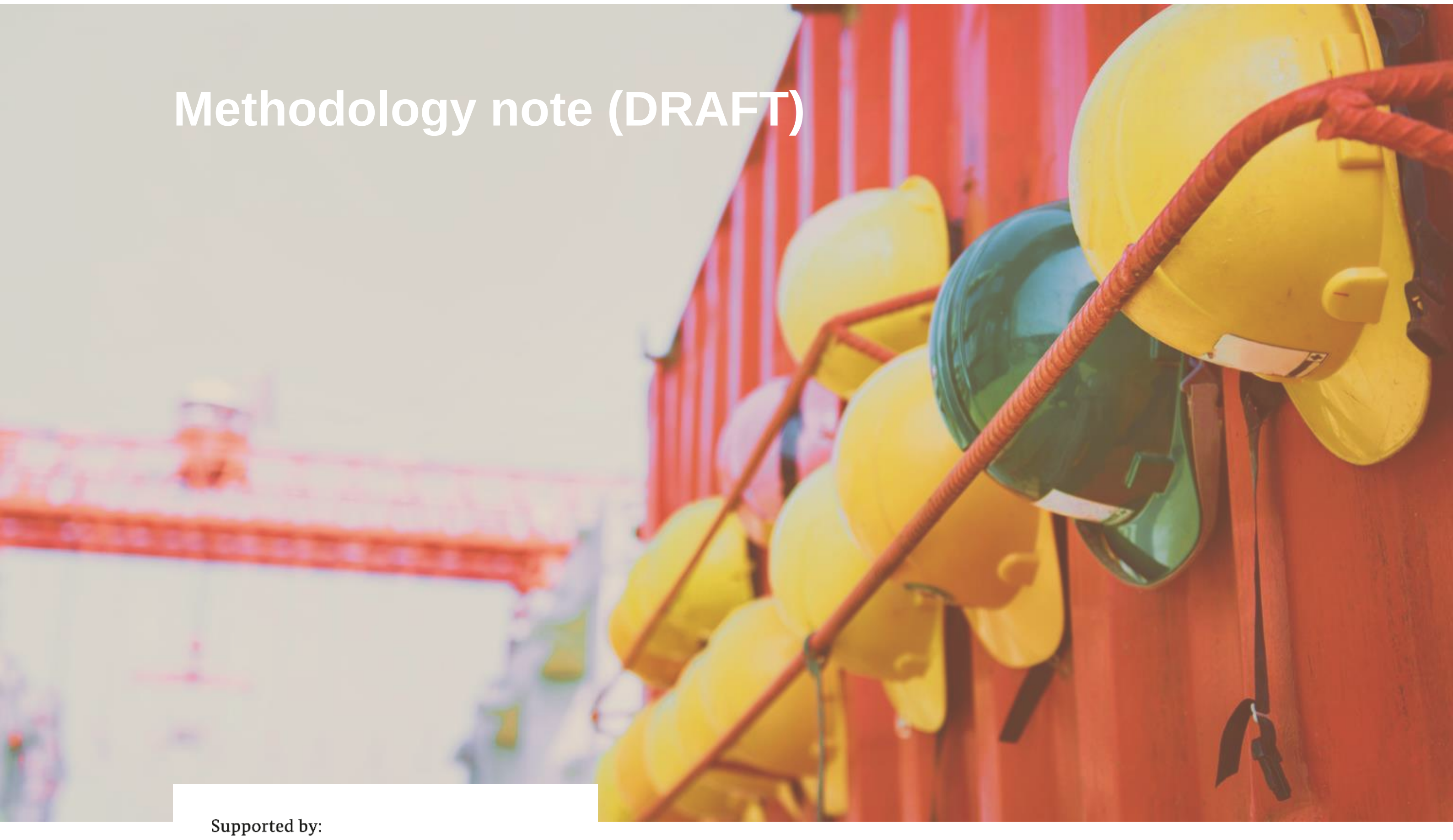
NEW CLIMATE INSTITUTE

Ambition to Action

Economic Impact Model for Electricity Supply

Methodology note (DRAFT)



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1 Introduction

A tool to analyse employment in the electricity supply sector and wider economic impacts

NewClimate Institute has developed a spreadsheet-based open source model to estimate the domestic employment and wider economic impacts of investments in new electricity generation capacity within a country. The Economic Impact Model for Electricity Supply (EIM-ES) can be set up to cover all relevant electricity generation technologies - both low carbon and fossil fuel based – to provide a comparative assessment of impacts under different future pathways for the development of the electricity sector.

Why analyse the sustainable development impacts of climate policy?

The Paris Agreement sets out a framework to address the global problem of climate change and limit temperature rise to well below 2 degrees Celcius above industrial levels. Achieving this goal requires rapid structural change across all economic sectors – notably the transition to low carbon energy systems is a fundamental component of efforts to mitigate climate change.

Growth in energy demand and the transition to low carbon technologies require large investments in capital, land and labour. The scale of the investment and the beneficiaries of these financial flows depend on a wide range of factors such as the choice of technology, location, rate of deployment, and capacity of local supply chains, among many others.

It is important that policy makers carefully consider the wider socio-economic and environmental impacts of their approach to tackling climate change, which can lead to a wide range of so-called “co-benefits” through improved air and water quality; more secure, accessible and sustainable energy supplies; and opportunities for economic growth and job creation in new sectors.

Investments present an opportunity for economic growth and typically directly impact employment levels. However, where these investments are made and the structure and capacity of the economy into which they are channelled can have important implications for the extent to which the investments support economic activity and employment within a given country.

As with any transition there will likely be those that stand to gain more and those that are potentially disadvantaged. An analysis of the likely magnitude and distribution of future impacts can help policy makers to prepare the skills and capacities required to support the transition, to ensure that those losing out as a result of the change are appropriately compensated and to best facilitate a just transition that works for all.

Approaches to assessing economic and employment impacts

Existing methods to evaluate the socioeconomic impacts - such as employment - of different investments in the electricity supply sector vary widely in their complexity, from the use of “jobs factors”, typically expressed as jobs per MW capacity installed for a given technology, to running sophisticated macroeconomic forecasting models. Three main approaches are typically used to estimate job impacts from a given project, policy or scenario:

- Job factors based on surveys (typically country/region and technology specific), e.g. Rutovitz et al (2015)
- Input Output models, e.g. NREL’s JEDI model
- Macroeconomic models, e.g. Cambridge Econometric’s E3ME

Selecting an appropriate method depends on the availability of data, capacity and skills available to undertake the analysis, the level of transparency desired and the type of questions the analysis is intended to inform.

In addition to estimating the scale of employment, measured in terms of the number of jobs, some studies aim to assess more detailed elements such as the quality of jobs and the extent to which the opportunities are likely to be distributed across genders, different demographic groups or regions.

The EIM-ES

NewClimate Institute has developed a transparent tool which can be tailored to specific scenarios, country features and the level of data available based on an analysis of investments across different electricity supply technologies over time. The model draws on Input Output tables which provide important context on the economic structure and sector inter-relationships of a country and allows an estimation of indirect and induced impacts which extend beyond the final products and services used to generate electricity. Users are provided with a wide range of economic and employment indicators which can be selected according to the context and need – including both gross and net effects, impacts over time, across sectors and technologies, and comparisons across technologies denominated in different units – all of which can provide critical insight to inform an assessment of different future pathways for the electricity sector.

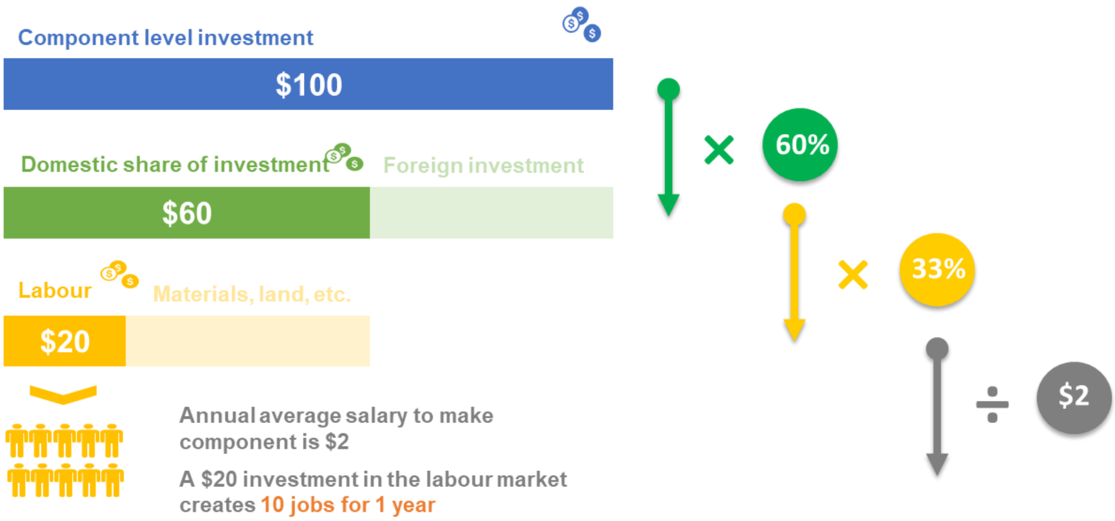
In the following sections we provide an overview of the methodology for the EIM-ES (2); a description of the coverage and scope of the model (3); information on data inputs (4); the indicators estimated by the model (0); and a discussion of some of the key limitations of the approach (6). Further information on the model, including an overview and userguide, as well as the model itself, is available at http://ambitiontoaction.net/outputs/.

2 Overview of methodology

Investment based analysis

The analysis is based on investment cost data that is disaggregated, where possible, into its component parts (see Table 1 for an example of component parts for onshore wind) for new and existing electricity generation capacity. The model calculates the share of each investment that is spent domestically and the share of that domestic investment that is directed to the labour market based on input data and underlying assumptions. Figure 1 shows an illustrative example of a $100 investment in a component part, such as the tower for a wind turbine. In this case $60 of the total is spent in the country and the remaining $40 is spent on imports. One third of the domestic investment ($20) is spent on the labour market, with the remaining amount spent on inputs such as land (where the wind turbine is sited) and materials, such as cement or steel and machinery used in the construction of the tower.

Figure 1: Overview of approach to estimating direct employment impacts



Direct jobs

The model calculates the direct employment impact of the investment in the labour market by dividing it by an estimate of the average wage paid to workers employed in that sector, including taxes and any other costs faced by employers, such as social security payments. In this illustrative example the annual wage is $2. The $20 investment in the labour market therefore directly stimulates 10 jobs for 1 year; or alternatively 5 jobs for a period of 2 years.

The model apportions the direct jobs created over time based on assumptions related to the duration of the various tasks and services. For example, construction jobs typically may last for 2 to 5 years preceding the start of operations of new capacity, depending on the technology. Jobs created to provide operational and maintenance services typically cover a much longer period of time, linked to the expected lifetime of the asset.

Indirect and induced jobs

In addition to estimating annual direct jobs, the model calculates indirect and induced employment impacts by drawing on economic multipliers derived from Input Output tables for the economy. Input Output tables reflect the interdependencies of sectors across the economy, based on national statistics. Economic multipliers are calculated from the data in the Input Output tables to reflect the wider ripple effect of investments extending into the supply chains of the final goods and services and, in turn, the whole economy. Their use provides an order of magnitude of the wider employment impacts of investment in electricity generation.

Economic impacts

The main focus and application of the model is in estimating employment impacts. To help inform the assessment of different scenarios the model also reports additional economic indicators beyond jobs, such as the total investment in the country over time, split by economic sector; the overall scenario cost, including spending on imports; and the added value to the domestic economy from the investments.

3 Coverage of analysis

Technologies

The EIM-ES can be set up to include up to 35 different electricity generation technologies. The technology coverage is defined by the user to best reflect the range of different technologies that are currently operating in the country and which are envisaged in long-term projections of new capacity. This allows an analysis of the full electricity supply system, aggregated according to the needs of the user and availability of data.

Required data inputs for each technology set up in the model include annual capacity and electricity generation projections as well as estimates of investment costs, split into capital expenditure as well as fixed and variable operational expenditure. These high-level cost estimates should then be broken down into their component parts (for example see Table 1 below). The model includes a set of default cost component breakdowns for a selection of common electricity generation technologies based on an analysis of publicly available sources. These default cost component breakdowns can be used where detailed country-specific data are unavailable.

Learning curves can be included, where available, for each technology in the form of an index that captures projected annual change in costs at the level of capital expenditure and both operational and fixed operational expenditure.

Timeframe

The analysis of direct employment and wider economic impacts is carried out for every year of the modelling horizon. The user can specify the start and end years for the analysis, with the standard model set up to extend to 2050, where required. This allows an assessment of the expected impacts over time, split by technology and economic sector, providing potentially critical information on the requirements for capacity in the labour market – e.g. in the construction sector. The temporal indications also show the rate at which employment needs may fall in some sectors – e.g. the extraction and processing of fossil fuels and the use of fossil-fuel based electricity generation technologies.

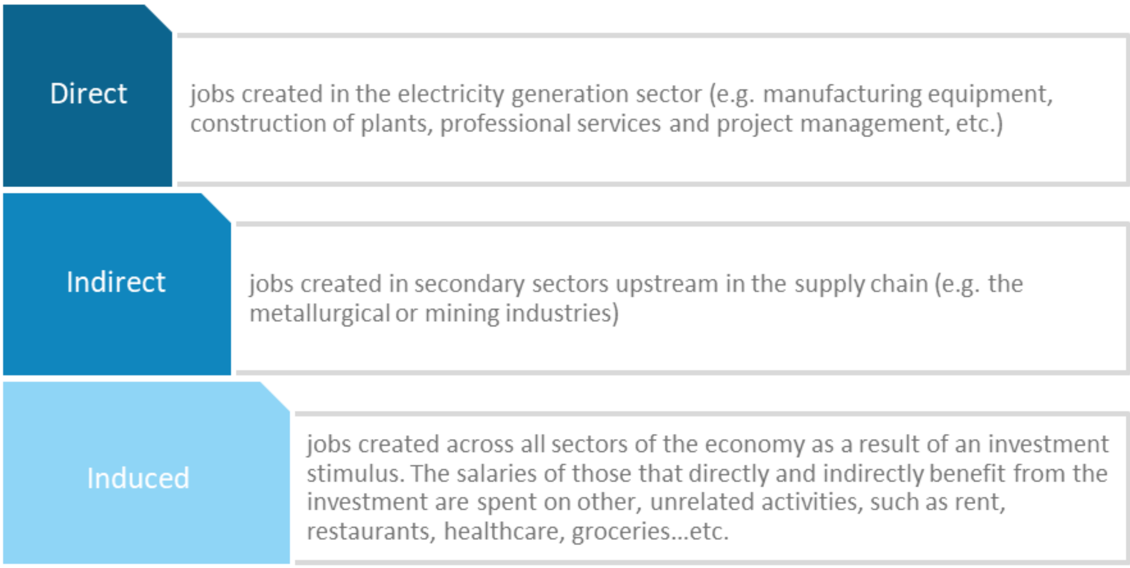
Scenarios

Up to ten different scenarios can be included in the EIM-ES for analysis. Each scenario includes information on electricity generation and capacity, as well as investment cost estimates, all broken down by technology. The model can therefore be set up to analyse the impacts of different future projections for the technology mix over time and to compare their results. For example, a business as usual scenario can be compared to a scenario reflecting an ambitious decarbonisation of the electricity sector in line with the Paris Agreement goals. Alternatively, the different scenarios can be set up to conduct sensitivity analysis, for example by maintaining the technology mix and varying input assumptions such as the cost level for given technologies, or the share of component parts that are produced in the country.

Direct, indirect and induced impacts

The economic analysis in the EIM-ES considers different categories of employment and investment that extend beyond the electricity generation sector to all areas of the economy. The main focus of the analysis is on the direct impacts of the investments in the electricity generation sector, which are estimated over time. However, the model also derives economic multipliers from the country Input Output table and uses these to estimate indirect and induced impacts. Examples of direct, indirect and induced impacts are set out in **Error! Reference source not found.**.

Figure 2: Direct, indirect and induced economic impacts



Indirect and induced economic impacts are estimated in aggregate over the time period set by the user, rather than on an annual basis. For example, if the modelling horizon is set to cover the period 2020 to 2040, the model calculates the aggregated investment by sector over this time horizon and estimates the indirect and induced impacts for the full period. As discussed below, there are a number of limitations regarding the accuracy of these estimates. Nonetheless, they provide an informative order-of-magnitude assessment of the impacts that extend beyond those deriving directly from the investments. An annual analysis of indirect and induced impacts is not included due to computational constraints of working with the model in Excel.

And what it does not cover…

The EIM-ES is designed to provide an accessible tool to analyse employment and wider economic impacts in the electricity supply sector, balancing its level of sophistication against the objective to make the model relatively easy to use, to ensure transparency of the calculations and considering constraints in data availability in many countries. There are a number of limitations to the analysis – as discussed in section 6 below – which are important to take into account when interpreting the results. In addition, it is important to note that the standard model does not cover the following areas:

- **Energy efficiency measures**: Scenarios with lower electricity demand (and corresponding supply) may include increased uptake of energy efficiency measures. These measures may stimulate jobs – for example workers employed in retrofitting household insulation – which are not considered within the EIM-ES. In comparing scenarios in the EIM-ES it is important to consider the overall electricity supply of the respective scenarios and analyse results expressed per unit of electricity generation or per unit of investment.
- **Grid infrastructure**: Electricity systems may require significant investment in either new electricity grids or upgrades to existing grids over time, particularly where transitioning from centralised systems, built around large fossil-fuel based power plants, to more decentralised systems. In the standard version of the EIM-ES the impact of required grid investments is not included even though these may have significant implications for the total investments required for a given scenario.

- **Sub-national or foreign impacts**: The EIM-ES is set up to calculate impacts at the national level, particularly given that Input Output tables are often not available at sub-national level. Any sub-national scenario analysis would have to incorporate assumptions about the local share of production within that particular region as well as the inter-relationship between economic sectors in the region. Additionally, it is important to note that the model is focused on assessing the impacts of investments within the country of interest. It does not consider the wider economic impacts accruing to other countries, for example, which export materials that are used in the electricity supply sector of the analysis country.
- **Quality of jobs**: The model estimates the number of full-time job years for a given scenario, broken down by technology and economic sector. It does not, however, provide any assessment of the likely quality of these jobs. Such an assessment could draw on the quantitative outputs of the model, complemented with further information on the potential quality of jobs according to economic sectors and the electricity generation technologies, where available.

4 Data inputs

The level of accuracy of the analysis depends on the quality of data inputs and the extent to which they reflect the country context. Where country-specific data points are either missing or unreliable it may be necessary to draw on regional and international information, adjusted as necessary to the target country. The model is set up to enable sensitivity analysis (via different scenarios) on key data inputs to offer information on the extent to which their level influences the final results. Figure 3 sets out the main inputs that are required for the model. The traffic light circles on the right-hand side provide an indication of which data inputs are typically the least resource intensive to collect (green) and those which are more challenging (red). Users of the model can adjust input data according to their needs and knowledge.

Figure 3: Data inputs required to set up EIM-ES

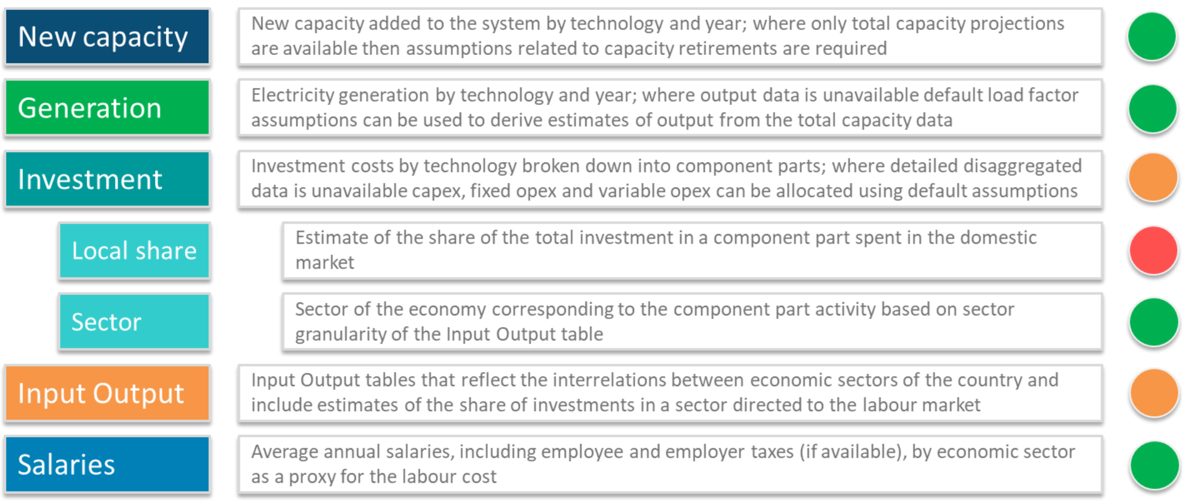


Table 1 provides an indication of the default cost component breakdown included in the model for onshore wind. The types of cost component and their level of disaggregation can be adjusted by the user depending on the extent and quality of the data available.

Table 1: Example of cost component parts for onshore wind

Onshore wind cost components (example)	Cost category
Nacelle	Capex (USD/MW)
Blades	Capex (USD/MW)
Tower	Capex (USD/MW)
Transport	Capex (USD/MW)
Electrical balance of plant	Capex (USD/MW)
Installation	Capex (USD/MW)
Project planning and management	Capex (USD/MW)
Civil works	Capex (USD/MW)
Contingency and finance	Capex (USD/MW)
Operation	Fixed opex (USD/MW/yr)
Maintenance	Fixed opex (USD/MW/yr)
Land lease costs	Fixed opex (USD/MW/yr)

For each cost component the user should include an estimate of the share of the investment that is made in the country. For example, if all wind turbine blades are imported, the local share of the investment in the cost component for blades will be zero. Identifying accurate data to inform the estimates of the local share of investments is challenging and likely to be the most resource intensive part of preparing input data for the EIM-ES, particularly as the estimates depend to a large extent on the supply chains in the country of interest. These data inputs should be informed by experts familiar with developing electricity generation projects in the analysis country, ideally drawing from knowledge across different technologies.

5 Indicators of employment and wider economic impacts

The spreadsheet model includes a results dashboard for each scenario to report the employment and wider economic impacts (see, for example, Figure 4). The dashboard sets out a number of different indicators with different levels of breakdown and denominated in a range of relevant units. For example, estimated impacts are shown by technology, cost category or economic sector as well as per unit of capacity, per unit of electricity generation or per unit of investment. The suite of indicators from each scenario can then be compared. All employment impacts are expressed in units of full-time job years, i.e. a full-time job that lasts for one year.

Figure 4: Overview of results dashboard

In addition to graphical illustrations of the employment and wider economic impacts, each scenario results sheet includes detailed tables setting out the quantitative results of the analysis. For a more in-depth or specific analysis these tables can be reviewed and compared across scenarios. They also allow all of the results to be traced back to the underlying model inputs, assumptions and calculation steps to facilitate the interpretation of results as well as the checking of the model outputs.

The different types of indicator can inform analyses of the relative attractiveness of investments in different technologies, the profile of investments over time and allow the user to assess the impacts in a way that can address their respective research objectives or questions.

6 Limitations and challenges

As with any modelling exercise, it is important to be aware of key limitations in the analysis that should be considered when interpreting results. The level of accuracy of the analysis using the EIM-ES depends on the quality and granularity of data inputs and the extent to which they are reflective of the country context. Where country-specific data points are either missing or unreliable the user can draw on regional and international information, adjusted where relevant to the target country. The model is set up to enable sensitivity analysis on key data inputs to offer information on the extent to which their level influences the final results.

The model draws on information included in Input Output tables to inform the estimation of impacts. These include economic multipliers as well as the share of spending that flows to the labour market for a given sector. The Input Output tables used in the EIM-ES provide a static representation of the structure of the economy and are based on historic data points that can, for some countries, be quite out-dated. The model does not include any mechanism or assumptions to dynamically update the economic structure over time (as is done in more sophisticated modelling tools). The sector inter-relationships are therefore an approximation of – but will not necessarily reflect - the future structure of the economy over the modelling period.

A further limitation is that the sector disaggregation in the model (based on the Input Output table and which is also applies to salary information) is typically at a relatively high-level, e.g. the sector for fabricated metal products or electrical machinery. The model therefore does not provide a detailed representation of the specific goods and services relevant to the electricity supply sector, but assigns each cost component to one of 36 economic sectors (in the case of tables from the OECD database). Where a cost component is not representative of the high-level sector it is allocated to, the results may be less accurate, particularly in the estimation of the indirect and induced impacts of investments.

Finally, an additional simplification within the model is to include cost estimates that are expressed in units of capacity (e.g. per MW) or, for variable costs, in units of electricity generation (e.g. per GWh). The model scales these estimates in a linear manner based on the total capacity added or electricity generated for a given technology without factoring in any potential economies of scale. For example, the relative impact of a 10MW wind farm is the same as that of a 100MW wind farm, even though in practice the costs per MW might be lower in the case of the larger project. As the model allows up to 35 technology types to be included, where there are significant differences in the cost per unit of a technology and relevant data is available, the issue can be partially mitigated by setting up separate technologies categories in the model, for example for large-scale and small-scale plants.

Further resources

The Economic Impact Model for Electricity Supply, an overview presentation and a userguide are available at http://ambitiontoaction.net/outputs/.

About NewClimate Institute

NewClimate Institute supports research and implementation of action against climate change around the globe. We generate and share knowledge on international climate negotiations, tracking climate action, climate and development, climate finance and carbon market mechanisms. We connect up-to-date research with the real-world decision-making processes, making it possible to increase ambition in acting against climate change and contribute to finding sustainable and equitable solutions. NewClimate Institute is a not-for-profit organisation based in Cologne and Berlin.

Ambition to action project

The **Ambition to Action** project aims to support the implementation of the Paris Agreement on climate change in four partner countries: Argentina, Kenya, Indonesia and Thailand. The project aims to develop sector roadmap documents for each of the four partner countries, drawing together the benefits evidence from a flagship initiative analysis and sector scenario comparisons to identify priority mitigation actions.

The project is funded by the International Climate Initiative of the German Government. It is implemented by ECN, part of TNO, and NewClimate Institute, working together with government partners and local experts.