and regulations, political will is lacking and strategic planning is absent [25]. To summarise, investments in the energy sector are driven by market forces as well as ad-hoc measures that are not indicative of long-term planning or coordination with other sectors, such as the environmental sector.

In this context of the Peruvian energy system, the formal impulse for the development of hydropower in the Marañón River was marked by a supreme decree issued by former president Alán García in 2011 [54]. The decree declared the construction of 20 hydropower plants with a total generation potential of more than 12 GW to be of national and social interest and defined the Marañón River as the 'energy artery' of the country [54]. Considering the total installed potential in Peru of 7.5 GW at that time, the hydropower project in the Marañón River was equivalent to almost twice the existing national installed potential [55]. The technical information regarding the hydropower potential of the Marañón River dates back to an inventory of hydroelectric resources in Peru realised by the German Development Cooperation GTZ and published in 1982 by the MEM [56,57].

The locations of 17 of the projected 20 hydropower plants in the river basin are depicted in Fig. 4. Until today, only one hydropower plant has been constructed and put into operation. With 18.4 MW, the so-called Marañón plant located in the upper-middle basin is considered small. Its planning began before the projected large-scale exploitation of the river and its socio-ecological impacts are comparatively smaller than those of the other projected plants. Apart from the existing Marañón plant, temporal and definite concessions have been granted for hydropower plants in the lower-middle basin, where socio-ecological impacts are expected to be substantial because of the need for large dams and the extensive flooding of rainforest areas [58]. However, according to a report from 2019, construction has not even started on the most advanced projects Chadín II and Veracruz, both counting with approved environmental impact studies (EIS) [59]. It thus becomes evident that the expansion of hydropower in the Marañón River has been experiencing ups and downs in the shadow of a changing energy system.

4. Key drivers and constraints of hydropower expansion

According to the analytical framework, we first depict the results on the governance of hydropower in the Marañón River to subsequently discuss its implications for change and continuity in the Peruvian energy system. The analysis of the empirical data showed that different entanglements of actors, institutions, and ideas exist that drive the expansion of hydropower as well as others that constrain it. These entanglements are divided into key drivers and key constraints and are further grouped thematically. The separation into drivers and constraints and the clear distinction between thematic groups facilitate the presentation of results; however, such separation and distinction are

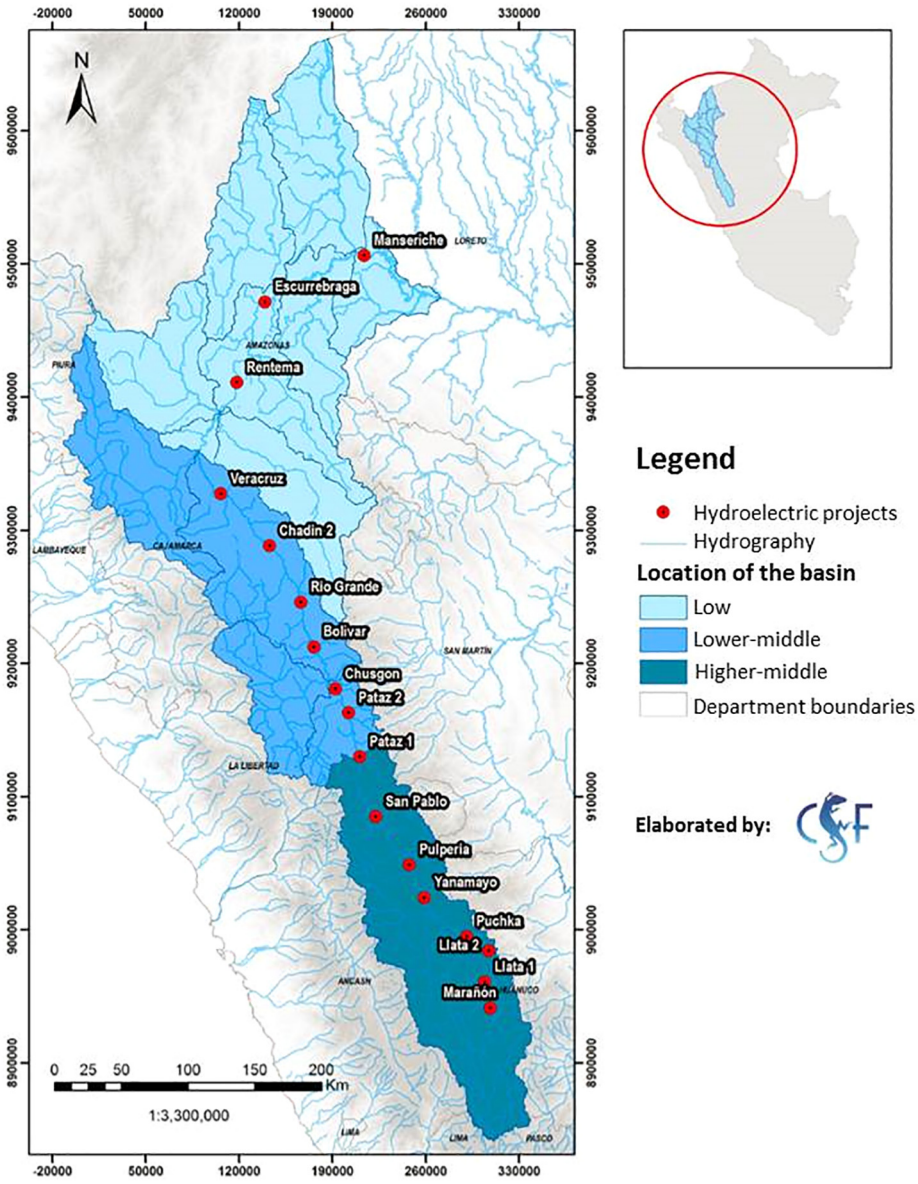

Fig. 4. Projected hydropower plants in the Marañón River, [58], translated.

artificial and the presented key drivers and constraints should not be considered independent from each other.

4.1. Key drivers of hydropower expansion

The key drivers of hydropower expansion in the Marañón River, derived from the analysis of the interviews, are the interdependence of the energy and mining sectors, the energy exported to Brazil, the role of international construction companies, and the perception of rivers as hydropower potential.

4.1.1. Interdependence of the energy and mining sectors

Peru is a country rich in mineral resources. In 2017, the export of minerals added up to 61.8% of the value of total exports with strong increases expected [60]. As an energy-intensive sector, the mining sector has strong implications for the energy sector, which was emphasised by interviewed actors from the public sector, the private sector, and NGOs.

The growth of the mining sector was argued to be a main reason for the expansion of energy generation in Peru. The interviewed representative of (r.o.) the Movimiento Ciudadano frente al Cambio Climático (MOCICC) argued the following:

> 'What is the main source of the expansion of the national energy matrix? It is not the people, it is not the households […] the main energy demand in the last 15 years has come from (eh) the mining or the extractive sector; we have a huge amount of natural resources and we have an energy demand that serves to extract those natural resources' (r. o. MOCICC)

Similarly, the interviewed r.o. the Sociedad Nacional de Minería, Petróleo y Energía (SNMPE) stated that the role of the mining sector and the industry are 'two of the main motors for the growth in the electricity sector'. Correspondingly, the interviewed r.o. the MEM explained how especially the growth of the mining sector is considered by the Ministry for the expansion of the energy sector:

> 'In the plans that the Ministry prepares, let's say, it is taken into account, because the evolution of the mining projects is monitored (…) for the planning, they are especially taken into account, because the vegetative[1] part is more or less constant and they are the ones who rather make the changes' (r.o. MEM)

This is why, according to him, the Ministry promotes energy projects in the southern and northern regions where the extractive industry is located. He emphasises that 'the one leading here is the mining sector, when it grows it drags everything with it'.

Relying on a cheap and safe energy supply, the mining sector is strongly affected by energy scarcity. The interviewed r.o. COES stated that 'some years, we had energy shortages in Peru and the mining companies where those, who complained the most'. The mining company Buenaventura therefore ended up building its own hydropower plant to secure its energy supply. The interviewed representative explained as follows:

> 'We ended up building our own hydroelectric power plant, a power plant that has a capacity up to 100 megas and with that we are attending essentially our total demand […] and now with a power plant of 100 mega, we have essentially solved our problems, probably' (r.o. Buenaventura)

This prioritisation of hydropower by the mining sector was also emphasised by the interviewed r.o. MOCICC, who argued that hydropower is the cheapest and most reliable energy source in the region. The interviewed representatives of SPDA and Derecho, Ambiente y Recursos Naturales (DAR) argued similarly:

> 'Hydroelectricity has until now and will continue experiencing a quite strong promotion by extractive industries' (r.o. SPDA)
> 'The percentage of electricity consumption of the extractive sector has been increasing […] it's them who have been pressuring to build hydroelectric plants ad-hoc for extractive activities' (r.o. DAR)

Concerning the case of the Marañón River, according to the interviewed r.o. MOCICC, the construction of the projected hydropower plants is related to the development of the specific mining project Conga and El Galeno. Fig. 5 is a map issued by ProInversión, the public institute for the promotion of private investments, and illustrates the proximity of the mining projects and hydropower projects in the Marañón River and reinforces the idea of this interdependence.

The supreme decree promoting the construction of hydropower plants in the Marañón River [54] argues that the projected hydropower plants 'support the productive development of Peru', whereas it does not refer to the energy needs of, for example, unelectrified settlements in the river basin. The analysis of the interviews showed that the mining sector is seen as one of the main explicit and implicit drivers of the expansion of hydropower in Peru in general and in the Marañón River in particular.

4.1.2. Energy export to Brazil

A second key driver, according to the interviewed experts from the public sector, the private sector, and NGOs, is the envisaged energy export to Brazil. The interviewed r.o. the MEM confirmed the interest in energy exportation and named Brazil as a potential client:

> 'The country has plans to export energy, let's say there are potential clients that are waiting, Brazil, well it's a giant market, isn't it? It's always there' (r.o. MEM)

The industrialisation and economic growth of Brazil has led to a strong increase in its national energy demand; the country has been striving to rapidly expand its energy supply and has also considered accessing energy resources outside the national territory [48]. An interviewed r.o. the Brazilian Embassy confirmed the following:

> 'There will always be, from my point of view, in principle a need for energy importation on the part of Brazil' (r.o. Brazilian Embassy)

The interviewed r.o. DAR saw the energy import initiative as an 'intrusion' of 'Brazilian interests in the electricity sector'.

For the generation of the additional energy, the focus lies on hydropower plants located in the Amazon region [62]. According to the representatives of MOCICC and the NGO Conservation Strategy Fund (CSF), Brazil, with by far the largest hydropower potential in Latin America itself, reduces economic, political, and social costs by moving its hydropower plants outside the national territory as opposition and social pressure are relatively strong and well-organised in the country:

> 'Over there the organisations are structured and powerful […] there is no such thing here, so they are considering the costs, reduce the social costs, reduce the economic costs, reduce the political costs, and its cheap a country that gives away its natural resources isn't it? And that additionally has low pressure on the hydroelectric issue, there is a lot of potential so it is cheaper' (MOCICC)

According to the interviewed r.o. SPDA, there was no actual need for the hydropower expansion on the Peruvian side:

> 'The Peruvian benefit […] was that we could get money from that, but there was actually no great need on the Peruvian side to be true' (r.o. SPDA)

The promotion of energy exportation from Peru to Brazil formally manifested in 2010 when the former presidents of both countries, Alán García and Lula da Silva, respectively, signed an energy agreement [63]. The agreement foresaw the construction of large hydropower plants on Peruvian territory financed by the Brazilian Development Bank (BNDES). The electricity generated was designated partly for consumption in Peru and partly for export to Brazil. After 30 years, the ownership of the hydropower plants would be transferred to Peru [64,65].

The interviewed actors who advocated for the energy agreement with Brazil and the subsequent construction of hydropower plants in the Amazon region were private actors, such as representatives from SNMPE and the Peruvian mining company Buenaventura, as well as the National Grid Operator COES, who stated the following:

> '… well, I am one of the few who think that it was a good idea (…) to build hydropower plants in the Peruvian Amazonia and to build lots of them for Peru, so that one part would remain in the country and one part would be exported to Brazil' (r.o. COES)

An interviewed r.o. CSF summarised his view on Brazil's role as follows:

> '… Brazil comes with cash and it becomes likely [*ed. the construction of hydropower plants*], because that is what happened with Brazil, they created the need of many projects because they had the financing of the Bank of Brazil' (r.o. CSF)

Even though the energy agreement does not indicate specific hydropower projects, according to Cueto la Rosa, five of the hydropower projects in the Marañón River were assigned exportation potential by the MEM [64]. Only a few months after the signing of the energy agreement, the former Peruvian president installed a commission for the energetic and agrarian development of the Marañón River, which finally led to the supreme decree on the construction of 20 large-scale hydropower plants along the river [54,66]. Even though the supreme decree did not refer to energy export, in the perception of the interviewed actors, the relation is evident. To conclude, the energy exported to Brazil was seen as a key driver for the hydropower expansion in the Amazon region, including projects located on the Marañón River.

4.1.3. Role of construction companies

The third main driver related to energy exports to Brazil, according to the interviewees, is the role of Brazilian construction companies. The

[1] The 'vegetative electricity demand' is the demand from residential and commercial sectors, middle-sized industrial companies, and public lighting. The electricity demand of large consumers such as extractive companies, the so-called 'free clients', is separately monitored [55].

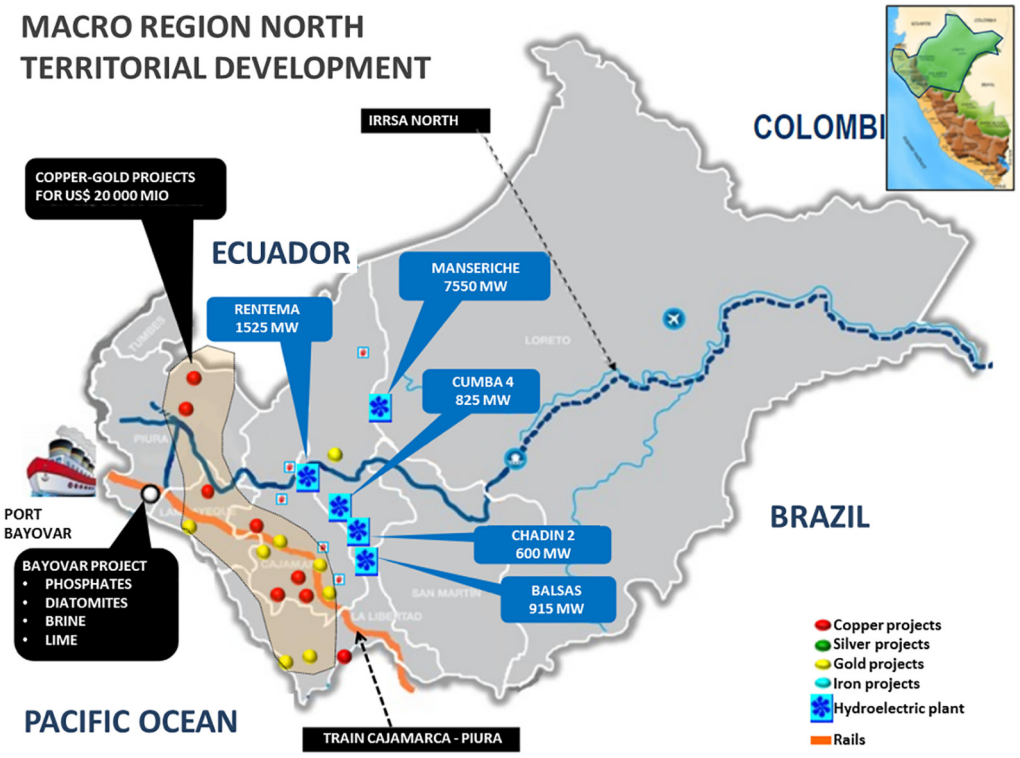

Fig. 5. Relation of mining and hydropower projects, [61], translated.

interviewed r.o. the COES, an advocate of the hydropower project, described the role of Brazilian construction companies in the context of the energy agreement between Peru and Brazil as follows:

> '…some years ago, Brazil developed a whole scheme; actually it was the Brazilian construction companies, it was not the Brazilian government, it was not the Ministry for Energy and Mining of Brazil, the construction companies with support of Lula developed an idea to build hydropower plants in the Peruvian Amazonia' (r.o. COES)

The interviewed r.o. the Brazilian Embassy in Lima confirmed that the Brazilian construction companies OAS and Odebrecht played a crucial role:

> 'Government agencies and, and also the private sector, these would be the most important to highlight, of course from the private sector also the large Brazilian construction companies right? OAS, Odebrecht, they were all involved in this, this big project, right?' (r.o. Brazilian Embassy)

The perspective of the interviewed NGOs, which all stressed the influence of Brazilian construction companies, was more critical. The r.o. SPDA spoke of a 'very obvious case of how all these interests have collided' (SPDA). The interviewed r.o. CSF claimed that

> '…a lot of the projects that have been developed have been motivated by corruption, by personal interests without really looking if the country needs it, well what they said is, I want to build a hydropower plant, I will give you money, I will generate the necessity for you and we will build it' (r.o. CSF)

In summary, the interests of construction companies were perceived as a main driver for the expansion of hydropower in general and in the Marañón River in particular.

4.1.4. Rivers seen as hydropower potential

It is self-evident that an existing hydropower potential is the basic requirement for generating hydroelectricity. However, it could be questioned whether it is also self-evident that the existing hydropower potential must be exploited. Asked generally about the future of the energy sector in Peru, the interviewed r.o. Buenaventura answered with the following:

> '… Peru has a very large hydropower potential, so we still have very much potential to develop, with large and small hydropower of course, because of the topography, because of the large falls, because of the water streams that we have, there we have approximately a potential of 70 thousand megawatts from which we have developed in hydroelectricity about 4,500 to 5,000 megawatts, not more than that, therefore there is much more to be done' (r.o. Buenaventura)

Rivers here are seen as a natural resource to be exploited, and consequently, the existing potential and not the energy demand is the determining factor for the expansion. Several interviewed private and public actors, such as the interviewed representatives of the MEM and ProInversión, argued that Peru has 'lots of potential' (MEM), and that the potential 'has to be exploited' (ProInversión). The rationale is that if there are no dams and hydropower plants, the water is lost to the sea and does not generate any wealth:

> 'It was a good scheme [ed. expansion of hydropower to export energy] […] if they didn't do anything those waters keep running and reach the sea and we won't take any profit out of that water' (r.o. COES)

The same reasoning can be found in the supreme decree promoting hydropower plants in the Marañón River. It states that the hydroelectric use of the river 'will allow us to benefit from a source of wealth that is currently unproductive and that is lost in its course towards the Atlantic Ocean' [54].

Advocates of hydropower, such as the interviewed representatives of COES or SNMPE, argued that it is a 'clean' or 'renewable' energy source. Similarly, the supreme decree on the promotion of hydropower in the Marañón River justifies that it is an

> '…obligation of the state to promote the investment and the

development of energy infrastructure, especially the infrastructure considered as clean, through the construction of hydroelectric plants which produce energy based on renewable sources and with minimal or zero impact on the environment' [54]

Where socio-environmental problems are mentioned, there was a strong belief in technology and its capacity to solve these problems in the future:

'… the technology will solve these problems [ed. environmental and social] and it will advance, but let's say that as hydroelectric potential we have a large, large potential' (r.o. SNMPE)

The analysis of the interviews showed that the existing hydropower potential – and not necessarily the energy demand – is seen by the interviewed public and private actors as the determining factor for its development. Hydropower was claimed to be a clean and renewable energy source with minimal environmental impact.

4.2. Key constraints

This section presents the key constraints resulting from the analysis of the interviews which eventually led to the paralysation of the hydropower projects in the Marañón River: contesting extractivism, opposition to energy agreement with Brazil, the corruption crisis, and alternative perceptions of rivers.

4.2.1. Contesting extractivism

The interviewed experts agreed that the mining sector is a key driver for the expansion of energy generation, especially in the case of hydropower. The interviewed actors from NGOs generally levelled the critique that the additional energy serves to extract natural resources and is not intended to alleviate energy poverty. Thus, it reinforces Peru's development model based on the exploitation of natural resources and the socio-ecological conflicts that accompany it. Furthermore, the interviewed NGOs criticised the lack of transparency in the relationship between the two sectors, especially when it comes to the relationship between a specific mining project and a specific hydropower project. In the case of hydropower in the Marañón River, the spatial and temporal proximity of the projected hydropower plants to the large-scale mining projects Conga and El Galeno indicates a potential relation, which is not transparent, according to the interviewed r.o. MOCICC:

'… let's see, pull the tongue of somebody [ed. means to force someone to tell the truth, to confess something] so that he tells you the truth! No, they will never tell it to you, I am absolutely convinced that Chadín II is made for Conga or Galeno, for that famous mining district' (r.o. MOCICC)

The relationship between the hydropower projects in the Marañón River and Conga mining project is also referred to in local protests, which use slogans such as 'Welcome to the land free of extractivism – No to Conga, Marañón without dams' [67]. It shows that the interviewed NGOs, as well as local protesters, strive to make the relationship between specific energy and mining projects explicit and to contest extractivism.

4.2.2. Opposition to the energy agreement with Brazil

The energy agreement experienced strong and diverse opposition in Peru. Part of the critique concerns the its procedural deficiency. The interviewed NGOs criticised the lack of transparency during the negotiations as well as the missing participation of sectoral authorities such as the National Water Authority, Ministry of Foreign Affairs, Ministry of Environment, and Peruvian companies as counterparts to the Brazilian companies. The fact that no integral analysis had been conducted to consider the social and environmental impacts was criticised as follows:

'The case of the Marañón, for example, would be about generating a lot of energy for export, but at the cost of our natural assets; in order to sell energy for 10 years we will lose 50 years of well-being of the communities that are settled in that region, so an analysis should be done from an integrated social, economic point of view' (r.o. CSF)

In addition to the procedural deficiency, the agreement was blamed for provoking substantial negative economic, environmental, and social impacts. Due to the broad opposition the agreement was transformed into a legislative proposal and therefore subjected to a vote in the Congress. This process was described by the interviewed r.o. DAR as follows:

'The validity only required the ratification of the executive, right? And therefore it was valid right? […] However, that was questioned by civil society and in the end it came up in the Congress of the Republic for discussion and debate' (r.o. DAR)

In May 2014, the legislative proposal was archived because of the argument that it would compromise natural resources on behalf of a foreign power, and therefore violate the constitution. Furthermore, the magnitude of the contract was criticised as the envisaged electricity export level exceeded the total national electricity demand of Peru [68]. The failure of the agreement was directly related to the strong opposition:

'There were various problems, there were different discordant voices to these agreements and that has been lasting until now, what has happened, these projects have not been realised' (r.o. SPDA)
'It was a good scheme but there was a lot of opposition especially environmental, strong strong […] they terribly opposed it' (r.o. COES)

The r.o. the Brazilian Embassy in Peru described the current state of the energy export initiative as being in a 'state of (.) of I would say of paralysis and with few, few very few perspectives of deepening, of further progress'. In summary, the broad opposition led to a paralysation of the energy export initiative and hence it slowed the hydropower expansion in the Peruvian Amazonia, including the Marañón River.

4.2.3. Corruption crisis

According to the interviews, one of the main reasons for the trend reversal of hydropower development in the Marañón River is the revelation of the corruption scandal around the Brazilian construction company Odebrecht and its ongoing investigations in Peru. According to the latest investigations into the so-called Operation Car Wash, the company supported its efforts in infrastructure construction in Peru using a structured system of illicit payments to decision-makers on different scales [69]. Brazilian investigations suspect cases of corruption in Peru, especially in the context of the construction of hydropower plants, gas pipeline, and roads [70,71]. The company has been involved in the concession and construction of four hydropower plants in the Marañón River under diverse owner structures that are currently being investigated. The revelations led to a severe political crisis in Peru with four former presidents involved or investigated [71,72]. Furthermore, all assets of the company were frozen, and any participation in public biddings was prohibited.

The r.o. COES, a proponent of the Energy Agreement and the hydropower expansion in the Marañón River, stated that the perspective of Peruvian and Brazilian energy cooperation has changed due to 'this corruption problem of the Brazilian construction companies'. Interviewed actors from NGOs and the Brazilian Embassy described how the revelation of the corruption scandal led to an abrupt change in the perspectives of hydropower in the Marañón River.

'Most of the hydroelectric plants have been falling over time, not physically collapsing but the projects have been paralysed, particularly due to the case of Odebrecht, no? (Uh) that more or less messed up everything' (r.o. MOCICC)
'Odebrecht is currently already in so much trouble that ((laughing))

that it will be quite difficult that they would like to reassume these, to put themselves in more trouble than they already are, you know? So of course there has been a change […] it would never occur to any politician in his right mind to get together with a corrupt company now; before there still has been a mantle of doubt' (r.o. SPDA)

'Odebrecht for obvious reasons is also leaving the country, but with a very complicated legal situation […] Odebrecht itself (.) at the moment (.) is the pole right? It is the emitting pole of these complaints right? Of these revelations that fully hit the political class' (r.o. Brazilian Embassy)

These statements show that the corruption crisis led to drastic changes in the political viability of the hydropower projects.

4.2.4. Alternative perceptions of rivers

Hydropower expansion based on the existing potential and not the energy demand was criticised by the r.o. MOCICC: '…the problem is not that there is an increasing demand, the problem is that there is a potential that wants to be exploited'. He criticised the discursive mercantilisation of nature where rivers are seen as a water resource, forests as wood, and mountains as minerals. According to him, this subsequently leads to a detrimental 'colonising role of the human being' (r.o. MOCICC) where the primary relation of society with nature is one of exploitation. Interviewed representatives of NGOs emphasised alternative perceptions of nature and water. The river flowing into the ocean is not seen as an economic loss but as a crucial fulfilment of an ecosystem function. The basin of the Marañón River is seen here as a complex ecosystem rich in endemism, as a livelihood and spiritual source for local communities. Consequently, the evaluation of hydropower by these actors emphasises the negative impact of large-scale hydropower projects. The hydroelectric exploitation of the basin is seen here as an 'ecological suicide' of sensitive ecosystems (r.o. MOCICC); as a disturbance for fish migration and the retention of sediments; as affecting agriculture and the livelihoods of local communities; as a source of GHG emissions due to the extensive flooding of dense vegetation; and as a loss of local communities that need to be relocated. However, changes in the perception of hydropower in Peru were noticed by the r.o. SPDA, who perceived that 'the discussion about the energy matrix has changed in the last years' and that it is not anymore 'taken for granted that the best energy is the one from large hydroelectric plants' (M9).

5. Discussion and suggestions

Based on the results, this section presents the interpretation of the identified key drivers and constraints to discuss change and continuity in the energy system. Finally, suggestions for rethinking energy governance are derived.

5.1. Paralysation of hydropower expansion: Change or continuity?

The results emphasised that hydropower expansion is promoted by the national state, whose role in the liberalised energy system is, essentially, that of a facilitator. Individual decision-makers such as the president decide on promotion measures without consulting relevant public authorities or civil society. Next to the state, private companies play a pivotal role in the promotion of hydropower. On the one hand, the mining industry is a main consumer of energy and promotes the expansion of hydropower to secure its energy demand; on the other hand, transnational construction companies are deeply involved in the hydropower development of the Marañón River. In this case, supranational interests also impact the energy expansion, as parts of the additional supply are designated to be exported. Fundamental to the promotion of hydropower is the perception of nature as a resource. Rivers are seen as a resource that must be exploited to generate value.

This entanglement of actors, institutions, and ideas driving the energy expansion resembles an extractivist development model. In a nutshell, the extractivist development model is based on the extraction of natural resources, mostly for export [73]. The principal actors shaping this model are transnational companies. National states are relegated to a facilitator role, to maintain a macro-economic, institutional, and legal context that enables the transactions of the companies [74–76]. The basic assumption of this development model is that economic growth leads to spillover and thus to wealth. The analysed case corresponds with these characteristics of the extractivist development model, which is deeply embedded in Peru [73]. Consequently, the projected energy expansion stands for continuity.

However, the projected hydropower development is paralysed by a diverse opposition. The opposition addresses two general and interrelated issues: first, the problematisation of the socio-ecological impacts, and second, the procedure of decision-making itself. The opposition stresses the negative socio-ecological impacts of large-scale hydropower and emphasises alternative perceptions and values of nature. The problematisation of the current governance structures and policymaking processes includes demands on more transparency and participation. The current paralysation of the hydropower projects on the Marañón River due to the broad opposition shows that public actors as well as actors of civil society are willing to take an active role in the energy system. Does this mean that the paralysation represents a fundamental change in the energy system?

The results indicated that the apparent conflict of energy governance is rooted more fundamentally in disparate ideas of socio-nature relations and development. On the one hand, the extractivist idea was identified as highly embedded and as shaping the decision-making processes, whereas on the other hand, alternative ideas of socio-nature relations emphasised the value of nature itself. Interviewees stressed that even though the hydropower project in the Marañón River is paralysed, there has been no fundamental change in the underlying extractivist development ideas. It was argued that as long as these ideas last, discovered potentials of natural resources are always under pressure from exploitation. According to the r.o. of MOCICC, the reversal in the case of the Marañón is thus temporary, and the project is postponed rather than paralysed. Statements of decision-makers and private actors reinforce the temporal character of the trend reversal: according to the r.o. the MEM, the mega-project in the Marañón 'has cooled down' (M7); according to the Brazilian Embassy, the progress of the energy exportation project seems unlikely in the 'medium term' (M13); the COES stated that the project '…will be dead for a few years (…) no one is going to dare to even bring the subject up, I think, in a decade' (M6); the SNMPE expressed that '…the export of energy is a long-term issue' (M11); and ProInversión considered the energy exportation project to be regaining strength 'maybe in the next years' (M12).

The analysis revealed that decisions on energy expansion rely more fundamentally on competing ideas of development and socio-nature relations. This further demonstrates that these ideas are highly embedded and difficult to challenge, and hence lead to path dependence.

5.2. Rethink energy governance

The paralysation of the projects in the Río Marañón happened post hoc, which evinces a lack of consultancy or participation during the decision-making processes, where not only citizens were left out but also relevant public authorities. Drawing on Section 2, we suggest the following adaptations to energy governance.

First, the vertical complexity and interdependence of the energy system with other sectors require a high level of coordination. In the case of hydropower expansion on the Marañón River, formal intersectoral coordination remains weak. Energy authorities such as the MEM or individual decision-makers such as the president keep their pivotal roles while other implicated authorities such as the National Water Authority, the Ministry of Environment, and others are not

involved. Furthermore, the strong interdependence with the mining sector lacks transparency.

Second, the variety of actors from different scales involved in the energy system requires governance arrangements that ideally address those scales simultaneously. The case of the Marañón River shows that when this complexity is not reflected in decision-making processes, conflicts arise [34]. It must be considered that the severe liberalisation of energy systems increases the number of actors involved and accentuates the need for coordination [30]. In the case of hydropower expansion on the Marañón River and concerning the role of Brazil, a lack of coordination and striking imbalances between actors on different scales become evident. National and supranational actors promote the expansion, whereas the recognition of regional and local actors who are directly affected remains negligible.

Third, complex and multi-layered institutions, laws, and regulations must be developed to coordinate collective action in the energy sector. In Peru, however, because of the paradigm of a liberalised energy system, a formalised and structured energy planning process does not exist at the moment [48]. The case study showed that interventions in the energy sector consist mainly of ad-hoc measures taken by individual politicians, such as in the case of the supreme decree or the Energy Agreement that were induced by the former national president. Gamboa Balbín and Cueto La Rosa stress that a 'political voluntarism or corporative interest' is the determining factor and that there is no 'applicable energy balance' that allows the energy demand to be identified to orient the generation capacity required [48,64].

To address these governance challenges, Goldthau suggests a polycentric approach to energy governance [30]. This means to 'blend scales and engage multiple stakeholder groups' towards a system that 'simultaneously comprises multiple levels and decision-making bodies' [30]. However, this requires a central state that is willing to intervene while also sharing power with other actors [28]. In Peru, it could be observed that diverse stakeholders, including the civil society and state authorities on different scales, are willing to take an active role in decision-making about the future energy system.

We argue that beyond the reformulation of energy governance instruments, an inclusive debate about the underlying ideas of development and socio-nature relations is fundamental to challenge path dependence and achieve far-reaching changes in the energy system. As Kuzemko et al. argue, the changing of energy systems equals a 'battle of ideas' and is enabled by well-articulated alternative narratives that succeed in contesting established 'governance orthodoxies' [10]. The results showed that energy expansion can represent the momentum for questioning and contesting established ideas.

6. Conclusion

The aim of this paper was to explore potential synergies and conflicts of simultaneous transition and expansion in energy systems. Therefore, we first analysed competing actors, institutions, and ideas shaping the governance of hydropower expansion in the Marañón River, and then reflected on implications for change and continuity in the Peruvian energy system.

The empirical results indicated that large-scale hydropower expansion in Peru and on the Marañón River is rooted in extractivist development, and that the additional electricity was mainly designated for export to Brazil as well as the mining sector. Brazilian construction companies as well as the mining industry were critical promoters of the project, which was further facilitated by the state. However, the results also showed that parts of the civil society and public institutions contested the hydropower expansion in the Marañón River and the export of energy to Brazil, stressing the lack of transparency and participation as well as socio-ecological impacts, and claimed an active role in decision-making on the future energy system.

The results emphasised how general ideas on socio-nature relations and development compete in decisions on energy expansion and reinforce that ideas, once they are highly embedded, are difficult to challenge and lead to path dependence. We argue that besides the reformulation of the energy governance configuration, an inclusive debate about diverse ideas of development and socio-nature relations is fundamental to challenge path dependence and achieve fundamental changes in the energy system.

This is where we see potential synergies of simultaneous expansion and transition in energy systems: the expansion of the energy system represents a window of opportunity to foster a debate on the future energy system as well as the underlying development model. To advance the understanding of the conditions for change, it would be valuable to analyse further examples of expansion beyond hydropower in Peru and in other regional contexts. Finally, revealing opportunities for change in expanding energy systems can contribute to harmonising the ambivalent aims of promoting energy access and reducing GHG emissions.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

[1] P. Munro, G. van der Horst, S. Healy, Energy justice for all? Rethinking sustainable development goal 7 through struggles over traditional energy practices in Sierra Leone, Energy Policy 105 (2017) 635–641, https://doi.org/10.1016/j.enpol.2017.01.038.
[2] S.C. Bhattacharyya, Energy access programmes and sustainable development: a critical review and analysis, Energy for Sustainable Development 16 (3) (2012) 260–271, https://doi.org/10.1016/j.esd.2012.05.002.
[3] M. Bazilian, S. Nakhooda, T. van de Graaf, Energy governance and poverty, Energy Research & Social Science 1 (2014) 217–225, https://doi.org/10.1016/j.erss.2014.03.006.
[4] International Energy Agency, Energy Access Outlook 2017: From Poverty to Prosperity (February 11, 2019), Available from: https://www.iea.org/publications/freepublications/publication/WEO2017SpecialReport_EnergyAccessOutlook.pdf.
[5] UNDP, Human Development Report 2015: Work for Human Development, New York.
[6] K. Araújo, The emerging field of energy transitions: progress, challenges, and opportunities, Energy Research & Social Science 1 (2014) 112–121, https://doi.org/10.1016/j.erss.2014.03.002.
[7] IEA, World Energy Outlook 2019, Available from: https://www.iea.org/reports/world-energy-outlook-2019.
[8] R.K. Pachauri, L. Mayer (Eds.), Climate Change 2014: Synthesis Report, Intergovernmental Panel on Climate Change, Geneva, Switzerland, 2015.
[9] P.A. O'Connor, Energy Transitions: Boston University, The Frederick S. Pardee Center for the Study of the Longer-Range Future, THE PARDEE PAPERS / No. 12/ November 2010 IBSN 978-0-9825683-7-8, 2010. Available from: https://www.bu.edu/pardee/files/2010/11/12-PP-Nov2010.pdf?PDF=pardee-paper-012-energy.
[10] C. Kuzemko, M. Lockwood, C. Mitchell, R. Hoggett, Governing for sustainable energy system change: politics, contexts and contingency, Energy Research & Social Science 12 (2016) 96–105, https://doi.org/10.1016/j.erss.2015.12.022.
[11] B.K. Sovacool, F.W. Geels, Further reflections on the temporality of energy transitions: a response to critics, Energy Research & Social Science 22 (2016) 232–237, https://doi.org/10.1016/j.erss.2016.08.013.
[12] B.K. Sovacool, What are we doing here?: Analyzing fifteen years of energy scholarship and proposing a social science research agenda, Energy Research & Social Science 1 (2014) 1–29, https://doi.org/10.1016/j.erss.2014.02.003.
[13] F.W. Geels, F. Kern, G. Fuchs, N. Hinderer, G. Kungl, J. Mylan, et al., The enactment of socio-technical transition pathways: a reformulated typology and a comparative multi-level analysis of the German and UK low-carbon electricity transitions (1990–2014), Research Policy 45 (4) (2016) 896–913, https://doi.org/10.1016/j.respol.2016.01.015.
[14] L. Gailing, T. Moss (Eds.), Conceptualizing Germany's Energy Transition: Institutions, Materiality, Power Space, Palgrave Macmillan UK, London, 2016.
[15] P.S. Bromley, Extraordinary interventions: toward a framework for rapid transition and deep emission reductions in the energy space, Energy Research & Social Science 22 (2016) 165–171, https://doi.org/10.1016/j.erss.2016.08.018.
[16] B.K. Sovacool, How long will it take?: Conceptualizing the temporal dynamics of energy transitions, Energy Research & Social Science 13 (2016) 202–215, https://doi.org/10.1016/j.erss.2015.12.020.
[17] F. Kern, K.S. Rogge, The pace of governed energy transitions: agency, international dynamics and the global Paris agreement accelerating decarbonisation processes? Energy Research & Social Science 22 (2016) 13–17, https://doi.org/10.1016/j.erss.2016.08.016.
[18] V. Smil, Examining energy transitions: a dozen insights based on performance,

Energy Research & Social Science 22 (2016) 194–197, https://doi.org/10.1016/j.erss.2016.08.017.
[19] O. Renn, J.P. Marshall, Coal, nuclear and renewable energy policies in Germany: from the 1950s to the "Energiewende", Energy Policy 99 (2016) 224–232, https://doi.org/10.1016/j.enpol.2016.05.004.
[20] F. Joas, M. Pahle, C. Flachsland, A. Joas, Which goals are driving the Energiewende?: Making sense of the German energy transformation, Energy Policy 95 (2016) 42–51, https://doi.org/10.1016/j.enpol.2016.04.003.
[21] K. Sühlsen, M. Hisschemöller, Lobbying the 'Energiewende'. Assessing the effectiveness of strategies to promote the renewable energy business in Germany, Energy Policy 69 (2014) 316–325, https://doi.org/10.1016/j.enpol.2014.02.018.
[22] E. Schmid, B. Knopf, A. Pechan, Putting an energy system transformation into practice: the case of the German Energiewende, Energy Research & Social Science 11 (2016) 263–275, https://doi.org/10.1016/j.erss.2015.11.002.
[23] K.S. Rogge, P. Johnstone, Exploring the role of phase-out policies for low-carbon energy transitions: the case of the German Energiewende, Energy Research & Social Science 33 (2017) 128–137, https://doi.org/10.1016/j.erss.2017.10.004.
[24] B.K. Sovacool, G. Walter, Internationalizing the political economy of hydroelectricity: security, development and sustainability in hydropower states, Review of International Political Economy 4 (3) (2018) 1–31, https://doi.org/10.1080/09692290.2018.1511449.
[25] Aita P. Gamio, Transición energética: un cambio necesario en el Perú, pluriversidad 1 (1) (2018) 179–191.
[26] U.V. Baca, P. Gamio, Transición energética con energías renovables para la seguridad energética en el Perú: Una propuesta de política pública resiliente al clima, Espacio y Desarrollo 31 (2018) 195–224.
[27] F.W. Geels, R. Kemp, Dynamics in socio-technical systems: typology of change processes and contrasting case studies, Technology in Society 29 (4) (2007) 441–455, https://doi.org/10.1016/j.techsoc.2007.08.009.
[28] B.K. Sovacool, An international comparison of four polycentric approaches to climate and energy governance, Energy Policy 39 (6) (2011) 3832–3844, https://doi.org/10.1016/j.enpol.2011.04.014.
[29] L. Gailing, Die räumliche Governance der Energiewende: Eine Systematisierung der relevanten Governance-Formen, in: O. Kühne, F. Weber (Eds.), Bausteine der Energiewende, Springer Fachmedien Wiesbaden, Wiesbaden, 2018, pp. 75–90.
[30] A. Goldthau, Rethinking the governance of energy infrastructure: scale, decentralization and polycentrism, Energy Research & Social Science 1 (2014) 134–140, https://doi.org/10.1016/j.erss.2014.02.009.
[31] A. Goldthau, B.K. Sovacool, The uniqueness of the energy security, justice, and governance problem, Energy Policy 41 (2012) 232–240, https://doi.org/10.1016/j.enpol.2011.10.042.
[32] M. Jehling, M. Hitzeroth, M. Brueckner, Applying institutional theory to the analysis of energy transitions: from local agency to multi-scale configurations in Australia and Germany, Energy Research & Social Science 53 (2019) 110–120, https://doi.org/10.1016/j.erss.2019.01.018.
[33] V. Martínez, O.L. Castillo, The political ecology of hydropower: Social justice and conflict in Colombian hydroelectricity development, Energy Research & Social Science 22 (2016) 69–78, https://doi.org/10.1016/j.erss.2016.08.023.
[34] J. Budds, L. Hinojosa, Restructuring and rescaling water governance in mining contexts: the co-production of waterscapes in Peru, Water Alternatives 5 (1) (2012) 119–137.
[35] A. Israel, M. Jehling, How modern are renewables? The misrecognition of traditional solar thermal energy in Peru's energy transition, Energy Policy 133 (2019) 110905, , https://doi.org/10.1016/j.enpol.2019.110905.
[36] J. Giles, Methane quashes green credentials of hydropower, Nature 444 (7119) (2006) 524–525, https://doi.org/10.1038/444524a.
[37] P.M. Fearnside, Greenhouse gas emissions from hydroelectric dams: controversies provide a springboard for rethinking a supposedly 'Clean' energy source. An editorial comment, Climatic Change 66 (1/2) (2004) 1–8, https://doi.org/10.1023/B:CLIM.0000043174.02841.23.
[38] R. Fletcher, When environmental issues collide: climate change and the shifting political ecology of hydroelectric power, Peace & Conflict Review 5 (1) (2010) 1–17.
[39] D. Moore, J. Dore, D. Gyawali, The world commission on dams + 10: revisitng the large dam controvery, Water Alternatives 3 (2) (2010) 3–13.
[40] A. Tjora, Qualitative Research as Stepwise-Deductive Induction, Routledge, London, New York, 2018.
[41] A. Blackstone, Principles of Sociological Inquiry: Qualitative and Quantitative Methods, Saylor Foundation, Washington, D.C., 2014.
[42] T. Dresing, T. Pehl (Eds.), Praxisbuch Interview, Transkription & Analyse: Anleitungen und Regelsysteme für qualitativ Forschende, seventh ed., Eigenverlag, Marburg, 2017.
[43] P. Mayring, Qualitative Inhaltsanalyse: Grundlagen und Techniken, Beltz Verlagsgruppe, s.l., 2010.
[44] U. Kuckartz, Qualitative Inhaltsanalyse: Methoden, Praxis, Computerunterstützung, third ed., Beltz Juventa, Weinheim, Basel, 2016.
[45] J.A. Cherni, F. Preston, Rural electrification under liberal reforms: the case of Peru, Journal of Cleaner Production 15 (2) (2007) 143–152, https://doi.org/10.1016/j.jclepro.2006.01.029.
[46] Ministerio de Energía y Minas, Ley de Concesiones Eléctricas: Ley° 25844 (May 29, 2018), Available from: http://www2.osinerg.gob.pe/MarcoLegal/pdf/LEYCE-DL25844.pdf.
[47] OLADE, Modelos de Mercado, Regulación Económica y Tarifas del Sector Eléctrico en América Latina y el Caribe - Perú (May 29, 2018). Available from: http://www.olade.org/wp-content/uploads/2015/08/Informe-Final-PERU.pdf.
[48] C. Gamboa Balbín, V. Cueto La Rosa, Matriz Energética en el Perú y Energías Renovables: VI, Hidroeléctricas y conflictos sociales recomendaciones para mejor gestión ambiental, 2012.
[49] Ministerio de Energía y Minas, Ley Para Asegurar El Desarrollo Eficiente De La Generación Eléctrica: Ley° 28832 (June 25, 2018), Available from: https://docs.peru.justia.com/federales/leyes/28832-jul-21-2006.pdf.
[50] R.E. Mitma Ramírez, Análisis de la Regulación de Energías Renovables en el Perú, Revista Derecho & Sociedad (45):167–176.
[51] Ministerio de Energía y Minas, Plan Energético Nacional 2014-2025 (February 13, 2019), Available from: http://www.minem.gob.pe/minem/archivos/file/institucional/publicaciones/InformePlanEnerg%C3%ADa2025-%20281114.pdf.
[52] OSINERGMIN, Evolución del coeficiente de electrificación nacional y rural, 1995-2018 (November 26, 2019), Available from: http://observatorio.osinergmin.gob.pe/evolucion-coeficiente-electrificacion.
[53] World Bank, Access to electricity, rural (% of rural population) – Peru (November 26, 2019), Available from: https://data.worldbank.org/indicator/EG.ELC.ACCS.RU.ZS?locations=PE.
[54] Alán García, Declaran de interés nacional y social la construcción de 20 hidroeléctricas en la Cuenca del Río Marañón: Decreto Supremo No. 020-2011-ES, 2011.
[55] Osinergmin, La indústria de la electricidad en el Perú: 25 años de aportes al crecimiento económico del país, Lima (2016).
[56] G.T.Z. Lahmeyer-Salzgitter, Evaluación del Potencial Hidroeléctrico Nacional: Volumen XVII: cuencas Marañón y afluentes (June 28, 2018), Available from: http://repositorio.ana.gob.pe/handle/ANA/1580.
[57] M. Arana Cardó, Proyectos Hidroeléctricos en la cuenca del Río Marañón (May 30, 2018), Available from: http://www.psf.org.pe/institucional/wp-content/uploads/2014/05/cuadernos-integracion-003.pdf.
[58] J. Rubio, A. Escobedo, C. Vallejos, E. Oyague, A. Vera, M. Estrada Marañón, Costo social de los impactos acumulativos de cinco proyectos hidroeléctricos, Lima (2017).
[59] S. Elbein, Of concrete and corruption: resistance kills Andes Amazon dams (June 06, 2019), Available from: https://news.mongabay.com/2019/01/of-concrete-corruption-peoples-resistance-kills-andes-amazon-dams/.
[60] El Comercio, Minería en Perú: Exportaciones mineras en 2017 crecieron 24%: El MEM señaló que Perú registró US$27.745 millones en exportaciones de minerales el año pasado, destacando el cobre, zinc y oro respectivamente. El Comercio 2018, 8 February 2018, Available from: https://elcomercio.pe/economia/peru/mineria-peru-exportaciones-mineras-2017-crecieron-24-noticia-495708# (June 25, 2018).
[61] ProInversión, Macro Región Norte Desarrollo Territorial, ProInversión, 2014.
[62] A. Acosta, Guijarro J. Cajas, Patologías de la abundancia Una lectura desde el extractivismo, in: H.-J. Burchardt, R. Domínguez, C. Larrea, S. Peters (Eds.), Nada dura para siempre: Neo-extractivismo tras el boom de las materias primas, Ediciones Abya-Yala, Quito, 2016, pp. 391–425.
[63] Alán García, Lula da Silca, Acuerdo entre el Gobierno de la República del Perú y el Gobierno de la República Federativa del Brasil para el Suministro de Electricidad al Perú y Exportación de Excedentes al Brasil (June 26, 2018), Available from: http://www.minem.gob.pe/minem/archivos/file/Electricidad/acuerdo%20peru%20brasil%2016%20julio%202010.pdf.
[64] V. Cueto La Rosa, Acuerdo para el suministro de electricidad al Perú y exportación de excedentes al Brasil: Buscando la Gobernanza energética en el Perú (June 25, 2018), Available from: http://dar.org.pe/archivos/publicacion/1_buscando_gobernanza.pdf.
[65] E.F. Ráez-Luna, J.L. Dammert Bello, Reflexiones y Lecciones sobre la toma de decisiones ante grandes proyectos minero-energéticos en el Perú: El caso de la hidroeléctrica de Inambari en la Amazonía Peruana (June 25, 2018), Available from: https://spda.org.pe/wpfb-file/cuaderno-7-pdf/.
[66] El Peruano, Proyecto Marañón: Comisión para el Desarrollo Energético y Agrario del Río Marañón: R.S. N° 342-2010-PCM (June 25, 2018), Available from: http://busquedas.elperuano.pe/download/url/proyecto-maranon-comision-para-el-desarrollo-eergetico-y-a-resolucion-suprema-n-342-2010-pcm-584596-8.
[67] Grupo de Formación e Intervención para el Desarrollo Sostenible – Cajamarca, En LIMA borran murales, en CELENDÍN pintan más y más murales en homenaje y respeto a la PACHAMAMA, 2015.
[68] Congreso de la República - Comisión de Relaciones Exteriores, Dictamen recacaído en el proyecto de resolución legislativa N° 391/2011, 23 Mayo de 2014.
[69] Anthony Faiola, The corruption scandal started in Brazil. Now it's wreaking havoc in Peru, The Washington Post 2018, 23 January 2018, Available from: https://www.washingtonpost.com/world/the_americas/the-corruption-scandal-started-in-brazil-now-its-wreaking-havoc-in-peru/2018/01/23/0f9bc4ca-fad2-11e7-9b5d-bbf0da31214d_story.html?noredirect=on&utm_term=.8478ada91167 (June 26, 2018).
[70] BBC News World, Odebrecht case: Politicians worldwide suspected in bribery scandal. BBC News World 2019, 17 April 2019, Available from: https://www.bbc.com/news/world-latin-america-41109132 (April 18, 2019).
[71] BBC News Brasil, Alan García: Como o escândalo da Odebrecht no Peru culminou com suicídio de ex-presidente. BBC News Brasil 2019, 17 April 2019, Available from: https://www.bbc.com/portuguese/internacional-47968498 (April 18, 2019).
[72] B.B.C. Mundo, PPK: Los políticos salpicados por el escándalo Odebrecht. El Comercio 2018, 23 March 2018, Available from: https://elcomercio.pe/mundo/latinoamerica/ppk-politicos-salpicados-escandalo-odebrecht-bbc-noticia-506405 (June 26, 2018).
[73] A. Acosta, Extractivismo y neoextractivismo: Dos caras de la misma maldición, in: M. Lang, D. Mokrani, S. Jarrín (Eds.), Más allá del desarrollo: Grupo Permanente de Trabajo sobre alternativas al desarrollo, second ed., Ed. Abya-Ayla, Quito, 2012, pp. 83–120.
[74] E. Gudynas, Diez tesis urgentes sobre el nuevo extractivismo: Contextos y demandas

bajo el progresismo sudamericano actual, in: J. Schuldt, A. Acosta, A. Barandiarán, M. Folchi, CEDLA-Bolivia, A. Bebbington (Eds.), Extractivismo, política y sociedad, Centro Andino de Acción Popular and Centro Latino Americano de Ecología Social, Quito, Ecuador, 2009, pp. 187–225.
[75] M. Svampa, E. Viale, Maldesarrollo: La Argentina del extractivismo y el despojo, first ed., Katz Editores; Fundación Rosa Luxemburgo, Buenos Aires, Madrid, 2014.
[76] H.-.J. Burchardt, R. Domínguez, C. Larrea, S. Peters (Eds.), Nada dura para siempre: Neo-extractivismo tras el boom de las materias primas, Quito, Ediciones Abya-Yala, 2016.

4. Beitrag III

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Change and path dependency in expanding energy systems: Explaining Peru's energy transition beyond a North–South divide

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ABSTRACT

Energy research often differentiates between energy systems in the Global South and the Global North. We argue that this differentiation, which shifts the focus on deficiencies for systems in the Global South, hampers the identification of opportunities for change towards sustainable energy supply and limits our understanding of energy transition processes. We argue that from a socio-technical perspective immanent characteristics of energy systems instead of predefined country categories should guide empirical research. Subsequently, we develop and test the conception of expanding energy systems, which stand for systems with an increase in electricity generation and territorial coverage. We argue that these expansion processes in combination have important implications for energy transition. We integrate the conception of expansion in a socio-technical, neo-institutional understanding of energy systems. To test the applicability, we analyse change and path dependency in the energy system of Peru. We explore different processes of renewable energy expansion: a massive distribution of solar home systems, a projected expansion of large-scale hydropower, and a local niche of the production and use of solar water heaters. The results show how embedded actors and institutions strive for continuity and shape expansions. However, the results also indicate in what way the momentum of expansion is a window of opportunity for socio-technical change. We see a valuable contribution of the differentiation of expanding energy systems to the understanding of energy transitions and advocate for a further development of the concept.

1. Introduction

Global climate change is directly linked to how energy is produced and consumed. To mitigate the negative effects on climate, we must fundamentally change current energy systems. Efforts to govern for sustainable energy transitions are made globally on different scales and among highly diverse actors. These efforts not only have ecological and economic impacts but also imply fundamental societal changes. A broad strand of research on socio-technical energy systems focuses on this societal dimension of transitions [1–9]. The conditions and outcomes, however, differ greatly between energy systems [10].

In the energy literature, a common distinction is made between energy systems in the Global North and those in the Global South [11–18]. This distinction is justified by the different political, social, and economic contexts [19]. However, a criticism arises in how energy systems in the Global South are perceived. Prominent theories and concepts concerning the sustainable transition of energy systems originated in the Global North [20,21]. Implicitly, concepts such as the Multi-Level Perspective make the Global North's energy systems and transitions the norm. As a reaction, several authors have stressed these concepts' limited applicability to energy transitions in the Global South [22–25]. Lawhon et al. argued that there 'needs to be a more intensive engagement with the Global South in order to improve the theory's broader applicability and rigor' [22]. A similar critique was made of the burgeoning concept of energy justice by Apfel et al., who questioned 'the extent to which the analytical frameworks of justice need to be adopted to realities in the Global South, as these embed Eurocentric notions' [24]. As the Global North's energy systems represent the norm, a focus on deficiencies is often laid on energy systems in the Global South. Subsequently, local practices in the pursuit of sustainable energy provision are misrecognised [26].

Over the last decade, the body of literature on energy systems and transitions in the Global South has grown significantly. Also, crucial progress in integrating alternative perspectives has been made [23,26–30]. However, this research typically consists of case studies, while inductively developed conceptualisation and theorisation are rare.

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Beyond, a further critique of energy research in the Global South is its prevalent technoeconomic focus and lack of insights on power, imaginaries, and narratives [24]. We hence argue that this dualism in the energy literature is problematic. The normativity that lies beneath the implicit categorisation of energy systems in North and South is particularly difficult as it impedes an understanding of conditions for or outcomes of energy transitions. We therefore stress the need for an alternative differentiation of energy systems to allow for a focused, context-specific analysis that avoids predefined categories as highlighted by [31].

The aim of this research is to develop and empirically apply a conception of energy systems based on system-immanent characteristics instead of normative and developmentalist country categories. In developing such an analysis-oriented concept based on the case of Peru's energy transition, we seek to contribute to an enhanced understanding of energy transitions in various global contexts. We identify and analyse three types of expansion processes of renewable energies with contrasting technical and institutional conditions and examine to what extent these stand for continuity or induce change in the energy system [32,33]. The remainder of this paper is organised as follows. Section 2 develops and integrates the theoretically derived concept of expanding energy systems within a socio-technical and neo-institutionalist framework. Section 3 introduces to the empirical case of Peru and describes the methods of empirical social research applied. Section 4 presents the identification and analysis of three types of socio-technical expansion processes: the national distribution of solar home systems (SHSs), the projected development of 20 large hydropower plants in the Marañón River, and the local niche for the production and use of solar water heaters (SWHs). Based on these, we discuss the implications for institutional change and path dependency derived from the cases. Finally, we reflect on the contribution of the concept for a better understanding of energy transitions in various global contexts.

2. Integration of relevant concepts

2.1. Socio-technical transitions within expanding energy systems

From a socio-technical perspective, energy systems are constituted by 'analytically separable but dynamically inter-related areas' [10]. These areas concern technology, actors, and institutions [34] and 'make up an entire system of consumption and production' [10]. The co-evolution of physical infrastructures, user practices, ideas, and formal regulations along with a large variety of involved heterogeneous actors lead to a complex system that is further interrelated with economic sectors, such as transportation and energy-intensive industries [35].

Studies on the transition of energy systems have applied various analytical frameworks to what is commonly understood to be a process that involves 'far-reaching changes along different dimensions:

technological, material, organizational, institutional, political, economic, and socio-cultural' [36]. Transition focuses on 'change in large socio-technical systems' whereas transformation refers to 'change in physical aspects of energy systems' [37]. Due to the complexity of energy systems, transitions occur over considerable time spans [10]. Sovacool discussed various views on the possible time spans of transitions and reached the conclusion that 'most energy transitions have been, and will likely continue to be, path-dependent rather than revolutionary, [and] cumulative rather than fully substitutive' [38]. The path dependency of energy systems is explained by large sums of labour, capital, and effort 'sunk' into them, which create 'inertia' [38]. Additionally, the interrelation with institutional legacies, political regulations, and further immaterial elements reinforce the path-dependency of energy systems [39].

In the significance of sunk capital for path dependency is where we saw an opportunity – namely to differentiate national energy systems to obtain an enhanced understanding of them and, in a normative sense, promote transitions towards a sustainable energy supply. In our previous study, we found that expansion processes of national energy systems represent a window of opportunity for change and that its analysis allows for conclusions regarding the transition to be drawn [31]. In this sense, expanding energy systems are national energy systems characterised by an expansion of the energy supply in terms of overall generation and territorial coverage. By contrast, consolidated energy systems exhibit relatively constant supply rates, as has been observed in OECD countries for the last decade. Fig. 1 presents a graph that plots the total electricity consumption over time in OECD and non-OECD countries and illustrates the difference between consolidated and expanding energy systems.

We argued that differentiating between expanding and consolidated energy systems is valuable because it offers the required descriptive and neutral differentiation with crucial implications for transitions: The physical expansion, of the national energy system, meaning the construction of additional generation and distribution infrastructures, might facilitate the use of innovative technologies, business models, and actor constellations and hence induce change. The lower weight of sunk capital might lead to lower reluctance towards new technologies and thus explain a lower path dependency.

However, the transition literature highlights the role of immaterial components such as ideas, institutions, and political power for path dependency. We argued that the implications of expansion processes on the transition have not been adequately conceptualised and emphasise its role in setting the course for future energy systems. The extent to which expansion processes reinforce path dependency or facilitate cumulative change needs to be explored. We agreed with Kuzemko et al. regarding the importance of historically embedded norms and power structures in understanding change and continuity in energy systems [10]. This led us to historical institutionalism as a framework for the analysis of sociotechnical energy expansions.

2.2. A neo-institutionalist framework for analysing expanding energy systems

Institutionalist theory applied to the analysis of energy systems [32,33] suggests that institutions and actors influence each other and structure the socio-technical system [10,41,42]. Israel et al. showed that historical institutionalism is well suited to demonstrating the evolution of energy systems [43]. For expanding energy systems, historical institutionalism indicates how actions and interests for promoting or prohibiting change are constrained and affected by institutions. These institutions are considered to form and then evolve in a path-dependent manner over time. Attention is given to the unintended future consequences of past or current institutional settings [44,45].

Institutional settings and their dynamics within energy systems can be described through modes of constraints, namely written rules,

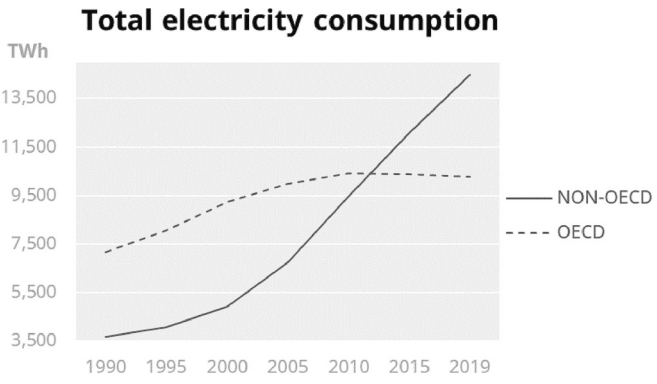

Fig. 1. Total electricity consumption in OECD and non-OECD countries since 1990.
Source: own representation based on [40].

practices, and narratives [33,42]. Rules, which are laws or regulations, are *formally recorded.* By contrast, practices are patterns of behaviour transmitted through demonstration. Lastly, narratives are repetitive processes of explanation and persuasion that develop rationalities that put action into a *meaningful whole*. That these three modes have different levels of explicitness does not mean that they are unequally powerful in their constraining effects. Whereas conformity to rules can be officially sanctioned, narratives encompass effects on actors' agency in a subtle, socially sustained manner, such as attributions of modern or traditional [43].

Actors apply institutions to pursue their own interests, gain or exercise power through them or they are hampered by them. Actors in expansion processes are either rule-makers, who set rules, or rule-takers, who apply rules to their specific interests and local circumstances [42], which refer to different regulatory levels [35]. Both groups form a dynamic relationship through which rule-takers' practices can

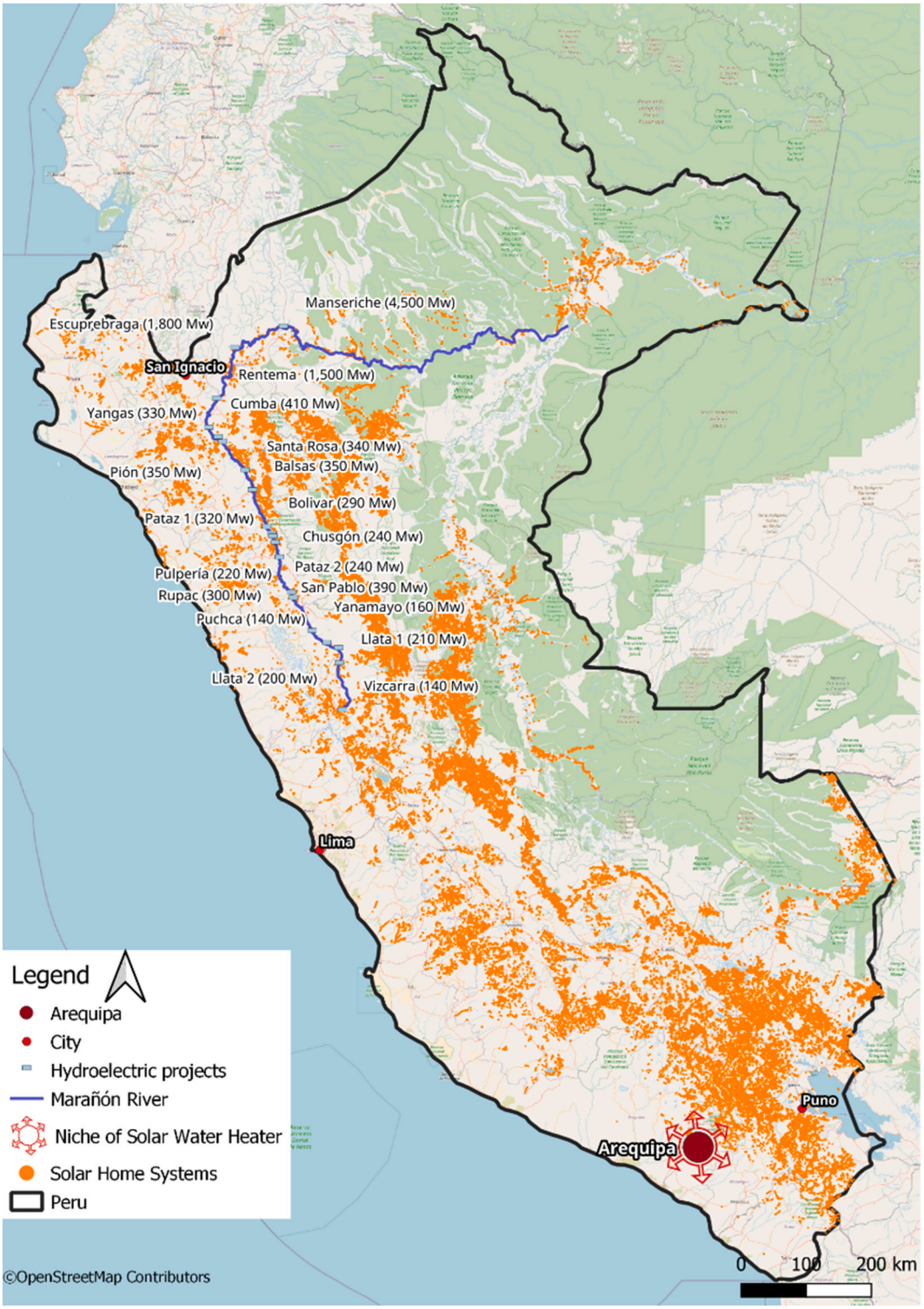

Fig. 2. Three cases of socio-technical expansion processes.
Source: Own elaboration based on data from MINEM, [51].

transform into rules and new (i.e., made) rules are adapted to established practices. Consequently, institutions change in a path-dependent manner [46]. This neo-institutional framework stresses the importance of narratives on different regulatory levels while expecting formal regulation to be lacking or to play a minor role in constraining or enabling actors.

The conception of socio-technical transitions within expanding energy systems integrated with the neo-institutional framework provided the foundation for the empirical analysis of the Peruvian energy system.

3. Case and methods

We selected the Peruvian energy system as a case because it has experienced a strong expansion in terms of its generation capacities and in terms of territorial coverage over the last three decades [47]. From 1999 to 2019, Peru's overall electricity generation more than doubled from 20.3 TWh to 57 TWh [40]. Similarly, the electrification rate experienced a rapid increase during this period; specifically, while Peru was lagging behind the Latin-American average in the 1990s with a national electrification rate of less than 70 %, today 97 % [40] to 99 % [48] of the population has access to electricity. The expansion of the Peruvian energy system has been driven by a variety of actors, has been implemented through a variety of newly introduced energy technologies, and has involved diverse institutional settings.

To understand actor and institutional relationships in expansion processes, we applied exploratory methods to examine the 'opinions, attitudes, perceptions and understandings of people and groups in different contexts' [49]. Well suited to these requirements and widely applied in social science energy research are semi-structured interviews [49]. In the first step, 13 semi-structured interviews were conducted in 2016 with decision-makers, academics, representatives of energy and mining companies, NGOs, interest groups, and an international political foundation. The interviews focused on the expansion of the Peruvian energy system, including actors, institutions, and technologies. The selection of the interviewees followed a purposive sampling strategy and aimed at covering a broad range of perspectives and at ensuring that actors with different perspectives were interviewed [50]. Based on the interviews, types of socio-technical energy expansions were developed (presented in 4.1) and specific cases were selected for each. Fig. 2 depicts the three cases of expansion processes within the national context of Peru: The national distribution of SHS, the projected expansion of hydroelectric plants in the Marañón River and the expanding niche of SWH in Arequipa.

According to Sovacool et al., comparing 'samples from different cases, regions or settings can frequently produce more useful results' [49]. Flyvbjerg further emphasises that the quality and generalizability of case studies do not necessarily depend on the quantity of analysed cases but rather on the strategy of the selection process [52]. The three selected cases were analysed in further field research visits in 2017 and 2018 and complemented by virtual interviews in 2021.Semi-structured interviews were held with decision-makers, academics, representatives of energy companies, NGOs and interest groups. The selection of the interviewees, this time, followed a purposive sampling strategy complemented with the snowball sampling. Because data saturation was difficult to guarantee, we followed the criteria of diminishing returns. This means that considering the resources available we argue that there were sufficient data to answer the research question and that strongly diverging perspectives are unlikely [53]. The topics of the interviews are depicted in Fig. 3.

The total empirical material of the three field research stays between 2016 and 2018 and the complementation with virtual interviews in 2021 sums up to more than 40 semi-structured interviews conducted in Lima, Arequipa, Puno, and San Ignacio. Except two, all interviews were held face-to-face. The mean duration of the recorded interviews is 45 min. The complete sample of interviews can be found in the appendix. The interviews are complemented by field visits in the southern and northern Andes (Puno, Arequipa, and Cajamarca); secondary data such as laws, plans, news, reports, and geocoded data. The interviews were analysed using qualitative content analysis [54,55]. The categories resulted from a multistep process that integrated inductive and deductive procedures [56]. After testing and adapting the categories, the transcribed interviews were coded. Quotes in this manuscript are translated from Spanish, German, or Portuguese into English.

4. Results: socio-technical expansion processes in the Peruvian energy system

This chapter presents the empirical results of the expansion processes observed in Peru. It first gives a general overview of the expansion of the Peruvian energy system and its regulative framework. It than shows how three different socio-technical expansion processes could be differentiated and presents an empirical example of each.

4.1. Actors and institutions of expansion processes in Peru

As previously mentioned, Peru's energy system has been significantly expanded in terms of its generation capacities and territorial coverage. The additional electricity has mainly been generated by large hydroelectric power plants and, from the 2010s onwards, natural gas-fired power plants [57]. Besides these main sources, 3 % of Peru's electricity comes from wind energy and 1 % each from oil, biofuels, and solar energy [40]. Furthermore, the system's territorial expansion has been achieved mainly through grid extension, which is increasingly complemented by renewable off-grid technologies. According to Peru's National Institute of Statistics and Information, 83.5 % [58] of rural households were connected to the public grid in 2019 with the aim of

Fig. 3. Content of semi structured interviews on three expansion processes.
Source: authors' own work.

reaching 85 % by 2022 [59]. Figures concerning rural electrification are subject to variation according to the source.

The regulatory framework of the Peruvian energy system and its expansion have their origins in the 1990s, a decade of eager neoliberal reforms aimed at restructuring the electricity sector; until then, the sector had mostly been state-driven and executed by public companies [60]. According to the neoliberal paradigm, market forces were established with the aim of ensuring a more efficient administration and attracting private investment for the expansion of the energy system. The Electrical Concessions Law of 1992 was the formal starting point of the far-reaching reforms and regulations, which has transformed the electricity sector until today [61]. An interviewed representative of the Committee for the Economic Operation of the National Interconnected System (COES), emphasised the role of private actors for the expansion of generation in the liberalised energy system,

> 'investment decisions are entirely in the hands of private investors, so generation grows according to market conditions'.

According to representatives of the Ministry for Energy and Mining (MINEM), the desired effects of liberalisation on the expansion of the energy system did not materialise. Therefore, in 2006, the 'Law to ensure the efficient development of electricity generation' was enacted. The law N° 28832 introduced the option for energy tenders at guaranteed prices, thereby allowing the government to gain influence over the expansion of energy generation.

> 'before the law 28832 (eh) the system was simply through concessions, authorisations and concessions, where the investor assumed his own risks, both of demand and price risk, he paid/received what the system provided him, but because there was no investment in the sector, the law was modified, with the 28832 [law] the issue of tenders and auctions was introduced, no?'

Investments in the electricity sector are regulated by the following three main authorities: the MINEM, the COES, and the Supervisory Agency for Investment in Energy and Mining of Peru (OSINERGMIN). According to an interviewed representative of the ministry, a projection of the future energy demand elaborated by the MINEM serves as the basis for determining the size of tenders:

> 'there is no indicative plan for generation, because this is basically based on the law of supply and demand (…) it is based on the projection and the need established by the government, which determines, right? For example, they say that depending on the demand growth, they project that by 5 or 10 years from now they need so many megawatts, so they evaluate and see the need to put it out to tender or also as an auction, as a RER'.

According to him, large increases in energy demand are especially caused by the implementation of large mining and industrial projects, while the domestic energy demand remains relatively constant. In 2008, the regulatory framework was further adapted to the introduction of nonconventional renewable energies (NRCEs) [62]. The corresponding legislative decree introduced the option for auctions on grid-based solar, wind, small hydropower, biomass, geothermal, and tidal electricity generation at allocated prices [57]. Up until 2016, four auctions resulted in 64 projects with a total installed capacity of 1.3 GW [62]. Since then, there have been no further NCRE auctions [63]. Experts have criticised the lack of a clear direction of the future of renewable energies as well as a lack of continuity of public policies [47,57]. Several interviewees emphasised the political influence of thermal and hydroelectric generation companies and their engagement against the introduction of NCRE auctions. An interviewed representative of the CENERGIA describes their position as follows:

> '…the companies that manage thermal, gas-fired thermoelectric projects are not in a favourable position; I mean they do not support [NCREs] ((laughs)) because they are competitors ((laughs))'.

According to further statements, they repeatedly asserted that NCREs were excluded from public tenders.

During the field research in 2017, many interviewed actors problematised a misguided expansion of the generation capacities resulting in a pronounced oversupply of electricity. According to an interview with a representative of the National Society of Mining, Petroleum and Energy, SNMPE, the installed capacity exceeded the maximum demand by approximately 60 %. The high costs caused by public contracts at guaranteed prices were buried by so-called 'regulated users', which are households and small businesses or industries. According to the interviewed SNMPE representative, 'free users' with high energy demands, such as large industries or mining companies, are entitled to freely negotiate prices [64] and benefit from the oversupply. Moreover, the reason for the excessive expansion is twofold: no indicative planning for energy generation and weak liability of the ministry's projections. Public decisions on tenders and auctions are, according to the interviews not the result of a planning process but rather political decisions:

> 'we are living in a special circumstance resulting from the fact that a few years ago we were growing very fast and investment decisions were taken and some resulted purely political decisions of/of electoral promises'
>
> (COES)

> 'a demand projection was made and it was said that we are going to need a lot of energy, the study was not/truly was not a serious study but it was done that way, so decisions were made 6 years ago, 8 years ago, those decisions we are paying for today, today's oversupply can be explained by that'.
>
> (SNMPE)

Besides the expansion of generation capacities, the energy system also experienced a strong territorial expansion. Providing electricity to remote and dispersed households with very low energy consumption is not profitable and was, for a long time, mainly practised by international cooperation agencies. According to an interviewed academic expert, this has changed in past years due to an increase in financial resources of the Peruvian government:

> 'The government has just got money, it has just got money in the last three or four years but before that, it was international technical cooperation, wasn't it? GIZ, Finland, Norway, Canada, United States'.

The responsible state authority for rural electrification in Peru is the Rural Electrification Directorate (DGER) of the MINEM. In addition, regional and local governments are entitled to realise electrification projects on a smaller scale up to 20 MW, which has led to a multitude of actors in the field. The relation of the public authorities at different scales was described by one DGER representative as follows: 'We are fighting over the cake'. According to him, no cooperation occurs in the planning processes nor in the project implementation and queries from the central government about electrification needs remain unanswered by subordinate authorities:

> 'annually in the month of august we send official documents to the eighteen hundred/two thousand districts provinces regional governments here in Peru (…) to send us their electrification needs so that we can include them in a plan called Rural Electrification Plan for 10 years which is our basis for executing projects, there are no answers, I don't know if the communications reach them or not because some places are also very difficult to reach, but I suppose that 80% must reach them, no? they don't want to answer'.

An interviewed academic expert criticised the strong hierarchy and distance of central state actors:

> 'in the big projects everything comes from Lima, Lima is the boss, isn't it? and I have been part of several projects, so Lima doesn't even

know the people, no? they take the map, no? and they say 'what population? let's see, now we are going to help this one, I don't like the name, this one yes, this one…'.'

The competitive situation between public actors in the field of electrification can partly be explained by the political value of electrification projects. Those of the DGER were, until 2015, exclusively grid-based, whereas international actors and regional or local governments sporadically promoted off-grid renewables. The challenge for completing national electrification is, at this point, that the last unelectrified households are dispersed and located in very remote areas where grid extension is not viable.

From the first field research, the insights on the actors and institutions that drive the expansion of the Peruvian energy system allowed to derive various types of socio-technical expansions. These two-dimensional types considered the technological differentiation of centralised or decentralised energy generation and the social differentiation of top-down expansions driven by rule-makers or bottom-up expansions driven by rule-takers. In two further field research studies, we analysed a specific case for each expansion type identified in Peru and depicted in Fig. 4.

4.2. Massive electrification through solar home systems: top-down and decentralised

This section analyses the Massive Photovoltaic Programme [65] as an example of a top-down expansion based on decentralised renewable energies. It is a state programme of SHS distribution and operation described as 'unique' in Latin America, particularly in terms of scope and programme design. According to a representative of the DGER, the impetus for the programme came 'from the very top' with the aim of achieving a 100 % electrification rate by the 200th anniversary of Peru's independence in 2021. As argued in Section 4.1, the electrification based on grid extension has already advanced so far that missing households are mostly in locations that are very difficult to access; therefore, SHSs were perceived as the only technically viable solution for achieving the ambitious aim. The expansion of off-grid renewables required an adaption of the regulative framework. Therefore, the existing regulation

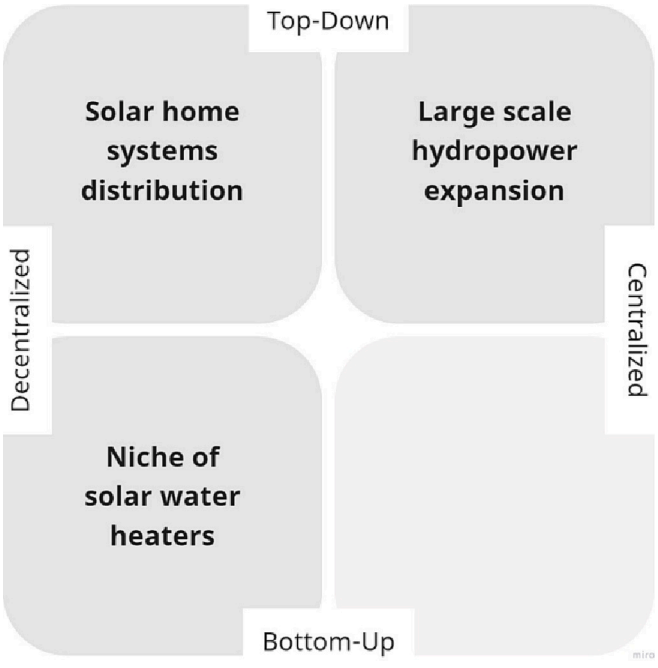

Fig. 4. Schematic representation of socio-technical expansion processes and analysed cases in Peru.
Source: authors' own work.

of grid-based renewables was extended by a supreme decree regulating '[t]he promotion of the electrical investment in areas not connected to the grid' [66]. This marked the beginning of the first off-grid renewable energy auction in Peru in 2015.

The largest obstacle to the implementation of the programme, according to a representative of the DGER, was not the lack of financial resources but rather missing human and technological resources in the responsible authority. He stressed that the DGER has 70 employees, of whom only three are responsible for renewable energies, and that it has no regional or local agencies outside of Lima. An interviewed representative of CENERGIA further problematised the lack of capacity development due to frequent personnel changes in the ministry:

'the Ministry is an institution where there is a lot of turnover of people, isn't it? so they can't/the capacities are not adequately developed'.

Another challenge was the lack of information regarding unelectrified households. The DGER had only the number of approximately 410,000 unelectrified households, whereas information on the identity or location of the households did not exist.

'To be able to carry out this auction (eh) we had nothing we only knew more or less (…) what was the deficit of electricity coverage […] we knew that there was that number but we did not know how those people were called nor where they were what was their address where they were located, no?'.

(DGER)

Attempts to collect this information in cooperation with regional public authorities failed. The costs of the project were financed mainly by two public funds, complemented by a monthly user tariff of approximately US$2.80. The calculation of the user tariff was based on the average energy costs of unelectrified households consisting of expenses for candles, kerosene etc.

The auction, the first in Peru for off-grid renewables, was designed by OSINERGMIN and MINEM and without further coordination with other public authorities from the environmental or social sector. According to the auction, the winning company committed to the installation of a minimum number of SHSs as well as to a 15-year operation phase. The minimum of 150,000 SHSs could be installed throughout the whole territory, excluding technical restriction zones, and can be installed in private households, schools, and health posts. The identification and selection of beneficiaries of the programme were left to the winning company:

'two considerations were established, one was a number, we said well you have the whole country and here you must find, or we need to install at least a minimum of 150 thousand photovoltaic systems at national level (eh) (eh) as I say you have to carry out the census and registration and locate and identify through a register of users those 150 thousand at least'.

(DGER)

The company Ergon Perú S.A.C, part of the Italian group Tozzi Green, identified a total of 200,000 potential beneficiaries for the installation of SHSs, was awarded the contract, and committed to install the SHSs by July 2019 [65]. The national distribution companies were obliged by supreme decree to participate in the implementation and operation of the programme for a fixed fee, where they were responsible for the individual verification of each Installed SHS, the handling of the physical distribution of bills, and the communication during the 15-year operation phase.

The installation of the SHSs was conducted partly by Ergon Perú S.A.C itself and partly by subcontractors. The first step was the registration of households, schools, and health posts willing to participate in the programme. Therefore, local information meetings were held with mayors and community leaders, who passed the information on to the

population and provided Ergon Perú S.A.C with a list of potential beneficiaries. Access to remote households was difficult and the installation companies relied on the support of the local population, who provided canoes, horses, and donkeys for the transportation of materials. Another challenge was communication, which was due to the use of languages other than Spanish, which are much more prevalent in rural areas, as well as the social distance between unelectrified households and decision-makers in Lima. This can be seen in the following statement by a representative of the MINEM in Lima, who complained about difficult communication with the citizens who called and requested the installation of SHSs:

> 'I need the names and coordinates but don't give them to me written on paper, I want them in Excel, I want you to give me your e-mail address – *I don't have an e-mail address* – he says to me. How can I help you if you can't help me? Then go down to your village and get a person with whom one can talk'.

Requesting information by email and in Excel spreadsheets from non-electrified households and asking for people 'with whom one can talk' emphasises the distance.

The operation phase started with the verification of the installations from 2017 onwards, when the user tariff became applicable. Instantly, it became apparent that there are high levels of nonpayment, which concerns approximately 90 % of the households. Experts offered several reasons for this, such as false information on the costs beforehand, difficult logistics of payments, and – starting in 2020 – the COVID-19 lockdown. Interestingly, an academic expert interviewed in 2016 predicted the problem of payments for the programme:

> 'if you don't pay you don't pay no? Well, the state won't force you, they can't take it away no? Because the photovoltaic panel is on the roof of your house, they can't enter whereas the electricity grid can be cut'.

In summary, between 2017 and January 2020, a total of 205,000 rural households, 2400 educative institutions, and 640 health posts throughout the national territory were equipped with SHSs. A SHS for a household consists of a 150-watt system and includes the panel, a battery with a USB charging slot, two 12-volt DC sockets, and two bulbs. The technology covers basic needs for lightning, which were previously covered with candles and kerosene lights, as well as the charging of small appliances, which often occurred in distant villages. Other energy needs, which vary according to the climate and productive activities, cannot be met. For example, a lack of mobile solar devices was mentioned during the visits as many households live seminomadic lifestyles and thus have several periodically used shelters. On the other hand, in the southern Andes, small coffee farmers mentioned that they still lacked electricity for operating machinery such as coffee peelers. The SHS technology was perceived by the interviewees as an improvement but not as comparable to a grid connection, as illustrated in the following statement by a subcontractor of Ergon Perú S.A.C in Cajamarca:

> 'It is like when you are hungry and they give you a bread so that you can wait more quietly for lunch'.

4.3. Doubling capacity through hydroelectric expansion: top-down and centralised

This section analyses the promotion of large-scale hydropower development in the Marañón River, a main source of the Amazon River, as an example of a top-down expansion of centralised energy infrastructure. Public promotion of hydropower in the Marañón River began to intensify with a supreme decree issued in 2011 that designated the Marañón River as the national energy artery and declared the construction of 20 large hydropower plants to be of national and social interest [67]. The 20 projected hydropower plants along the Marañón River are depicted in Fig. 1. The installed potential of the projected hydropower plants equals 12.4 GW, exceeding the overall installed potential of 8.6 GW in Peru at that time [67]. According to the decree,

> 'it is the duty of the State to promote investment and development of energy infrastructure, especially that considered clean, through the construction of hydroelectric plants, which produce energy from renewable sources and with minimal or no impact on the environment'.
>
> [67]

The supreme decree is further related to a bilateral energy agreement between Peru and Brazil signed in 2010 [31]. The agreement gave consent for the construction of large hydropower plants in Peru financed by the Brazilian Development Bank with the aim of exporting electricity to Brazil. A document issued by the MINEM assigned five projected hydropower plants along the Marañón River with export potential to Brazil [68]. The negotiations of the energy agreement were held by the former Brazilian and Peruvian presidents, the Brazilian Development Bank, and Brazilian companies from the construction and energy sectors. According to the interviewees, the negotiations occurred behind closed doors and without further participation on the Peruvian side. The interviewed representative of a national NGO emphasised the role of Brazilian interests and evaluated the actual need for the expansion as follows:

> 'The Peruvian benefit […] was that we could get money from that, but there was actually no great need on the Peruvian side to be true'.

Another powerful advocate of hydropower development in general and along the Marañón River in particular is the mining sector. A representative of the MINEM stated that 'the one leading here is the mining sector, when it grows it drags everything with it'. The spatial proximity of the projected hydropower plants to large projected mining districts emphasises this interrelation [31]. Interviewed actors criticised the missing transparency of the sector's influence on energy expansions:

> '… let's see, pull the tongue of somebody [ed. means to force someone to tell the truth, to confess something] so that he tells you the truth! No, they will never tell it to you, I am absolutely convinced that Chadín II [projected hydropower plant in the Marañón River] is made for Conga or Galeno, for that famous mining district'.
>
> (r.o. MOCICC)

A deeply rooted narrative among public and private interviewees who advocated the expansion was that Peru has great hydropower potential that needs to be exploited. In this narrative, the expansion of hydropower was not reasoned by a need for additional energy; rather, it was argued that an unexploited potential is equivalent to a loss:

> 'It was a good scheme [ed. expansion of hydropower to export energy] […] if they didn't do anything those waters keep running and reach the sea and we won't take any profit out of that water'.
>
> (r.o. COES)

This narrative is also present in the supreme decree, which argues that hydropower development along the Marañón River 'will allow us to benefit from a source of wealth that is currently unproductive and that is lost in its course towards the Atlantic Ocean' [67].

The proponents of hydroelectric development along the Marañón River face broad and diverse opposition, as lamented by the interviewed representative of the COES who advocates the expansion:

> 'there was a lot of opposition especially environmental, strong strong […] they terribly opposed to it'.

In addition to common protests by affected populations and their advocates in the context of large-scale hydropower, a broad opposition consisting of civil society, NGOs, as well as public authorities formed against the bilateral energy agreement with Brazil. The procedure of the

agreement was criticised, in which only the presidents of both countries as well as the Brazilian Development Bank (BNDES) and Brazilian companies participated. The lack of transparency and participation of critical state authorities, such as the National Water Authority and the Ministry of Foreign Affairs, as well as a missing analysis of the integrated impacts were at the centre of the criticism:

> 'The case of the Marañón, for example, would be about generating a lot of energy for export, but at the cost of our natural assets; in order to sell energy for 10 years we will lose 50 years of well-being of the communities that are settled in that region, so an analysis should be done from an integrated social, economic point of view'.
>
> (r.o. CSF)

Interviewed actors who opposed the expansion argued that the country does not need the additional energy and that the reasons for the expansion are personal and corporate interests, as stated by a representative of an international NGO:

> '[A] lot of the projects that have been developed have been motivated by corruption, by personal interests without really looking if the country needs it'.

The strong opposition led to the energy agreement being turned into a legislative proposal and voted on in congress. The congress rejected the proposal in 2014 on the grounds that the project violated the Constitution due to the compromise of national natural resources on behalf of a foreign power. The congress further criticised the magnitude of the proposal as the intended amount of electricity export exceeded the national demand of Peru [69]. Additionally, a corruption crisis involving the Brazilian construction company Odebrecht, which participated in the energy agreement and developed concessions of hydropower plants along the Marañón River, led to a severe political crisis:

> 'Most of the hydroelectric plants have been falling over time, not physically collapsing but the projects have been paralysed, particularly due to the case of Odebrecht, no? (Uh) that more or less messed up everything'.
>
> (r.o. MOCICC)

This crisis ultimately forced the company to leave the country and led to a state of paralysis of the projected expansion:

> 'There were various problems, there were different discordant voices to these agreements and that has been lasting until now, what has happened, these projects have not been realised'.
>
> (r.o. SPDA)

According to a current study of the NGO Law, Environment and Natural Resources (DAR) only one of the 20 projects has a valid concession and two projects account with primary technical sheets [70]. Interestingly, according to the interviews, the debate on hydropower in the Marañón River led to changes in the perception of the technology. An interviewed representative of an NGO illustrates: '[T]he discussion about the energy matrix has changed in the last years' – it is no longer 'taken for granted that the best energy is the one from large hydroelectric plants'.

4.4. Local niche of solar water heater production and use: bottom-up and decentralised

This section analyses the production and use of SWHs in the Andean city of Arequipa, the second largest city in Peru as an example of a bottom-up expansion of the decentralised energy devices. The practice of solar thermal energy use is deeply rooted in Arequipa and facilitated by the very high and constant solar irradiation [43]. The first prototype of a SWH was installed as early as the 1930s by a local university professor. This prototype consisted of a simple flat-plate collector in which water was conducted through copper tubes under a black surface and kept warm in an insulated tank [71].

In the 1980s, the national government pursued a strategy of import substitution and supported national industrialisation through the development of technology. In this context, the former public industry research institute INTINTEC, together with national universities, refined the solar water heating technology and licensed the so-called *Sistemas de Calentamiento de Agua con Energía Solar* ('Systems for Water Heating with Solar Energy' [71]). A company from Arequipa bought the licence to produce and distribute these SWHs. This led to the spontaneous emergence of production and distribution companies as well as the diffusion of the technology in Arequipa. The following interview statement of an academic expert describes the process:

> '[The first enterprise] starts to produce, and as it is such a simple technology, other people watch and start to copy […] so everybody starts, enterprises, and the technology starts to spread'.

Today, approximately every fourth household in Arequipa uses a SWH, totalling an estimated 55,000 devices produced by approximately 50 manufacturing enterprises in the city [72]. According to an interview, information about the technology is widespread in Arequipa:

> '[E]verybody knows it; an arequipeño has to have his solar thermal collector because he knows that he saves money'.

In addition to households, SWHs are used in small industries, businesses, and public buildings, such as hotels, police departments, and health centres. The success of the technology is attributed to its economic advantage. Compared with electric water heating, SWHs are significantly cheaper in the long-run. In addition, interviewed academic experts argued that the historically embedded use of solar thermal energy facilitated the spread of the new technologies:

> 'since ancient times, from the time of the Spanish to the time of the Incas themselves, the people (eh) put some container of water in the sun and heated it, so there was already this culture'

In the context of increasing market saturation in Arequipa, some companies have expanded their operations. The urban periphery of Arequipa has become a particular focus. Here, attempts are being made to reach lower-income sections of the population with the help of credit-based sales. In addition, sales points are being set up in other Andean towns. In the interviews, the experts emphasised that the entrepreneurial spirit of the *arequipeños* enables the diffusion of the technology beyond Arequipa.

In this expansion process, the role of the state is different. Other than the one-time promotion in the 1980s, no promotion or regulation of SWHs occurs at the national, regional, or local level. This is emphasised by an interviewed academic expert:

> 'what has happened in Arequipa is something spontaneous that [happend] on its own, without any (eh) how can I say (eh) state intervention to massify this, indeed this has been a multiplier effect'.

Moreover, interviewed representatives of the national and regional energy authorities did not mention SWHs when asked about renewable energy in Peru. When asked directly about their use, one representative of the MINEM in Lima answered as follows: 'No, that has not yet been developed'. Israel and Jehling presented the reasons for the marginalisation of local renewable energy technologies in more detail [43]. The lack of regulations has led to several problems in the local manufacturing cluster. The production of SWHs consists mainly of simple welding activities and the necessary technical equipment can be classified as limited. Furthermore, the manufacturing often occurs in family businesses and garage workshops. As the barriers to market entry are low, new competitors continually enter and leave the market: 'one is born, another dies, it's like that'.

The competition in the local cluster was described as 'aggressive', which leads to problematic competition strategies, quality problems in the SWH cluster, and a strong mistrust between the manufacturing companies. Interviewed entrepreneurs problematize the situation as

follows:

> 'some thirty companies were created, small ones that are really small workshops that do not (.) do not provide greater security, they really caused many problems, many of them',
>
> 'it's cheap, buy it straight away, a year and two months passes and this company has shut down, right? you don't know who to complain to anymore, right? so this is a factor that is happening quite a lot here in Arequipa, right? so far nobody has started to regulate this'

Interviewed companies stressed that missing regulations for the production and use of the technology are the main problem. However, due to the strong mistrust, no communication occurs between the companies and thus no joint articulation of the sector's interests. The missing regulations further imply a competitive disadvantage vis-à-vis imported and certified heat-pipe technology. This can be seen in the promotion of imported SWHs by external actors, such as international development agencies. Since 2015, a conglomerate of European development agencies has promoted the dissemination of SWHs in rural areas of Peru. The office, based in Arequipa, aims to boost the SWH market in rural areas. The project exclusively promotes the use of imported evacuated tube collectors. An interviewed representative of a development agency argued that the reasons for using imported technology are that, first, it is applicable in regions with extreme temperature variations, and second, the programme 'is not about promoting the products where nobody measures the quality'. Local producers are now increasingly selling imported devices in addition to locally produced SWHs. One interviewed expert described the changes in the local niche from locally produced flat-plate collectors to imported heat-pipe collectors.

5. Discussion: reflecting on transition in expanding energy systems

In this section, we clarify the ways in which historically embedded actors and institutions influence energy expansions in Peru [10,32,33,43], we examine the reluctance towards socio-technological change in expansions [7,9,10], and reflect on the implications of expansions on change and path dependency in energy systems [31].

The two-dimensional perspective on socio-technical expansions provided insights on the rule-making process of different renewable energy expansions and accounts for specific challenges and opportunities of centralised and decentralised energy technologies. For the analysis of the rule-making process, we considered the criticism of a 'relative dearth of published analyses which draw explicitly on the institutional literature to frame their arguments' and applied HI [32]. We further addressed the common critique about the missing consideration of material aspects in institutionalist approaches by adopting a two-dimensional perspective considering the centrality of infrastructure [44]. The three analysed cases showed similar rule-making patterns and its resulting constraints: Today's regulative framework, a result of neoliberal reforms and later adjustments, leaves far-reaching decisions on energy expansions to powerful individual actors of the central state without the participation of subordinate levels or further sectoral authorities. In the case of the Massive Photovoltaic Programme, the decision came 'from the very top' and manifested in the form of a supreme decree. The hierarchical and centralised rule-making led to a programme design that was not adapted to local energy practices and that did not meet the diversity of energy needs. The missing consideration of the decentralised nature of the energy technology by central rule-makers caused further problems, such as the missing payment of 90 % of the users. This missing adaptation and path-dependency of institutions is explained in HI by the constraining effects of institutions on political and economic transactions 'but also from the resilience or resistance to change of institutions themselves' [32].

A similar pattern of rule-making was observed in the case of the projected hydropower expansion in the Marañón River. Similarly, the national president issued a supreme decree and signed a bilateral energy agreement without the participation of subordinate levels or further sectoral authorities. Different is here, that the magnitude of the centralised energy expansion led to resistance and resulted in a broad alliance of opponents propagating an alternative narrative. The case of the bottom-up expansion of SWHs in Arequipa is the result of the agency and the entrepreneurial spirit of the *arequipeños* together with the economic advantage of the decentralised renewable energy device. However, their agency is limited and embedded rule-makers continue hierarchical and centralised rule-making or in this case, *non*-rule-making. The misrecognition and missing regulation lead to competitive disadvantages and threatens the future of the local niche. The results thus show that in all three cases a disconnection between rule-makers and rule-taker's practices hampers the sustainability of the energy expansions. They confirm the suitability of the HI beyond the context of advanced democracies [44]. The consideration of rules, practices, and narratives and the non-judgemental emphasis on informal institutions allow an analytical perspective on socio-technical expansion processes without an a-priori marginalisation of informality. The results further showed the pivotal role of private companies in the decision-making processes on energy expansions. In the case of the Marañón River, private construction companies participated in the negotiations of the bilateral energy agreement, whereas sectoral and subnational public authorities were excluded. Additionally, companies from the mining sector are recognised as a driving force for the hydropower expansion, even though this relation is not transparent. Furthermore, companies and rule-makers advocating the hydropower expansion in the Marañón River, share the same idea of a hydropower potential that needs to be exploited. Similarly, the private sector has far-reaching decision power in the Massive Photovoltaic Programme. The responsible state authority delegates far reaching decisions, such as the selection of households to be electrified, to a private company. These findings agree with Kuzemko et al. who argue that the neoliberal paradigm in energy systems leads to a critical role of incumbent energy companies and to the coevolution of energy policy following similar ideas [10]. Hi proves suitable to show to how the institutional setting 'may work for or against capture of energy sector governance by incumbents' [44].

The results on the role of private companies and the centralised and hierarchical rule-making highlighted the influence of historically embedded actors and institutions on expansions and reinforce the role of immaterial components for continuity. However, the results also demonstrated that the momentum of expansion facilitates institutional change [44]. Embedded actors and institutions in the hydropower expansion were challenged by a broad opposition and a well-articulated alternative narrative that emphasises the missing need and substantial socioecological impacts of the expansion. This led to changes in rules and the perception of hydropower, which suggests that energy expansions represent a window of opportunity for institutional change. This corresponds to the conception of change in HI, which focuses 'on formative moments and path dependence' [42]. Formative moments can be crises that lead to the replacement of institutions, also called 'critical junctures' [42]. In other words, if energy transitions are a 'battle of ideas' [10], the expansion of energy systems is the boxing ring.

The aim was to scrutinise, alongside institutional factors of change and path dependency, the reluctance towards technological change in the momentum of expansion. The Massive Photovoltaic Programme implies a technological change towards decentralised renewable energies as well as a low reluctance towards technological change even among the embedded actors and institutions. Likewise, the expansion of SWHs symbolises a technological change towards decentralised renewable energy devices with low reluctance towards technological change. The marginalisation of SWH by rule-makers is not interpreted as reluctance towards new technologies but rather as nonrecognition of the energy technology as modern (see [43]). The results confirmed that in the analysed expansions of *decentralised* off-grid renewable energies, there is low sunk capital and thus a low reluctance towards

technological change. A different picture was observed for *centralised* expansions. The income generation opportunities in centralised on-grid expansions are relatively higher compared to off-grid expansions. Since the introduction of auctions and tenders for expansions, incumbent hydro and carbon companies compete with renewable energy companies for energy generation projects with guaranteed prices. Even though *sunk capital* in energy expansions is relatively low, an important factor are the *lost profits* of incumbent energy companies in the light of a political privilege to renewable energy technologies. As argued in Section 4.1, hydro and carbon companies counteracted the expansion of on-grid renewable energies (NRCE in particular) and achieved at least a temporary suspension of related auctions. The two-dimensional perspective could empirically show the different interest of incumbents for off-grid and on-grid expansions [44]…

The results are in line with Sovacool regarding the time spans of transitions and in that they are mostly 'path dependent rather than revolutionary, cumulative rather than fully substitutive' [38]. The concept of expanding energy systems adds a perspective on specific moments, where institutional and technological change is facilitated and contributes to the understanding and promotion of cumulative change. Insights from Lund's Choice Awareness theory could be integrated in order to open the debate about diverse technologies and to enable 'radical technological changes' in these moments. To raise awareness for choice enables us 'to debate our common future and make better decisions' [73].

6. Conclusion

To overcome the dualism between energy research in the Global North and South, we developed the conception of expanding energy systems. Even though we criticise the Global South–North divide, we recognise that global structural inequalities that are highly relevant to energy systems and their transitions exist, and must be considered. Nevertheless, through empirically application, we could show that the conception is highly suitable for contributing to an enhanced understanding of different conditions for and outcomes of energy transitions towards sustainable energy supply.

We analysed the case of the expanding energy system of Peru, which has experienced large increases in generation capacity and territorial coverage. The analysis drew on neo-institutionalism and was based on empirical social research. It revealed that expansions can be described through different types of socio-technical processes, such as the top-down expansion of centralised energy technology, top-down expansion of decentralised energy technology, and bottom-up expansion of decentralised technology. The analysis of actors and institutions, of one empirical example for each expansion type, revealed critical implications for change and continuity. The results highlighted the influence of embedded actors and institutions on expansions and reinforced the role of immaterial components for continuity. Most importantly, they indicated that expansions represent a window of opportunity for institutional change as they are able to provoke debates on the future energy system. Moreover, the results demonstrated that the reluctance for change in expanding energy systems is low when it comes to *decentralised* technologies as sunk capital is limited. However, when it comes to the expansion of centralised NCRE, incumbent energy companies counteract this by exerting political pressure against NCRE auctions. This indicates that in expanding energy systems, 'lost profits' of incumbents may affect the spread of grid-connected NCRE.

We argue that the concept of expanding energy systems and the structuration of expansion processes is a step towards conceptualising energy systems based on system-immanent characteristics that are key for transition processes. On this basis, future research should further elaborate on the applicability and add a comparative perspective, which includes different global and political contexts or contrasting expanding and consolidated systems. For policy development, the results indicate that the concept is suitable for identifying windows of opportunities for change. It is thus a suitable tool for rule-makers to use to identify and promote innovation potentials or to adapt embedded institutions to new technologies. In contrast, it is also a suitable tool for rule-takers to prepare for the 'battle of ideas' around the future energy system.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The data that has been used is confidential.

Appendix A

n°	Type of institution	Institution	Interviewees	Site	Year	Duration (min) if recorded
1	Academic	UNI/CER - National University of Engineering/Centre for Renewable Energies	1	Lima	2016	33
2	Academic	PUCP/CIGA - Pontifical University of Peru/Research Centre in Applied Geography	1	Lima	2016	116
3	Academic	UNI - National University of Engineering PhD Graduate School Energies	1	Lima	2016	29
4	Academic	UNSA- National University of Saint Augustine/Centre for Renewable Energies and Energy Efficiency	1	Arequipa	2016	31
5	Academic	PUCP/INTE - Pontifical University of Peru/Institute for the Science of Nature, Territory and Renewable Energies	1	Lima	2016	44
6	Academic	PUCP/GRUPO - Pontifical University of Peru/Support Group for the Rural Sector	1	Lima	2016	58
7	Academic	UNSA - National University of Saint Augustine	1	Arequipa	2017	101
8	Credit cooperative	FONDESURCO	1	Arequipa	2017	36
9	Diplomatic representation	Embassy of Brazil in Lima	1	Lima	2017	68
10	International development agency	International Cooperation Agency	1	Arequipa	2017	28
11	International political foundation	KAS - Konrad Adenauer Foundation/Regional Programme Energy Security and Climate Change in Latin America	1	Lima	2016	58
12	NGO	Forum Cities for Life	1	Lima	2016	76
13	NGO	MOCICC - The Citizen's Movement against Climate Change	1	Lima	2017	54
14	NGO	DAR - Law, Environment and Natural Resources	1	Lima	2017	35
15	NGO	CSF - Conservation Strategy Fund	1	Lima	2017	20
16	NGO	SPDA - Peruvian Society for Environmental Law	1	Lima	2017	31

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(*continued*)

n°	Type of institution	Institution	Interviewees	Site	Year	Duration (min) if recorded
17	Non-profit organization	CENERGIA - Centre for Energy and Environment Conservation	1	Lima	2016	45
18	Non-profit organization	FONAM - The National Environmental Fund	1	Lima	2017	23
19	Non-profit organization	SNMPE - National Society of Mining, Petroleum and Energy	2	Lima	2017	70
20	Non-profit with public law status	COES - Economic Operation Committee of the National Interconnected System	1	Lima	2017	26
21	Private company	Duke Energy Peru - Area I (not specified due to anonymity)	1	Lima	2016	40
22	Private company	Duke Energy Peru - Area II (not specified due to anonymity)	1	Lima	2016	65
23	Private company	Enterprise for Solar Water Heater	1	Arequipa	2017	28
24	Private company	Enterprise for Solar Water Heater	1	Arequipa	2017	26
25	Private company	Enterprise for Solar Water Heater	1	Arequipa	2017	–
26	Private company	Enterprise for Solar Water Heater	1	Arequipa	2017	–
27	Private company	Enterprise for Solar Water Heater	1	Arequipa	2017	46
28	Private company	Mining Company Buenaventura S.A.A.	1	Lima	2017	25
29	Private company	Subcontractor - TRE Tozzi Renewable Energy	1	San Inacio	2018	–
30	Private company	TRE Tozzi Renewable Energy	1	Lima	2018	–
31	Public - national	MINEM/DGER Ministry of Energy and Mining/General Directorate of Rural Electrification	1	Lima	2016	41
32	Public - national	SERNANP - System of Protected Natural Areas of Peru	1	Lima	2017	22
33	Public - national	MINEM/DGE - Ministry of Energy and Mining/General Directorate of Electricity	2	Lima	2017	30
34	Public - national	ANA - National Water Authority	2	Lima	2017	–
35	Public - national	ProInversión. Agency of Promotion of Private Investment in Peru	1	Lima	2017	26
36	Public - national	MINAM - Ministry of the Environment (former executive)	1	Lima	2017	80
37	Public - national	OSINERGMIN - Supervisory Agency for Investment in Energy and Mining of Peru	1	Lima	2018	–
38	Public - national	MINEM/DGER Ministry of Energy and Mining/General Directorate of Rural Electrification	1	Lima	2018	64
39	Public - national	MINEM/DGER Ministry of Energy and Mining/General Directorate of Rural Electrification	1	virtual	2021	39
40	Public - regional	Regional Office of Energy and Mining Arequipa	1	Arequipa	2016	21
41	Public company of private law	Electrooriente	1	virtual	2021	36

References

[1] M.J. Burke, J.C. Stephens, Political power and renewable energy futures: a critical review, Energy Res. Soc. Sci. 35 (2018) 78–93, https://doi.org/10.1016/j.erss.2017.10.018.

[2] X. Wang, K. Lo, Just transition: a conceptual review, Energy Res. Soc. Sci. 82 (2021), 102291, https://doi.org/10.1016/j.erss.2021.102291.

[3] R. Leonhardt, B. Noble, G. Poelzer, P. Fitzpatrick, K. Belcher, G. Holdmann, Advancing local energy transitions: a global review of government instruments supporting community energy, Energy Res. Soc. Sci. 83 (2022), 102350, https://doi.org/10.1016/j.erss.2021.102350.

[4] B.K. Sovacool, M.-C. Brisbois, Elite power in low-carbon transitions: a critical and interdisciplinary review, Energy Res. Soc. Sci. 57 (2019), 101242, https://doi.org/10.1016/j.erss.2019.101242.

[5] B.K. Sovacool, D.J. Hess, S. Amir, F.W. Geels, R. Hirsh, L. Rodriguez Medina, et al., Sociotechnical agendas: reviewing future directions for energy and climate research, Energy Res. Soc. Sci. 70 (2020), 101617, https://doi.org/10.1016/j.erss.2020.101617.

[6] U. Bhattarai, T. Maraseni, A. Apan, Assay of renewable energy transition: a systematic literature review, Sci. Total Environ. 833 (2022), 155159, https://doi.org/10.1016/j.scitotenv.2022.155159.

[7] F.W. Geels, B.K. Sovacool, T. Schwanen, S. Sorrell, The socio-technical dynamics of low-carbon transitions, Joule 1 (3) (2017) 463–479, https://doi.org/10.1016/j.joule.2017.09.018.

[8] A. Cherp, V. Vinichenko, J. Jewell, E. Brutschin, B. Sovacool, Integrating techno-economic, socio-technical and political perspectives on national energy transitions: a meta-theoretical framework, Energy Res. Soc. Sci. 37 (2018) 175–190, https://doi.org/10.1016/j.erss.2017.09.015.

[9] F.W. Geels, B.K. Sovacool, T. Schwanen, S. Sorrell, Sociotechnical transitions for deep decarbonization, Science 357 (6357) (2017) 1242–1244, https://doi.org/10.1126/science.aao3760.

[10] C. Kuzemko, M. Lockwood, C. Mitchell, R. Hoggett, Governing for sustainable energy system change: politics, contexts and contingency, Energy Res. Soc. Sci. 12 (2016) 96–105, https://doi.org/10.1016/j.erss.2015.12.022.

[11] A.J. Wieczorek, Sustainability transitions in developing countries: major insights and their implications for research and policy, Environ. Sci. Pol. 84 (2018) 204–216, https://doi.org/10.1016/j.envsci.2017.08.008.

[12] M. Asif, Energy and Environmental Security in Developing Countries, Springer International Publishing, Cham, 2021.

[13] U.E. Hansen, I. Nygaard, H. Romijn, A. Wieczorek, L.M. Kamp, L. Klerkx, Sustainability transitions in developing countries: stocktaking, new contributions and a research agenda, Environ. Sci. Pol. 84 (2018) 198–203, https://doi.org/10.1016/j.envsci.2017.11.009.

[14] M.M. Vanegas Cantarero, Of renewable energy, energy democracy, and sustainable development: a roadmap to accelerate the energy transition in developing countries, Energy Res. Soc. Sci. 70 (2020), 101716, https://doi.org/10.1016/j.erss.2020.101716.

[15] A. Goldthau, L. Eicke, S. Weko, The global energy transition and the global south, in: M. Hafner, S. Tagliapietra (Eds.), The Geopolitics of the Global Energy Transition, Springer International Publishing, Cham, 2020, pp. 319–339.

[16] K. Kaygusuz, Energy for sustainable development: a case of developing countries, Renew. Sust. Energ. Rev. 16 (2) (2012) 1116–1126, https://doi.org/10.1016/j.rser.2011.11.013.

[17] C. Liao, A. Agrawal, Sustainable and just energy transition in the global south, World Dev. 152 (2022), 105798, https://doi.org/10.1016/j.worlddev.2021.105798.

[18] B. Radley, P. Lehmann-Grube, Off-grid solar expansion and economic development in the global south: a critical review and research agenda, Energy Res. Soc. Sci. 89 (2022), 102673, https://doi.org/10.1016/j.erss.2022.102673.

[19] K.K. Iychettira, Lessons for renewable integration in developing countries: the importance of cost recovery and distributional justice, Energy Res. Soc. Sci. 77 (2021) 1–15, https://doi.org/10.1016/j.erss.2021.102069.

[20] D. Loorbach, N. Frantzeskaki, F. Avelino, Sustainability transitions research: transforming science and practice for societal change, Annu. Rev. Environ. Resour. 42 (1) (2017) 599–626, https://doi.org/10.1146/annurev-environ-102014-021340.

[21] M.P. Schlaile, S. Urmetzer, Transitions to sustainable development, in: W. Leal Filho, T. Wall, U. Azeiteiro, A.M. Azul, L. Brandli, P.G. Özuyar (Eds.), Good Health and Well-being, Springer International Publishing, Cham, 2018, pp. 1–16.

[22] M. Lawhon, J.T. Murphy, Socio-technical regimes and sustainability transitions, Prog. Hum. Geogr. 36 (3) (2012) 354–378, https://doi.org/10.1177/0309132511427960.

[23] S. Becker, M. Naumann, Energy democracy: mapping the debate on energy alternatives, Geogr. Compass 11 (8) (2017), e12321, https://doi.org/10.1111/gec3.12321.

[24] D. Apfel, S. Haag, C. Herbes, Research agendas on renewable energies in the global south: a systematic literature review, Renew. Sust. Energ. Rev. 148 (2021) 1–16, https://doi.org/10.1016/j.rser.2021.111228.

[25] K. Furlong, STS beyond the "modern infrastructure ideal": extending theory by engaging with infrastructure challenges in the south, Technol. Soc. 38 (2014) 139–147, https://doi.org/10.1016/j.techsoc.2014.04.001.

[26] P. Munro, G. van der Horst, S. Healy, Energy justice for all? Rethinking sustainable development goal 7 through struggles over traditional energy practices in Sierra

Leone, Energy Policy 105 (2017) 635–641, https://doi.org/10.1016/j.enpol.2017.01.038.
[27] V. Castán Broto, I. Baptista, J. Kirshner, S. Smith, Alves S. Neves, Energy justice and sustainability transitions in Mozambique, Appl. Energy 228 (2018) 645–655, https://doi.org/10.1016/j.apenergy.2018.06.057.
[28] V.C. Broto, L. Stevens, E. Ackom, J. Tomei, P. Parikh, I. Bisaga, et al., A research agenda for a people-centred approach to energy access in the urbanizing global south, Nat. Energy 2 (10) (2017) 776–779, https://doi.org/10.1038/s41560-017-0007-x.
[29] J. Cloke, A. Mohr, E. Brown, Imagining renewable energy: towards a social energy systems approach to community renewable energy projects in the global south, Energy Res. Soc. Sci. 31 (2017) 263–272, https://doi.org/10.1016/j.erss.2017.06.023.
[30] M. Power, P. Newell, L. Baker, H. Bulkeley, J. Kirshner, A. Smith, The political economy of energy transitions in Mozambique and South Africa: the role of the rising powers, Energy Res. Soc. Sci. 17 (2016) 10–19, https://doi.org/10.1016/j.erss.2016.03.007.
[31] A. Israel, R.J. Herrera, The governance of peruvian energy transitions: path dependence, alternative ideas and change in national hydropower expansion, Energy Res. Soc. Sci. 69 (101608) (2020) 1–12, https://doi.org/10.1016/j.erss.2020.101608.
[32] P. Andrews-Speed, Applying institutional theory to the low-carbon energy transition, Energy Res. Soc. Sci. 13 (2016) 216–225, https://doi.org/10.1016/j.erss.2015.12.011.
[33] M. Jehling, M. Hitzeroth, M. Brueckner, Applying institutional theory to the analysis of energy transitions: from local agency to multi-scale configurations in Australia and Germany, Energy Res. Soc. Sci. 53 (2019) 110–120, https://doi.org/10.1016/j.erss.2019.01.018.
[34] F.W. Geels, From sectoral systems of innovation to socio-technical systems, Res. Policy 33 (6–7) (2004) 897–920, https://doi.org/10.1016/j.respol.2004.01.015.
[35] A. Goldthau, Rethinking the governance of energy infrastructure: scale, decentralization and polycentrism, Energy Res. Soc. Sci. 1 (2014) 134–140, https://doi.org/10.1016/j.erss.2014.02.009.
[36] J. Markard, R. Raven, B. Truffer, Sustainability transitions: an emerging field of research and its prospects, Res. Policy 41 (6) (2012) 955–967, https://doi.org/10.1016/j.respol.2012.02.013.
[37] M. Child, C. Breyer, Transition and transformation: a review of the concept of change in the progress towards future sustainable energy systems, Energy Policy 107 (2017) 11–26, https://doi.org/10.1016/j.enpol.2017.04.022.
[38] B.K. Sovacool, The History and Politics of Energy Transitions: Comparing Contested Views and Finding Common Ground, UNU-WIDER, 2016.
[39] A. Goldthau, B.K. Sovacool, The uniqueness of the energy security, justice, and governance problem, Energy Policy 41 (2012) 232–240, https://doi.org/10.1016/j.enpol.2011.10.042.
[40] International Energy Agency, IEA World Energy Balances: Peru: Key energy statistics, Available from: https://www.iea.org/data-and-statistics/data-product/world-energy-statistics-and-balances, 2022.
[41] S. Becker, R. Beveridge, A. Röhring, Energy transitions and institutional change: between structure and agency, in: L. Gailing, T. Moss (Eds.), Conceptualizing Germany's Energy Transition, Palgrave Macmillan UK, London, 2016, pp. 21–41.
[42] V. Lowndes, M. Roberts, Why Institutions Matter: The New Institutionalism in Political Science, Palgrave Macmillan, Basingstoke, Hampshire, New York, 2013.
[43] A. Israel, M. Jehling, How modern are renewables? The misrecognition of traditional solar thermal energy in Peru's energy transition, Energy Policy 133 (110905) (2019) 1–8, https://doi.org/10.1016/j.enpol.2019.110905.
[44] M. Lockwood, C. Kuzemko, C. Mitchell, R. Hoggett, Historical institutionalism and the politics of sustainable energy transitions: a research agenda, Environment and Planning C: Politics and Space 35 (2) (2017) 312–333, https://doi.org/10.1177/0263774X16660561.
[45] P. Pierson, Politics in Time: History, Institutions, and Social Analysis, Princeton University Press, Princeton, 2004.
[46] M. Hitzeroth, M. Jehling, M. Brueckner, Apples and oranges? A multi-level approach explaining social acceptance of renewable energy in Germany and Australia, IJGEI 40 (3/4) (2017) 141, https://doi.org/10.1504/IJGEI.2017.086617.
[47] A.P. Gamio, Transición energética: un cambio necesario en el Perú, pluriversidad 1 (1) (2018) 179–191.
[48] World Bank, World Bank Global Electrification Database: Access to electricity, rural (% of rural population) - Peru, Available from: https://data.worldbank.org/indicator/EG.ELC.ACCS.RU.ZS?locations=PE, 2022.
[49] B.K. Sovacool, J. Axsen, S. Sorrell, Promoting novelty, rigor, and style in energy social science: towards codes of practice for appropriate methods and research design, Energy Res. Soc. Sci. 45 (2018) 12–42, https://doi.org/10.1016/j.erss.2018.07.007.
[50] A.T. Rubin, Rocking Qualitative Social Science: An Irreverent Guide to Rigorous Research, Stanford University Press, Stanford, California, 2021.
[51] M. Arana Cardó, Proyectos hidroeléctricos en la cuenca del Río Marañon: Serie de Cuadernos de Integración. Lima, 2012.
[52] B. Flyvbjerg, Five misunderstandings about case-study research, Qualitative Inquiry 12 (2) (2006) 219–245, https://doi.org/10.1177/1077800405284363.
[53] A. Tjora, Qualitative Research as Stepwise-Deductive Induction, Routledge, Abingdon, Oxon, New York, NY, 2019.
[54] T. Dresing, T. Pehl, Praxisbuch Interview, Transkription & Analyse: Anleitungen Und Regelsysteme für Qualitativ Forschende, 8th ed., Eigenverlag, Marburg, 2018.
[55] P. Mayring, Qualitative Inhaltsanalyse: Grundlagen Und Techniken, 11th ed., Beltz, Weinheim, 2010.
[56] U. Kuckartz, Qualitative Inhaltsanalyse: Methoden, Praxis, Computerunterstützung, 3rd ed., Beltz Juventa, Weinheim, Bergstr, 2016.
[57] R.E. Mitma Ramírez, Análisis de la Regulación de Energías renovables en el Perú, Derecho Soc. 45 (2015) 167–176.
[58] INEI, Encuesta Nacional de Hogares, Available from: https://www.inei.gob.pe/estadisticas/indice-tematico/poblacion-y-vivienda/, 2022.
[59] El Peruano, 125,500 peruanos de áreas rurales accedieron a electricidad el 2021: Por su parte, el MVCS ejecutó 3,523 millones de soles para brindar viviendas sociales, Available from: https://elperuano.pe/noticia/136626-125500-peruanos-de-areas-rurales-accedieron-a-electricidad-el-2021, 2022.
[60] J.A. Cherni, F. Preston, Rural electrification under liberal reforms: the case of Peru, J. Clean. Prod. 15 (2) (2007) 143–152, https://doi.org/10.1016/j.jclepro.2006.01.029.
[61] Gobierno de Emergencia y Reconstrucción Nacional, Ley de Concesiones Eléctricas y Reglamento: Decreto Ley N° 25844, 1992, 19 de noviembre de.
[62] U.V. Baca, P. Gamio, Transición energética con energías renovables para la seguridad energética en el Perú: Una propuesta de política pública resiliente al clima, in: Espacio y Desarrollo 31, 2018, pp. 195–224.
[63] OSINERGMIN, Energías Renovables - Subastas, Available from: https://www.osinergmin.gob.pe/seccion/institucional/regulacion-tarifaria/licitaciones-y-subastas/renovables, 2022.
[64] OSINERGMIN, Mercado Libre de Electricidad, Available from: https://prie.osinergmin.gob.pe/mercado-libre-de-electricidad, 2022.
[65] FISE, Programa Masivo Fotovoltaico, Available from: http://www.fise.gob.pe/programa-masivo-fotovoltaico.html, 2022.
[66] Gobierno del Perú. Decreto Supremo N° 020-2013-EM. [June 09, 2022]; Available from: https://www.gob.pe/institucion/osinergmin/normas-legales/733932-020-2013-em.
[67] García Pérez A. Declaran de interés nacional y social la construcción de veinte (20) centrales hidroeléctricas en la Cuenca del Río Marañón: D.S. N° 020-2011-EM. [June 08, 2022]; Available from: http://www.minem.gob.pe/archivos/legislacion-n47b81u0zwf06-D_S_N%C2%BA_020-2011-EM.pdf.
[68] Q&amp, V Inenieros SAC, Informe Final: Elaboración de resúmenes ejecutivos y fichas de estudios de las centrales hidroeléctricas con potencial para la exportación a Brasil. Lima, 2007.
[69] Congreso de la República. Dictamen recaido en el proyecto de resolución legislativa N° 391/2011. [June 20, 2022]; Available from: https://www2.congreso.gob.pe/Sicr/ApoyComisiones/comision2011.nsf/0238C60CCC5C435A05257CF40059BBEA/$FILE/RR.EE._391-2011-PE_Negativo.Mayor%C3%ADa.pdf.
[70] D. Villena Delgado, R. Orcotorio Figueroa, V. Avalos Barrio de Mendoza, Hidroeléctricas en Sudamérica y en el Perú: Situación actual en la cuenca del Río Marañón, 1000th ed., 2021. Lima.
[71] M. Tinajeros Salcedo (Ed.), Sistemas de calentamiento de agua con energía solar en la ciudad de Arequipa, 2011.
[72] P. Gamio Aita, Energías renovables y cambio climático: 7 proyectos demostrativos de un desarrollo sustentable, 1000th ed., 2014. Lima.
[73] H. Lund, Renewable Energy Systems: A Smart Energy Systems Approach to the Choice and Modeling of 100% Renewable Solutions, 2nd ed., Elsevier Academic Press, Amsterdam, Boston, Heidelberg, London, 2014.

Abkürzungsverzeichnis

BNDES	Brasilianische Entwicklungsbank
COES	Komitee für den wirtschaftlichen Betrieb des nationalen Verbundsystems
DAR	Recht, Umwelt und natürliche Ressourcen
DGER	Direktion für ländliche Elektrifizierung
EZ	Entwicklungszusammenarbeit
HI	Historischer Institutionalismus
INDECOPI	Nationales Institut für die Verteidigung des Wettbewerbs und den Schutz des geistigen Eigentums
MINEM	Ministerium für Energie und Bergbau
MLP	Multilevel-Perspektive
OSINERGMIN	Aufsichtsbehörde für Investitionen in Energie und Bergbau
SNMPE	Nationale Gesellschaft für Bergbau, Erdöl und Energie
STS	Sozio-technische Transition
SWH	Solarwarmwasserbereiter

Abbildungsverzeichnis

Anhang

Nr.	Art der Einrichtung	Einrichtung	Anzahl Interviewte	Ort	Jahr	Dauer der Aufnahme (Min)
1	Akademisch	UNI/CER - Nationale Universität für Ingenieurwesen / Zentrum für Erneuerbare Energien	1	Lima	2016	33
2	Akademisch	PUCP/CIGA - Päpstliche Katholische Universität von Peru / Forschungszentrum für Angewandte Geographie	1	Lima	2016	116
3	Akademisch	UNI - Nationale Universität für Ingenieurwesen / „Energie“ Graduiertenschule für Doktoranden	1	Lima	2016	29
4	Akademisch	UNSA- Nationale Universität zu Sankt Augustin von Arequipa / Zentrum für Erneuerbare Energien und Energieeffizienz	1	Arequipa	2016	31
5	Akademisch	PUCP/INTE - Päpstliche Katholische Universität von Peru / Institut für Natur, Territorium und Energie	1	Lima	2016	44
6	Akademisch	PUCP/GRUPO - Päpstliche Katholische Universität von Peru / Unterstützungsgruppe für den ländlichen Raum	1	Lima	2016	58
7	Akademisch	UNSA - Nationale Universität zu Sankt Augustin von Arequipa	1	Arequipa	2017	101
8	Kreditkooperative	FONDESURCO	1	Arequipa	2017	36
9	Diplomatische Auslandsvertretung	Brasilianische Botschaft in Lima	1	Lima	2017	68
10	Internationale Entwicklungsagentur	Internationale Entwicklungsagentur	1	Arequipa	2017	28
11	Politische Stiftung	KAS - Konrad Adenauer Stiftung / Regionalprogramm Energiesicherheit und Klimawandel Lateinamerika	1	Lima	2016	58
12	NRO	Forum Städte für das Leben	1	Lima	2016	76
13	NRO	MOCICC - Die Bürgerbewegung gegen den Klimawandel	1	Lima	2017	54
14	NRO	DAR – Recht, Umwelt und natürliche Ressourcen	1	Lima	2017	35
15	NRO	CSF - Conservation Strategy Fund	1	Lima	2017	20
16	NRO	SPDA – Peruanische Gesellschaft für Umweltrecht	1	Lima	2017	31
17	Gemeinnützige Organisation	CENERGIA - Zentrum für Energie- und Umwelterhaltung	1	Lima	2016	45
18	Gemeinnützige Organisation	FONAM -Nationaler Umweltfond	1	Lima	2017	23
19	Gemeinnützige Organisation	SNMPE - Nationale Gesellschaft für Bergbau, Erdöl und Energie	2	Lima	2017	70
20	Gemeinnützige Organisation nach öffentlichem Recht	COES - Komitee für den wirtschaftlichen Betrieb des nationalen Verbundsystems	1	Lima	2017	26
21	Privatunternehmen	Duke Energy Peru - Bereich I	1	Lima	2016	40
22	Privatunternehmen	Duke Energy Peru - Bereich II	1	Lima	2016	65
23	Privatunternehmen	Unternehmen für Solarwarmwasserbereiter	1	Arequipa	2017	28
24	Privatunternehmen	Unternehmen für Solarwarmwasserbereiter	1	Arequipa	2017	26
25	Privatunternehmen	Unternehmen für Solarwarmwasserbereiter	1	Arequipa	2017	-
26	Privatunternehmen	Unternehmen für Solarwarmwasserbereiter	1	Arequipa	2017	-
27	Privatunternehmen	Unternehmen für Solarwarmwasserbereiter	1	Arequipa	2017	46

28	Privatunternehmen	Buenaventura S.A.A. (Bergbausektor)	1	Lima	2017	25
29	Privatunternehmen	Subunternehmer von TRE Tozzi Renewable Energy	1	San Ignacio	2018	-
30	Privatunternehmen	TRE Tozzi Renewable Energy	1	Lima	2018	-
31	Staatlich - national	MINEM/DGER Ministerium für Energie und Bergbau/ Direktion für ländliche Elektrifizierung	1	Lima	2016	41
32	Staatlich - national	SERNANP - Nationaler Dienst für staatlich geschützte Naturgebiete	1	Lima	2017	22
33	Staatlich - national	MINEM/DGE - Ministerium für Energie und Bergbau/ Generaldirektion für Elektrizität	2	Lima	2017	30
34	Staatlich - national	ANA – Nationale Wasserbehörde	2	Lima	2017	-
35	Staatlich - national	ProInversión . Agentur für die Förderung privater Investitionen in Peru	1	Lima	2017	26
36	Staatlich - national	MINAM – Umweltministerium (former executive)	1	Lima	2017	80
37	Staatlich - national	OSINERGMIN - Aufsichtsbehörde für Investitionen in Energie und Bergbau	1	Lima	2018	-
38	Staatlich - national	MINEM/DGER Ministerium für Energie und Bergbau / Direktion für ländliche Elektrifizierung	1	Lima	2018	64
39	Staatlich - national	MINEM/DGER Ministerium für Energie und Bergbau / Direktion für ländliche Elektrifizierung	1	virtuell	2021	39
40	Staatlich - regional	Regionalbüro für Energie und Bergbau Arequipa	1	Arequipa	2016	21
41	Öffentliches Unternehmen privaten Rechts	Electrooriente - Energieversorgungsunternehmen	1	virtuell	2021	36