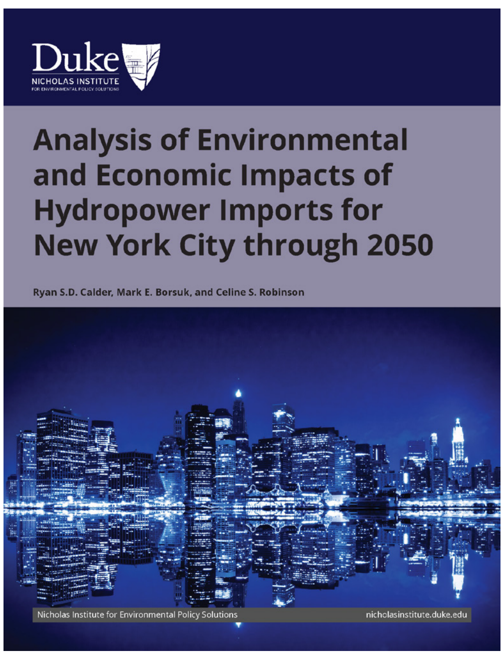
Analysis of Environmental and Economic Impacts of Hydropower Imports for New York City through 2050

Ryan S.D. Calder, Mark E. Borsuk, and Celine S. Robinson

Read the full report



Author Affiliations

Ryan S.D. Calder, Department of Population Health Sciences, Global Change Center, and Faculty of Health Sciences, Virginia Polytechnic Institute and State University; Department of Civil and Environmental Engineering, Duke University

Mark E. Borsuk and Celine S. Robinson, Department of Civil and Environmental Engineering, Duke University

Publication Number: NI R 20-12a

INTRODUCTION

Indian Point Energy Center (IPEC), a nuclear power plant north of New York City (NYC), is in the process of being decommissioned. IPEC has been producing roughly 15 terawatt-hours (TWh) of electricity per year, or enough to power more than two million households. IPEC is scheduled to be completely shut down in 2021.

There has been debate over how to replace the power previously supplied by IPEC. While Upstate New York has many renewable and low-emission sources of electricity, it is more likely that in the near term, additional power will instead come from existing natural gas plants in the NYC area. For the longer term, there have been proposals to either build new natural gas plants, import hydroelectricity from Canada, or build additional wind and solar power capacity. Each of these options is associated with different monetary costs, economic consequences, environmental impacts, and timelines, making them difficult to compare directly.

Quebec's Ministry of International Relations and La Francophonie (MRIF) asked us to conduct an independent review of the potential impacts of various alternatives for replacing the power formerly supplied by IPEC. We identified many possible options and used publicly available information and engineering and economic analysis to produce fair comparisons to support decision making. This document provides a plain-language summary of our analysis.

METHODS

Scenario Description

We identified a range of potential actions that could be taken in response to the closure of IPEC, which we grouped into scenarios. Each scenario represents a specific future development with distinct costs, impacts, and benefits. Some infrastructure decisions, such as the installation of a new transmission line from Canada to NYC, appear in multiple scenarios. Below are brief descriptions of the scenarios that we analyzed:

Scenario A – No action. This is our baseline or reference scenario. Here, we assume that following the closure of IPEC, there will be no new generation or transmission projects. Power previously supplied by IPEC would instead be supplied by existing natural gas plants in the vicinity of NYC. IPEC is scheduled to close imminently, therefore this scenario is the most likely for the immediate future.

Scenario B – Installation of the Champlain-Hudson Power Express (CHPE), a 1,000-MW transmission line from Canada to the NYC area. This line would provide the NYC area with hydroelectricity generated in Canada to replace roughly half of the power formerly generated by IPEC. We assume that existing natural gas capacity would provide all the power formerly supplied by IPEC while CHPE is under construction as well as roughly half of the power formerly supplied by IPEC after CHPE is installed.

Scenario C – Construction of a new natural gas plant in the vicinity of New York City, with two subscenarios: Scenario C1: the new plant would replace IPEC in its entirety; and Scenario C2: the new plant would be coupled with CHPE (as in Scenario B) to provide the power formerly produced by IPEC but not supplied by CHPE. We do not explicitly take into account potential difficulties associated with development of natural gas in the context of New York State's Climate Leadership and Community Protection Act (CLCPA). We also do not consider a specific location for the new natural gas plant.

Scenario D – Development of new Downstate solar and wind generation, with two subscenarios: Scenario D1: development of wind and solar power up to the point at which the power previously supplied by IPEC is replaced; and Scenario D2: development of wind and solar power coupled with CHPE (as in Scenario B) to replace the power formerly supplied by IPEC, accounting for the contribution of CHPE. We use currently scheduled wind and solar power development as well as historical trends to estimate the timeline of future delivery of Downstate wind and solar power. We do not explicitly consider intermittency issues associated with wind and solar power, although we do consider relatively wide uncertainties around power produced by these technologies. We also do not consider specific locations for future wind or solar projects.

Outcomes of Interest

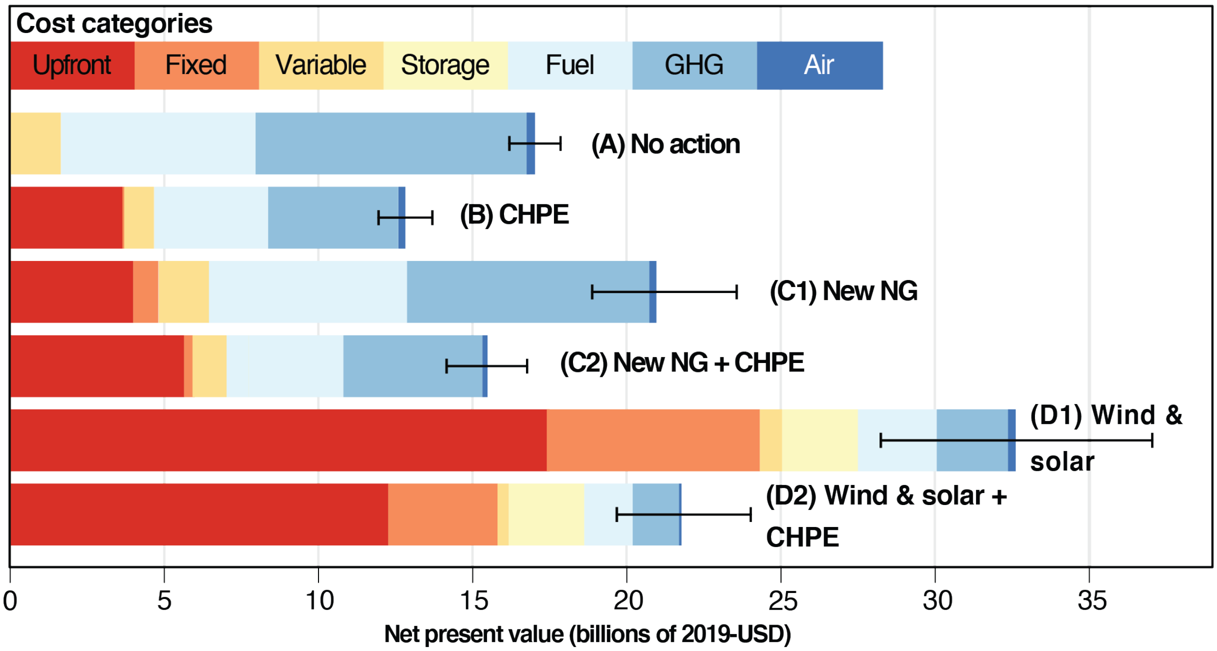
In addition to direct economic costs and benefits, we considered impacts such as changes to local air quality, greenhouse gas (GHG) emissions, and environmental impacts, including those typically considered in environmental impact statements prepared for projects similar to those considered in our scenarios. Indirect economic impacts such as creation of employment and stimulated economic activity were also included.

Data Synthesis

For each type of generation or transmission project we considered, we collected the following data from publicly available sources: 1) upfront capital costs; 2) recurring costs associated with operation and maintenance; 3) GHG emissions factors; 4) air pollutant emissions factors; and 5) local economic information (e.g., jobs created by new projects). We queried the databases of government agencies and national labs (notably the U.S. Environmental Protection Agency, the U.S. Energy Information Administration, and the National Renewable Energy Laboratory). We also used publicly accessible consulting reports prepared for the purpose of environmental permitting of past or future projects. We assembled these data in a form that can be queried by computer script to simulate the scenarios described above.

Economic Valuation

Figure 1. Net Present Value of Costs Incurred by Scenario over the Period 2021–2050 and Cost Category



Note. Net present value of costs incurred by scenario over the period 2021–2050 and cost category. Error bars denote 90% confidence interval around total.

To make it easier to compare scenarios, we converted most outcomes into monetary terms. Direct costs and economic impacts are already reported monetarily. We estimated the monetary equivalent of GHG emissions for each scenario using the "Social Cost of Carbon" (SCC). The SCC is an estimate of the economic impact of an emitted tonne of carbon dioxide (CO_2) considering the environmental and health problems caused. Other GHGs are considered in terms of CO_2 equivalents. The economic impact of air pollutants was based on the cost of addressing the resulting health impacts (e.g., excess cases of asthma associated with particulate matter emitted from power plants).

We did not monetarily value those environmental impacts for which: 1) the value would likely be much smaller than other impacts and not influence overall results; 2) there is no commonly accepted methodology for monetary valuation; and/or 3) effects would be too site-specific to evaluate for hypothetical projects with no identified location. For such environmental impacts, we provide only qualitative assessments.

Numerical Simulation

We wrote computer script to simulate the impacts of our various scenarios (Section 2.1) on selected outcomes (Section 2.2) using the compiled data (Section 2.3). When possible, this included economic valuation of these impacts (Section 2.4). Summary tables and figures are used to report our findings.

To reflect the uncertainties inherent in predicting future outcomes, we considered wide ranges for variables used in our simulations (e.g., unit costs, GHG emissions factors). We translated these ranges into the corresponding ranges in outcomes (e.g., total costs, total GHG emissions) using a technique called Monte Carlo simulation. This involves generating a large number of simulations (we used 10,000), with each simulation using a different value from within the ranges specified for each variable.

All simulations were carried out using free, open-source software. Input variables are compiled in the full version of our report, and the underlying computer code is available upon request.

Sensitivity Analysis

Any numerical simulation will necessarily employ a variety of simplifications and assumptions. Sensitivity analysis is the process of evaluating how results are impacted by changes to those assumptions. We assessed the sensitivity of our results to changes in: 1) the geographical extent around NYC considered to be impacted by the closure of IPEC; 2) the types of generators compensating for the closure of IPEC (in our main analysis, we considered only natural gas generators); and 3) the "discount rate" used to compare future costs and benefits to present-day costs and benefits.

RESULTS

The closure of IPEC, without the development of new generating or transmission infrastructure (Scenario A, no action), is estimated to result in direct economic costs of $8.0 billion (with a 90% confidence interval (CI) of $7.2–$8.8 billion) and indirect environmental impacts valued at $11.0 billion (90% CI: $10.8–$11.2 billion) over the period 2021–2050, assuming a 3% discount rate (see Figure 1).

Every other scenario considered (Scenarios B, C1, C2, D1, D2) reduces environmental and health impacts relative to no action. The net present value of these savings ranges from $1.2 billion (90% CI: $1.2–$1.3 billion) in the case of new Downstate natural gas development (Scenario C1) to $7.4 billion (90% CI: $6.9–$7.6 billion) in the case of CHPE plus expansion of Downstate offshore wind and solar (Scenario D2) over the period 2021–2050, assuming a 3% discount rate.

When direct costs and environmental costs are combined, the scenarios calculated to be more cost-effective than no action (Scenario A) all involve development of CHPE (Scenarios B, C2). CHPE also improves cost-effectiveness of other technologies considered when it is combined with them (Scenario C2 vs. C1 and D2 vs. D1). This is primarily because the large benefit of avoided GHG emissions comes earlier (as of 2025) when CHPE is installed.

Development of Downstate offshore wind and solar power (Scenarios D1 and D2) is expected to generate the largest indirect economic benefits, in the form of local expenditures and job creation, relative to the other alternatives. However, this scenario also has the largest up-front costs ($12.3 billion, 90% CI: $10.4–14.2 billion at 3% discount rate). The comparative cost-effectiveness of Downstate offshore wind and solar development is improved by simultaneous implementation of CHPE, a scenario with total net present costs of $21.8 billion (90% CI: $19.6–$24.0 billion) compared to $32.7 billion (90% CI: $28.3–$37.0 billion) for wind and solar alone. This is due to upfront avoided GHG emissions while development of offshore wind and solar is occurring and because CHPE reduces the wind and solar capacity needed to compensate for the loss of IPEC.

Confining attention **to direct and environmental costs (without considering local economic benefits),** the scenario that minimizes total costs over the period 2021–2050 is CHPE alone (Scenario B) at $12.8 billion ($12.0–$16.9 billion) compared to $16.9 billion (90% CI: $16.1–$17.8 billion) for no action. Uncertainty and sensitivity analyses suggest that the main conclusions are robust to large changes to underlying modeling assumptions.

LIMITATIONS

To facilitate comparison of scenarios using common units, this analysis focused on outcomes that can be valued economically or otherwise quantified (e.g., jobs created, costs borne). We recognize that using the monetized sum of total impacts to represent overall cost-effectiveness, may not fully capture the relative importance of certain impacts to certain constituencies. We therefore encourage readers to consider the individual impacts of each scenario, both quantitative and qualitative, in addition to the total costs. Total values also do not capture the distribution of costs and benefits across stakeholders. For example, we did not distinguish benefits that would accrue specifically to residents of NYC in the form of potentially lower electricity prices. Ultimately, how costs and benefits are distributed for any given scenario will be determined by contractual and political considerations, which are beyond the scope of this analysis.

We have limited our analysis of to those impacts which can be clearly linked to near-term actions in response to the closure of IPEC. We did not consider potential second-order impacts on future generation in Canada or on the viability of future fossil fuel generation. It has been claimed that development of CHPE would divert exports from short-term spot markets, thereby increasing fossil fuel generation in those markets. While we did not explicitly consider such a causal association, in our sensitivity analysis, we did evaluate the robustness of our main conclusions to alternative assumptions and the plausible values of opportunity costs associated with energy transmitted via CHPE.

It is well-established that the creation of new hydroelectric reservoirs transforms terrestrial and aquatic environments and is associated with diverse environmental and health impacts. However, historically, U.S. regulators have excluded generation-side impacts in Canada from consideration in U.S. environmental impact assessments. Further, to our knowledge, there are no currently planned hydroelectric projects in Québec beyond La Romaine, development of which has been in progress for many years, independent of negotiations surrounding CHPE. For these reasons, we did not consider generation-side impacts in this analysis. An assessment of the costs and benefits of further exploitation of hydroelectric resources in Canada would require a broader scope than the present analysis, but may benefit from the framework developed here.