Science#based analysis for climate action: how HSBC Bank uses the En#ROADS climate policy simulation

NOTES AND INSIGHTS

Science-based analysis for climate action: how HSBC Bank uses the En-ROADS climate policy simulation

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Introduction: ambitious climate action from businesses

In 2018, the Intergovernmental Panel on Climate Change (IPCC, 2018) found that rapid decarbonization and net negative greenhouse gas (GHG) emissions by mid-century are required to "hold the increase in global average temperature to well below 2 °C above pre-industrial levels and pursue efforts to limit the temperature increase to 1.5 °C," as stipulated by the Paris Agreement (UNFCCC, 2015, p. 2). Meeting these goals reduces physical climate-related risks from, for example, sea-level rise, ocean acidification, extreme weather, water shortages, declining crop yields, and other impacts.[i] These impacts threaten our economy, security, health, and lives.[ii]

At the same time, policies to mitigate these harms by rapidly reducing GHG emissions can create transition risks for businesses—for example, stranded assets and loss of market value for fossil fuel producers and firms dependent on fossil energy (Carney, 2019). Rapid decarbonization requires an unprecedented energy transition (IEA, 2021a) driven by and affecting economic players including businesses, asset managers, and investors in all sectors and all countries (Kriegler *et al.*, 2014).

However, GHG emissions are not falling rapidly enough to meet the goals of the Paris Agreement (Holz *et al.*, 2018). The UNFCCC, 2021 found that the emissions reductions pledged by all nations as of early 2021 "fall far short of

[i]Physical risk includes the effects of severe climate-change-related weather events that can be either acute (e.g. damage to physical infrastructure from a storm) or chronic (e.g. reduced agricultural yield due to ongoing droughts).

[ii]Recent studies that seek to quantify climate value at risk—"the size of loss on a portfolio of assets over a given time horizon, at given probability" (Dietz *et al.*, 2016, p. 676)—include Bos and Gupta (2019), Dietz *et al.* (2016), Goldstein *et al.* (2019), McKinsey Global Institute (2020), Sen and von Schickfus (2020), and The Economist Intelligence Institute (2015). For example, Dietz *et al.*'s, 2016 study estimates a climate value at risk of global financial assets of US$2.5 trillion under a business-as-usual scenario. McKinsey's 2020 study, which assesses risks for certain regions, estimates that the average number of lost daylight working hours in India from increased temperatures could increase to the point where between 2.5 and 4.5 percent of GDP is at risk.

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what is required, demonstrating the need for Parties to further strengthen their mitigation commitments under the Paris Agreement" (2021, p. 5). Businesses are faring no better. Despite high-profile calls to action from influential firms such as BlackRock (Fink, 2018, 2021), corporate action to meet climate goals has thus far fallen short (e.g. the Right, 2019 analysis of the German DAX 30 companies' emissions targets by NGO "right."). Instead of implementing climate strategies that might mitigate the risks, managers are often caught up in "firefighting" and capability traps that erode the resources needed for ambitious climate action (Sterman, 2015). Firms may also exaggerate environmental accomplishments, leading to greenwashing (Lyon and Maxwell, 2011); implement policies that are vague, rely on unproven offsets, or are not climate neutral (e.g. Sterman *et al.*, 2018); or simply take no action at all (Delmas and Burbano, 2011; Sterman, 2015).

Adding to the confusion are difficulties evaluating the effectiveness of different climate policies. Misperceptions include wait-and-see approaches (Dutt and Gonzalez, 2012; Sterman, 2008), underestimating time delays and ignoring the unintended consequences of policies (Sterman, 2008), and beliefs in "silver bullet" solutions (Gilbert, 2009; Kriegler *et al.*, 2013; Shackley and Dütschke, 2012). These beliefs arise in part because the climate–energy system is a high-dimensional dynamic system characterized by long time delays, multiple feedback loops, and nonlinearities (Sterman, 2011), while even simple systems are difficult for people to understand (Booth Sweeney and Sterman, 2000; Cronin *et al.*, 2009; Kapmeier *et al.*, 2017). Although senior executives might receive briefings on climate change, simply providing more information does not necessarily lead to more effective action (Pearce *et al.*, 2015; Sterman, 2011).

Alternatively, interactive approaches to learning about climate change and policies to mitigate it can trigger climate action (Creutzig and Kapmeier, 2020). Decision-makers require tools and methods grounded in science that enable them to learn for themselves how a low-carbon economy can be achieved and how climate policies condition physical and transition risks. The system dynamics climate–energy simulation En-ROADS (Energy-Rapid Overview and Decision Support; Jones *et al.*, 2019b), codeveloped by the climate think-tank Climate Interactive and the MIT Sloan Sustainability Initiative, provides such a tool.

Here we show how En-ROADS helps HSBC Bank U.S.A., the American subsidiary of U.K.-based multinational financial services company HSBC Holdings plc, focus its global sustainability strategy on activities with higher impact and relevance, communicate and implement the strategy, understand transition risks, and better align the strategy with global climate goals. We show how the versatility and interactivity of En-ROADS increases its reach throughout the organization. Finally, we discuss challenges and lessons learned that may be helpful to other organizations.

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En-ROADS supporting corporate decision-making on climate action

En-ROADS is grounded in state-of-the-art climate and energy science and is fully documented and freely available via Climate Interactive's (2021a) website. It is calibrated against historical data (e.g. BP, 2019; IEA, 2021a; IRENA, 2020; Lazard, 2020) and to future scenarios generated by large climate models, including the Integrated Assessment Models (Calvin *et al.*, 2017; Fricko *et al.*, 2017; Fujimori *et al.*, 2017; Kriegler *et al.*, 2017; van Vuuren *et al.*, 2017). Since its launch in December 2019, more than 81,000 people in 86 nations have participated in interactive briefings or role-play simulations using En-ROADS, including over 1000 business leaders (including C-suite executives and investor groups), more than 150 elected officials (including senators, governors, and state legislators) and 200 congressional staff members in the United States, and dozens of leaders at nonprofits and foundations around the world (as of November 2021).

Its interactive design enables En-ROADS users to explore a wide range of assumptions, policies, and actions as they create their own scenarios (Figure 1). En-ROADS can be used in multiple modes, including the Climate Action Simulation (Rooney-Varga *et al.*, 2020), a role-playing game in which participants take the roles of global stakeholders at a mock UN climate summit and negotiate agreements to mitigate climate change, and the En-ROADS Climate Workshop (Jones *et al.*, 2018), an interactive group learning experience. Both are well-suited for use in companies.

En-ROADS at HSBC Bank U.S.A.

HSBC supports the objectives of the Paris Agreement (UNFCCC, 2015) and is committed to the transition to a low-carbon economy through its climate change and sustainable financing strategy (HSBC, 2020a, 2020b). To deliver its commitments, the bank's corporate-sustainability function uses a variety of tools and methods, among which En-ROADS has a central position. In the following, we show how HSBC uses En-ROADS to improve employee understanding of the risks of climate change, particularly transition risks, and catalyze action at senior levels. En-ROADS stimulates dialogue on sustainability and fosters collaboration on climate change with partners and across industries. To date, more than 2600 HSBC employees across different organizational levels and regions have experienced En-ROADS, with more than 300 in En-ROADS workshops and over 2300 as part of a risk-management training.

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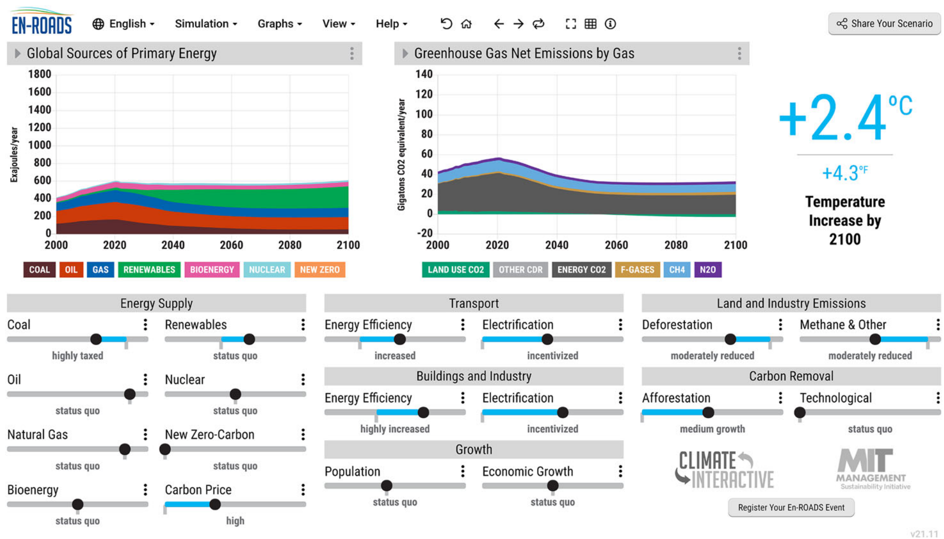

Fig 1. En-ROADS interface showing the sources of energy and their pathways from 2000 until 2100 (upper left) and the greenhouse gas emissions by gas (upper right). On the bottom, users can set the sliders for 18 policy and action levers affecting energy supply; end use in transport, buildings, and industry; economic and population growth; emission from land use; emissions of non-CO2 GHGs, and CO2 removal technologies. Assumptions can be changed via the "Simulation" menu. Every time a lever is "pulled," En-ROADS displays the results in less than a second. The scenario shown is hypothetical and not intended to represent a desirable pathway. *Note*: All scenarios in this article were created with En-ROADS v. 21.11. [Color figure can be viewed at wileyonlinelibrary.com]

Speaking climate: using En-ROADS to build understanding of the climate–energy system

En-ROADS Climate Workshops at HSBC run for approximately 1 hour. Workshops begin with a brief grounding in climate science and risks and a demonstration of the model before moving into interactive exploration using En-ROADS. Employees relate HSBC's climate commitments to levers in En-ROADS and mentally simulate and express their thoughts about the possible effect on climate change if the bank's commitments were achieved at global scale. A facilitator then runs the model, exploring the results together with the group. The workshop closes with a debrief in which participants discuss their insights and share their reactions and feelings, which evaluative research has found to be an important contributor to its impact (Rooney-Varga *et al.*, 2018).

Post-workshop evaluations show that participants feel more confident in their ability to "speak climate," better understand HSBC's sustainability commitments, and are more energized and inspired to take climate action. Interactive exploration through En-ROADS enables people to develop their own scenarios and reflect on the implications and impacts of different policies,

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stimulating their thinking about HSBC's and their own role in solutions. Because En-ROADS is transparent and grounded in the latest scientific research, the debate and discussion around corporate action are strengthened. These outcomes arise through the collaborative learning process that En-ROADS fosters. Facilitators "hand over" En-ROADS to the participants so they can learn together with colleagues across the organization, enabling them to debate and challenge their assumptions about climate change.

Since engagement with En-ROADS began in May 2018, originally with a development version, more than 300 HSBC employees at different organizational levels and functions within HSBC in the United States, the United Arab Emirates, France, and Germany have participated in 30 intensive En-ROADS workshops. These workshops help elevate the priority of sustainability work within these areas, particularly at senior levels. Bespoke En-ROADS sessions held with members of the C-suite and their direct reports help embed sustainability thinking in their business units and functions, connect their work to HSBC's sustainability strategy, and ensure that relevant messaging cascades through their units. Participants explore the bank's commitments relevant to their roles using En-ROADS. For example, following a discussion about the effect on global warming of energy efficiency and renewables, the Chief Operating Officer and the Head of Corporate Real Estate were better able to express to each other the importance of the bank's objective to reduce emissions from energy use in its offices and data centers.

Working with En-ROADS helps HSBC employees understand the urgency of large emissions cuts and how different actions connect to specific elements of HSBC's sustainability strategy. For example, improving energy efficiency and reducing GHG emissions from its operations is an important component of the bank's strategy to achieve net zero GHG emissions. En-ROADS workshop participants explore how much faster efficiency and the electrification of the built environment must improve, globally, along with other actions, to achieve the Paris climate goals. En-ROADS workshops are tailored to the goals and responsibilities of the participants to foster deeper discussions on aspects of climate change that are of particular relevance to them. For example, participants in a session with credit-risk managers and bankers who manage power-sector clients explored the effect of taxes, subsidies, regulations, and market conditions on existing fossil fuel infrastructure and the risk of stranded assets. They also examined the impact of technological breakthroughs that could reduce the cost of carbon capture and storage technologies. Another session with members of the strategy team explored carbon-price scenarios with different carbon prices and phase-in schedules, helped them assess how they could reduce the bank's exposure to the resulting transition risks in carbon-intensive sectors, including stranded assets, loss of market value, write-downs, and increases in nonperforming loans.

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Engaging beyond climate: using En-ROADS to stimulate dialogue on related themes

HSBC and other large corporations consider a variety of sustainability challenges and opportunities beyond the physical impacts of climate change, including the economic impacts of climate change, the social co-benefits of climate action, and the climate implications of the COVID-19 pandemic. En-ROADS supports exploration of these themes.

The COVID-19 pandemic changed global patterns of energy demand, leading to CO_2 emissions reductions of 17 percent in the first half of April 2020 (Le Quéré *et al*., 2020), which was then followed by a substantial rebound toward prior levels and is expected to climb to record highs in 2021 (IEA, 2021b). Clearly, disease, death, and economic depression are not acceptable ways to cut emissions. Instead, the terrible toll of the pandemic should foster policies for recovery that simultaneously promote a healthy environment, a healthy society, and a healthy economy (Sterman, 2020). Many initiatives to "build back better" take this approach (Climate Interactive, 2021b; United Nations, 2020; World Bank, 2020). While the model is not detailed enough to capture the specifics of all such actions, En-ROADS helps people explore how they might affect the climate–energy system. HSBC facilitators relate different pandemic recovery proposals to policy options in En-ROADS. For example, the German stimulus package (approximately €130 billion) includes at least €40 billion in climate-related action (Bundesministerium für Finanzen, 2020), including funding for public transport (in En-ROADS: increase efficiency in transport), energy efficiency in buildings (increase energy efficiency in and electrification of buildings and industry), renewable energy (increase subsidies for renewables), clean tech innovations for the automotive sector and infrastructure for electric vehicles (increase electrification in transport), and forest management (increase afforestation). In the United States, COVID-relief legislation passed in December 2020 and March 2021, and new proposals for infrastructure now debated in Congress include a range of climate policies such as tax credits for renewable energy projects, a clean electricity standard, hydrofluorocarbon phaseouts, and policies to reduce the disproportionate environmental harms to communities of color (U.S. Congress, 2021a, 2021b).

Asking participants to reflect on their feelings in the debrief revealed that most were more hopeful and optimistic about a post-COVID world than they felt before. One participant was inspired to run for a seat in her county government following her experience with En-ROADS.

HSBC also uses En-ROADS in workshops to test the latest climate-solution headlines for scientific rigor to better understand their potential impact on the climate. For example, Bastin *et al*. (2019a, 2019b, 2020) claimed that afforestation is "among the most effective strategies for climate-change mitigation" (Bastin *et al*., 2019b, p. 76). Their work received significant media attention (Parker, 2019) and led to the "Trillion Tree Campaign—a plan to

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plant a trillion trees" (Plant-for-the-Planet Foundation, 2020). To address the potential of afforestation in climate-change mitigation, HSBC uses Jones *et al.*'s (2019a) and Sterman and Kapmeier's (2020) En-ROADS analyses of afforestation (Figure 2). They found that aggressive afforestation has limited climate benefits due to the long time required for newly planted trees to grow large enough to remove significant amounts of CO_2 from the atmosphere (Figure 2a). Although trees provide many benefits, aggressive afforestation reduces expected global average surface temperature by only 0.1 °C by 2100 compared to the baseline (Figure 2c). Further, the land required to reforest on the scale Bastin *et al.* suggest is about 2.8 times the size of India (Figure 2d), raising questions about feasibility and the potential impacts on people who depend upon that land for agriculture and other uses.

Participants in En-ROADS workshops often ask how much the transition to an emissions pathway consistent with 1.5–2 °C would cost. Some believe that the costs are prohibitive and conclude that it is not worth acting upon or that, despite the urgency, policymakers will never act. En-ROADS workshops foster discussion of these concerns.

The costs of reducing GHG emissions must be weighed against the costs of the physical damage caused by climate change. These include significant harms to health, life expectancy, and economic output through declining crop yields, rising sea levels, more extreme weather, ocean acidification, and other impacts (IPCC, 2019a, 2019b). Integrated assessment models capture these harms through a "damage function" that reduces GDP as warming increases. Estimates of the damage function vary substantially (Burke *et al.*, 2015; Dietz and Stern, 2015; Nordhaus, 2017; Weitzman, 2012). En-ROADS allows users to choose damage functions that span the range in the literature, and to test their own assumptions, then immediately see the resulting net present value of the lost output through 2100 and the social cost of carbon—the economic loss caused by each ton of CO_2 emitted (Figure 3) that shows how much can be spent to reduce global GHG emissions with the benefits outweighing the costs.

The other significant uncertainty in cost–benefit discussions is the cost of emissions reductions. The costs of climate-friendly technologies such as wind power, solar power, storage, and electric vehicles have fallen dramatically, processes included endogenously in En-ROADS. More importantly, many policies to reduce GHG emissions generate "co-benefits" that improve economic welfare (Bain *et al.*, 2016; Smith *et al.*, 2016; Watts *et al.*, 2021). Sawin (2018) defined the term *multisolving* to describe actions that reduce GHG emissions and generate co-benefits including near-term job creation, better health, increased community resilience, and greater social and environmental justice. Multisolving reduces mitigation costs, and in some cases, outweighs them (Epstein *et al.*, 2011; Markandya *et al.*, 2018; National Academies, 2021; WHO, 2018), e.g. with health co-benefits outweighing mitigation costs by a ratio of 1.4 to 2.45 (Markandya *et al.*, 2018). For example,

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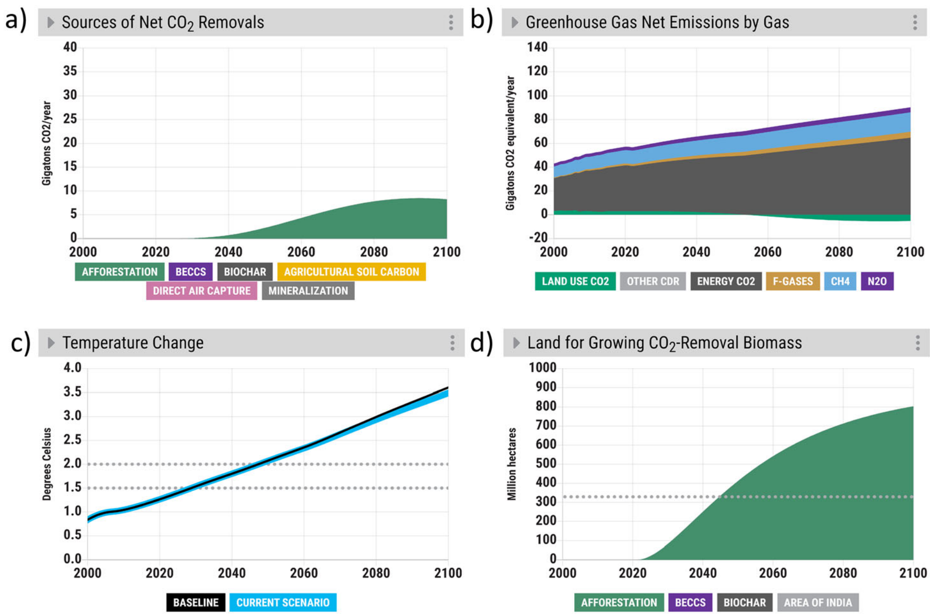

Fig 2. Impact of aggressive afforestation and reforestation program in En-ROADS assuming "Percent available land for afforestation" = 100% and "Max available land for afforestation" = 900Mha, as suggested by Bastin *et al.* (2019). (a) CO2 removals from afforestation; (b) GHG emissions by gas, showing afforestation program causes negative emissions from forestry and land use by midcentury; (c) Temperature change: baseline in black, impact with afforestation in blue; (d) Land required for growing the trees in green, compared to the land area of India (dotted line). For deeper critical analysis of Bastin *et al.*'s suggestion, see Sterman and Kapmeier (2020). Link to scenario: https://en-roads.climateinteractive.org/scenario.html?v=21.10.0&p65=100&p214=900&g0=117&g1=63. [Color figure can be viewed at wileyonlinelibrary.com]

lower coal production immediately improves air quality, indicated by $PM_{2.5}$ emissions in En-ROADS, benefiting all, especially historically disadvantaged people who are disproportionately likely to live near power plants and other $PM_{2.5}$ sources (Tessum *et al.*, 2021). Multisolving is increasingly relevant to the financial industry demands for ESG investing grow. The multisolving lens in En-ROADS workshops draws some of the highest levels of engagement. Participants often ask how they can bring En-ROADS to other audiences, including their towns, faith communities, and children's schools.

Using En-ROADS for deeper climate-risk assessment

En-ROADS can also be used for transition-risk analysis. Transition risk captures the financial risks to businesses arising from actions that accelerate the transition to zero or net negative emissions (Carney, 2019). Most obviously, the physical assets of fossil fuel companies can become stranded. Further, businesses and value chains that are dependent, directly or indirectly, on

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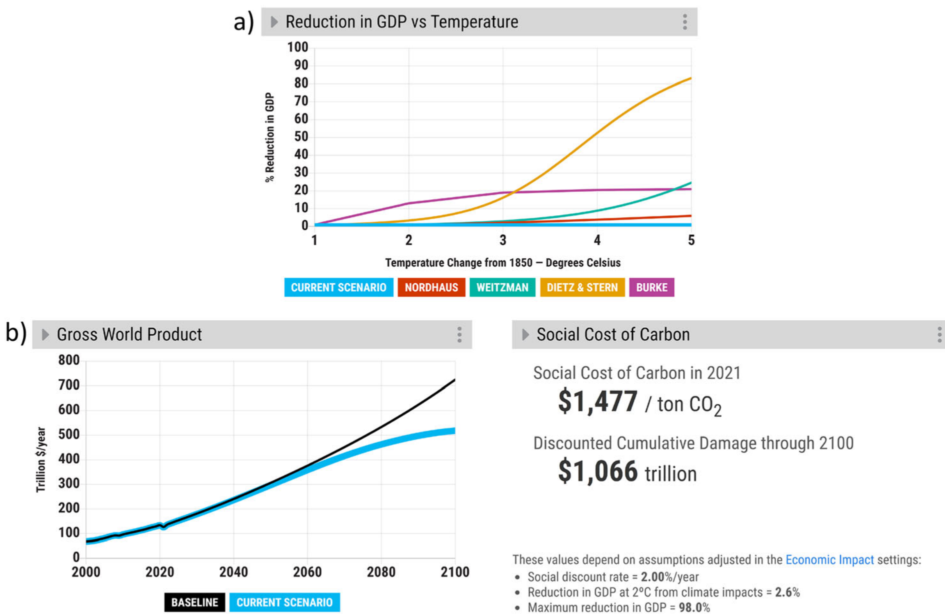

Fig 3. Damage functions as represented in En-ROADS. Panel (a) shows reduction in GDP over an increase in temperature, according to the different estimates (Burke *et al.*, 2015; Dietz and Stern, 2015; Nordhaus, 2017; Weitzman, 2012). Users can also choose and create their own damage function. Panel (b) shows the reduction in Gross World Product over time from climate impacts according to the chosen damage function (here Dietz and Stern, 2015 in current scenario, assuming the widely used social discount rate of 2%/year (Drupp et al., 2018)) against baseline (left) and the discounted cumulative damage until 2100 and the related social cost of carbon (right). Link to scenario: https://en-roads.climateinteractive.org/scenario.html?v=21.10.0&p243=2.6&p242=98&p252=2&g0=54&g1=139. [Color figure can be viewed at wileyonlinelibrary.com]

fossil fuels or existing regulatory frameworks, such as those governing electric power production, distribution, and pricing, are at risk of disruption.

Because of the positive experience with En-ROADS workshops, HSBC embedded En-ROADS in a global transition-risk training required for over 2300 bankers and credit-risk managers over a two-month period in mid-2021. The training begins with a 10-minute En-ROADS simulation in which facilitators show the impact of increased transport electrification to initiate the discussion of transition risks to an automotive supplier, including regulatory risk (policy mandates phasing out internal combustion), technology risk (adoption of disruptive technologies as the industry electrifies), and end-user-demand risk (changing consumer preference for electric and hybrid-electric vehicles) to illustrate how a Paris-aligned scenario affects specific transition risks affecting the bank's clients in carbon-intensive sectors.

En-ROADS can be used to explore transition risks more deeply. While all emissions pathways consistent with the Paris climate goals require rapid

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decarbonization, different policies are consistent with those goals (e.g. Holz *et al.*, 2018). Pathways consistent with warming of 1.5–2 °C differ in the mix of low and zero emissions energy, energy efficiency, and "negative emissions" from forests or carbon dioxide removal technologies and in the policies and regulations required to achieve those results. The transition risks in a scenario emphasizing end-use efficiency and electrification may differ from one emphasizing a high carbon price or one emphasizing incentives and subsidies to accelerate the deployment of renewables.

For example, Figure 4 shows two examples of emission paths for a shared socioeconomic pathway 4.5 scenario (Riahi *et al.*, 2017), with the graphs in each panel showing the energy mix (upper left) and the demand for natural gas (upper right). Both scenarios have the same basic policies in place regarding land use and other GHGs. Scenario 1 (Figure 4a) also includes a carbon price of US$110/ton, phased in over 10 years. As the carbon price increases, the demand for and price of all fossil fuels, including gas, decreases (left graph). Gas demand is much lower than in the baseline. In contrast, Scenario 2 (Figure 4b) shows a rapid phaseout of coal with increases in energy efficiency and electrification. Here, demand for gas increases above the baseline for decades as it is substituted for coal.

While expected warming by 2100 is the same in both scenarios, the different policies yield a significantly different energy demand and supply mix, with different impacts on particular economic sectors and their businesses. The rapid decline in natural gas and resulting low prices in Scenario 1 would erode the value of gas resources and infrastructure, leading to stranded asset losses (Bos and Gupta, 2019; Dietz *et al.*, 2016). However, in Scenario 2 natural gas demand increases, leading to greater profitability and value for gas assets for the next 10 to 20 years. En-ROADS Pro, the proprietary version of the model, captures the likely financial impacts of different pathways, including the operating income of different industry sectors and other variables not available in the online version. Managers who understand that two pathways yielding the same end-of-century temperature might have vastly different financial risks and outcomes over the next few decades will be better able to assess transition risks for their firm's lending or investment portfolio.

Using En-ROADS to collaborate across companies

The path toward a sustainable future requires collaboration (Henderson, 2020) and knowledge sharing within and across industries. En-ROADS offers companies an opportunity to engage with other firms, nongovernmental organizations, universities, and governments.

HSBC uses En-ROADS to collaborate with clients and other external stakeholders. HSBC's facilitators provide tutorials on En-ROADS and demonstrate systems thinking to help these partners better understand how their

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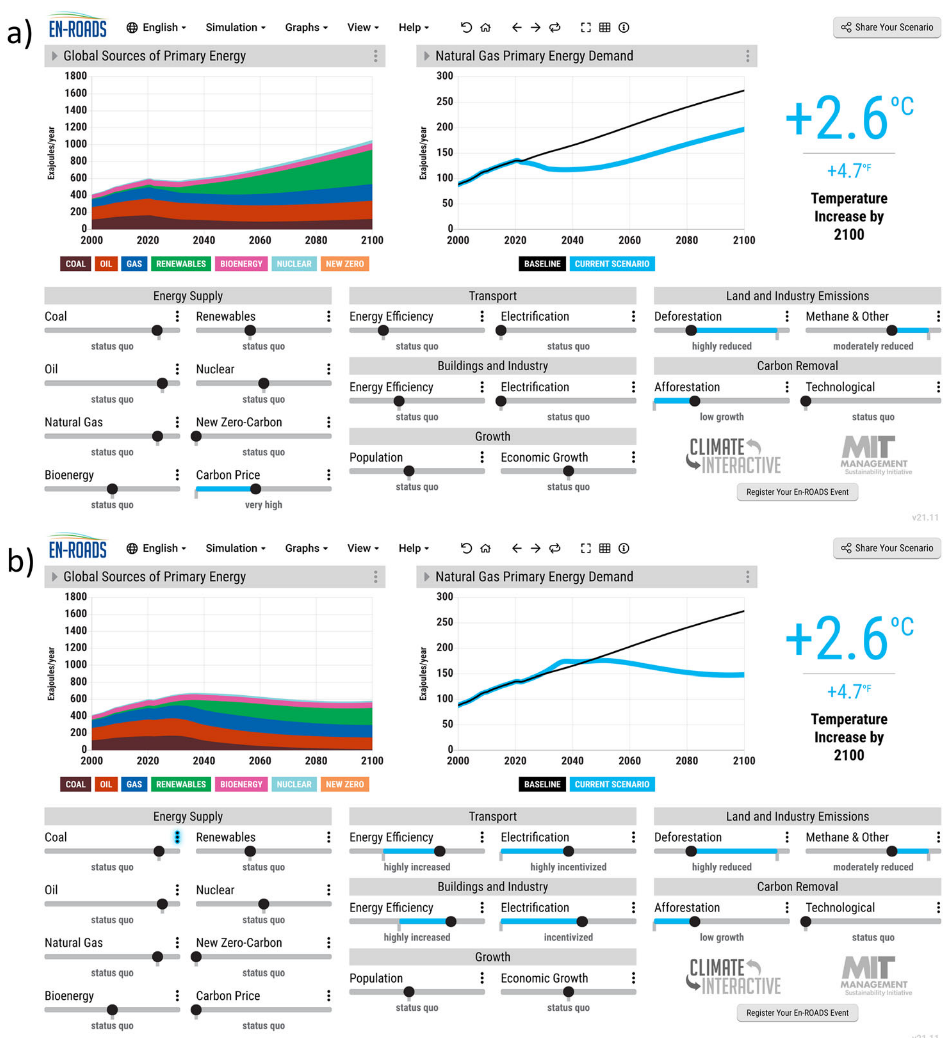

Fig 4. Different policies and actions in a shared socioeconomic pathway (SSP) 4.5 scenario to decrease temperature with different business impacts. Similar assumptions in both scenarios including reductions in deforestation, methane and other GHGs, and afforestation. Additional assumptions: (a) Carbon price" = \$110/tCO2. Link to scenario: https://en-roads.climateinteractive.org/scenario.html?v=21.10.0&p1=2&p39=110&p57=-7&p59=-30&p65=30&g0=2&g1=7. (b) "Stop building new coal infrastructure" = Yes, "Transport energy efficiency" = 3.0%/year, "Electrification of new transport—road and rail" = 50%, "Buildings and industry energy efficiency" = 3.5%/year, "Electrification of new buildings and industry" = 60%. Link to scenario: https://en-roads.climateinteractive.org/scenario.html?v=21.10.0&p211=1&p47=3.5&p50=3&p53=50&p55=60&p57=-7&p59=-30&p65=30&g0=2&g1=7. [Color figure can be viewed at wileyonlinelibrary.com]

sustainability strategies align with the Paris Agreement, reduce emissions, and address climate risks. These joint sessions build agreement on climate science, inform what is possible throughout the value chain between clients

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and suppliers, and align their relationships more closely with the bank's climate goals. HSBC also facilitates events at various industry forums, sharing its expertise, stimulating dialog on sustainability, and building capability. For example, an HSBC facilitator led a World Climate Simulation with 150 energy professionals at the 2019 World Energy Congress in Abu Dhabi, as well as an En-ROADS Climate Workshop, which earned the highest ratings among 111 events in a participant survey, at GreenBiz 2020, the premier event for sustainability professionals in the United States.

Discussion

Interactions with En-ROADS at HSBC catalyze greater insights into the climate–energy system, greater understanding of HSBC's engagement on climate action, and optimism about what is possible for climate-change mitigation. HSBC employees now better understand how financial products can help the organization meet its environmental and social goals (e.g. green bonds and sustainability-linked loans). They are also more aware of the linkages between climate and credit risk. En-ROADS has provided a way for bankers to contextualize business opportunities on climate solutions and how they may fit within HSBC's strategy and the bank's appetite for risk. For example, HSBC has entered a joint venture to build the world's leading natural capital-asset manager and has launched a technology venture debt fund to support cleantech innovation.

HSBC's Corporate Sustainability team has worked through a number of challenges in the process of integrating En-ROADS into its training. The lessons may be relevant to other firms seeking to use En-ROADS.

First, senior-management endorsement is vital. The Corporate Sustainability team pursued senior sponsorship with many, but not all, members of the executive committee. Those who participated generally provided explicit support for En-ROADS workshops in their businesses and functions, but that did not transfer to other areas, limiting the number of employees reached. Outreach to all senior leaders early in the process is recommended. That could take the form of additional small-group sessions with senior leaders or a joint session with the full executive committee and the head of learning and development.

Second, we recommend companies intending to use En-ROADS identify the appropriate human resources and allow for a considerable time commitment. At HSBC, the iterative and time-intensive learning process from pilot to the rollout took approximately 18 months. One HSBC facilitator, supported by the team at Climate Interactive, led a series of pilot workshops with five to 30 staff in relevant functions, revising the session structure based on the feedback from each session. Despite the time required, the process was effective in developing a format, length, and content appropriate to

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the audience and to balance delivery with the schedules of busy participants. We caution against attempting to scale up faster than the organization can build a skilled team of En-ROADS facilitators. From Forrester's "market growth" model (Forrester, 1968) to People Express Airlines (Sterman, 1988), the system dynamics literature amply documents the dangers of expanding faster than the capabilities required to deliver quality service can be developed (e.g. Oliva and Sterman, 2001; Sterman, 2015).

Regardless of the chosen format, companies must develop expert facilitator capability. HSBC's Corporate Sustainability team originally envisioned building a pool of skilled facilitators delivering En-ROADS workshops across the bank. However, mastery of the complexities of climate science and the dynamics of the model, a solid understanding of the bank's sustainability strategy, excellent public-speaking ability, and the ability to think on one's feet is a rare combination. Several months into program design and testing, the Corporate Sustainability team realized that enough qualified facilitators could not be fully trained given the time constraints. To avoid quality erosion, the team scaled down the original goal to a smaller number of workshops, co-facilitated by the program lead and three colleagues.

However, new opportunities to engage HSBC employees outside the United States soon arose. First, the U.S.-based program leader was invited to co-facilitate En-ROADS workshops with members of the local Corporate Sustainability teams in other countries through the bank's global Corporate Sustainability network. This turned out to be an effective way of expanding the program organically. These teams were staffed with colleagues who already had the skills and knowledge to become facilitators and were then trained by the program lead on En-ROADS, leading to facilitator training and customized workshops at HSBC in France, Germany, and the United Arab Emirates. Second, by embedding En-ROADS in the mandatory transition-risk training, over 2300 HSBC employees around the world experienced En-ROADS. Integrating En-ROADS into existing programs can help organizations scale its impact.

Nevertheless, building in-house En-ROADS capability takes time. A formal collaboration with Climate Interactive or recruiting trained En-ROADS Climate Ambassadors—facilitators who have completed thorough training with Climate Interactive (approximately 410 individuals globally as of November 2021)—can accelerate development of internal capabilities.

Even with a well-designed program and trained facilitators, successful workshop delivery is not guaranteed. Effective En-ROADS facilitators may need to play four roles in the same session: coach, professor/teacher, storyteller, and ally. Multiple facilitators with complementary skills may be needed. Workshop quality should be measured through participant feedback (e.g. with tools such as the net promoter score), and facilitators should debrief and reflect on each session to drive continuous improvement. Organizations should partner with researchers to assess whether the process

DOI: 10.1002/sdr

leads to policy or behavior change. Such longitudinal studies are more difficult, but they are an important area for future work.

The En-ROADS model protocols for its use continue to evolve with new developments in climate science and user feedback. Feedback from users, including those in finance and business, along with educators, policymakers, and others, helps shape the agenda for improvements. For example, the model could be augmented to include additional cobenefits and physical climate impacts, such as clean energy jobs created, heat- and cold-related deaths, and people exposed to coastal flooding, with graphics to make these impacts more tangible. Facilitator materials specifically designed for particular groups, including financial institutions, fiduciaries, investors, and philanthropists, can be created to help these stakeholders better relate the model to the challenges and opportunities they face. Finally, successful En-ROADS experiences might generate opportunities for other systems thinking and system dynamics model applications in companies.

Conclusion

While corporations increasingly recognize that mitigating climate change is vital, there is still confusion about how to achieve the Paris climate goals. Here we described how HSBC, a global player in the finance industry, uses En-ROADS to engage its employees to learn more about climate change and to understand HSBC's climate strategy. We discussed lessons learned through the use of En-ROADS at HSBC, lessons that may help other organizations successfully adopt En-ROADS and other systems thinking tools.

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