# Annex 5. Description of existing measures and the modelling platform (Denmark’s energy and climate model)

[Dette bilag vil blive opdateret med relevante aftaler og politikker, der er en del af frozen-policy-beregningerne i Klimastatus og –Fremskrivning 2023. I mellemtiden henvises til det offentliggjorte materiale bag Klimastatus og –Fremskrivning 2023.]

*Denmark’s Energy and Climate Model*

All the projections are based on constant prices 2021, specific selection of exogenous factors and the Denmark’s Energy and Climate Model. All modelling set- up used is explained as follows:

DCE

Danish Energy Agency

*Figure 1. Overall elements in the model platform with inputs on the left and outputs on the right.* (Energistyrelsen, 2019a)*.*

**INPUTS include**: Projection of emissions based on, amongst other things, DECO’s energy balance and on emissions from e.g. agriculture in collaboration with the Danish Centre for Environment and Energy (DCE) at Aarhus University; projections by the Danish Ministry of Finance and the Ministry of Economic Affairs and the Interior of economic and demographic developments, business productivity and CO2 allowances; the International Energy Agency's (IEA's) projection of world market prices of fossil fuels adapted to a Danish level; detailed plant data on Danish energy plants, based, among other things, on the Danish Energy Agency's energy production statistics and master data register; Statistics Denmark's input-output matrices for exchanges between sectors; the Danish Energy Agency's technology catalogues; and the projection of the electricity demand, energy production capacity and interconnectors of 23 European countries, based on data from the European Network of Transmission System Operators, ENTSO-E.

**OUTPUTS include**: (year-by-year and hour-by-hour up to 2035) energy consumption by sector, by use and by technology; energy balances for supply facilities and for district heating areas; greenhouse gas emissions; key indicators such as shares of renewables in accordance with the requirements of the RE Directive (Eurostat, 2018); electricity exchange and the electricity price for each of the 15 European electricity market areas included in the electricity market model; security of electricity supply; fiscal revenue lags; socioeconomic and corporate financial performance; as well as developments in the energy intensities of businesses.

**THE MODEL PLATFORM INTEGRATES THE FOLLOWING SUB MODELS**:

* **The summary model "Denmark's Energy and Climate Model"**, which integrates the two sector models mentioned below as well as results from the DCE's emissions model such as to provide an overall projection result at system level. Furthermore, the summary model forms the basis for the comparative analyses of projection scenarios vis-a-vis impact assessments at system level.
* **RAMSES**, which models electricity and district heating supply. RAMSES is a technical-economic model for operations optimisation, which is based on a detailed description of all energy-producing facilities and district heating areas in the Danish energy system as well as on an aggregated description of the electricity production plants in the European electricity markets included in the model, including interconnectors between these markets. RAMSES simulates operations in the interlinked European energy system on an hourly basis. RAMSES does not automatically take account of new investments. RAMSES includes Denmark as well as 23 countries broken down by 15 European electricity market areas. Trends in new production capacity are defined partly exogenously based on specific knowledge as well as on capacity development models, e.g. for wind power and solar PV, and partly based on a coupling to DH- Invest, which is a new investment model for small-scale district heating areas.
* **IntERACT**, which models energy consumption by the corporate sector and households. The model comprises two sub models: An economic model which describes the macroeconomic correlations using a neoclassical, general equilibrium model and a technical energy system model based on the IEA' s TIMES model (IEA-ETSAP, 2018). The model describes fundamental energy- technology, thermodynamic and physical relationships on a theoretical energy- economics basis. The model uses output data from RAMSES on electricity prices and district heating prices.
* **DH-INVEST**, which is an investment model for small-scale district heating areas. This investment model simulates operations and investments for each district heating area in order to determine investment scenarios that are optimal from the perspective of corporate economics. The investment scenarios include decommissioning of existing facility units. The investment model is integrated

with RAMSES and uses a common assumptions basis, after which the calculated changes in capacity for the individual district heating area are included in the basis used by RAMSES in its modelling of the overall Danish electricity and district heating system.

* **FREM**, which models energy consumption in the transport sector. Amongst other things, FREM is based on input from the Danish Transport, Construction and Housing Authority, which uses the National Transport Model (LTM) (Technical University of Denmark, 2018) to describe developments in road traffic and energy consumption by railways. FREM projects road transport based on projections for growth in transport volume, developments in the energy efficiency of vehicles by 44 vehicle categories and survival rates, journeys as a function of the age of vehicles, as well as choice of vehicle. FREM projects energy consumption in air transport based on developments in GDP and population numbers, as well as expected developments in energy efficiency in aviation.
* **Technology Deployment Models** for offshore wind, onshore wind, solar PV and biogas use, which model the profitability of technology investments in terms of corporate finances against the profitability requirements of relevant investors, which means the models model the most probable capacity deployment scenario against the current investment and operating conditions.