amazon | sustainability

Economic Impact of Amazon Investment in Renewables Methodology

As part of our commitment to be net-zero carbon by 2040—10 years ahead of the Paris Agreement—Amazon is on a path to power our operations with 100% renewable energy by 2025—five years ahead of our original 2030 commitment. To meet this commitment, Amazon has invested in utility-scale solar and wind projects globally that support thousands of jobs and generate billions of dollars of investment in local communities.

Amazon developed an industry-leading economic model that follows guidance from the U.S. Department of Energy's National Renewable Energy Laboratory (NREL) to estimate the investment generated by these utility-scale solar and wind projects in the U.S. We further commissioned economic advisory firm Oxford Economics to adapt our model globally and independently validate its findings.

Approach

Amazon's methodology uses industry-leading sources from NREL to estimate the investment generated by the construction and operation of the utility-scale solar and wind projects to support Amazon's power purchase agreements (PPAs). This investment by developers would not have occurred without Amazon's energy purchases through PPAs. This attribution of downstream investment to Amazon's PPAs is consistent with the input-output methodology that Amazon uses to estimate the impact of its infrastructure investments. The investment in renewable energy projects attributable to Amazon PPAs lead to direct effects (hiring and spending by the developer) and creates ripple effects (hiring and spending by suppliers and workers) in the economy.

Our model uses the OECD input-output tables to estimate the contribution of local spending associated with the project to gross domestic product (GDP) and the average number of jobs supported over the lifecycle of the investment. Following this methodology, imported goods and services do not create economic impacts in the local economy. AWS uses standard procedures for calculating multipliers from the I-O data supplied by the OECD.[1]

The economic model estimates local spending using NREL data on renewable energy supply chains. Our analysis assumes 100% of materials and components are imported from foreign manufacturers and that 100% of labor is sourced from local talent pools. While a number of countries included in this study have domestic industries that produce these materials and components, the model assumes that it is more appropriate to underestimate impacts while it validates these assumptions.

Channels of Economic Impact: Direct, Indirect, and Induced Effects

The investment generated by AWS' PPAs, which include both capital (CAPEX) and operating (OPEX) expenditures, result in three types of economic impact through supporting local spending in the economy. These impacts occur during the construction and operational phases of renewable energy projects.

- **Direct Effects:** Amazon's PPAs create revenue at developers that generate direct effects on the economy and support the hiring of workers. To support the delivery of energy to Amazon, renewable energy developers employ and provide compensation to managers, technical experts, and maintenance personal responsible for operating the project. The revenue created at firms and compensation provided to these workers directly benefits the local economy where the project is located.

[1] *See Ronald Miller and Peter Blair, "Input-Output Analysis: Foundations and Extensions," 2009, Cambridge University Press for more documentation and examples.*

- **Indirect Effects:** Developer purchases made to support renewable energy projects create revenue and support jobs at their direct suppliers and at businesses in the downstream supply chain. During the construction phase of a project, developers purchase construction labor and materials from contractors. These purchases create downstream business-to-business transactions, where the contractor purchases inputs from their own suppliers. These might include engineering services or raw materials required for them to support construction. Similarly, developers make purchases to support the operation of a renewable energy project, such as spare parts, technical expertise, and professional services, such as accounting and financial services.

- **Induced Effects:** Developers, their suppliers, and the renewable energy supply chain pay compensation to workers to support upstream purchases from their customers. The compensation earned by these workers is then spent on consumer goods and services, such as housing, restaurants, entertainment, health care, and education. The purchases induced by the renewable energy project then create their own indirect effects throughout the local consumer goods supply chain.

Estimating the Total Economic Impact of Renewable Energy Projects

The direct, indirect, and induced effects are created by the revenue earned by developers from Amazon's PPAs, and the purchases and compensation paid to support this economic activity.

- **Revenue:** The annual revenue earned by developers from operating their project were estimated using Amazon internal data on PPA rates per megawatt-hour (MWh) and conservative estimates of MWh generated by renewable energy projects. This economic model assumes the project revenue will continue for the remaining useful life of the project rather than for the term of the PPA—either by extension of the PPA by Amazon or the sale of energy to another customer. In the case that project data was not available, the model uses the average PPA price per MWh for other projects in the country, and the average utilization rates provided by NREL for solar (15%) and wind (45%) utility-scale projects.

- **CAPEX:** Project CAPEX is estimated on a per MW basis and evenly spread out over the construction period evenly for solar (2 years) and wind (3 years) utility-scale projects. CAPEX is estimated by component using NREL data, informing the estimation of what was spent locally vs. spent outside the state or country in the analysis. The indirect and induced effects of local CAPEX on revenue, compensation, and employment are estimated using OECD data and the input-output methodology for Type 1 and Type 2 economic multipliers.

- **OPEX:** Project OPEX is estimated on a per MW basis and calculated annually for the useful life of solar (30 years) and wind (25 years) project and is informed by NREL data. The indirect and induced effects of local OPEX on revenue, compensation, and employment are estimated using OECD data and the input-output methodology for Type 1 and Type 2 economic multipliers.

Key Formulas

The following formulas provide the method for calculating the investment, GDP and jobs supported by direct, indirect, and induced effects.

Investment

Annual CAPEX = Construction Costs * MW Capacity / Years of Construction (from NREL)

Annual OPEX = Annual Operational Costs * MW Capacity (from NREL)

Local CAPEX = Annual CAPEX * Local Spending Patterns (from NREL)

Local OPEX = Annual OPEX * Local Spending Patterns (from NREL)

Direct Effects

GDP = Revenue[2] – OPEX + Compensation of Employees

Compensation of Employees = Share of OPEX Attributable to Labor Costs (from NREL)[3]

Jobs Supported = Compensation of Employees * Ratio of Employees to Compensation (From OECD)[4]

Indirect Effects

Total Revenue (Output) = (Local CAPEX + Local OPEX) * Type 1 Economic Multipliers (from OECD)

Compensation = Total Revenue * Industry Ratio of Compensation to Revenue (from OECD)

GDP = Total Revenue * Industry Ratio of GDP to Revenue (from OECD)

Jobs Supported = Total Revenue * Industry Ratio of Jobs to Revenue (from OECD)

Induced Effects

Spending by Employees = Compensation * (1 – Savings Ratio) (from OECD)

Total Revenue (Output) = Spending by Employees * Type 2 Economic Multipliers (from OECD)

GDP = Total Revenue * Industry Ratio of GDP to Revenue (from OECD)

Jobs Supported = Total Revenue * Industry Ratio of Jobs to Revenue (from OECD)

[2] *Revenue for 2014-2054 is inflated using Oxford Economics' GDP Deflator, a measure of inflation in the economy.*

[3] *According to NREL, 10.4% of utility-scale renewable energy OPEX is attributable to labor costs. Oxford Economics estimated revenue for projected years using their GDP Deflator.*

[4] *This ratio is taken from the OECD definition of the energy sector: SIC 35: Electricity, gas, steam and air conditioning*

Modeling Assumptions

All cost assumptions were provided by NREL and adapted by the AWS R&A team.

CAPEX and OPEX for Utility-Scale Solar and Wind Projects

These costs are provided on a $ per kilowatt basis for projects with 100 MW by NREL.

Project Type	Spend Type	2014	2015	2016	2017	2018	2019	2020	2021
Solar	CAPEX	2,530	2,080	1,630	1,190	1,185	1,020	1,017	894
Solar	OPEX	26	24	23	22	20	19	17	16
Wind	CAPEX	1,438	1,438	1,438	1,438	1,438	1,438	1,462	1,462
Wind	OPEX	43	43	43	43	43	43	43	43

Local OPEX for Utility-Scale Solar and Wind Projects

These costs are presented as a share of total OPEX.

Industry	Share
DOM 64T66: Financial and insurance activities	19%
DOM_31T33: Manufacturing nec; repair and installation of machinery and equipment	6%
DOM 29: Motor vehicles, trailers and semitrailers	3%
DOM_36T39: Water supply; sewerage, waste management and remediation activities	2%
DOM_77T82: Administrative and support services	1%
DOM_35: Electricity, gas, steam and air conditioning supply	1%

Local CAPEX for Utility-Scale Solar and Wind Projects

These costs are presented as a share of total CAPEX.

Project Type	Industry	Share
Solar	DOM_41T43: Construction	14%
Solar	DOM 25: Fabricated metal products	6%
Solar	DOM 69T75: Professional, scientific and technical activities	5%
Solar	DOM_84: Public administration and defence; compulsory social security	2%