Investments for Carbon Footprint Reduction: An Instructional Case*

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ABSTRACT

This instructional case explores strategic decision-making at CarCompany (CarCo), a large automaker that is transitioning to battery electric vehicles. CarCo aims to reduce the carbon dioxide (CO_2) emissions at their own sites and at suppliers' sites. The challenge is to select a group of CO_2 reduction initiatives that achieves the objectives set by CarCo's management while staying within budgetary restrictions. Another challenge is renegotiating some CO_2 reduction initiatives with suppliers so that greater overall CO_2 reductions can be achieved. Finally, decentralization of objectives and budgets for CO_2 reductions needs to be considered. CarCo's Sustainability Manager, Julia Neumann, has been asked to select from the list of proposed projects and present her recommendations to CarCo's board. In this case, students need to apply rigorous analyses on the basis of cost-benefit analysis, justify their decisions, and think outside the box. They are asked to assess how existing evaluation techniques can be used and adapted to CO_2 emissions. The case delves into the complexities of the transition to cleaner production processes and the expanding network of suppliers, employees, and other stakeholders that need to be involved in the process.

Keywords: carbon footprint reduction, cost-effectiveness analysis, environmental management accounting, investment project selection, sustainability

INVESTISSEMENTS VISANT À RÉDUIRE L'EMPREINTE CARBONIQUE : ÉTUDE DE CAS PÉDAGOGIQUE

RÉSUMÉ

La présente étude de cas pédagogique se penche sur la prise de décisions stratégiques chez CarCompany (CarCo), un vaste fabricant automobile qui se tourne vers la production de véhicules électriques à batterie. CarCo vise à réduire les émissions de dioxyde de carbone (CO_2) dans ses propres installations et celles de ses fournisseurs. Le défi consiste à choisir une série d'initiatives de réduction des émissions de CO_2 permettant d'atteindre les objectifs établis par la direction de CarCo tout en respectant les contraintes budgétaires. Il faut également renégocier certaines initiatives de réduction du CO_2 avec les fournisseurs pour réduire davantage les émissions totales de CO_2. Enfin, il est

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nécessaire d'envisager de décentraliser les objectifs et les budgets associés aux réductions du CO_2. La responsable de la durabilité chez CarCo, Julia Neumann, a été chargée de choisir des initiatives dans la liste de projets proposés et de présenter ses recommandations au conseil d'administration de CarCo. Dans le cadre de cette étude de cas, les étudiants sont tenus d'effectuer des analyses rigoureuses fondées sur une analyse coûts-avantages, de justifier leurs décisions et de faire preuve de créativité. Ils doivent également évaluer comment les techniques d'évaluation existantes peuvent être utilisées et adaptées aux émissions de CO_2. L'étude de cas s'attarde aux complexités associées à une transition vers des processus de production plus propres et au réseau de plus en plus vaste de fournisseurs, d'employés et d'autres parties prenantes qui doivent participer au processus.

Mots-clés : analyse coût-efficacité, choix des projets d'investissement, comptabilité de gestion environnementale, durabilité, réduction de l'empreinte carbonique

INTRODUCTION

Julia Neumann, CarCompany's (CarCo) Sustainability Manager, is under pressure. In 7 days, she needs to present her recommendations to the executive board of CarCo for reducing the company's carbon dioxide (CO_2) footprint. The CO_2 footprint of a company is the sum of CO_2 emissions and CO_2 equivalents of other greenhouse gases, such as methane and nitrous oxide, that are emitted into the atmosphere to produce a company's output (Li et al., 2024).[1] The list of proposed projects is long. How can Julia make a selection and justify it?

CarCo has announced that it will significantly reduce the carbon footprint of its cars during their entire life cycle, including emissions from driving the car as well as emissions that occur during car production. Moving to battery electric vehicles (BEV) means that the cars will cause much lower CO_2 emissions from driving compared to conventional internal combustion engine vehicles (ICEV). However, the CO_2 emissions during car production will increase, and the total CO_2 emissions accumulated up to the point of sale—one of the measures CarCo has promised to reduce—are higher for BEV than for ICEV. This effect in particular occurs because the production of the battery requires a lot of energy, which is a significant contributor to the total CO_2 emissions at the point of sale (Kim et al., 2016). Therefore, CarCo is now implementing initiatives to reduce CO_2 emissions during production, both in its own production activities and with its suppliers. Specifically, CarCo has announced that the emissions during production should be reduced by 1,356,000 tons of CO_2 equivalent per year on average in the next 5 years.

Part 1 of the case addresses the selection of projects for the reduction of CO_2 emissions. At the conclusion of Part 1, Julia needs to go further and think creatively about ways to improve the given projects through greater CO_2 reductions and/or lower costs. Part 2 of the case places the efforts for reducing CO_2 emissions in an organizational context with multiple decision-makers and decentralized reduction targets and budgets.

1. For brevity, we talk only about CO_2 here.

PART 1: PROJECTS FOR CO_2 REDUCTION

Initiatives to reduce CO_2 emissions vary greatly with respect to their costs. They are sometimes quite easy and inexpensive. The best example is buying green energy from energy suppliers and installing solar panels on the roofs of buildings. The purchase price of green electricity and the full cost of power from solar panels are often not much higher per kilowatt hour (kWh) than for conventional purchase contracts. However, some other initiatives CarCo can take to reduce emissions are more expensive. For example, the production of aluminum causes significantly fewer CO_2 emissions when renewable electricity and recycled aluminum are used or when the production process deploys anodes of inert materials. Such aluminum is available, but the prices are higher than for conventionally produced aluminum.

CarCo has announced that it will make a considerable investment in the next 5 years on projects for reducing CO_2 emissions (see Table 1). This budget will be used for improving the energy efficiency of machines, installations, and buildings in CarCo's production. (Of course, energy efficiency will also be improved outside production, such as in office buildings, IT systems, and business travel, but production is the big lever.) Some initiatives are related to capital investments, while others affect operational expenditures. If more energy-efficient assets require higher investments, the additional investment might be paid from this budget. The budget is based on cash flows, so an investment is to be "paid" out of the budget of the first year of that project. For example, if a reduction project requires an investment of €4,000,000 that will be used and depreciated over the next 5 years, the budget in the first year should cover the full €4,000,000. The budget can also be used to fund CarCo's higher operational costs for improving energy efficiency. For example, transporting incoming materials by rail or ship instead of by truck typically causes lower CO_2 emissions, but it is sometimes more expensive.

The budget can also be used for supporting suppliers to take initiatives for reducing CO_2 emissions related to products and services supplied to CarCo. If that requires suppliers to make investments, CarCo might help to fund those investments through higher per unit purchase prices or a one-time payment, but the latter is less customary in the automotive industry. If supplier projects increase the supplier's operational costs, CarCo might agree to paying a higher purchase price per unit. Thus, the budget enables buying products and services from suppliers that have a lower carbon footprint but are more expensive.

TABLE 1
Target and budget for CO_2 reduction

Year	1	2	3	4	5	Total 1–5
Number of vehicles	630,000	670,000	700,000	730,000	780,000	3,510,000
CO_2 reduction target (tons)	900,000	1,150,000	1,400,000	1,600,000	1,730,000	6,780,000
Annual budget (euro)	€110,000,000	€110,000,000	€115,000,000	€115,000,000	€125,000,000	€575,000,000

Selecting Projects for Reducing CO_2 Emissions

Several of CarCo's suppliers and a number of its departments, such as Purchasing, Production, Facility Management, and R&D, have created a set of possible projects to reduce CO_2 emissions during production. These are listed in Table 2. The timing of these projects is indicated by the starting year and ending year. Some actions are readily available, such as buying green electricity and improving building insulation. Other initiatives for CO_2 reduction are under development and will take longer before becoming available—for example, because suppliers are still ramping up their production capacity for particular materials or because the required technology for CO_2 reduction is still being developed.

Projects involving capital investments have a *fixed* project horizon of several years. Such a project cannot be done for a shorter period than indicated by the starting and ending year. The starting year may be somewhat flexible (although the project horizon remains fixed), but it might be fixed (e.g., because a significant government subsidy will be available only in specific years). Such project-specific information is provided in the comments in Table 2. The investment amount refers to the entire project.

Other projects involve operational actions that can be done for one or several years or for a smaller or larger number of vehicles. The operational costs are expressed either per year or per vehicle.

The challenge is now to select which group of the proposed projects to implement as well as when and to what extent. Besides an analysis and a comprehensive table describing the selection of projects, Julia also wants to provide management with a visualization of the projects in terms of their attractiveness.

Renegotiating Projects

Julia completed the analysis for the selection of projects, and it was met with enthusiasm within CarCo. Only a few weeks later, however, it became clear that CarCo had to undertake more efforts to keep up with the competition. CarCo's top management increased the CO_2 reduction ambitions: an additional 400,000 tons of CO_2 equivalent needs to be reduced in total in 5 years, but it must be within the same total budget. Julia realizes it will be impossible to achieve these targets with the current set of projects as specified in Table 2. She decides to renegotiate some projects with suppliers.

PART 2: DECENTRALIZING CO_2 REDUCTION

Two years after starting to implement the projects Julia suggested, CarCo has gained much experience with projects to reduce the CO_2 footprint of cars during production. It publicly announced the CO_2 footprint of an average car during the entire life cycle (both production and use) and specified its targets for reducing this number in the next 10 years. CarCo also decentralized the CO_2 reduction responsibilities. Rather than having one overall CO_2 reduction target and budget, CarCo introduced separate CO_2 reduction targets and budgets for each product line. A product line is a profit center that concerns a

TABLE 2
Potential projects for CO_2 reduction

Project	Project description	Starting year	Ending year	CO_2 reduction (ton)[a]	Per unit[b]	Investment[c]	Operational costs[d]	Comments
1	Build cars partly with low CO_2 aluminum	1	5	0.3000	Vehicle		€50.00	Availability is limited but growing. The number of vehicles is scalable between 100,000 and 300,000 per year
2	Build cars partly with low CO_2 steel	3	5	0.2000	Vehicle		€40.00	Availability is limited but growing. The number of vehicles is scalable between 100,000 and 450,000 per year
3	Build cars partly with low CO_2 copper	1	5	0.1000	Vehicle		€30.00	Availability is limited but growing. The number of vehicles is scalable between 50,000 and 150,000 per year
4	Use more composite materials with natural fibers (supplier project)	1	5	0.2000	Vehicle		€30.00	There are significant technical implications, and the number of vehicles cannot be decreased, only increased, year over year.
5	Use recycled materials for particular interior parts	1	5	0.0200	Vehicle		€7.00	Available in all 5 years without restrictions
6	Mount cars with low CO_2 tires	1	5	0.0500	Vehicle		€5.00	Available in all 5 years without restrictions
7	Implement new technology in battery production	3	5	320,000	Project	€25,000,000		The technology is still being developed and is only available from Year 3 onwards
8	Use residual heat in battery production	1	5	60,000	Year	€20,000,000		The investment amount is related to a project horizon of 5 years
9	Use electricity from renewable sources in battery production	1	5	120,000	Year		€3,600,000	This project can be started at any time

(The table is continued on the next page.)

TABLE 2 (continued)

Project	Project description	Starting year	Ending year	CO_2 reduction (ton)[a]	Per unit[b]	Investment[c]	Operational costs[d]	Comments
10	New state of the art energy-efficient production installation	4	10	700,000	Project	€42,000,000		The asset is available at the start of Year 4, with a useful life of 7 years
11	Use electricity from renewable sources in production (apart from batteries)	1	5	300,000	Project		€1,800,000	This project can be started every year, but if it is started, it needs to continue for 5 years
12	Switch from coal to gas for own power plant	1	5	100,000	Project	€10,000,000		The investment is subsidized by 35%, but it can be started in Year 1 only
13	Require major first-tier suppliers to use electricity from renewable sources	1	5	0.2500	Vehicle		€18.00	Available in all 5 years without restrictions
14	Require logistic companies to use synthetic aviation fuel	2	5	100,000	Year		€8,000,000	Downward scalable (fewer transportation movements)
15	Switch as much of the incoming supplies as possible from truck to rail and ship transport (intermodal)	1	5	90,000	Year		€6,000,000	Downward scalable (fewer transportation movements)
16	Develop and implement reusable packaging materials for incoming parts with suppliers	1	5	40,000	Project	€10,000,000		This project can be started at any time
17	Improve controlling units of one installation	1	5	40,000	Project	€10,000,000		Pilot project to learn about energy efficiency; it can be started at any time

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TABLE 2 (continued)

Project	Project description	Starting year	Ending year	CO_2 reduction (ton)[a]	Per unit[b]	Investment[c]	Operational costs[d]	Comments
18	Install insulation in the car assembly building	1	10	800,000	Project	€35,000,000		This project can be started at any time and runs for 10 years
19	Installation for residual heat recovery milling lines	1	5	300,000	Project	€18,000,000		This project can be started at any time
20	Switch from gas to electricity (for production processes requiring heat)	3	8	180,000	Project	€18,000,000		This needs to be developed and is therefore only available from Year 3 onwards
21	Upgrade energy efficiency of the painting line	1	5	50,000	Project	€4,000,000		This and the next project (22) cannot both be implemented (they are mutually exclusive)
22	Partly new painting line, state of the art regarding energy efficiency	1	5	60,000	Project	€4,900,000		This and the previous project (21) cannot both be implemented (they are mutually exclusive)
23	Energy efficiency upgrade of the quality control building	2	5	50,000	Project	€3,800,000		This and the next project (24) cannot both be implemented (they are mutually exclusive)
24	Core renovation of the office building next to the main production hall	4	10	60,000	Project	€5,400,000		This and the previous project (23) cannot both be implemented (they are mutually exclusive)
25	Transport cars with new liquefied natural gas (LNG) ships	4	10	900,000	Project	€90,000,000		There is significant preparation needed. The project is available from Year 4 onwards

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TABLE 2 (continued)

Project	Project description	Starting year	Ending year	CO_2 reduction (ton)[a]	Per unit[b]	Investment[c]	Operational costs[d]	Comments
26	Rent a carbon capture facility from a local startup that makes bricks used in building from carbon captured from the air	1	1	115,000	Year		€6,000,000	The facility has several prospective renters from Year 2 onwards
27	Train the production floor employees to identify possible saving opportunities around production (e.g., turning off machines if they are not used for a while)	1	5	200,000	Project	€15,000,000		This project can be started at any time
28	Transport finished cars by train instead of by truck	1	5	0.1000	Vehicle		€11.00	Switching to rail freight requires some additional infrastructure and personnel to be built up. Availability is limited to 400,000 cars in the first year of usage but increases by 100,000 every year of consecutive usage
29	Commit to restoring a large hydropower plant, gaining usage rights for 5 years. The plant generates a significant amount of energy, paying for its own costs. However, it	1	5	420,000	Project		€7,400,000	The yearly operational costs for this project concern each year, but the actual payments occur consolidated in Year 4 and 5 equally. The project can only be started in Year 1 and must be used throughout all 5 years

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TABLE 2 (continued)

Project	Project description	Starting year	Ending year	CO_2 reduction (ton)[a]	Per unit[b]	Investment[c]	Operational costs[d]	Comments
	needs to be renovated in Year 4 and 5							
30	Send employees to plant trees on a former local landfill through an internal program, "Teambuilding for the Earth"	1	5	5,000	Year		€600,000	The new forests are protected by the city council and locals who can visit the new park

Notes:

[a]CO_2 refers to CO_2 and equivalent units of other greenhouse gases, such as methane and nitrous oxide. The reduction is calculated as the difference between the described project in the table and an implicit default decision that does not specifically aim to achieve CO_2 reduction. The reduction is calculated, as much as possible, on the basis of standards, such as ISO 14067.

[b]Unit refers to the unit of measurement for expressing the relative amount of CO_2 reduction and the financial impact (investment, costs), which can be per vehicle, per year, or for the entire project horizon of an investment project.

[c]Investment refers to the additional investment (CAPEX) resulting from the described project in comparison to an implicit default capital investment that does not specifically aim to achieve CO_2 reduction.

[d]Operational costs refer to the additional, recurring operational costs (OPEX) resulting from the described project in comparison to an implicit default decision that does not specifically aim to achieve CO_2 reduction.

particular car model and comprises all revenues and all costs for that particular car model. Product line management responsibility starts with product development (which takes several years until the start of production [SOP]) and continues through the entire life cycle of the car model. This typically ends around 10 years after SOP, with a product upgrade in between.

At this point, the BMA product line has selected and partly implemented many projects. This has been a great success. Through these projects, it will meet its CO_2 reduction target of 1.5 tons per vehicle at a cost per vehicle of €195. The budget was €200 per vehicle. BMA could stop now and thereby improve its financial results (because its costs are lower compared to implementing further costly initiatives for CO_2 reduction). Alternatively, BMA management can exhaust its complete budget and reduce CO_2 beyond the target. Another product line, 3C4, has been less successful so far. After spending its complete budget of €220 per vehicle, it has only reduced CO_2 by 1.8 tons per vehicle, while the target was 2.0 tons per vehicle.

Julia is still heavily involved in CarCo's investment program for carbon footprint reduction. Management is relying on her to formulate a method for dealing with these overshoot and undershoot situations with various product lines.

TEACHING NOTES

Teaching notes for instructional cases are not published in the journal but are made available to full CAAA member subscribers via the CAAA website. If you are a full member of the CAAA and wish to obtain a copy of the Teaching Notes, log in to http://www.caaa.ca to access and download the notes.

REFERENCES

Kim, H. C., Wallington, T. J., Arsenault, R., Bae, C., Ahn, S., & Lee, J. (2016). Cradle-to-gate emissions from a commercial electric vehicle Li-ion battery: A comparative analysis. *Environmental Science & Technology*, *50*(14), 7715–7722. https://doi.org/10.1021/acs.est.6b00830

Li, X., Li, X., Sun, L., Zhang, Y., Li, Q., Zhu, L., & Wang, L. (2024). Discussion on key issues of carbon footprint accounting for wool products. *Journal of Cleaner Production*, *445*, Article 141336. https://doi.org/10.1016/j.jclepro.2024.141336