PROSPECTS+:
A tool for climate policy analysis at the sectoral and national level

PROSPECTS

NEW CLIMATE INSTITUTE

Climate Action Tracker

ClimateWorks FOUNDATION

ICAT INITIATIVE FOR Climate Action Transparency

PROSPECTS+: A tool for climate policy analysis at the sectoral and national level

Approach, methodology, documentation, structure

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1 Acknowledgements

This methodology description has been prepared by NewClimate Institute and is based on an internal working document that was originally prepared for an earlier version of the PROSPECTS tool by the Climate Action Tracker (CAT) team (NewClimate Institute, Climate Analytics, Ecofys).

2 Introduction

Responding to the threats of global warming, the Paris Agreement has determined very specific long-term goals: keeping the increase in global average temperature to well below 2°C above pre-industrial levels and aiming to limit the increase to 1.5°C. However, the current mitigation action is not yet ambitious enough to achieve these goals. Thus, there is an urgent need to identify where rapid decarbonization is occurring, what we can learn from these processes, and where more action can be taken. Modelling greenhouse gas (GHG) emission on sector-level is essential to do this evaluation.

ClimateWorks Foundation has developed the Carbon Transparency Initiative (CTI) tool for 5 countries/regions (Mexico, China, India, EU, USA). The CTI tool is spreadsheet-based, with a detailed methodology to determine greenhouse gas emission pathways between 2010 and 2030, across all sectors of the economy. Besides, the Climate Action Tracker (CAT) has developed a database which contains emission data of more than 30 countries/regions.

Based on feedback from the user community, that the CTI is too complex to use in certain use cases, especially in the context of developing countries, the Climate Action Tracker team developed a simplified version of the CTI tool: The PROSPECTS+ (Policy-Related Overall and Sectoral Projections of Emission Curves and Time Series) tool. The development of the tool was supported by the ClimateWorks (CW) Foundation. After initially focusing on the structure of the tool to serve analysis undertaken under the CAT, it was further developed by NewClimate Institute with the funding of ClimateWorks Foundation to become more accessible to developing country stakeholder and became the PROSPECTS+ tool. The tool is a sector-level bottom-up Excel tool which can track and provide projections of overall and sectoral GHG emissions trends of a country, based on the historic and future development of relevant indicators for decarbonisation. It allows for projections of future GHG emissions responding to policy and technology shifts.

The tool combines merits of the CTI tool and the CAT database: (a) it simplifies the sectoral level details in the current CTI tool to achieve the ability to cover a wider range of countries more easily, and (b) uses a range of data sources representing a large number of countries (currently only 6 CTI country models exist), which are contained in the CAT database. Through the proposed sectoral level approach, the PROSPECTS+ tool can reveal where rapid decarbonization is occurring and where more action can be taken. To mitigate data-issues, PROSPECTS+ also provide the option for buildings, transport, cement and iron & steel to apply a simplified approach. This reduces data-requirements and time spent on a sector that might be less important for certain analyses.

The PROSPECTS+ framework is driven by key indicators that shape emission trends on sectoral level for each country (e.g. emission intensity of electricity generation for the power sector or passenger km travelled per person for the transport sector). By breaking down macro-level emissions into sectoral-level indicators, the approach increases transparency on decarbonization in each sector and allows comparisons among regions and over time at multiple levels of the economy. An aggregation of all sectoral trends in the model then leads to an overall emissions profile of a country.

The tool covers all emissions-generating sectors: power and heat, buildings, transport, various industrial sectors, waste, agriculture and forestry. Electricity and heat sectors are supply-side sectors since they provide electricity and heat, respectively, to other sectors. The other sectors are demand-side sectors.

The tool covers the time period from 1990 to 2050 and can be readily configured to extend into the second half of the century.

By providing sufficient details at sector level and allowing users to define different scenarios, this model can provide better transparency on GHG emission in a country and provide ideas of how to achieve the goals of Paris Agreement efficiently. Furthermore, the developed model will be usable in general to assess a country's emission profile under various types of policy scenarios and enhanced-ambition scenarios.

3 Objectives and purposes

This section describes for what purposes PROSPECTS+ can be used and how its general functioning is designed to do this.

3.1 Objectives

The general objective is for the model to be able to provide a bottom-up projection of a country's future emissions, considering user-defined sector-level developments of activity and intensity. The user of the tool can construct (one or more) emission scenarios, based on the assumed impact of certain external drivers—policies, socio-economic changes, market developments—on sector-level activity and intensity data.

3.2 Advantages and disadvantages

There are several advantages of using the presently proposed PROSPECTS+.

- The bottom-up approach allows direct assessments of policy impacts. For example, vehicle activity and related metrics are part of its input drivers and can thus be easily adapted to investigate the effect of such sectoral trends.
- In the bottom-up approach, there are various (mostly energy-related) metrics calculated in between the input (sectoral activity, intensity) and the output (emissions) that are of interest in policy assessment, such as energy demand from industry, electricity demand in the transport sector, et cetera.
- The bottom-up approach and the consideration of economy-wide indicators allow direct assessments of the interaction of different sectoral developments (mostly energy-related). For instance, the potential effect on emissions mitigation in the transport sector due to the electrification of the vehicle fleet is determined and evaluated by the decarbonisation of the power supply sector.
- Data availability might be a limitation, for some sectors or e.g. for smaller countries, or data gathering may be time-intensive in these cases. PROSPECTS+ mitigates this issue for buildings, transport, cement and iron & steel by allowing a simplified approach, which requires less data.

The main disadvantages of the bottom-up approach compared to a macro-level approach are the following:

- The user needs to collect data on every sector to construct an economy-wide emissions scenario. One also needs to have a full understanding of all sectors in order to define a sensible scenario.
- Combining different sources leads to potential inconsistencies (e.g. assumed economic growth may differ among input sources).

4 Functional and technical design

This section describes considerations of the overall abilities of the tool and how the user will interact with it. It points out what the user needs to do in order to use the tool for policy/driver analysis, and how this is handled in the tool.

4.1 Structure of the tool

The tool has four categories of sheets with which the user interacts: Navigation, Results, Historic Data and Scenarios. Next to this, there are sheets with international datasets (population data, GDP) and calculations. The latter sheets do not require input from the user.

4.1.1 Navigation sheets

Navigation sheets help the user navigate thought the tool when collecting data and create scenarios. The navigation sheets are:

Wizard allows the user to navigate to the right place to start collecting historical data, scenario data or navigate to the Data validation sheet or the Country Summary.

Wizard – Sectors helps the user navigating to the different sectors when updating historical data. Either by directly linking to the right section in Input – Historical Data, or by moving to: *Wizard – Industry, Wizard – Buildings* or *Wizard – Transport*.

The latter three sheets single out one sector, because for transport, buildings, cement and iron & steel, the user can select to use a simplified approach. The simplified approach requires less data and could be used in case of limited data-availability or if a sector is not important in the analysis.

Users do not have to use the navigation sheets, but if used, the navigation buttons trigger macro's that auto-hides rows that are not relevant to the selected sections.

4.1.2 Result sheets

Data Validation contains a table where users can enter external scenarios corresponding to emissions and energy from individual sectors, which will be shown together in a graph. The sectoral emissions and energy curves calculated in PROSPECTS+ will also be shown in this graph, allowing the user to check on consistency of values and trends. In this sheet, there is also a table where the user can enter external time series of economy-wide emissions. This can then be used to produce a time series of emissions harmonised to one or more of these scenarios.

The *Country Summary* sheet displays main global indicators and key outputs from the calculation sheets. The sheet draws all energy and emission data from the different sectors' calculation sheets, summarizes, and adds them up to get total emissions profile of a country.

This sheet contains buttons to select scenarios and update the corresponding global indicators, key outputs. It also contains graphs with the resulting emissions and energy developments.

The *PivotTable* sheet allows the user to export all input and results in one table. To reduce calculation time, a macro is used to update the tables. The macro to do this is triggered by a button. Only one scenario at a time can be imported in the (pivot)table.

4.1.3 Historic data sheets

Input – References contains a list of all sources used in the data collection in the tool.

Input – Historical Data collects all input data from 'Input – IEA Data' and 'Workbook – Historical Data'.

Input – IEA Data is the sheet where all data from IEA databases (energy balances and emissions from fuel combustion) is collected.

Workbook – Historical Data contains primary historical (non-IEA) data for every sector from literature as well as "macro" data such as population size. Data requirements are described in more detail in section 4.4. The sheet contains tables in the required format as well as free calculation fields.

4.1.4 Scenario sheets

In these sheets, the user can evaluate emission-related policies and calculate the potential impacts of policies (and of other drivers, such as socio-economic and technology-related ones) on indicators in different sectors. The scenario development is split into two parts:

1. Up to nine different pathways can be defined for each indicator.
2. Different pathways (selected per sector) can be combined into scenarios..

Input – Create scenarios: Here, different scenarios can be created by selecting pathways for each sector. These pathways can be created in the sheet 'Workbook – Scenarios';

Workbook – Scenario: here scenario-pathways can be created. The user can define up to nine scenarios in this sheet. This is described in more detail in the next section.

The scenario sheets are thus split up in one sheet where pathways per sectors are created and one where pathways are combined to allow more flexibility in the creation of scenarios: as one can quickly switch between pathways instead of overwriting input. This e.g. allows ceteris paribus analysis.

4.1.5 Calculation sheets

Every sector has a Calculation sheet with a uniform structure for all sectors, as shown in Figure 1: Historical data are used to calculate indicators in historic years. Based on policy evaluations, the development of indicators is estimated. By combining historic indicator values with estimated indicator developments, future indicator values are calculated. Historic and future indicator values are then combined to calculate the emissions pathways in a sector.

- Historical indicators in sector are calculated based on primary historical data (1990-2016) in the historical data sheets. For example, historical data of electricity generation by fuel is given in *Input – IEA Data* sheet, with which historical total generation and fuel mix is calculated in this part.
- Projections of indicators (2017-2030) are made with the input from *Input – Create scenarios*. For example, for the fuel emission intensity in the electricity sector, the assumed growth rate (representing e.g. a shift to cleaner coal or more efficient coal plants) would be input in the *Workbook – Scenario* sheet. Combined with the input on historical data, future fuel emission intensity can be calculated.
- With historical and predicted data for activity and intensity indicators, overall energy demand and emissions from each sector can then be calculated. In the electricity sector, for instance, total emissions are the product of total electricity generation (activity indicator) and average emission intensity (intensity indicator).
- The calculations per sector are discussed in detail in the next chapter.

The *Admin* sheet contains a number of standard values, conversion factors, text strings, etc., needed in one or more of the Calculation sheets.
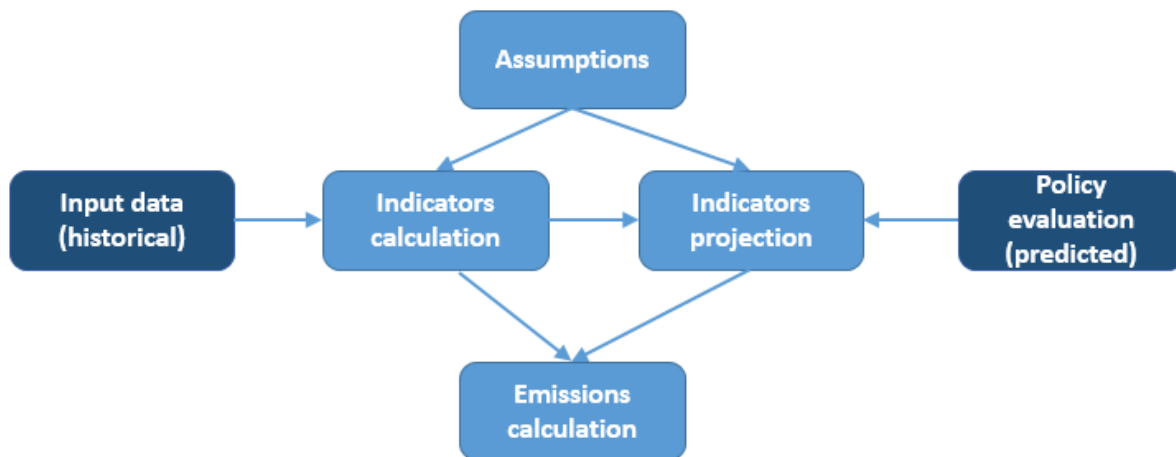
Figure 1: Structure of calculation sheets

4.1.6 Energy Security Indicators sheet

The tool produces a set of *Energy Security Indicators* for the country under analysis drawing from the sector-level and economy-wide data contained in PROSPECTS+. No additional input data is required. This information can help inform the impacts of climate policies and future sectoral developments on the country's energy security, given the underlying assumptions of each scenario developed in the tool.

The *Energy Security Indicators* are included in the tool in a sheet with the same name, both in tabular and graphical form. The *Energy Security indicators[1]* included in the tool are listed below:

- Primary energy demand* per capita and per unit of GDP
- Electricity generation per capita and per unit of GDP
- Diversity of energy supply* (Shannon-Weiner diversity index)
- Diversity of electricity supply (Shannon-Weiner diversity index)
- Share of intermittent technologies in electricity supply
- Reliance on electricity imports (total imports and share in total electricity generation)
- Share of fossil fuels in primary energy demand*
- Quantity of fuel requirements (coal, oil and natural Gas)
- Cost of fuel requirements (coal, oil and natural Gas)[2]

The indicators listed above offer, individually, insights into specific elements of energy security that may be relevant to a country. The combined range of different indicators may offer insights into some of the trade-offs within the energy system. However, a complete assessment of the country's energy security should be accompanied with additional information of the country that puts the results of the indicators into context and allows for consideration of a longer list of relevant indicators.

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[1] The indicators related to primary energy sources, marked with (*) in the list, assume energy efficiency of 100% for renewable energy and other non-fossil, non-nuclear sources. This assumption underestimates the participation of these resources compared to fossil and nuclear energy sources with efficiencies lower than 100% (i.e., the share of each energy source in total primary energy supply or demand is increased by a factor of 1/(1-EE%), which affects only those sources with EE lower than 100%)

[2] Where these fuels are produced domestically the cost – which is based on a global commodity price projection – can be thought of as an *opportunity* cost, i.e. the revenue forgone from consuming the fuel domestically rather than exporting it to satisfy demand elsewhere.

4.2 Policy scenarios

The tool will allow the user to enter assumptions corresponding to different input scenarios, as mentioned above. This section describes the *Workbook – Scenario* sheet in more detail.

In this sheet, the user is presented with a list of indicators—grouped by the different sectors—for which a projection, expressed as one of the following two metrics, needs to be entered for each year in the period 2017-2030:

- A percentage share (%) if the indicator is itself a percentage, such as the share of renewables in electricity generation, the share of a certain steelmaking technology in overall steel production, etc.
- A growth rate (%) if the indicator is an activity- or intensity-related metric in absolute units, such as the emissions intensity of coal, overall steel production, etc.

This numerical data must be entered for each future year, because some policies will only have an impact on the short term before their effect flattens off, while others might only start showing an impact a number of years post-implementation.

Defining a pathway[3] representing "current policies" therefore consists of determining the changes expected in each indicator under current policies. The user can enter up to nine different pathways in this sheet.

An illustrative example is the following. One of the indicators required for policy analysis in the buildings sector in PROSPECTS+ is the heating/cooling energy intensity (TJ / m2) in housing:

- X% improvement per year until 2030 could mean autonomous improvement without further policies (this could be called a "base case" scenario);
- Y% improvement (with Y > X) until 2020, followed by Z% (with Z > Y) improvement until 2030, could mean insulation measures under current building standards ("current policy scenario") that are expected to be tightened in 2020;
- Z% improvement until 2030 could mean better insulation measures under an immediate tightening of building standards ("enhanced policy scenario").

One of the main challenges lies in selecting the most relevant indicators when it comes to assessing how the impact of a policy could be quantified:

- In some cases, the indicators used for policy assessment could be the same as those required as input data—e.g. fuel mix in the power sector).
- In other cases, an "intermediate indicator" may be needed for increased policy-relevance—e.g. having energy use in buildings as input data (1990-2015), but converting it to the intermediate indicator energy intensity per unit floor area (TJ/m2) for the policy scenarios, defining the latter's growth rate (2016-2030), and then using the corresponding projected energy intensity to determine the projection of energy use in the period 2016-2030.

Some indicators may not need to be defined for each specific scenario. For instance, population projections (needed for per-capita indicators) exist from authoritative sources (e.g. UN population projections) and are not related to climate policies, so these need not be re-entered for each of the up to nine pathways but are instead determined once for the entire tool (where the user may however have the possibility to choose between different projections from the chosen external source, e.g. "high", "medium" or "low" fertility scenarios in the UN population projections).

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[3] Here we use the term pathway for the developments of individual parameters. The combination of pathways (defined in the sheet 'Input – Create scenarios') adds up to a scenario.

4.3 Indicators

All the indicators in the tool can be classified into 3 groups: **activity metrics, intensity metrics** and **aggregate metrics**.

- Activity metrics refer to the level of emission-related activities: they include quantities such as electricity generation, steel production, cement production, etc.
- Intensity metrics are measures of the amount of energy or emissions resulting from one unit of activity.
- Aggregate metrics are combinations of the two, resulting in time series of e.g. overall energy demand, overall electricity demand, or overall emissions from a sector.

Activity metrics and intensity metrics are driver metrics, because policies or other trends determine the development of those, which in turn influence the outcome metrics, such as calculated electricity and energy demand and the corresponding emissions, as well as aggregate intensity metrics.

Taking the steel sector as an example, steel production by production method, and the share of each production method, describe the activity of steel production, so they are activity metrics. Emissions intensity (direct energy-related, indirect energy-related and process-related) measure the amount of emissions resulting from one unit of steel production, so they are intensity metrics.

4.4 Data requirements, availability and validation

This section describes the requirements and constraints on data needed to run an emissions scenario in PROSPECTS+. It also discusses how the sectoral and overall emissions scenarios generated by PROSPECTS+ can be validated against external (third-party) scenarios.

4.4.1 Input data

A variety of input data are needed to use the PROSPECTS+ approach to construct an emission projection for a country "from scratch". These are:

- Historical data for a list of indicators in each sector (the list per sector is provided in Section 5) from which the historical GHG emission time series of each sector can be calculated.
- Historical and projected data for economy-wide indicators, such as population size and GDP.
- The user needs to define the scope of the scenario(s) that they wish to develop. For instance, for a "current policy scenario", the user would need to define which currently existing policies they wish to explicitly include in the modelling approach.
- The user needs to input numerical data on the assumed development of the relevant sector-level indicators in each sector under the specific policy scenario under development, as explained in section 4.2. This numerical data can be obtained in different ways:
  - By using an external model or tool that assesses the influence of each specific policy considered in the policy scenario under development. For instance, in the electricity sector, this could be a tool that assesses the influence of the introduction of a feed-in tariff (if part of the policy scenario) on the share of renewables in total electricity production in each year until 2030. The output of this tool would then be used as one of the inputs in PROSPECTS+.
  - By making simple assumptions, based i.e. on external studies or expert input, on what, realistically, the quantitative effect of the policy under consideration could be on the sector-level indicators.
  - In case no specific policy is being assessed, by making assumptions on which drivers could influence the indicator in the future (e.g. increased electricity demand due to population growth), either from own assumptions or from external modelling scenarios

(e.g. existing predictions from authoritative sources on how this indicator would develop), and deriving from this the numerical values to be used as input.

  o The basis for this "policy assessment" can also be various user-determined considerations such as e.g.:

    ▪ What is the most cost-effective way of reducing emissions, given the boundary conditions set by the user in the scenario?

    ▪ Which policies could have the highest co-benefits and should therefore be prioritised in the assessment?

- For those sectors/indicators where historical data availability is limited, the user would have to make realistic assumptions on what the historical values of the indicator in the country could have been. A number of options are listed in section 4.4.2 below.

- Optional: Not all IPCC emission categories are covered in PROSPECTS+ calculations (e.g. LULUCF). To allow users to include these emissions in the calculations of the overall emissions, there are tables in 'Workbook - Historical Data' to collect the pathways of these emission categories.

4.4.2 Data availability

Whenever explicit data corresponding to the required input values is not available, the user needs to resort to one of a number of possibilities to estimate this input instead, some of which are listed here.

- "Proxy" variables can be used. A proxy variable is a variable that is known to be correlated with the variable needed for PROSPECTS+. This variable can be used to estimate the values of the required input data. For instance, in the CTI tools, this approach is used for some countries to estimate the waste generation per capita from data on GDP/capita.

- It can be assumed that a certain relative indicator related to the required input data is the same, or similar, as in another country for which data are known. An example could be to assume that energy intensity in buildings (TJ/m^2) and floor space per capita (m^2/cap) in country A is the same as in neighbouring country B with similar climate and similar socio-economic conditions. If data exists on energy use and floor space in country A, but not in country B, one can assume that these two indicators have similar values in both countries, and use these to estimate total energy use in country B.

- If data is unavailable on a level of granularity required by the model but available on a more aggregated level, one could directly use these data instead of a calculation from more granular indicators by manually overwriting the latter.

  o The levels on which "less granular data" can be used instead of the calculations should not exceed two for each sector (representing energy use, if applicable, and emissions).

  o Whether this option should be available at all, on one level, or on two levels, is different per sector.

  o For the sectors Buildings, Transport, Cement and Iron & Steel a simplified approach can be selected. This approach requires: IEA data (electricity demand, total non-electricity demand and the fuel mix) as historical input, cement and steel production and cement process emissions.

4.4.3 Output data

The tool produces a variety of sector-level and economy-wide data for the country in question. This covers historical and projected data series of the following:

- Emissions from each specific sector with electricity-related emissions allocated to the power sector;
- Emissions from each specific sector with electricity-related emissions allocated to the respective end-use sectors;
- Aggregated country-wide emissions under the scenarios investigated in the tool.
- Emissions categorised by energy-related CO_2 emissions, process-related CO_2 emissions, and non-CO_2 emissions;
- Final energy demand by sector and separated into electricity and direct energy demand;
- An estimation of primary energy supply;
- An overview of several relevant sector-level activity and intensity indicators calculated in the model.

The tool can thus be used both for sectoral analyses as well as overall energy and emissions scenarios. This means the tool can also be used to solely study specific sectors, with no requirement to collect data on all sectors. The exception is electricity and heat generation, which depends on electricity and heat demand in all sectors.

4.4.4 Data validation and harmonisation

Because the tool produces an overall emissions scenario based on sector-level indicators data collected from different sources, the resulting (sectoral and overall) emissions time series will deviate to some extent from authoritative, emissions time series from the country's own projections or other external sources.

The important questions that needs to be considered is whether the results are acceptable considering the specific simplifications, assumptions and data sources used in PROSPECTS+ as compared to other scenarios.

If considered inacceptable, the following reasons for the deviation need to be considered:

- **Coincidental errors**: Can the deviation be (partly) attributed to input data that is faulty? I.e. are the wrong numbers being fed into the calculations? This could include values that are plainly "off" (i.e. inaccurate estimations), or data whose definition deviates from what is needed in the tool.
- **Systematic errors**: Have all sources of emissions been considered or have any elements been left out? This may include elements that are of no importance in one country but more significant in another. Similarly, are any sources of emissions being double-counted?

To make sure the user can check and calibrate the PROSPECTS+ output against other emissions scenarios, the following functionalities are available:

- PROSPECTS+ has tables where the user can collect external sectoral emissions scenarios. The user can then plot each PROSPECTS+ sectoral emissions curve along with the external time series of that sector and check the consistency.
  - If the PROSPECTS+ output is comparable / falls in the range of external time series, the output can be considered acceptable. Otherwise, the uncertainty of input data and validity of the calculations will have to be reassessed.
  - A sectoral emissions curve could be generated from wrong input data, yet still be in line with external scenarios, since in theory, a range of activity/intensity indicator

combinations can result in roughly the same emissions curve. Thus, the user must be aware of the realistic ranges associated with these indicators.

- Secondly, in PROSPECTS+ users can collect overall (economy-wide) external emissions scenarios. If the tool is used for country analysis, the output emissions time series of the tool can be harmonised with an external emissions scenario (e.g. by harmonising to a certain year, or "on average" across a range of years).
  - o The exact mathematical step of harmonising (offsetting with a constant; applying growth rates; etc.) can be determined by the user. Depending on the type of harmonization, the user can perform this operation on any input parameter (e.g. adjusting emission factors to harmonize emissions or adjust total building area to match total final energy demand in the building sector).
  - o This is only recommended as a last step in the calculations, because performing the mathematical operation of harmonising a time series changes the overall outcomes without altering the indicators on sectoral level.
  - o It is important to distinguish here between the validation and the harmonisation process. The validation of the data should be done on a sectoral level wherever possible, because it may be that deviations in sectoral emissions (partly) cancel each other out on an economy-wide level (which the user would not notice if there was no sectoral validation performed). On the other hand, the harmonisation should only be done on an economy-wide level, not per sector, as the latter would still not result in a time series harmonised to the external economy-wide emissions scenarios (unless all sector-level scenarios would be consistent, and completely define, the economy-wide scenario).

5 Documentation of sector-level approaches

In the following sections, we describe the calculations performed in each sectoral module of PROSPECTS+ and the indicators and related policy (and other) drivers involved herein. The first section deals with indicators that are defined across all sectors. The second section describes the approaches used in all specific demand-side sectors. The third section lays out the approaches used for the supply-side (electricity and heat).

5.1 Globally-defined indicators

A number of indicators in PROSPECTS+ are defined on a cross-sectoral level and used throughout the tool and fed into the calculations of various end-use sectors. These indicators are discussed first, before the logic of each sector is introduced in the sections hereafter. It concerns the emissions intensity of electricity production and the emissions intensity of direct energy use.

5.1.1 Emissions intensity of electricity production

Buildings, industry, transport and agriculture require power. The PROSPECTS+ logic does not distinguish between sources of power in different sectors: if the electricity grid is fed with higher shares of low-carbon power, this reduction of carbon intensity has the same relative effect on electricity-related emissions in every end-use sector. The power sources explicitly reflected in PROSPECTS+ are coal, gas, oil, nuclear, hydro, geothermal, biomass, wind, solar, marine, waste and "others".

This simplification means that the auto-production of electricity (i.e. through solar panels on rooftops or the on-site generation of power in industrial installations) is not explicitly included. It is assumed that associated emissions are already attributed to direct energy use.[4] The increased use of renewables in power generation overall can always be reflected in the "power mix" indicator in the tool (see also section 5.3). Figures are based on the IEA CO2 Emissions from Fuel Combustion and the IEA Energy Balances.

5.1.2 Emissions intensity of direct energy use

The emissions intensity of direct energy use—which in PROSPECTS+ is categorised into coal, oil, gas, waste, heat, and others—must be treated with more caution. The reason is that the categorisation into these categories does not reflect the differences between direct energy use patterns in different sectors (which does not arise in the electricity sector because of the presence of a centralised grid that delivers the power to the end-use sectors).

A good example is the steel sector, whose direct energy mix typically has much higher shares of coal than in other industrial sectors, due to the use of coke (which has a very high relative carbon content as compared to other products categorised under "coal"). Thus, taking the same average emissions intensity of "coal" indiscriminately in the steel sector as in other industrial sectors would systematically underestimate the emissions from steelmaking.

An analysis of the IEA Energy Statistics and Balances data reveals that, on an aggregated level, the emissions intensities of direct energy are generally comparable across different industrial sectors and others (buildings, agriculture)[5]. The one strong exception is indeed the steel sector, where—due to the use of coke-related products for coke ovens—the weighted average emission factor of all coal products aggregated is much higher than in other sectors. However, when removing the coke-related products from the fuel mix in the iron and steel sector, numbers match much. For this reason, the calculations in

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[4] "Fuel inputs for the production of heat consumed within the auto-producer's unit are not included here but are included with figures for the final consumption of fuels in the appropriate consuming sector." (Quote from the database documentation of the 2016 World Energy Balances) (IEA, 2016a).

[5] Note: the value for gas is applied universally, because there is only one type of "natural gas" considered in the IEA Energy Statistics and Balances, as compared to 19 different types of energy carrier that fall under "coal".

the iron and steel sector will be done based on this adapted fuel mix, so that the same direct energy emission factor can be applied across all sectors. Emissions from coke-related products are then accounted for separately, as explained in section 5.2.

The fuel mix of direct energy is specified per sector in PROSPECTS+. Not distinguishing between these would introduce considerable systematic errors.

5.2 Demand side

This section describes the model logic in all demand-side and other emitting sectors of the economy: buildings, industry, transport, waste and agriculture/forestry. Each of the separate modules in the PROSPECTS+ logic is shortly described and a breakdown of the necessary input data is given. A description of the indicators used for defining the policy scenarios is also included for each module.

The legend for interpreting the various logic trees given in this section is presented in Figure 2.
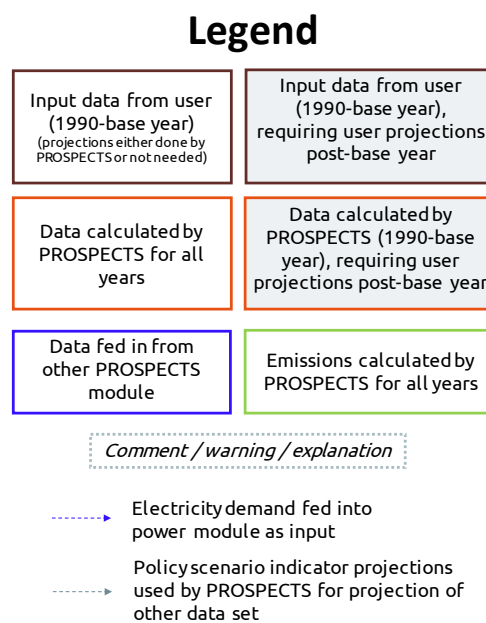
Figure 2: Legend for all logic trees presented in the remainder of this document.

5.2.1 Buildings

Table 1, Table 2, Table 3 and Table 4 show the input data and policy scenario input indicators needed for the buildings module in PROSPECTS+. The complete logic tree for the buildings sector is shown in Figure 3.

As input, historical data on final energy demand (direct energy and electricity) is needed, which (along with the fuel mix) is available from the IEA Energy Statistics and Balances.

Non-simplified approach

To distinguish between different types of energy use, PROSPECTS+ splits energy demand in heating (incl. water heating), cooling, and cooking & appliances (incl. lighting). This could be estimated from the split in the IEA ETP (for instance for OECD vs. non-OECD countries).

Data on floor space will not be obtained from a single source for all countries. When it is not directly available, we propose to estimate it by assuming the floor space intensity (m^2/capita) is the same or close to that of another country with comparable cultural/climatic factors affecting the building stock. Important for this mapping are factors such as same climatic zones, similar building type compositions (e.g. single family vs. multifamily) and rural/urban split.

These data are converted into several indicators that are used in defining the policy scenarios: the total energy intensity per square metre (direct energy and electricity together) for heating, cooling, and cooking and appliances, and the electrification rate in heating and in cooking/appliances (it is assumed to be 100% in cooling).

The building stock projection is divided into two categories in PROSPECTS+ – "old" and "new/renovated" buildings – with a simple stock turnover calculation. Here, "old" refers to buildings constructed before the base year of the calculations (i.e. the last year until of the historical data). The stock turnover is based on the renovation of buildings and construction rate of buildings (the percentage of the building stock being either reconstructed or undergoing deep renovation). This new/renovated stock can then be assigned a lower energy intensity for heating/cooling than the old buildings stock.

Simplified approach

In the simplified approach, the IEA data is sufficient, combined with assumption on future energy demand growth rates.

Table 1: Input data for buildings sector in the non-simplified case (separately needed for residential and commercial buildings)

Indicators	Units	Data sources
Total floor space	million m^2	IEA Buildings (IEA, 2013) and/or estimates from countries with similar climatic zones, cultural settings, building types and rural/urban split.
Direct energy demand for heating	PJ	(IEA, 2016a) + estimate from (IEA, 2016b)
Direct energy demand for cooking/appliances	PJ	(IEA, 2016a) + estimate from (IEA, 2016b)
Fuel mix direct energy use	%	(IEA, 2016a)
Electricity demand for water / space heating	TWh	(IEA, 2016a) + estimate from (IEA, 2016b)
Electricity demand for cooling	TWh	(IEA, 2016a) + estimate from (IEA, 2016b)
Electricity demand for cooking / lighting / appliances	TWh	(IEA, 2016a) + estimate from (IEA, 2016b)

Table 2: Input data for buildings sector in the simplified case (separately needed for residential and commercial buildings)

Indicators	Units	Data sources
Total direct energy demand	PJ	(IEA, 2016a)
Fuel mix direct energy use	%	(IEA, 2016a)
Total Electricity demand	TWh	(IEA, 2016a)

Table 3: Policy scenario input for buildings sector in the non-simplified case (separately needed for residential and commercial buildings)

Indicators	Units	Input required	Driver type
Total floor space per capita	m²/cap	% growth rate	Socio-economic
Renovation / renewal rate	%	% rate	Policy
Improvement in energy intensity for heating/cooling for new/renovated buildings	%	% rate of reduction (relative to old stock)	Technology
Total energy intensity for water / space heating	GJ/m²	% growth rate	Policy, technology
Total energy intensity for cooling	MWh/m²	% growth rate	Policy, technology
Total energy intensity for cooking/appliances	GJ/m²	% growth rate	Policy, technology
Electrification rate in water / space heating	%	% share	Technology
Electrification rate in cooking / lighting / appliances	%	% share	Technology
Fuel mix direct energy use	%	% share	Policy, technology

Table 4: Policy scenario input for buildings sector in the simplified case (separately needed for residential and commercial buildings)

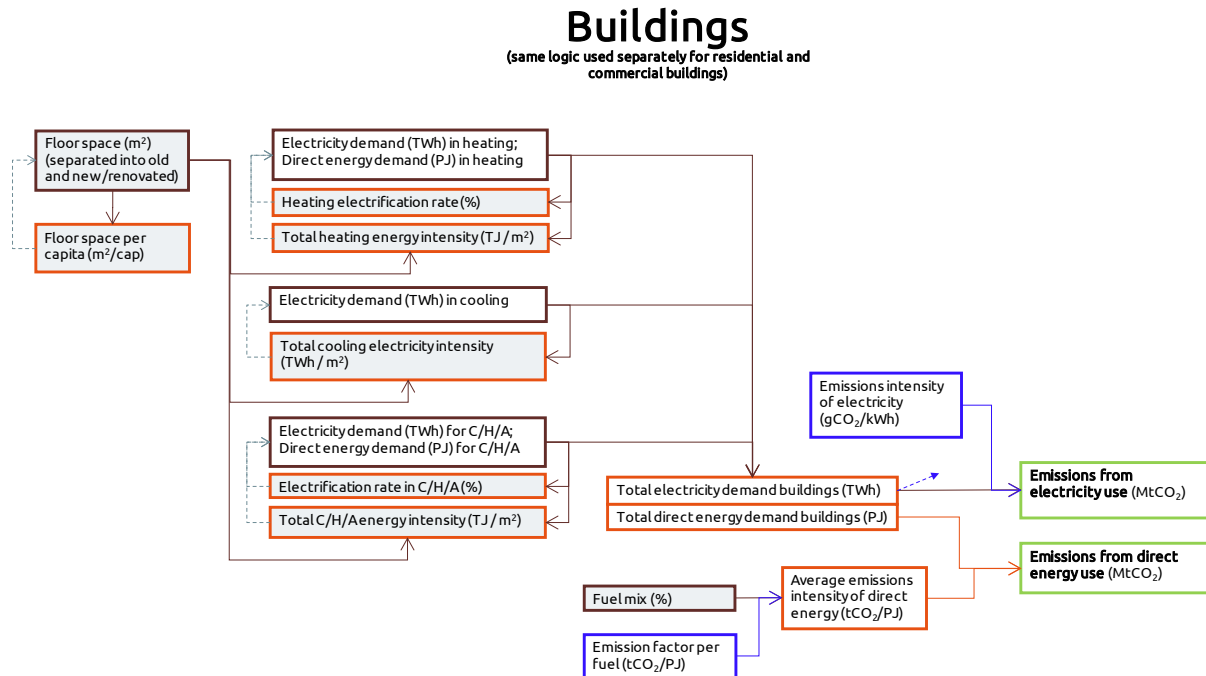| Indicators	Units	Input required	Data sources
Total direct energy per capita intensity growth rate	GJ/capita	% growth rate	Policy, technology, socio-economic
Fuel mix direct energy use	%	% share	Policy, technology, socio-economic
Total electricity per capita intensity growth rate	GJ/capita	% growth rate	Policy, technology, socio-economic

Figure 3: The logic tree for the buildings sector in PROSPECTS+

5.2.2 Cement industry

Table 5, Table 6, Table 7 and Table 8 show the historical data and policy scenario inputs needed for the cement sector in this prototype of PROSPECTS+. Figure 4 shows the logic tree of the cement sector.

The emissions of the cement industry come mainly from 3 sources: **electricity use**, **direct energy use** and **process emissions**. *Electricity use* refers to electricity consumption from the grid in the cement industry. *Direct energy use* mainly refers to traditional fuels and renewables that are burned or directly used onsite. *Process emissions* means the emissions released during the manufacturing process in specific industry sectors (e.g. cement, ammonia). In the cement industry, process emissions come mainly from a chemical process called calcination. Calcination occurs when limestone, which is made of calcium carbonate, is heated, breaking down into calcium oxide and CO_2.

Data on cement production are available, for instance, from the United States Geological Survey. A separate data series on clinker production is necessary to ensure that cement produced from imported clinker does not result in additional process or direct energy-related emissions, since those should be counted in the clinker-producing country (and similarly for clinker destined only for export).

Data on energy and electricity intensity of cement making can be estimated from WBCSD time series (Cement Sustainability Initiative, 2016), whereas data on the fuel mix can be obtained from the IEA Balances (IEA, 2016a)—where cement is the main energy-using process (Blok, 2007).

Most of these indicators are retained for the policy analysis (requiring a future percentual or growth rate value as input). An exception is that the link between total cement and total clinker production is made more explicit by calculating another indicator: the ratio of locally *processed* clinker to locally *produced* clinker. (If this indicator is >100%, this indicates that the country, to some extent, uses imported clinker in its cement production; conversely, a number <100% indicates that not all clinker produced in the country is used for cement production in that country, and most likely used for exports.) This prevents potentially inconsistent projection time series of cement and clinker production.

Simplified approach

In the simplified approach, clinker conversion is not evaluated and calculations are made based on total cement production, process emissions and IEA data.

Table 5: Input data for cement sector in the non-simplified case

Indicators	Units	Data sources
Cement production	Mt cement	(USGS, 2015) or (Cement Sustainability Initiative, 2016)
Clinker / cement ratio	%	
Total clinker production	Mt clinker	
Electricity intensity of cement production	TWh / Mt cement	(Cement Sustainability Initiative, 2016)
Direct energy intensity of clinker production	PJ / Mt clinker	
Direct energy fuel mix	% share	(IEA, 2016a) (category "non-metallic minerals")
Process emission intensity	$MtCO_2e$ / Mt clinker	Combining production data from (Cement Sustainability Initiative, 2016) with process emissions from (UNFCCC, 2017). Should be a constant value throughout the calculations.
Emissions captured with CCS	% of process and direct energy emissions	

Table 6: Input data for cement sector in the simplified case

Indicators	Units	Data sources
Cement production	Mt cement	(USGS, 2015) or (Cement Sustainability Initiative, 2016)
Electricity intensity of cement production	TWh / Mt cement	(Cement Sustainability Initiative, 2016)
Direct energy intensity of clinker production	PJ / Mt cement	Calculated
Direct energy fuel mix	% share	(IEA, 2016a) (category "non-metallic minerals")
Process emissions	MtCO$_2$e	(UNFCCC, 2017)
Emissions captured with CCS	% of process and direct energy emissions	

Table 7: Policy scenario input for cement sector in the non-simplified case

Indicators	Units	Input required	Driver type
Cement production	Mt cement	% growth rate	Socio-economic
Clinker / cement ratio	%	% ratio	Technology
Ratio of locally processed clinker to locally produced clinker	%	% ratio	Economic
Electricity intensity of cement production	TWh / Mt cement	% growth rate	Technology
Direct energy intensity of clinker production	PJ / Mt clinker	% growth rate	Technology
Direct energy fuel mix	% share	% share	Policy, technology
Emissions captured with CCS	% of process and direct energy emissions	% captured	Policy, technology

Table 8: Policy scenario input for cement sector in the simplified case

Indicators	Units	Input required	Driver type
Cement production	Mt cement	% growth rate	Socio-economic
Electricity intensity of cement production	TWh / Mt cement	% growth rate	Technology
Direct energy intensity of cement production	PJ / Mt clinker	% growth rate	Technology
Direct energy fuel mix	% share	% share	Policy, technology
Emissions captured with CCS	% of process and direct energy emissions	% captured	Policy, technology

Cement industry
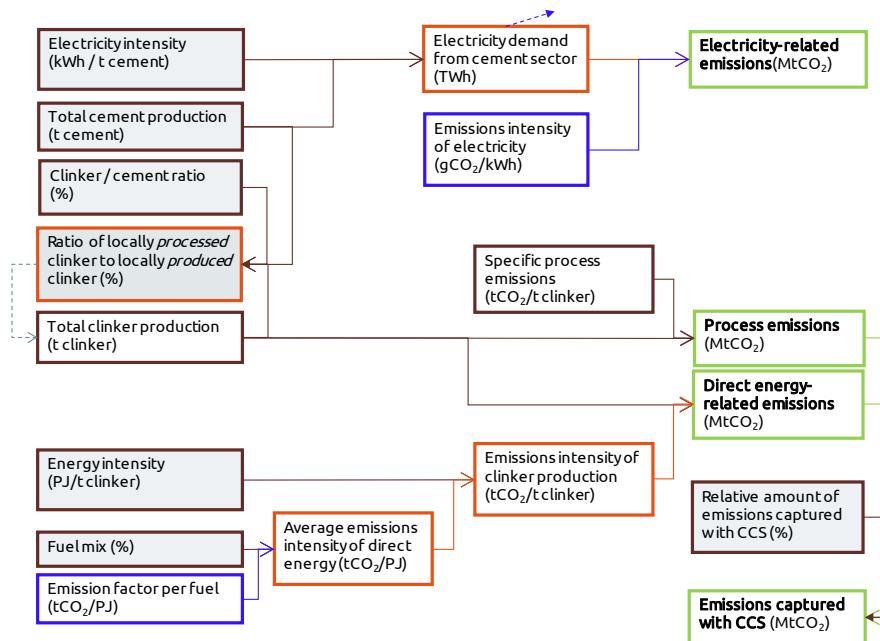
Figure 4: The logic tree for the cement sector in PROSPECTS+

5.2.3 Steel industry

Table 9, Table 10, Table 11 and Table 12 show the historical input data and policy scenario input needed for the steel sector in PROSPECTS+. The contemporary steel industry mainly relies on three types of furnaces to produce steel: The **Blast Furnace with Basic Oxygen Furnace (BF-BOF)** route, the **scrap-based Electric Arc Furnace (EAF-scrap) route, and the direct reduced iron-based Electric Arc Furnace (EAF-DRI).** These routes have significant differences in electricity intensity and direct energy intensity. Thus, the three types of steel production are distinguished throughout the calculation. Potential future steelmaking routes may be summarised under the denominator "other" with user-defined intensities.

Data on steel production and shares of steel production routes can be obtained from the WSA (World Steel Association, 2016). Data on the electricity and direct energy intensities will have to be taken/inspired from scientific literature, such as (Oda *et al.*, 2012; Arens *et al.*, 2016; Kuramochi, 2016).

The fuel mix in the steel sector, when taken directly from the IEA Energy Balances, is significantly affected by the high demand for coke products in blast furnaces. Thus, this fuel mix cannot be indiscriminately taken for all three production routes. Instead, in the PROSPECTS+ methodology, coke-related products for use in blast furnaces – coke oven coke, coke oven gas and blast furnace gas – are separated out from the fuel mix according to the guidelines in (IPCC, 2006c). This fuel mix without coke is used as overall direct energy mix for all steelmaking routes. The use of coke is accounted for with the coke intensity (in PJ / t steel), which, together with a separate emission factor for coke, is used to calculate emissions from coke (with the steel production from the BOF route as activity driver).

Direct energy emissions intensities are globally defined in the model. The only exception to this is formed by the direct energy emissions intensity of **coke products** in the steel sector. This is because of the significantly higher average emissions intensity in the steel sector as compared to other sectors, owing

to the high share of coke necessary for coke ovens. For this reason, it must be separately specified for steelmaking in blast furnaces.

Note that emissions resulting from blast furnace gas would be counted under emissions from direct energy use in the relevant end-use sectors in the IEA Energy Statistics and Balances, so these need not be explicitly incorporated in the steel sector in PROSPECTS+. Also, while emissions from coke use in coke ovens are sometimes categorised as process emissions, we count them here under direct energy-related emissions, as coke is an energy carrier that is counted as one of several coal products in, for instance, the IEA Energy Balances and Statistics.

Simplified approach

In the simplified approach, no steel production routes are distinguished, and coke is included in the fuel mix tables (but directly taken from the IEA data as well).

Table 9: Input data for steel sector in the non-simplified case

Indicators	Units	Data sources
Steel production	Mt steel	(World Steel Association, 2016)
Share of production methods (BF-BOF, EAF-scrap, EAF-DRI, "other")	%	
Electricity intensity of steel production (BF-BOF, EAF-scrap, EAF-DRI, "other")	TWh / Mt steel	Scientific literature, i.e. (Arens, Worrell, Eichhammer, Hasanbeigi, & Zhang, 2016; Kuramochi, 2016; Oda et al., 2012)
Direct energy intensity of steel production (BF-BOF, EAF-scrap, EAF-DRI, "other")	PJ / Mt steel	
Coke intensity of steel production (BF-BOF)	PJ / Mt steel	
Direct energy fuel mix	s	(IEA, 2016a) (category "iron and steel")
Direct energy emissions intensity of coke	$MtCO_2e$ / PJ	
Emissions captured with CCS	% of direct energy-related emissions (incl. from coke)	

Table 10: Input data for steel sector in the simplified case

Indicators	Units	Data sources
Steel production	Mt steel	(World Steel Association, 2016)
Direct energy fuel mix	%	(IEA, 2016a) (category "iron and steel")
Direct energy emissions intensity of coke	$MtCO_2e$ / PJ	
Emissions captured with CCS	% of direct energy-related emissions (incl. from coke)	

Table 11: Policy scenario input for steel sector in the non-simplified case

Indicators	Units	Input required	Driver type
Steel production	Mt steel	% growth rate	Socio-economic
Share of production methods (BF-BOF, EAF-scrap, EAF-DRI, "other")	% share	% share	Technology
Electricity intensity of steel production for each route (BF-BOF, EAF-scrap, EAF-DRI, "other")	TWh / Mt steel	% growth rate	Technology
Direct energy fuel mix	%	% share	Policy, technology
Direct energy intensity of steel production for each route (BF-BOF, EAF-scrap, EAF-DRI, "other")	PJ / Mt steel	% growth rate	Technology
Emissions captured with CCS	% of direct energy-related emissions (incl. from coke)	% captured	Policy, technology

Table 12: Policy scenario input for steel sector in the simplified case

Indicators	Units	Input required	Driver type
Steel production	Mt steel	% growth rate	Socio-economic
Direct energy fuel mix incl. coke	%	% share	Policy, technology
Direct energy intensity of total steel production	PJ / Mt steel	% growth rate	Technology
Electricity intensity of total steel production	TWh / Mt steel		
Emissions captured with CCS	% of direct energy-related emissions (incl. from coke)	% captured	Policy, technology

Steel industry
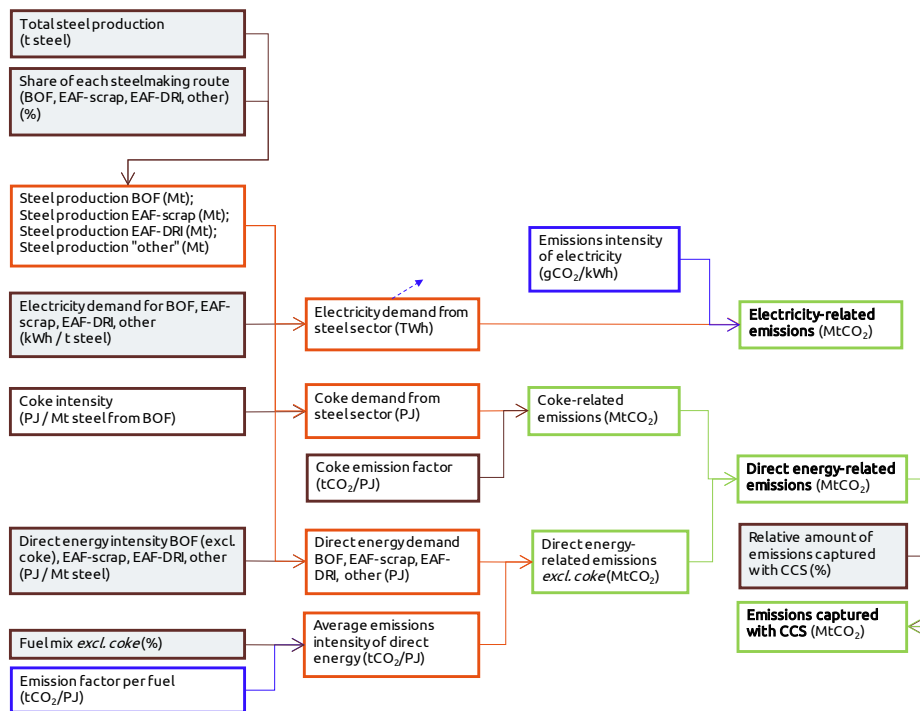
Figure 5: The logic tree for the steel sector in PROSPECTS+

5.2.4 Other industry

Due to low data availability in industry sectors outside of cement and steel, the "other" industrial sectors are lumped together in the PROSPECTS+ approach to form a simplified representation of a range of diverse activities. In the context of the IEA Energy Balances and Statistics, "other" industry is equivalent to the sum of the following (divided into "light" and "heavy" industry):

Heavy industry

- Chemicals and petrochemicals
- Non-ferrous metals
- Transport equipment
- Machinery
- Mining and quarrying

Light industry

- Food and tobacco
- Paper, pulp and print
- Wood and wood products
- Construction
- Textile and leather
- Non-specified (industry).[6]

In the PROSPECTS+ approach, light and heavy industry are separated because of potential substantial differences in fuel mix as well as in measures and opportunities for energy efficiency improvement between heavy and light industry types, which would influence future emissions pathways differently. It can be seen, for instance, that "light" industry types in the EU28 had significantly higher shares of "other" fuels (e.g. biofuels and renewables) than heavy industry types.

Table 13 and Table 14 show the historical input data and policy scenario input needed for the steel sector in this prototype of PROSPECTS+.

The simplified approach distinguishes between direct energy and electricity demand in "other" heavy and light industry, which can be obtained from the IEA Energy Balances and Statistics. The activity indicator used for "other" industry—in the absence of a different type of output that unites all the above sectors—is the gross value added (GVA) of industry. Since this is not (generally) available for precisely the range of sectors listed above, we use the total value added in industry as a proxy.

The policy indicators that are needed as user input are the growth of GVA, the total energy demand per unit of GVA, as well as the electrification rate in "other" industry to obtain the right split into direct energy and electricity demand again.

Process emissions in "other" industry consist of a wide variety of categories, including limestone and dolomite use, road paving with asphalt, emissions of halocarbons, etc. These are available for all Annex I countries from the UNFCCC (UNFCCC, 2017). These emissions will not be explicitly modeled in PROSPECTS+ but rather added to the other emissions. For the policy projection, they will get the same growth rate as overall GVA of other industry.

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[6] This could theoretically be both heavy or light industry. It is counted under "light industry" in PROSPECTS+.

Table 13: Input data for other industry

Indicators	Units	Data sources
Value added in other industry	million USD 2012	(World Bank Group, 2015)
Direct energy demand in other industry (heavy / light industry)	PJ	(IEA, 2016a) (category "industry" excluding "iron and steel" and "non-metallic minerals")
Electricity demand in other industry (heavy / light industry)	TWh	
Direct energy fuel mix (heavy / light industry)	%	
Process emissions	$MtCO_2e$	UNFCCC for Annex I countries; national sources and/or rough estimates for other countries. This category includes all industrial process emissions, except iron & steel, and cement emissions.
Emissions captured with CCS (heavy / light industry)	% of process and direct energy emissions	

Table 14: Policy scenario input for other industry

Indicators	Units	Input required	Driver type
Value added in industry	million USD 2012	% growth rate	Economic
Total energy intensity of GVA (heavy / light industry)	PJ / million USD 2012	% growth rate	Proxy for energy efficiency
Electrification rate in other industry (heavy / light industry)	% electricity in energy demand	%	Technology
Direct energy fuel mix (heavy / light industry)	% share	% share	Policy, technology
Emissions captured with CCS (heavy / light industry)	% of process and direct energy emissions	% captured	Policy, technology
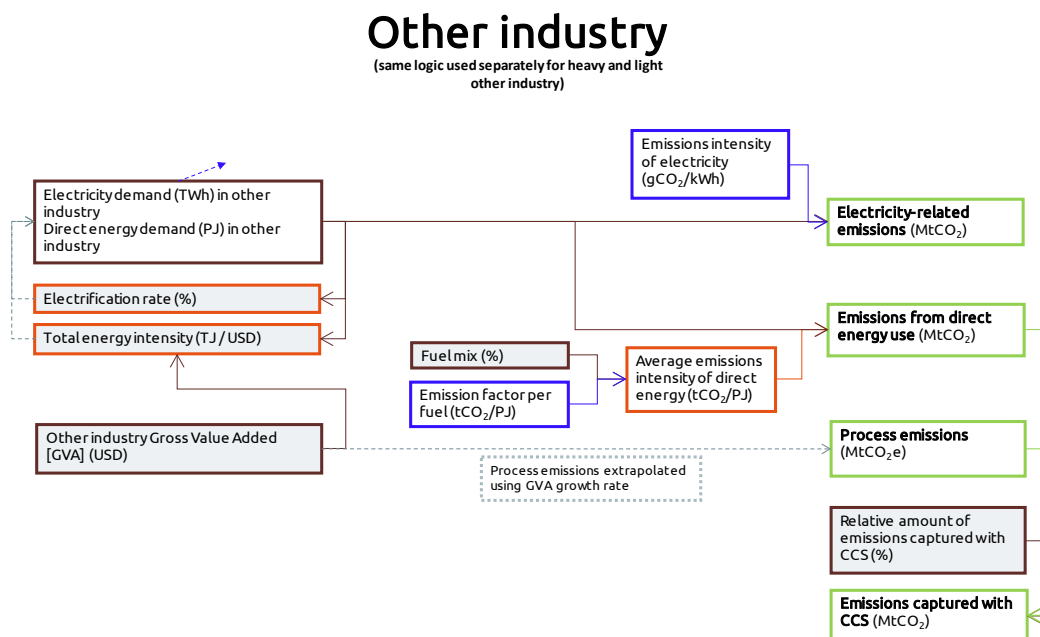
Figure 6: The logic tree for the heavy and light other industry sectors in PROSPECTS+ (logic is the same for heavy as for light industry).

5.2.5 Oil and gas

The oil and gas sector in PROSPECTS+ refers to upstream and midstream emissions from oil and gas extraction, i.e. from gas flaring and fugitive methane emissions.

Input data (see Table 15) partly consists of fugitive emissions (one of the instances in PROSPECTS+ where input data is given in emissions, not in energy activity or product activity, the other instances being in the waste and the agriculture/forestry sector) which can be obtained from the EDGAR database (JRC and PBL, 2014). This includes fugitive emissions of CH_4, CO_2 and N_2O that may occur as a result of oil and gas extraction (Picard, 1999). Other data series needed are the total amount of flared gas (NOAA, 2011) and the total production volumes of oil and gas. The conversion from gas flaring to emissions is done via a constant value representing the emission factor of flared gas (tCO_2 / Gm^3 gas). In reality, this factor differs per country and indeed per installation (Picard, 1999), but this level of detail is outside the scope of PROSPECTS+.

These data series are converted to two other indicators for the policy scenarios (see Table 16): the flaring ratio (measured as % of gas flared) and the fugitive emissions intensity (tCH_4 / PJ). The first is dependent on flaring practices; the second is a rather volatile indicator when looking at historical data series, so while it might not be directly relevant to policy analysis, taking it by default as a constant value is not reasonable. Such values always represent average emission factors and can thus not be applied to individual or small numbers of sources (Picard, 1999).

Table 15: Input data for oil and gas sector

Indicators	Units	Data sources
Fugitive emissions	tCH_4	(JRC & PBL, 2014)
Amount of gas flared	Gm^3	(NOAA, 2011)
Total production of oil & gas	PJ	(IEA, 2016a)

Table 16: Policy scenario input for oil and gas sector

Indicators	Units	Input required	Driver type
Total production of oil & gas	Mtoe	% growth rate	Economic
Fugitive emissions intensity	tCH_4 / Mtoe	% growth rate	Technology
Flaring ratio	%	%	Technology, practices

Oil & gas
(upstream and midstream emissions)

Figure 7: The logic tree for oil and gas (up/midstream) emissions in PROSPECTS+

5.2.6 Transport

Calculations in the transport sector can be divided into three parts: passenger transport, freight transport, and aviation and shipping. Different modes and different types of fuels in passenger and freight transport are split out in PROSPECTS+, while international aviation follows a much more simplified approach.
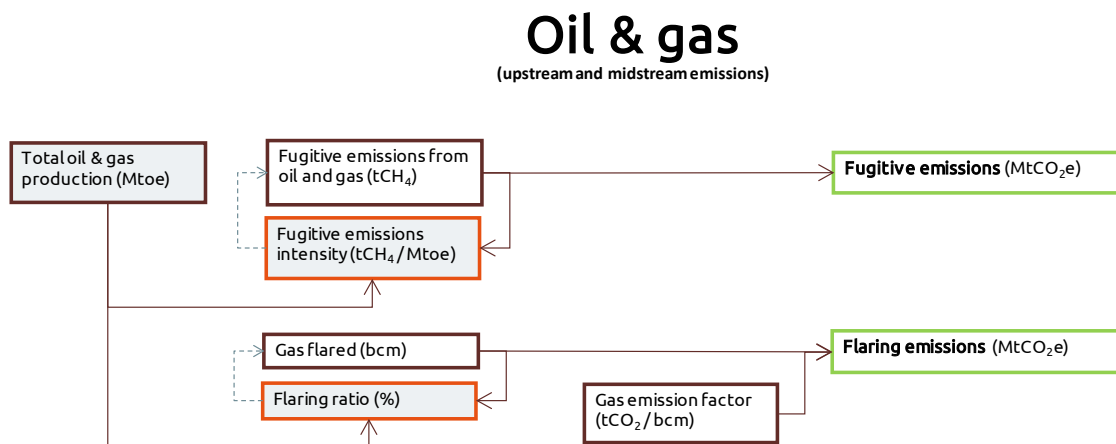
Simplified approach

The historical input data and policy scenario data of transport in the simplified approach are listed in Table 17 and Table 18.

In case more granular data is not available or transport is less important in the analysis, the simplified approach could be used. This approach only requires IEA data and assumptions on the future growth in overall energy demand and change in fuel mix. This means the impact of some policies should be assessed outside of PROSPECTS+ when the simplified approach is selected. The simplified approach does not distinguish freight and passenger transport, whereas the non-simplified approach does.

Table 17: Input data for transport sector in the simplified case

Indicators	Units	Data sources
Total direct energy demand	PJ	(IEA, 2016a)
Fuel mix direct energy use	%	(IEA, 2016a)
Total electricity demand	TWh	(IEA, 2016a)

Table 18: Policy scenario input for passenger transport in the simplified case

Indicators	Units	Data sources
Total direct energy demand growth rate	%	Policy, technology, socio-economic
Fuel mix direct energy use	%	Policy, technology, socio-economic
Total electricity demand growth rate	%	Policy, technology, socio-economic

Passenger transport

The historical input data and policy scenario data of passenger transport are listed in Table 19 and Table 20. In the passenger transport part, vehicles are grouped under four types: *personal vehicle*, *bus*, *train* and *plane*. The vehicle type "personal vehicle" includes light duty vehicles (LDVs), 2-wheelers (2Ws), and 3-wheelers (3Ws). The mode "plane" includes only *domestic* aviation. Considered fuel types (depending on the mode) include gasoline, diesel, compressed natural gas (CNG)/ liquefied petroleum gas (LPG), jet fuel and biofuel. Historical data on passenger transport activity can be obtained for a number of regions from the ICCT Global Transportation Roadmap Model (ICCT, 2012), as can the share by mode and by fuel type.

Insofar as such data may not be available for all regions, one could resort again to assuming that an activity indicator such as the amount of pkm per capita is equal or similar to the values of another, similar, country for which data is available, although this indicator is very sensitive to the population density and size of a country.

Figure 8 shows the logic tree of (non-simplified) passenger transport emissions (along with freight transport emissions; see below). Passenger transport emissions are driven by the passenger transport activity, which is input as the total amount of person-kilometres for passenger transport, and converted to vehicle-kilometres using a load factor. With passenger transport activity and modal split as inputs, distances travelled by every vehicle type (car, bus, train, plane) can be calculated. Then, with the share

of electrified transport, distances travelled by different types of electrified vehicles and distances travelled by different types of internal combustion engine (ICE) vehicles can be calculated.[7]

Multiplying electrified vehicle kilometres with electricity intensity gives the electricity demand. Electricity emissions from passenger transport can then be obtained as the product of electricity demand and electricity emission intensity (an output from the electricity sector).

For ICE vehicles, the sum-product of the fuel mix and the fuel emission intensity for a certain type of vehicles is the average emission intensity for this type of vehicles. Multiplying the distances travelled by ICEs with the average emission intensity results in direct energy emissions. Adding up electricity emissions and direct energy emissions from different types of vehicles then gives emissions from passenger transport.

Table 19: Input data for passenger transport

Indicators	Units	Data sources
Passenger transport activity	pkm	e.g. (ICCT, 2014) and (ICAO, 2016b)
Modal split	% of pkm with personal vehicle, bus, train, airplane	
Load factor for each mode (for personal vehicles, buses, trains, airplanes)	pkm / vkm	
Share of electrified passenger transport activity (for personal vehicles, buses, trains)	%	For cars e.g. (IEA, 2016c) For trains e.g. (ICCT, 2014)
Electricity intensity of electrified transport (for personal vehicles, buses, trains)	kWh / vkm	e.g. (ICCT, 2014)
Fuel mix for non-electrified transport (for personal vehicles, buses, trains, airplanes)	% gasoline, diesel, CNG/LPG, biofuels (for cars) % diesel, CNG/LPG, biofuels (for trains) % jet fuel, biofuels (for planes)	
Energy intensity by fuel type (for personal vehicles, buses, trains, airplanes)	MJ / vkm for gasoline, diesel, CNG/LPG, biofuels (for cars, trains) MJ / pkm for jet fuel, biofuels (for planes)	
Emission intensity by fuel type	gCO_2 / MJ (constant values)	

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[7] For the category "cars" and "buses", this means electric cars/buses; for "trains" this refers to electrified railway lines.

Table 20: Policy scenario input for passenger transport

Indicators	Units	Input required	Driver type
Passenger transport activity	pkm / cap	% growth rate	Socio-economic
Modal split	% car, bus, train, plane	% car, bus, train, plane	Socio-economic, policy
Load factor	pkm / vkm	% value	Socio-economic
Share of electrified passenger transport activity (for personal vehicles, buses, trains)	% share	% share	Technology
Electricity intensity of electrified transport (for personal vehicles, buses, trains)	kWh / vkm	% growth rate	Technology
Fuel mix for non-electrified transport (for personal vehicles, buses, trains, airplanes)	% gasoline, diesel, CNG/LPG, biofuels (for cars) % diesel, CNG/LPG, biofuels (for trains) % jet fuel, biofuels (for planes)	% share	Policy, technology
Emissions intensity by fuel type (for personal vehicles, buses, trains, airplanes)	gCO_2 / vkm for gasoline, diesel, CNG/LPG, biofuels (for cars, trains) gCO_2 / vkm for jet fuel, biofuels (for planes)	% growth rate	Technology (emission standards)

Transport
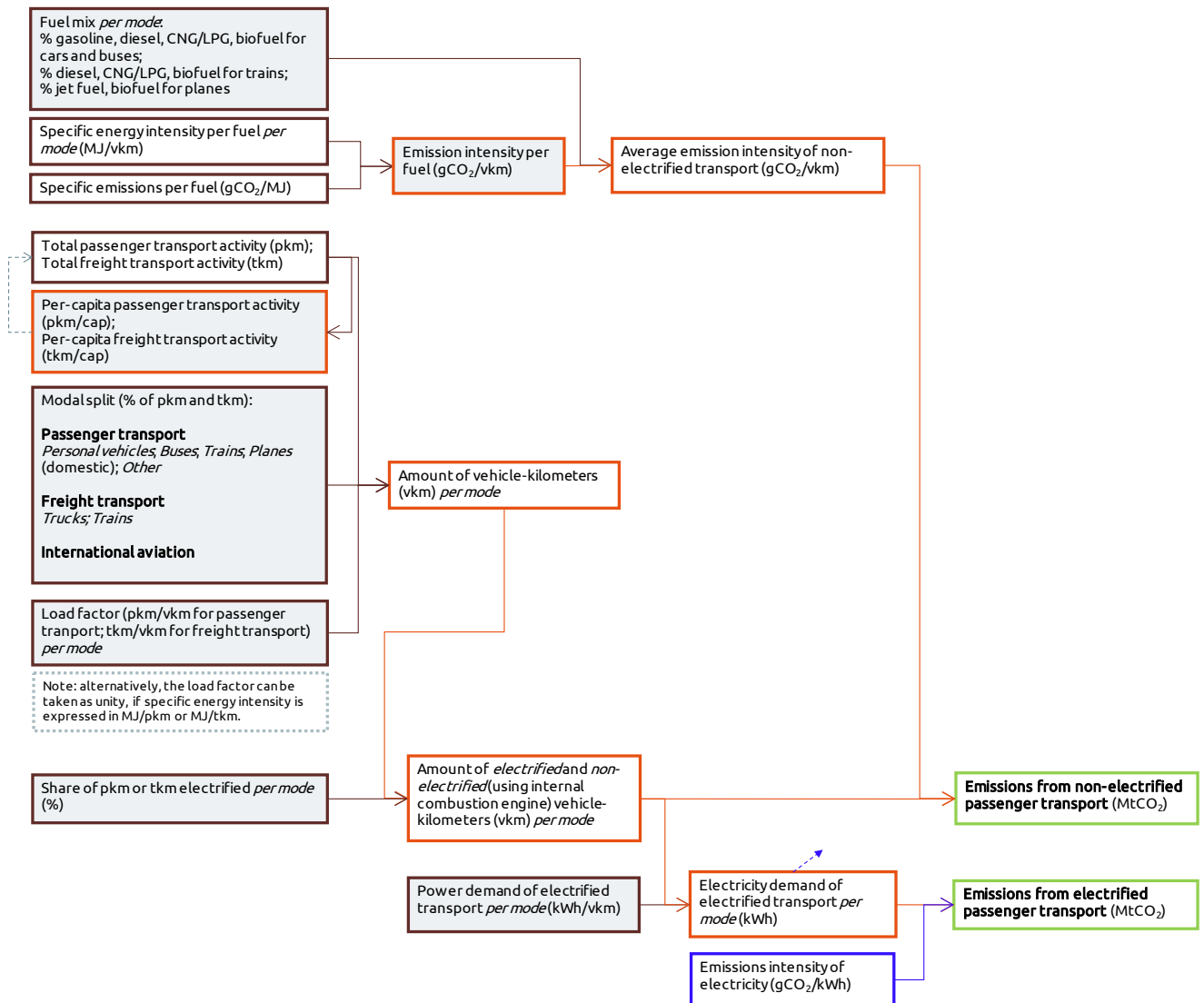
Figure 8: Logic tree of passenger and freight transport emissions

Freight transport

The historical input data and policy scenario data for freight transport are listed in Table 21 and Table 22. In the freight transport part, vehicles are grouped under two types: *trucks* and *trains*. This module will not include planes (neglecting any amount of freight that would be shipped through domestic aviation). Apart from this, the approach is identical to that for passenger transport. Figure 8 shows the logic tree of freight transport emissions in PROSPECTS+.

Table 21: Input data for freight transport

Indicators	Units	Data sources
Freight transport activity	tkm	e.g. (ICCT, 2014)
Modal split	% truck, train	
Load factor for each mode (for trucks, trains)	tkm / vkm	
Share of electrified transport activity (for trucks, trains)	%	
Electricity intensity of electrified transport (for trucks, trains)	kWh / vkm	
Fuel mix for non-electrified transport (for trucks, trains)	%	
Energy intensity by fuel type (for trucks, trains)	MJ / vkm	
Emission intensity by fuel type	gCO_2 / MJ (constant values)	

Table 22: Policy scenario input for freight transport

Indicators	Units	Input required	Driver type
Freight transport activity	tkm / cap	% growth rate	Socio-economic
Modal split	% truck, train	% truck, train	Socio-economic, policy
Load factor for each mode (for trucks, trains, airplanes)	tkm / vkm	Value	Socio-economic
Share of electrified transport activity (for trucks, trains)	% share	% share	Technology
Electricity intensity of electrified transport (for trucks, trains)	kWh / vkm	% growth rate	Technology
Fuel mix for non-electrified transport (for trucks, trains, airplanes)	% gasoline, diesel, CNG/LPG, biofuels (for trucks) % diesel, CNG/LPG, biofuels (for trains) % jet fuel, biofuels (for planes)	% share	Policy, technology
Emission intensity by fuel type (for trucks, trains)	tCO_2e/vkm for gasoline, diesel, CNG/LPG, biofuels (for trucks, trains)	% growth rate	Technology (emission standards)

International aviation

The approach on international aviation will be a simplified version of the calculations under passenger transport. No different modes are considered, only the amount of activity (pkm in international aviation), the type of fuel (biofuel and jet fuel) and the fuel emissions intensity. Input data and policy scenario indicators are given in Table 23 and Table 24 and graphically shown in Figure 8.

Table 23: Input data for international aviation passenger transport

Indicators	Units	Data sources
International aviation activity	pkm	e.g. (ICAO, 2016a)
Fuel mix (jet fuel vs. biofuel)	%	Assumption: near zero today
Energy intensity by fuel type	MJ / pkm	e.g. (ICCT, 2014)
Emissions intensity by fuel type	gCO$_2$ / MJ (constant values)	

Table 24: Policy scenario input for international aviation passenger transport

Indicators	Units	Input required	Driver type
International aviation activity	pkm / cap	% growth rate	Socio-economic
Fuel mix (jet fuel vs. biofuel)	%	% truck, train	Socio-economic, policy
Emission intensity by fuel type	tCO$_2$e / pkm for jet fuel, biofuels	% growth rate	Technology (emission standards)

Shipping

Maritime emissions are not modelled in the country-level approach in PROSPECTS+. This is due to the challenges involved in attributing emissions from fuel use to specific countries, chiefly because of the practice of tinkering—shipping additional fuel along in order to avoid refuelling at ports where fuel prices are higher, thus potentially avoiding fuel taxes etc. (Bows, Anderson and Upham, 2008). If the PROSPECTS+ methodology were to be applied on a global level or country-level results were to be aggregated to a global level, a global timeseries of shipping emissions should be added.

5.2.7 Waste

Municipal solid waste

Emissions from waste are primarily due to the release of landfill gas from anaerobic decomposition of waste material in landfills. This means that there is no linear relationship between the yearly waste production and the total emissions from waste, since waste deposited on landfills in previous years still contributes to the production of landfill gas in the present. The IPCC provides guidelines for a first-order decay method to take this into account (IPCC, 2006a). The waste module in PROSPECTS+ calculates these emissions based on the IPCC approach. This approach is summarised here.

First, the model needs an estimation of the total amount of MSW generated and the percentage sent to landfills. The product of these two gives the amount of deposited waste $W(t)$, where t is the year of deposition. The total amount $M_{degr}(t)$ of degradable organic matter (DOCM) in the yearly deposited waste $W(t)$ as

$$M_{degr}(t) = W(t) \cdot DOC \cdot DOC_f \cdot MCF, \qquad (1)$$

where DOC stands for the fraction of carbon in the deposited waste (gC/g waste), DOC_f stands for the fraction of this that can decompose, and MCF is the "Methane Correction Factor", which accounts for differences between aerobic and anaerobic decomposition (dependent on the type of landfill). Generally, DOC depends on the country/region, and MCF depends on the landfill type. The IPCC provides default or common values for these factors in its Waste Model (IPCC, 2006d) (see below).

The total accumulated decomposable waste $M_{degr,acc}(t)$ is then calculated with a first-order decay approach:

$$M_{degr,acc}(t) = \sum_{n=0}^{N} M_{degr}(t-n) \cdot e^{-nk}, \qquad (2)$$

where k is the reaction constant, with values typically in the order of 0.05 yr^{-1}, and N is the number of historical years to which the decay curve approach is applied; the IPCC consider it good practice (IPCC, 2006a) to use data for (at least) 50 years back, e.g. $N = 50$. The reader may check that the above equation is equivalent to equation (3.4) in (IPCC, 2006a).

The total amount of waste M_{dec} decomposed in each year t is then calculated from the accumulated decomposable waste using first-order decay:

$$M_{dec}(t) = M_{degr,acc}(t) \cdot (1 - e^{-k}). \qquad (3)$$

Finally, the total amount E_{MSW} of CH$_4$ emitted from decomposed waste in each year is calculated as follows:

$$E_{MSW}(t) = M_{dec}(t) \cdot F \cdot \frac{4}{3}, \qquad (4)$$

where F is the volume fraction of CH$_4$ in the generated landfill gas, and $\frac{4}{3}$ is the molecular weight ratio of CH$_4$ to C.

Thus, the general formula linking waste deposited on landfills to CH$_4$ emissions is

$$E_{MSW}(t) = \frac{4}{3} \cdot DOC \cdot DOC_f \cdot MCF \cdot F \cdot (1 - e^{-k}) \cdot \sum_{n=0}^{N} [W(t-n) \cdot e^{-nk}]. \qquad (5)$$

The values that need specification in PROSPECTS+ and the way they have been chosen (or made adaptable) in order to perform the above calculations are given in Table 25 below.

Table 25: Quantities needed in PROSPECTS+ for calculation of CH$_4$ emissions from waste based on waste generation data.

Quantity	Symbol	Unit	Value in PROSPECTS+	Based on
Fraction of carbon in deposited waste	DOC	gC/g waste	19% default (in "Admin" sheet), but adaptable by user.	Values given by region in IPCC Waste Model (IPCC, 2006d)
Fraction decomposable	DOC_f	-	0.5	Advised by (IPCC, 2006a), page 3.13
Methane correction factor	MCF	-	0.7 default, (in "Admin" sheet), but adaptable by user.	Between 0.4 and 1.0 depending on landfill type, advised by (IPCC, 2006a), Table 3.1
Reaction constant	k	yr^{-1}	0.05	Typically close to 0.05 based on type of waste, advised by (IPCC, 2006a), Table 3.3; see also (IPCC, 2006d)
Number of historical years in estimation	N	yr	50	Advised by (IPCC, 2006a), page 3.12
Volume fraction CH$_4$ in landfill gas	F	-	0.5	Advised by (IPCC, 2006a), page 3.15

Using the above approach requires at least $N = 50$ years of data on waste generation before the start year 1990, in order to be able to calculate E_{MSW} from 1990 onwards. Data on municipal waste generation is generally taken from (OECD, 2015), but does not extend to before 1990. The IPCC advise, in the absence of data for 50 years back, to base municipal waste generation with population size as one possibility. In PROSPECTS+, we use the average growth rate of a country's population in the period 1990-2015 to extrapolate waste generation back to 1940. It has been tested that this method gives

almost the same results as using population data from (UN, 2015) back to 1950, assuming either linear or exponential relationships between waste generation and population data.

The waste generation pathway for the policy scenarios is constructed using the waste generation per capita as indicator, which can be related to e.g. socio-economic indicators such as GDP per capita. The percentage of landfilled waste is also a scenario indicator, as it can reflect certain practices such as e.g. the prohibition or limitation of landfilling, or increased recycling rates.

Lastly, to ensure that waste-to-energy (WtE) generation in the power and heat supply sectors is consistent with the waste module in PROSPECTS+, a consistency check is made in the model to assess whether the estimated percentage of waste sent to landfills is compatible with the implied amount of WtE generation in the power and heat supply sectors (as this has to come from waste that is not landfilled). This is done using estimations of the average energy content of waste used for energy generation.

Medical and industrial waste are not specifically included in the PROSPECTS+ approach as sources of emissions.

Wastewater

The PROSPECTS+ logic also contains a small module dealing with wastewater. The input needed for the module is the total production of wastewater and the wastewater treatment rate, which also serve as indicators for the policy scenario. An estimation of the emissions intensity of wastewater is used to calculate overall emissions.

Data on many countries, although patchy, can be obtained for instance from the AQUASTAT database of the FAO (FAO, 2016). Data on emissions could be cross-checked with the approach advocated by the IPCC on wastewater (IPCC, 2006b).

Table 26: Input data for the waste module

Indicators	Units	Data sources
Amount of MSW generated	kt	e.g. (OECD, 2015)
Share of MSW sent to landfill	%	National statistics; estimations from recycling rate, composting rate, etc.
Amount of wastewater generated	t BOD	e.g. (FAO, 2016)
Wastewater treatment rate	%	

Table 27: Policy scenario input for the waste module

Indicators	Units	Input required	Driver type
Waste generation per capita	t / cap	% growth rate	Socio-economic
Share of MSW sent to landfill	% share	% share	Policy
Amount of wastewater generated	t BOD	% growth rate	Socio-economic
Wastewater treatment rate	%	%	Policy

Waste
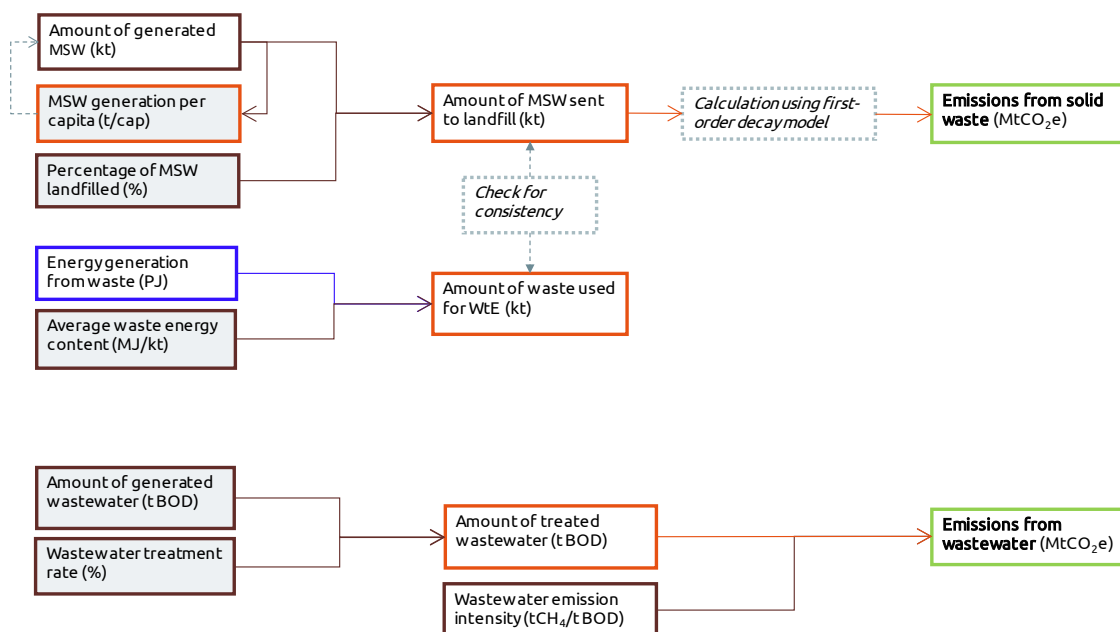
Figure 9: Logic tree of emissions from waste

5.2.8 Agriculture and forestry

In the agriculture and forestry sectors, PROSPECTS+ distinguishes between energy-related emissions and non-energy-related emissions from various agricultural and forest-related sources. The former category is treated in the same way as the energy-related emissions in e.g. the buildings and industry sectors: with input data on direct energy and electricity use based on the IEA Energy Balances and Statistics, and using total agricultural GVA as indicator.

The latter category is based on the categorisation of agricultural and forestry emissions into various categories (FAOSTAT, 2016).

Agriculture

The non-energy-related emissions from agriculture are split into three overall emission types in PROSPECTS+: animal-related, rice-related and other land-related[8], as follows:

Animal-related emissions

- Emissions from enteric fermentation
- Emissions from manure management, manure applied to soils, manure left on pasture

Rice-related emissions

- Emissions from rice cultivation

Other land-related emissions

- Emissions from synthetic fertiliser usage
- Emissions from crop residues

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[8] According to IPCC guidelines, the categories "burning of crop residues" and "savanna burning" are not to be included in inventory totals but only "noted for information" (IPCC, 1996).

- Emissions from cultivation of organic soils

While the agricultural emissions profile in each country will be dominated by a few of these types of emissions, these profiles differ significantly between countries and thus none of these categories can be left out of an explicit activity/intensity indicator calculation in PROSPECTS+, to ensure applicability across all countries. Input data for these categories is needed directly in tCO_2e, unlike in most other sectors (except the oil & gas upstream emissions and the waste sector, where a similar approach is used).

Table 28 shows the input data needed to run the agriculture module in PROSPECTS+ for historical periods, whereas Table 29 shows the data needed to create policy scenarios. The energy-related tool logic is shown in Figure 10, whereas that for all other emissions is shown in Figure 12.

Table 28: Input data for agriculture

Indicators	Units	Data sources
Energy-related		
Direct energy use in agriculture (and forestry)	PJ	(IEA, 2016a), category "agriculture and forestry"
Electricity use in agriculture (and forestry)	GWh	
Direct energy fuel mix	%	
Total GVA of agriculture	USD	(World Bank, 2016)
Animal-related		
Emissions from enteric fermentation	$MtCO_2e$	(FAOSTAT, 2016)
Stock of animals responsible for enteric fermentation (= total mammal livestock)	#	
Stock of animals (= total mammal livestock + total poultry livestock)	#	
Emissions from manure management / manure applied to soils / manure left on pasture	$MtCO_2e$	
Rice-related		
Emissions from rice cultivation	$MtCO_2e$	(FAOSTAT, 2016)
Area harvested for rice paddy	ha	
Other land-related		
Emissions from synthetic fertilizer, crop residues and cultivation of organic soils	$MtCO_2e$	(FAOSTAT, 2016)
Total area of grassland and cropland organic soils	ha	

Table 29: Policy scenario input for agriculture

Indicators	Units	Input required	Driver type
Energy-related			
GVA of agriculture	USD	% growth rate	Economic
Total energy demand per GVA in agriculture	PJ / USD GVA	% growth rate	Proxy for energy efficiency
Electrification rate in agriculture	%	%	Technology
Direct energy fuel mix	%	%	Technology, policy
Animal-related			

Emissions from enteric fermentation per animal	MtCO₂e / animal	% growth rate	Animal feedstock
Emissions from manure per animal	MtCO₂e / animal	% growth rate	
Total mammal livestock	#	% growth rate	Economic
Total poultry livestock	#	% growth rate	Economic
Rice-related			
Emissions from rice cultivation per hectare	MtCO₂e / ha	% growth rate	Agricultural practices
Area harvested for rice paddy	ha	% growth rate	Economic
Other land-related			
Emissions from synthetic fertilizer, crop residues and organic soil cultivation use per ha grass/cropland	MtCO₂e / ha	% growth rate	Agricultural practices (fertiliser use, practices on crop residues); fertiliser chemical characteristics
Total area of grassland and cropland organic soils	ha	% growth rate	Economic

Agriculture - energy
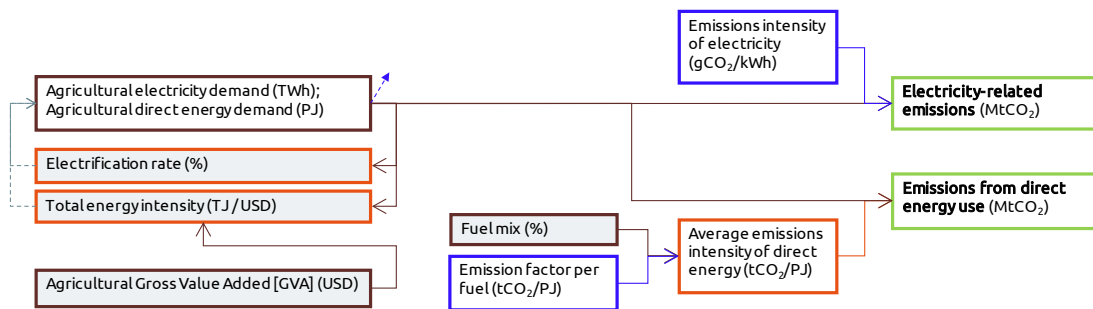
Figure 10: Logic tree of agricultural energy-related emissions

Agriculture - non-CO$_2$
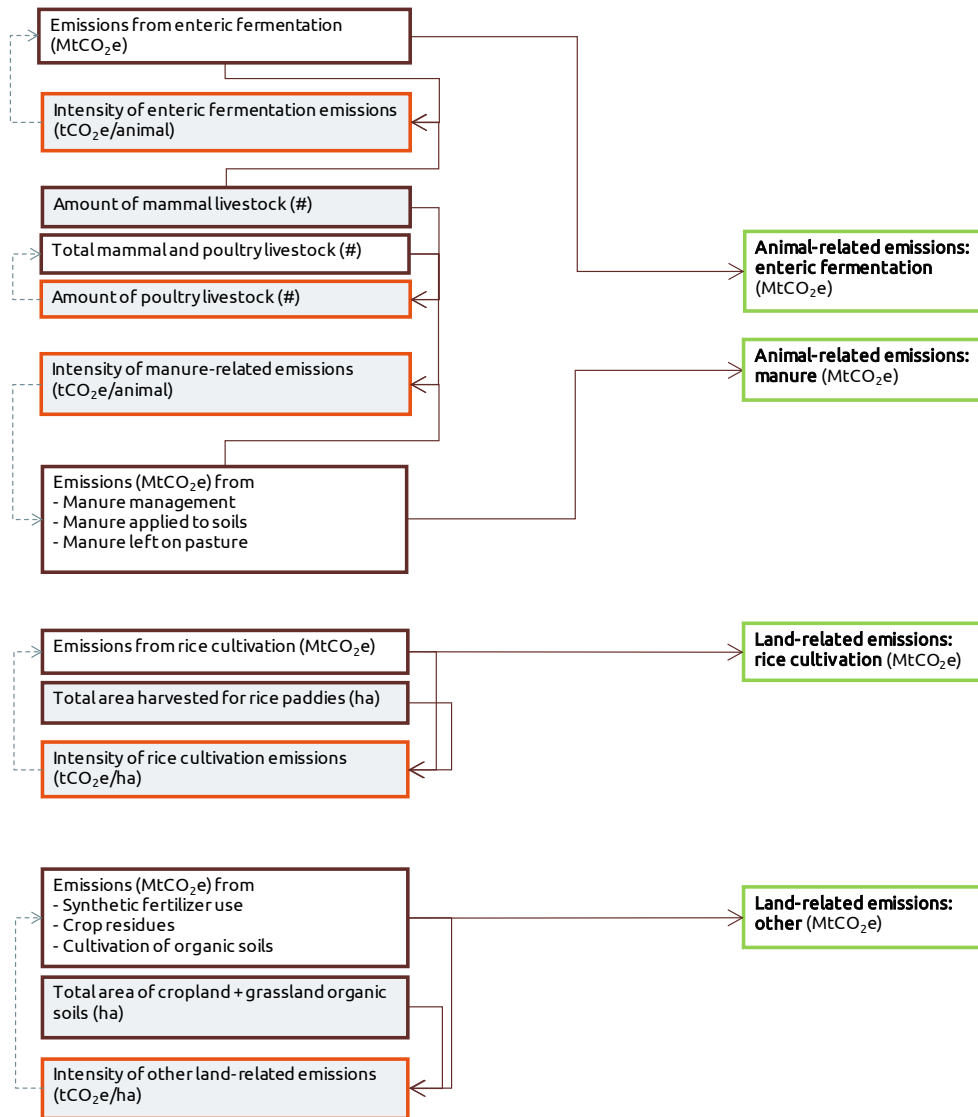
Figure 11: Logic tree of non-energy-related emissions in agriculture

Forestry

Types of emissions that are considered in FAOSTAT as "forest emissions" are those from forest burning, peatlands under croplands and grasslands, and forest land conversion.

Owing to the very different nature of forestry-related emissions, these are treated differently from the usual activity/intensity split employed in all the other sectors. The forestry module in PROSPECTS+ is therefore a separate calculation area where historical time series on forest-related emissions can be combined with user assumptions on what may happen with these in the future.

The reason for treating them in this way is that defining activity and intensity indicators is not at all straightforward for emissions related to forest land conversion: for instance, giving a growth rate to intensity/activity indicators cannot model a change from a net source to a net sink in an intuitive way.

5.3 Supply side

5.3.1 Power supply

The power supply module analyses emissions related to electricity generation and consumption. It plays a crucial role in PROSPECTS+, since it is closely connected to any other sectors where electricity is consumed. It receives electricity demand from other sectors as input for **total generation**. At the same time, it calculates the **average emission intensity** (GHG emissions produced per unit of electricity generation) of electricity generation as an output, which is again used as input in other sectors.

Table 30 and Table 31 show the historical input data and policy scenario input for electricity sector. The fuel types considered in this sector include coal, gas, oil, nuclear, hydro, geothermal, biomass, wind, solar, marine, waste and others.

One of the functionalities of PROSPECTS+ is that the user can allocate electricity-related emissions either to the end-use sectors or to the power sector. The only emissions that are *always* counted in the electricity sector are those from exported electricity, from own use of the energy industry, and from losses. The ratio of the energy industries' own use of electricity, and of losses (e.g. in T&D), to total electricity generation are calculated and used as an indicator in the policy scenarios.

As the import of electricity adds to the supply of electricity in a country without increasing the emissions—as those are counted in the producing country—we calculate the ratio of imported power to total generated power, and use this factor to correct the aggregate emissions intensity of electricity downwards. This ensures that no systematic error towards too high emissions is included in the tool. This correction applies to all emissions on the demand side (i.e. from the end-use sectors), but not to emissions that can be allocated only to the energy supply sector, such as those from exported electricity.

As indicator in the policy scenarios to quantify future imports of electricity, we use the ratio of imported electricity to total electricity demand, which is deemed a more intuitive indicator than the ratio of imported electricity to total electricity production (the former is 100% in case all power is imported, whereas the latter would be infinity). As indicator to quantify future exports of electricity, we use the ratio of exported electricity to total electricity generation (equal to total electricity demand, plus losses, own use needs, and exports, minus imports).

It should be noted that several fuel types in the electricity sector (nuclear, hydro, geothermal, wind, solar and marine) could be combined as "non-fossil fuel" type if the data availability on individual types were to be poor in certain countries, since emission intensities of these fuel types could all be considered zero at present.

In the power supply sector, PROSPECTS+ has more limited resolution than other electricity models dedicated to simulate the operation and evolution of the system in more detail. PROSPECTS+ also lacks spatial representation and does not capture issues related to grid infrastructure.

Table 30: Input data for the power supply sector

Indicators	Units	Data sources
Emissions intensity by fuel type	$MtCO_2e$ / TWh	
Electricity generation by fuel type		
Electricity needed for energy industries own use		
Losses (T&D)	TWh	(IEA, 2016a)
Imports		
Exports		

Table 31: Policy scenario input for the power supply sector

Indicators	Units	Required as	Driver type
Fuel mix	%	% share	Policy, technology
Emissions intensity of electricity by fuel type	$MtCO_2e$ / TWh	% growth rate	Technology
Share of own use in total electricity generation	%	% share	Technology
Share of losses in total electricity generation	%	% share	Technology
Share of exported power in total electricity generation	%	% ratio	Policy
Share of imported power in total electricity demand	%	% ratio	Policy
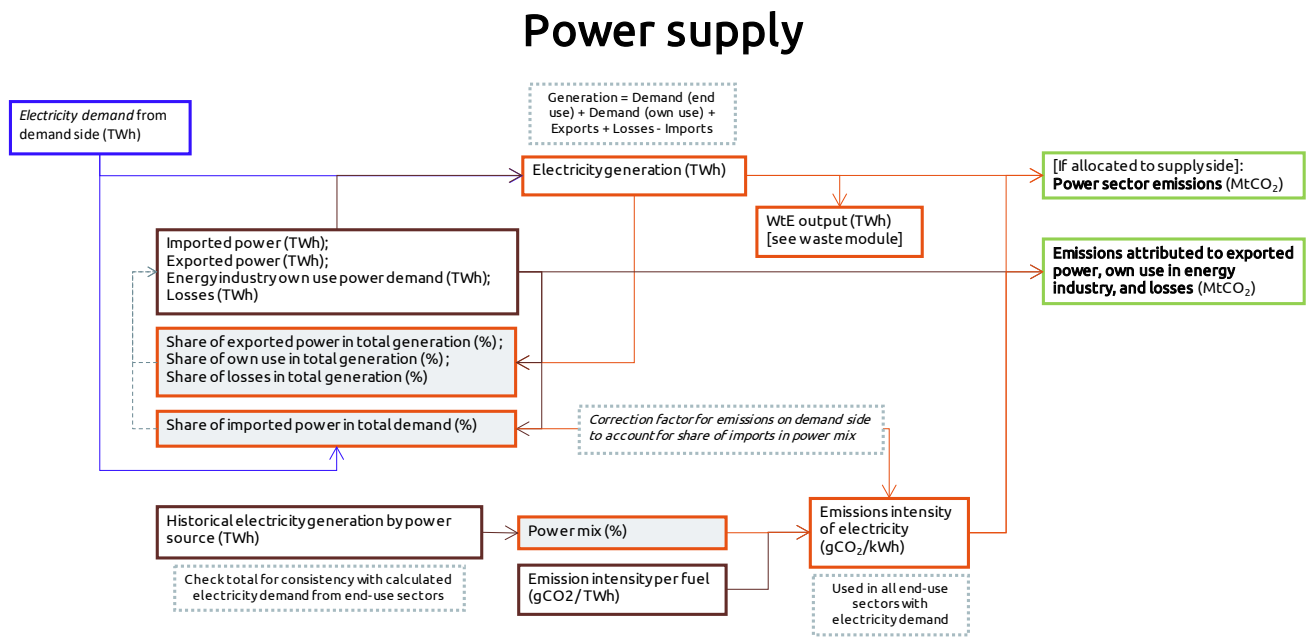
Power supply

Figure 12: The logic tree for the power supply sector in PROSPECTS+.

5.3.2 Heat supply

The PROSPECTS+ logic contains a small module on the commercial heat sector. The purpose of this module is to estimate the average emission factor of commercial heat, which is counted among the types of "direct energy" that the demand-side sectors receive in the IEA Energy Statistics and Balances.

The module requires a historical data series on heat generation by fuel, from which the fuel mix of heat generation can be inferred (IEA, 2016d). The weighted average of the emissions intensities of direct energy with the fuel mix then gives the average emissions intensity of commercial heat. The fuel mix serves as an indicator for the policy projections.

While in theory the precise same logic as for electricity generation could be employed, this is further simplified here by neglecting imports and exports (which are in the order of 0.01% of electricity imports and exports worldwide (IEA, 2016d). Thus, we assume that total heat generation and total heat supply are equivalent. However, losses and own use of heat in the energy industry need to be taken along and their emissions accounted for on the supply side. These can be expressed in an indicator showing their ratio to the total heat demand, similar to the electricity sector logic.

CHP is not included in PROSPECTS+. For countries with significant amounts of CHP, the emission factors of electricity and heat generation should include CHP, where the user can decide how to allocate the emissions.

Table 32: Input data for heat supply sector

Indicators	Units	Data sources
Heat generation by fuel type		
Heat needed for energy industries own use	TJ	(IEA, 2016a)
Losses (T&D)		

Table 33: Policy scenario input for heat supply sector

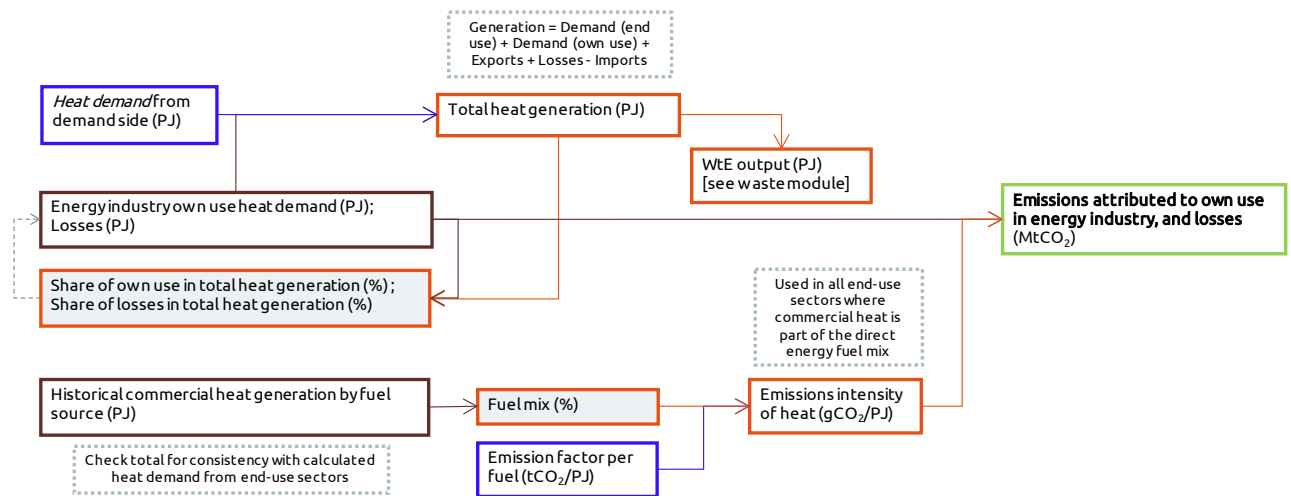| Indicators	Units	Required as	Driver type
Fuel mix	%	% share	Policy, technology
Share of own use in total heat generation	%	% share	Technology
Share of losses in total heat generation	%	% share	Technology

Heat supply

Figure 13: The logic tree for the heat supply sector in PROSPECTS+.

5.4 Scope of emissions

The scope of GHG emissions included in the model is flexible and determined by the scope of the input data (emission intensities and historic emissions) included by the user.

The following greenhouse gases are always included in PROSPECTS+:

- carbon dioxide (CO_2)
- methane (CH_4)
- nitrous oxide (N_2O)

By default, emission factors for fuel combustion are calculated with IEA data (based on energy balances and CO_2 emissions from fuel combustion). Consequently, the emission factors, and thus the resulting emissions, only cover CO_2. This can be adjusted in the General section in 'Workbook - Historical Data', where the user can collect emissions intensities in CO_2 equivalents, based on, for example, default IPCC emission factors.

Methane and nitrous oxide are included in oil & gas, agriculture and industry (process emissions).

Other greenhouse gases as listed in the 2006 IPCC Guidelines that could be included in process and other emissions (provided historic data are available) are:

- hydroflurocarbons, HFCs: e.g. HFC-23 (CHF_3), HFC-134a (CH_2FCF_3), HFC-152a (CH_3CHF_2)
- perfluorocarbons, PFCs: e.g. CF_4, C_2F_6, C_3F_8, C_4F_{10}, c-C_4F_8, C_5F_{12}, C_6F_{14}
- sulphur hexafluoride: SF_6
- nitrogen trifluoride: NF_3
- trifluoromethyl sulphur pentafluoride: SF_5CF_3
- halogenated ethers: e.g., $C_4F_9OC_2H_5$, $CHF_2OCF_2OC_2F_4OCHF_2$, $CHF_2OCF_2OCHF_2$
- other halocarbons, not covered by the Montreal Protocol, including: CF_3I, CH_2Br_2, $CHCl_3$, CH_3Cl, CH_2Cl_2

Most of these emissions (unless they are industrial process emissions) should be collected in the table under Other Emissions in 'Workbook - Historical Data'.

5.5 Comparison to IPCC categories

Emissions from all key IPCC source/sink categories are set out in Table 34 along with a mapping of if, and where, they are included in PROSPECTS+. The identification is based on revised 2006 IPCC guidelines for national greenhouse gas inventories (IPCC, 2006e). All emission categories that are not covered by the calculations in PROSPECTS+ can be inserted directly into the model as exogenously determined data entries for each year of the modelling horizon.

The aim of specifying emissions in every sector with authoritative and widely accepted standards is: 1) to avoid omission or double counting in sectors and especially in national level; 2) to increase the transparency of the results obtained from PROSPECTS+; and 3) to increase the validity of the results of this research and make the results better communicable and comparable to those of other studies.

Table 34: Overview of categories in IPCC 2006 guidelines for national greenhouse gas inventories covered by PROSPECTS+ (also provided in the Excel of PROSPECTS+)

IPCC category ID	IPCC categories of emissions	In PROSPECTS+	PROSPECTS sector	Comments
1	**Energy**	Partial	Various, see sub-categories	
1A	**Fuel combustion activities**	Partial	Various, see sub-categories	
1A1	Energy industries	Partial	Various, see sub-categories	
1A1a	Main activity electricity and heat production	Yes	Electricity & heat sector	Including autoproducers, which is partly covered in industry in IPCC reporting
1A1b	Petroleum refining	Yes	Industry	
1A1c	Manufacture of solid fuels and other energy industries	Partial	Steel	Coke emissions included in steel sector; other category emissions can be entered via the 'Additional emissions' Wizard
1A2	Manufacturing industries and construction	Yes	Various, see sub-categories	
1A2a	Iron and steel	Yes	Steel	
1A2b	Non-ferrous metals	Yes	Heavy industry	
1A2c	Chemicals	Yes	Heavy industry	Heavy and Light industry sectors are not broken down into sub-categories
1A2d	Pulp, paper and print	Yes	Light industry	
1A2e	Food processing, beverages and tobacco	Yes	Light industry	
1A2f	Non-metallic minerals	Yes	Cement	Process emissions from cement industry
1A2g	Transport equipment	Yes	Heavy industry	
1A2h	Machinery	Yes	Heavy industry	
1A2i	Mining (excluding fuels) and quarrying	Yes	Heavy industry	
1A2j	Wood and wood products	Yes	Light industry	Heavy and Light industry sectors are not broken down into sub-categories
1A2k	Construction	Yes	Light industry	
1A2l	Textile and leather	Yes	Light industry	
1A2m	Non-specified industry	Yes	Light industry	
1A3	Transport	Yes		
1A3a	Civil aviation	Yes		International aviation emissions can be included as separate category within transport sector
1A3b	Road transportation	Yes	Passenger transport/ Freight transport / International aviation	Breakdown included in non-simplified approach. In the simplified approach, transport is one sector.
1A3c	Railways	Yes		
1A3d	Water-borne navigation	Yes		International water-borne naviation emissions can be entered via the 'Additional emissions' Wizard
1A3e	Other transportation	Yes		Breakdown included in non-simplified approach. In the simplified approach, transport is one sector.
1A4	Other sectors	Yes	Various, see sub-categories	
1A4a	Commercial/institutional	Yes	Buildings: Residential	Breakdown included in non-simplified approach. In the simplified approach, buildings is one sector.
1A4b	Residential	Yes	Buildings: Commercial	
1A4c	Agriculture/forestry/fishing/fish farms	Partial	Agriculture	Only agriculture included; fishing and forestry can be entered via the 'Additional emissions' Wizard
1A5	Non-specified	No		
1A5a	Stationary	No		Can be entered via the 'Additional emissions' Wizard
1A5b	Mobile	No		
1A5c	Multilateral Operations	No		
1B	**Fugitive emissions from fuels**	Partial	Oil & Gas	
1B1	Solid fuels	No		
1B1a	Coal mining and handling	No		Can be entered via the 'Additional emissions' Wizard
1B1b	Uncontrolled combustion and burning coal dumps	No		
1B1c	Solid fuel transformation	No		
1B2	Oil and natural gas	Yes		
1B2a	Oil	Yes	Oil & Gas	
1B2b	Natural gas	Yes		
1C	**Carbon dioxide transport and storage**	No		Can be entered via the 'Additional emissions' Wizard

IPCC category ID	IPCC categories of emissions	In PROSPECTS+	PROSPECTS sector	Comments
2	**Industrial processes and product use**	Yes	Various, see sub-categories	
2A	**Mineral industry**	Yes	Cement	
2B	**Chemical industry**	Yes	Other industry (Light and Heavy)	Other industry is not broken down into sub-categories 2B-2H
2C	**Metal industry**	Yes	Steel	2C1 Iron and Steel Production is a separate sector
2D	**Non-energy products from fuels and solvent use**	Yes		
2E	**Electronics industry**	Yes		
2F	**Product uses as substitutes for ODS**	Yes	Other industry (Light and Heavy)	Other industry is not broken down into sub-categories 2B-2H
2G	**Other product manufacture and use**	Yes		
2H	**Other**	Yes		
3	**Agriculture, forestry and other land use**	Partial	Agriculture	
3A	**Livestock**	Yes	Agriculture	
3A1	Enteric fermentation	Yes	Agriculture	
3A2	Manure management	Yes		
3B	**Land**	No		
3B1	Forest land	No		
3B2	Cropland	No		
3B3	Grassland	No		Can be entered via the 'Additional emissions' Wizard
3B4	Wetlands	No		
3B5	Settlements	No		
3B6	Other land	No		
3C	**Aggregate sources and non-CO2 emissions sources on land**	Partial	Agriculture	
3C1	Biomass burning	No		
3C2	Liming	No		
3C3	Urea application	No		
3C4	Direct N2O emissions from managed soils	No		Can be entered via the 'Additional emissions' Wizard
3C5	Indirect N2O emissions from managed soils	No		
3C6	Indirect N2O emissions from manure management	No		
3C7	Rice cultivations	Yes	Agriculture	
3C8	Other (please specify)	No		Can be entered via the 'Additional emissions' Wizard
3D	**Other**	No		
3D1	Harvested wood products	No		Can be entered via the 'Additional emissions' Wizard
3D2	Other (please specify)	No		
4	**Waste**	Partial	Waste	
4A	**Solid waste disposal**	Yes	Waste	
4B	**Biological treatment of solid waste**	Yes	Waste	
4C	**Incineration and open burning of waste**	No		Can be entered via the 'Additional emissions' Wizard
4D	**Wastewater treatment and discharge**	Yes	Waste	
4E	**Other (please specify)**	No		Can be entered via the 'Additional emissions' Wizard
5	**Other**	No		Can be entered via the 'Additional emissions' Wizard

6 References

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