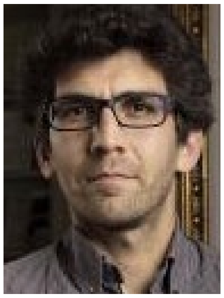

The Role of Modeling and Scenario Development in Long-term Strategies

Henri Waisman, Director of the Deep Decarbonization Pathways Project, IDDRI

All the interpretations and findings set forth in this expert perspective are those of IDDRI alone.

Long-term strategies in the Paris Agreement create a need for extensive and streamlined modeling activities and scenarios development

Long-term strategies, introduced in Article 4.19 of the Paris Agreement,[1] are a key to aligning emissions reductions with the global goal of "well below 2°C." These strategies are meant both to ensure that the regular revision of countries' short-term emissions targets in Nationally Determined Contributions (NDCs) is consistent with the long-term climate objective, and to support identification of collective priorities for knowledge sharing and international cooperation in the stocktaking dialogues. The nonbinding nature of the long-term strategies should help catalyze the exchange between alternative visions of long-term, low-emissions development. Different sets of policies and measures can be compatible with the Paris objectives, depending on the assumptions about the future development of socioeconomic, technical, and political systems. As long as these assumptions are internally consistent, the alternative visions of the future can conform with options available to decision-makers. Creating a space to incentivize the elaboration of these alternative possible futures and to structure the dialogue among them can broaden the possibilities in an open-mindset approach. This is different from the NDC process, a formal, binding contribution by Parties to other countries that will involve political negotiations and is therefore less suited to an open and transparent dialogue beyond administration and high-level policymakers. The complementarity between NDCs and long-term strategies lies in the capacity to seize the opportunity created by the latter to explore dimensions that can inform the design of NDCs, like different options for ambitious mitigation and associated complex and politically sensitive issues, like the articulation with development objectives. The relevance of this approach in turn depends on the availability of research inputs that offer transformational visions of emissions drivers in different countries, taking into account their specific socioeconomic, technical, and political circumstances.

More specifically, this will require the development and mobilization of many country-driven scenarios exploring different socioeconomic and technical trajectories to 2050 (or later) and their policy implications. These scenarios provide economy-wide, internally consistent sets of parameters characterizing the evolution of emissions and their drivers at the sectoral level, as well as key socioeconomic and development indicators. To make these analyses directly useful to the national and collective processes initiated in the Paris

Agreement, scenario development must be based on key generic methodological principles with a specific approach to modeling.

KEY METHODOLOGICAL INSIGHTS FOR SCENARIO DEVELOPMENT

A set of methodological principles for scenario development were formalized and implemented in the Deep Decarbonization Pathways Project (DDPP), a research collaboration, convened by IDDRI and the Sustainable Development Solutions Network, that gathers country teams elaborating and analyzing country-driven scenarios to 2050 compatible with global climate goals and national priorities. The first phase of the project included country research teams from 16 high-emitting countries representing 75 percent of global energy-related emissions in 2010.[2]

The DDPP results provide a proof of concept for how these principles can support the development of scenarios and the design of long-term strategies. More in-depth discussion can be found in related publications[3] and illustrations of the application of these principles are shown in the DDPP country reports 2015 and the cross-cutting analysis in the 2015 Synthesis Report.

a. Adopting benchmarks, not targets, to guide the design of country-driven scenarios without prescribing their content and outcomes
Imposing emissions targets for country-driven scenarios "from the outside," whatever the metrics used, would fail to capture the specifics of each national context. However, country teams working independently on their national scenarios need guidance on the requirements imposed by the collective ambition. In countries that have already produced country-specific official policy guidelines, country teams can adopt these benchmarks for emissions reductions to 2050 (e.g., "Factor 4" in France, the "80% or more reduction goal by 2050" commonly used by G7 countries, the "14 Gt carbon budget" in South Africa, or the 50 percent reduction compared to 2010 in Mexico). In other countries, collective benchmarks can take the form of a range of average per capita emissions in 2050 and sectoral performance indicators consistent with the 2°C limit for power generation, buildings, transport, and industry, derived from the literature and/or expert views. These "downward attractors" are quantified metrics providing a concrete indication of collective ambition on emissions levels and their drivers. They do not define which internal assumption each country team should adopt, but they are aimed at guiding teams lacking references for low-emissions scenarios to 2050 so that the ex post composite of the country visions aligns with the global constraints. To illustrate this approach, consider two examples of these "downward attractors" and how they can be used. First, the DDPP used an average of 1.5–2 tCO_2/capita as its "downward attractor" characterizing the range of average global 2050 emissions per capita in 2°C-compatible scenarios, consistent with global-scale estimates from the IEA 2°C scenario. Second, the DDPP used 50gCO_2/kWh for the carbon intensity of power generation, consistent with IPCC estimate, which shows that on average all 2°C-compatible scenarios reached values for this parameter lower than this value. Not all teams will converge at the same level: some will be higher (because of their technical and socioeconomic systems, development needs, etc.) and some will reach much lower levels; but these metrics proved useful as points of comparison in country teams' self-reflection on their scenarios' ambition.

b. Adopting a backcasting approach to investigate the sequencing of actions over time for long-term ambition
Backcasting is the process of defining a desirable future and working backward to identify the policies and programs needed to reach that future from the present. Scenario development should start by self-selection of 2050 targets (see Point a) and determine the steps required to get there. This process is iterative, requiring researchers to gradually increase emissions reductions by adjusting

their assumptions. Country teams should be free to autonomously define their target and assumptions, but a collaborative process can help push the boundaries of assumptions toward more ambition through knowledge sharing. Knowledge sharing on the fundamental drivers of the scenario results requires the adoption of a common language (i.e., being sure that parameters or variables mean the same thing for different teams; see Point d below), building a circle of trust among research teams (so that all teams feel comfortable to "open the box "of their analysis to make it understandable to the others) and creating occasions for such information exchange (through in-person meetings, which were organized every four months under the DDPP, and working groups gathering subsets of research partners around a given topic of common interest). This is the basis for the iterative process aimed at collectively supporting the self-selection of assumptions and methods by each country team. The coordination unit is closely connected to each partner in order to develop a clear understanding of everyone's priorities, challenges, obstacles, and opportunities. This will ensure that individual and collective methodologies are compatible with the requirements for knowledge exchange, and allow the events and structure required for such exchange to take place in a structured and continuous manner.

c. **Adopting a harmonized structure for elaborating the scenarios along the main families of transformation needed for ambitious mitigation**
   The elaboration of scenarios through backcasting requires a preidentified vision of the main families of transformation that must be considered for the ambition to be attainable. A "strategy matrix" can be used to structure the elaboration of scenarios as a combination of individual strategies able to actualize all the families of transformation. The nature of the strategies will vary according to the

specifics of the context, but, in all cases, strong action on main families of transformation must be implemented in all sectors in order to reach ambitious reductions of emissions. Investigation of energy-related emissions, for example, should include the "three pillars of decarbonization": energy efficiency, decarbonization of electricity and fuels, and end-use fuel switching to low-carbon fuels. This strategy matrix should align energy-consuming and supply sectors (buildings, passenger transport, freight transport, industries, power generation, and production of fuel and gas) in rows, with the three pillars listed above in columns.

d. **Adopting a granular and quantitative reporting template of the scenarios to translate strategies into pathways for key indicators**
To ensure that the content and outcomes of scenarios can be assessed and communicated in a structured manner, a transparent representation of underlying physical transformations must be provided at sufficient granularity. A reporting template should be systematically informed to provide a dashboard of key metrics measuring the underlying drivers of emissions trajectories in the scenarios. Such reporting, in comparable format across different research teams working on scenario development, is also essential to facilitate knowledge sharing on the assumptions adopted autonomously by each team and to support the self-selection of revised assumptions in the iterative process supporting backcasting (see Point b). The dashboard should contain physical indicators decomposed at the sectoral level to provide a tangible and measurable vision of the trajectories, like passenger-km for passenger transport, ton-km for freight transport, tons of product for steel or cement, or square meters for residential buildings.

e. **Designing several scenarios capturing transformations under different assumptions to build robust strategies in a context of major uncertainties**
The scenario design should acknowledge the need to consider uncertainties and bifurcations in the evolution of socioeconomic, technical, or political systems consecutive to disruptions, breakthroughs, or surprises (bad or good), and hence to depart from the standard optimization paradigm, in which pathways maximize an objective function with perfect knowledge of future trends. A multiple scenario approach should be promoted in which all scenarios for a given country are framed by similar assumptions of the long-term outcomes, notably regarding emissions trajectories, but follow different pathways corresponding to different narratives of the transformations. To implement this approach, scenario design should start by identifying key potential variants in long-term trajectories through expert-based judgments, including a clear vision of the main uncertainties and bifurcations over time. These alternative visions should be translated into consistent sets of strategies in the strategy matrix (see Point c). In addition to the availability, cost, and scale of low-carbon technologies that play an important role in most cases, other key factors may include international conditions, domestic socioeconomic circumstances, appreciation of risk and acceptability of certain technologies, articulation with other development objectives, and the efficiency of an infrastructure program.

f. **Ensuring that the scenario's emissions trajectory is well articulated with domestic socioeconomic priorities**
To ensure their relevance for domestic dialogues with various groups of stakeholders, the emissions scenarios should inform the articulation between emissions trends and socioeconomic aspects in a country-specific manner. The dashboard describing the content of the transformation should be expanded to capture the socioeconomic and development parameters most important in a given country. These indicators should be chosen according to the priority policy questions in that country, such as employment rates and skills profiles for labor markets, poverty rates and Gini indicators for inequalities, and trade-related parameters for competitiveness.

g. Enabling the emergence of a global vision as a composite of country scenarios that underscores the requirements, challenges, and opportunities of international cooperation

To inform collective discussions on international cooperation, country scenarios should be reported in a way that enables the recomposition of a global vision from the composite of national scenarios. This means adopting physical accounting of capacity additions and equipment rollover in key sectors (power generation, passenger transport, liquids production) in order to enable reconstruction of global trends as a summation of country annual capacity additions and replacements as well as derivation of investment assessments by applying an exogenous assumption regarding costs.

THE ROLE OF MODELS

Scenario design is supported by modeling tools able to assess a given transformative story, provide consistency checks, investigate complex and systemic issues, and capture the interplay between dimensions otherwise difficult to connect, like the role of development in emissions pathways.

The modeling tools should be used not to tell the story but rather to inform specific aspects of the strategies, which are designed primarily according to the methodological principles highlighted above. The specific aspects for which models are needed are those that require an in-depth investigation because of their importance in policy processes, but that also involve complex interplays not fully understandable without an analytical tool able to disentangle the multiple interactions at play. The model should therefore be chosen according to this objective. For example, trade, economic structure, or income effects could be best assessed by a hybridized Computable General Equilibrium; in contrast, the transformation of energy supply and of economic sectors could be better evaluated by a bottom-up or perhaps an accounting model. To incorporate issues of energy access and water security, linkages to appropriate models are needed to provide quantified assessments on this question explicitly.

A model-agnostic approach should therefore be adopted, recognizing that different model paradigms have different levels of abstraction and completeness, and provide different insights. Each country team should choose a modeling tool according to its relevance to their core domestic questions.

Beyond this crucial aspect, two additional criteria should be considered when selecting a model in a given context: (1) country system characteristics, notably in terms of formality/informality and differentiated spatial zones with distinctive functionings, and (2) key practicalities, including the limitations of model ease-of-use and data availability, and practical constraints such as the budget, timescales, and the need for stakeholder engagement.[4]

---

1. Article 4.19 invites Parties to "formulate and communicate long-term low greenhouse gas emission development strategies."
2. Australia, Brazil, Canada, China, France, Germany, India, Indonesia, Italy, Japan, Mexico, Russia, South Africa, South Korea, the United Kingdom, and the United States.
3. C. Bataille et al., "The Need for National Deep Decarbonization Pathways for Effective Climate Policy," Climate Policy 16 (2016): S7–S26; DDPP Network, "2050 Low-Emission Pathways: Domestic Benefits and Methodological Insights—Lessons from the DDPP," IDDRI Issue Brief no. 15/16 (2016), http://www.iddri.org/Publications/Collections/Syntheses/IB1516_DDPP%20network_lessons%20for%202050%20strategies.pdf.
4. For more details on the modeling approach in the DDPP, see S. Pye and C. Bataille, "Improving Deep Decarbonization Modelling Capacity for Developed and Developing Country Contexts," *Climate Policy* 16 (2016): S27–S46