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Operations

By Stephan Fuchs, Ruth Heuss, Stephan Mohr, and Jan Rys

Resource cleansheets assess component costs and carbon emissions at the same time—so designers and engineers can model design and production choices without compromising emissions goals.

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Article (9 pages)

CEOs increasingly recognize the green imperative. They understand that in the coming decades, environmental sustainability will drive core aspects of their businesses: financing, product portfolio and design, the supply chain, sales and aftersales, branding, purchasing, and even the production footprint. Beyond setting ambitious targets—such as aiming to be carbon neutral by 2030—some companies are already tying executives' salaries to climate targets.

Yet according to the latest UN Global Compact progress report, less than 25 percent of companies surveyed consider their efforts to mesh climate-change policies into their overall strategies to be on track.[1] But even at companies that have set explicit emission-reduction goals, senior executives tell us that they struggle to balance short-term cost pressures with their longer-term strategic objectives, such as sustainability. For many, making the business case for sustainability remains a tall order.

But action can no longer wait. To meet the 2015 Paris Agreement's global-warming cap, emissions must be halved every ten years until 2050. That is another tall order, given that just between 2000 and 2010, the rate of increase in CO_2 emissions doubled. So how can companies advance their carbon-reduction goals—and their broader sustainability goals—while operating profitably?

There are many avenues for pursuing sustainable strategies, but perhaps the single most powerful one is embedding sustainability into product design, which determines an estimated 80 percent of the future carbon footprint. Until now, such an approach—working with CO_2 life-cycle assessments and "should cost" estimates—was cumbersome. But by integrating robust methods of cost and carbon-emission analysis, a new methodology called "resource cleansheeting" makes it possible.

Cost engineering meets CO_2 analysis

For many years, companies have been able to optimize product and service designs—and identify cost-saving opportunities—using cost engineering, which, when executed well, involves taking a life-cycle view of costs. Cost engineering is about designing and implementing specifications at the lowest total cost of ownership, to balance the design with the costs of procurement, manufacturing and assembly, and in-service support.

Today, thanks to increasingly robust databases, benchmarks, and analytic capabilities, end-to-end costs can be computed with near-surgical precision. More recently, CO_2-footprint analysis has become more widely available, helping companies meet greenhouse-gas (GHG) regulatory targets and reporting requirements.

But the two forms of analysis have their complexities and, importantly, aren't interconnected. Most companies assess carbon emissions at a high-level view to meet company-level reporting requirements. In many cases, those calculations don't include the full sets of emissions (and rarely account explicitly for economic factors). The two sets of analysts are segregated, as well: carbon accounting is typically done by a corporate-sustainability team, whereas product decisions are usually made by engineering and purchasing teams. The latter tend not to consider CO_2 targets end to end; too often, they focus only on product emissions—and only if regulations are in place.

An integrated approach: Resource cleansheeting

Enter resource cleansheeting. The approach capitalizes on the transparency and optimization that bottom-up target costing provides. It allows companies to calculate CO_2 emissions in the same granular way.

Applying the well-established cost-engineering methodology, cleansheeting models the production process from the bottom up to determine the cost drivers associated with each process step—from inputs (such as receiving, checking, and storing materials) to in-house parts manufacturing, assembly, testing, packaging, and outbound transportation. Essentially, it's a matter of combining the direct costs (for input material, labor, equipment, tooling, energy consumption, and yield along the manufacturing process) with indirect costs (from indirect material to capital expenditures, overhead, administration, and onetime cost allocations).

Adding a benchmarked cost for fair margin yields the "should cost"—in other words, what the product should cost if all inputs were at the lowest feasible price. The should cost is then used in cost-engineering analyses, such as design-to-cost and design-to-value, supporting make-or-buy, footprint, and volume decisions, and in supplier negotiations.

Resource cleansheeting follows the same bottom-up analysis workflow for emissions, aggregating all relevant emission factors of the product or service along the value stream. That means gathering data on the full set of emissions corresponding to direct costs, including for upstream activities for purchased goods and services, energy consumption, transportation, direct manufacturing labor, equipment, and tooling. It also means gathering data on the emissions associated with all the indirect costs embedded in the product, such as for overhead, shared facilities, waste from operations, and even employee commuting.

Finally, emissions from downstream activities, such as transportation and storage, are factored in. Engineers can then map the granular product-emissions data into the well-established GHG Protocol classifications of Scopes 1, 2, and 3, which are used by more than 90 percent of Fortune 500 companies for their emissions reporting.

Thus, designers, engineers, and purchasers can identify the factors that affect costs and emissions along the entire value stream of a product or service and throughout its entire life cycle. Using an analytics solution to examine the cost and environmental footprint of a product at each stage of the production process provides greater transparency, enables smarter trade-offs, and informs stronger CO_2-abatement strategies.

The key benefit of resource cleansheeting is that the same bottom-up should-cost model can be reused to roll up the CO_2 emissions along the given value chain, as each material, production, and overhead resource comes with both a financial cost and a CO_2-emission cost. Resource cleansheeting requires only incremental modeling on top of traditional-cost cleansheeting. In addition, the should-cost model, which is usually compiled by the cost-engineering team, can simply be handed over to the sustainability team to rerun with the relevant CO_2 emissions.

Following carbon and cost through the life cycle

Not only can optimization of CO_2 emissions and product cost be analyzed together, but they can also be analyzed at every step of the life cycle, from raw materials and processing to retail and use to recycling or disposal. And because the analysis is done at a granular level, the company can analyze different cycles—not just the full cradle-to-grave life cycle, but also cradle-to-cradle, cradle-to-gate, and even gate-to-gate cycles.

Any optimization initiative can now be based on tangible analysis of the trade-offs in product cost and CO_2 emissions; the impact on emissions of any changes to the product is immediately visible. Such visibility is significant. It's no surprise that different materials have different carbon footprints, but companies can easily overlook the impact of the type of machinery required for their use. They can also easily overlook the related resource investment required for making the machine, the specific power consumption, and the cycle times required for production, all of which can account for a considerable proportion of emissions.

The emissions analysis can also be applied to secondary products, such as packaging, which can actually be sources of more CO_2 emissions than is the product itself. And all existing cost cleansheets can be easily updated with the emissions-analysis add-on, allowing them to optimize for cost and emission competitiveness at the same time.

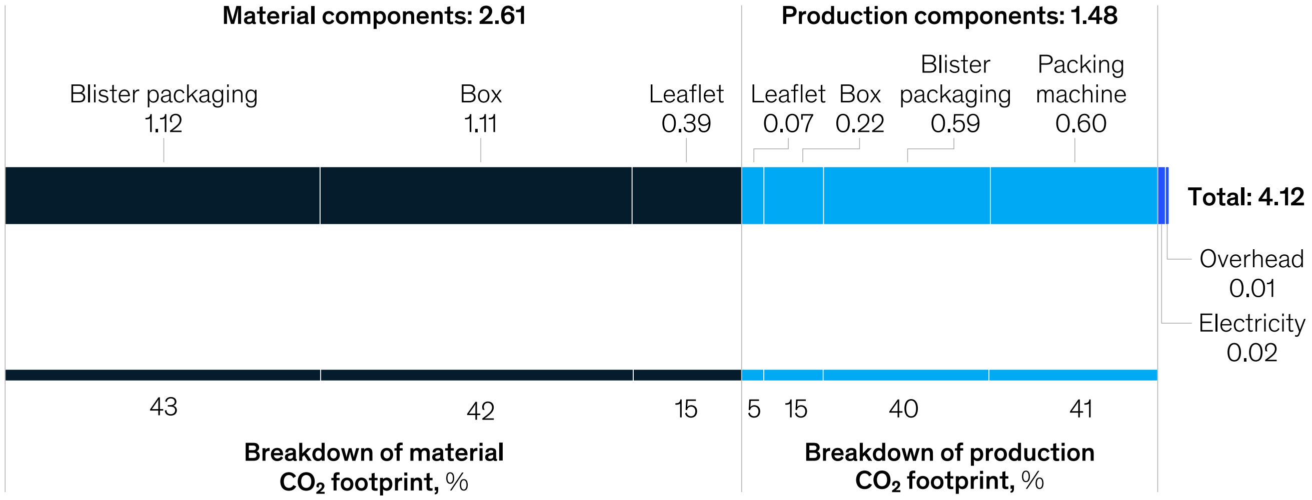
Case one: Decoding the carbon emissions of pain-medicine packaging

To test our integrated analysis, we bought a package of an over-the-counter painkiller at a local pharmacy and analyzed the packaging. The analysis showed that its direct (material-related) CO_2 emissions are higher than those from indirect sources (Exhibit 1). The CO_2 breakdown, along with our cost analysis, revealed that there were opportunities to reduce both CO_2 and product costs.

Exhibit 1

Resource cleansheets increase transparency by breaking down CO_2 emissions into value-stream subcategories.

CO_2 footprint of medication package, kilograms of CO_2 per 100 pieces



Note: Figures may not sum to listed totals, because of rounding.
Source: Resource Cleansheet by McKinsey

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We ran three different scenarios: reducing the box weight by 10 percent, increasing the packaging density (to save box and blister material), and relocating the packaging production to another country (Exhibit 2). The best outcome would result from increasing packaging density. Although it would increase cycle time by 5 percent, it would reduce costs by around 3 percent and CO_2 emissions by around 5 percent.

Exhibit 2

By integrating cost and carbon implications, resource cleansheets aid in comparing carbon-abatement strategies.

3 strategies for carbon abatement of medication package

Cost impact, € per 100 pieces	Original	**Reduce box weight by 10%** New	Change	**Increase tablet density per package** New	Change	**Relocate production** New	Change
Overhead	0.32	0.32	0.00	0.32	0.00	0.18	–0.14
Production	1.38	1.38	0.00	1.40	0.03	1.11	–0.27
Material	1.38	1.31	–0.07	1.27	–0.11	1.37	–0.01
Total	3.08	3.00	–0.07	2.99	–0.09	2.66	–0.42
Net change			**–2.4%**		**–2.8%**		**–13.6%**

CO_2 impact, kilograms of CO_2 per 100 pieces	Original	New	Change	New	Change	New	Change
Overhead	0.01	0.00	–0.01	0.01	0.00	0.01	0.00
Production	1.48	1.47	–0.01	1.51	0.03	1.75	0.27
Electricity	0.02	0.02	0.00	0.02	0.00	0.04	0.02
Material	2.61	2.50	–0.11	2.38	–0.22	2.61	0.00
Total	4.11	4.00	–0.12	3.92	–0.19	4.41	0.29
Net change			**–2.8%**		**–4.7%**		**7.1%**

Abatement cost, € per metric ton of CO_2	Reduce box weight by 10%	Increase tablet density per package	Relocate production
	–583	**–474**	**No abatement**

Note: Figures may not sum to listed totals, because of rounding.
Source: Resource Cleansheet by McKinsey

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Companies can do all sorts of scenario analyses in the product-design phase, looking at the different levers to evaluate trade-offs. An auto manufacturer, for instance, can see what happens when it switches between plant locations, with different levels of automation, power-grid emissions, and logistics costs. It can compare the effects of switching to higher-efficiency production equipment (bearing in mind that it will trigger CO_2 emissions in the production of that new equipment) with those of optimizing design by swapping materials or thinning out a component. The procurement team can analyze the full round-trip impact of buying parts from a supplier in a developing economy versus one in a developed economy. And supply-chain managers can weigh the trade-offs between using a higher-cost supplier with old machinery and using a lower-cost supplier with new equipment.

Resource cleansheets thus give companies a granular, bottom-up means of optimizing costs and CO_2 abatement. By making drivers transparent, they help managers readily identify reduction initiatives and define different scenarios based on the effects of variations in sequencing.

The drug manufacturer of the over-the-counter painkiller we analyzed, for instance, could use the analysis to decide that the greatest impact would result from changing its supplier of recycled pulp for cardboard packaging. It could then develop initiative road maps with short-, medium-, and long-term milestones and track progress in cost reduction and CO_2 abatement along the value chain. Cleansheet analysis allows companies to understand not only cost drivers but also dependencies, while enabling trade-off analysis for every design feature and production resource.

Case two: Prioritizing abatement options for a coffee maker's plastic part

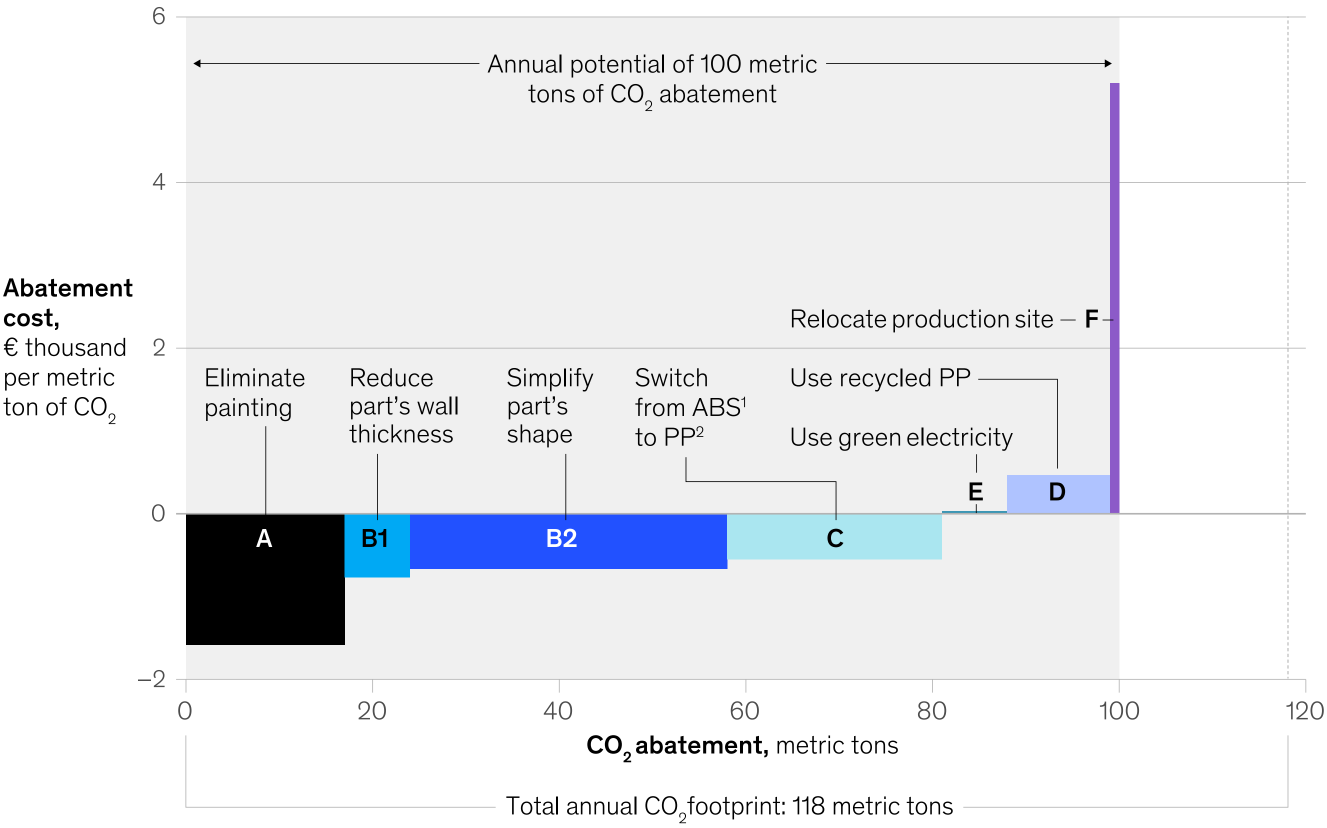
Testing of an injection-molded plastic part for the filter housing of a coffee machine also highlights potential CO_2-abatement and cost-reduction opportunities through a set of initiatives targeting direct and indirect emission sources. We assume that every year, 150,000 pieces of this small-appliance part are manufactured in acrylonitrile butadiene styrene (ABS) in batches of roughly 12,500 pieces. The manufacturing plant is located 1,000 kilometers from the company's main factory, where assembly and distribution take place.

Step one in the cleansheeting exercise calls for creating a cost and carbon-emissions model of how the part is currently designed and produced. Exhibit 3 shows the abatement costs and potential of seven levers: eliminating the need to paint by using molded-in color, optimizing design by reducing the wall thickness, optimizing design by simplifying the shape, switching to polypropylene (PP), using recycled PP, using a higher mix of green electricity in manufacturing, and relocating the production site. The x-axis reflects the CO_2-reduction potential of each lever. Levers A, B (split into two possible design optimizations), and C are win–win measures: both costs and CO_2 are reduced. Levers D, E, and F ultimately reduce CO_2 but require an initial investment that increases emissions at first. Together, the seven measures could cut CO_2 emissions by 85 percent annually—to 18 metric tons, from 118 metric tons.

Exhibit 3

A carbon-cost curve for an injection-molded part can prioritize initiatives according to their carbon-abatement and cost implications.

Up to 85% of annual CO_2 emissions could be abated through 7 initiatives



[1]Acrylonitrile butadiene styrene.
[2]Polypropylene.
Source: Resource Cleansheet by McKinsey

Exhibit 4 tallies the CO_2-abatement cost of each initiative, and the reason for careful sequencing becomes clear. Lever D (using recycled PP), viewed on its own, appears to have a negative CO_2-abatement cost. But it does so only when viewed in isolation, assuming a starting point of a part made from ABS. ABS is more expensive than recycled PP, so there's an apparent savings. But recycled PP is, in turn, more expensive than conventional PP. So if the company first makes the switch from ABS to PP (lever C), the later switch to recycled PP in lever D will cost more. Likewise, the abatement cost of relocating the production site (lever F) is dramatically lower when viewed in isolation, as shown in Exhibit 4, than when applied as the final lever in the sequence, as shown in Exhibit 3.

Exhibit 4

For every initiative, a resource cleansheet can calculate the impact on product cost and CO_2 emissions.

Emission reduction for injection-molded part can be achieved throughout value chain

Initiatives		Cost impact, € per 100 pieces	CO_2 impact, kilograms of CO_2 per 100 pieces	Abatement cost, € per metric ton of CO_2
A	Eliminate need to paint by using molded-in color	–18.1	–11.4	–1,589
B1	Optimize design by reducing wall thickness by 20%	–3.5	–4.6	–765
B2	Optimize design by simplifying shape	–15.3	–23.0	–665
C	Switch from ABS[1] to polypropylene	–17.2	–30.3	–567
D	Use recycled polypropylene	–9.8	–46.3	–212[2]
E	Use green electricity	0.1	–9.5	14
F	Relocate production site	11.5	–10.3	1,123

[1]Acrylonitrile butadiene styrene.
[2]Considering a switch from ABS to recycled polypropylene.
Source: Resource Cleansheet by McKinsey

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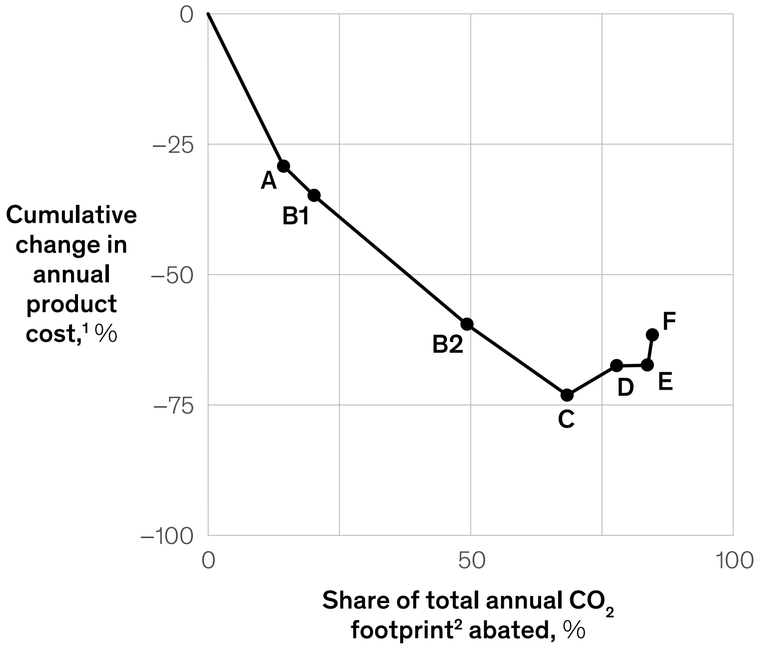
From there, the company can break down the impact of the abatement initiatives on product costs, tweaking the figures to understand the impacts when a parameter is changed (Exhibit 5). The initiatives should be undertaken in order of business priority; the order is important, of course, because of the interdependencies.

Exhibit 5

Resource cleansheets reveal product-cost evolution and corresponding CO_2-abatement potential.

Product-cost reduction depends on sequencing of initiatives and strategic business priorities



Initiatives

- **A** Eliminate painting
- **B1** Reduce part's wall thickness
- **B2** Simplify part's shape
- **C** Switch from ABS[3] to PP[4]
- **D** Use recycled PP
- **E** Use green electricity
- **F** Relocate production site

[1]Annual product cost = €93,000.
[2]Total annual CO_2 footprint = 118 metric tons.
[3]Acrylonitrile butadiene styrene.
[4]Polypropylene.
Source: Resource Cleansheet by McKinsey

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The resource cleansheet not only applies to consumer and medical companies but also provides insights across many other sectors. An automotive manufacturer, for example, could see the impact of using plastic instead of steel to manufacture body covers. Or an industrial-component manufacturer could evaluate high-efficiency, synchronous electric motors that use neodymium magnets versus conventional, low-efficiency asynchronous motors.

Along the value chain

Resource-cleansheet analysis can be put to use all along the value chain. In procurement and supply chain, the approach promotes the use of suppliers that follow more sustainable practices, and it can incentivize other suppliers to seek more carbon-conscious production methods. Both the enhanced transparency and the granular visibility of costs enables senior management to integrate sustainability across the enterprise. Marketing and sales can promote the company's achievements to boost brand perception—and, in some cases, to earn a premium.

The transparency that resource cleansheets enable gives companies a new level of flexibility. And it's present not just at the initial design or redesign phases but also when there's a need to change suppliers or make any change at any point in the value chain. Iteration and refinement aren't nearly as cumbersome, costly, or risky.

By creating an immediate, visible link between product cost and CO_2 emissions, companies can identify the most important levers that will yield the greatest savings and implement those first. They can analyze the impact as a trade-off between the CO_2 footprint, profit margin, and customer value. That enables companies to capture the most value based on their own requirements—to make strategic decisions based on the long-term riskmitigation potential and available resources. In this way, companies gain competitive advantage in their green-design strategies.

Beyond supporting regulatory compliance and goals, resource cleansheeting has the potential to spur innovation in energy efficiency, whether in materials, processes, or logistics. As more companies employ such a transparent, integrated approach, the pressure will grow on suppliers, outsourcing companies, energy producers, and other input providers to seek more eco-conscious practices. With incremental effort, resource cleansheets can be extended beyond CO_2 emissions to additional environment, social, and governance factors, such as water consumption, waste generation, hazardous-materials use, and other GHG emissions.

Since 2017, the European Union's sustainability policy has required many companies to report their environmental strategies. At the same time, leading market-listed companies are increasingly codifying their commitment to greener practices over the coming decades, as stakeholders demand greater transparency and documentation of companies' carbon footprint. Apart from the implications for compliance and customer demand, lagging in sustainability efforts has real consequences: our colleagues' research has found that companies without an environment, social, and governance strategy risk a double-digit decline in earnings before interest, taxes, depreciation, and amortization.

Using an integrated cost- and resource-cleansheeting approach can move organizations forward, from a best-guess calculation to a methodical and sound assessment that is built on transparency and flexibility. That assessment gives them the agility they need to be good stewards and still compete profitably in a rapidly changing business environment.

1. *Uniting business in the decade of action: Building on 20 years of progress*, United Nations, January 2020, unglobalcompact.org.

ABOUT THE AUTHOR(S)

Stephan Fuchs is a practice expert in McKinsey's Munich office, where **Stephan Mohr** is a partner; **Ruth Heuss** is senior partner in the Berlin office; and **Jan Rys** is a consultant in the Zurich office.

The authors wish to thank Ann-Sophie Ahlers, Katharina Bäuerlein, Piotr Cependa, Mauro Erriquez, Eric Hannon, Bernd Heid, and Peter Spiller for their contributions to this article.

This article was edited by Christian Johnson, an editor in the Hong Kong office.