



Aurora's power modelling methodology

March 2020

Our forecasts use Aurora's proprietary European power market model

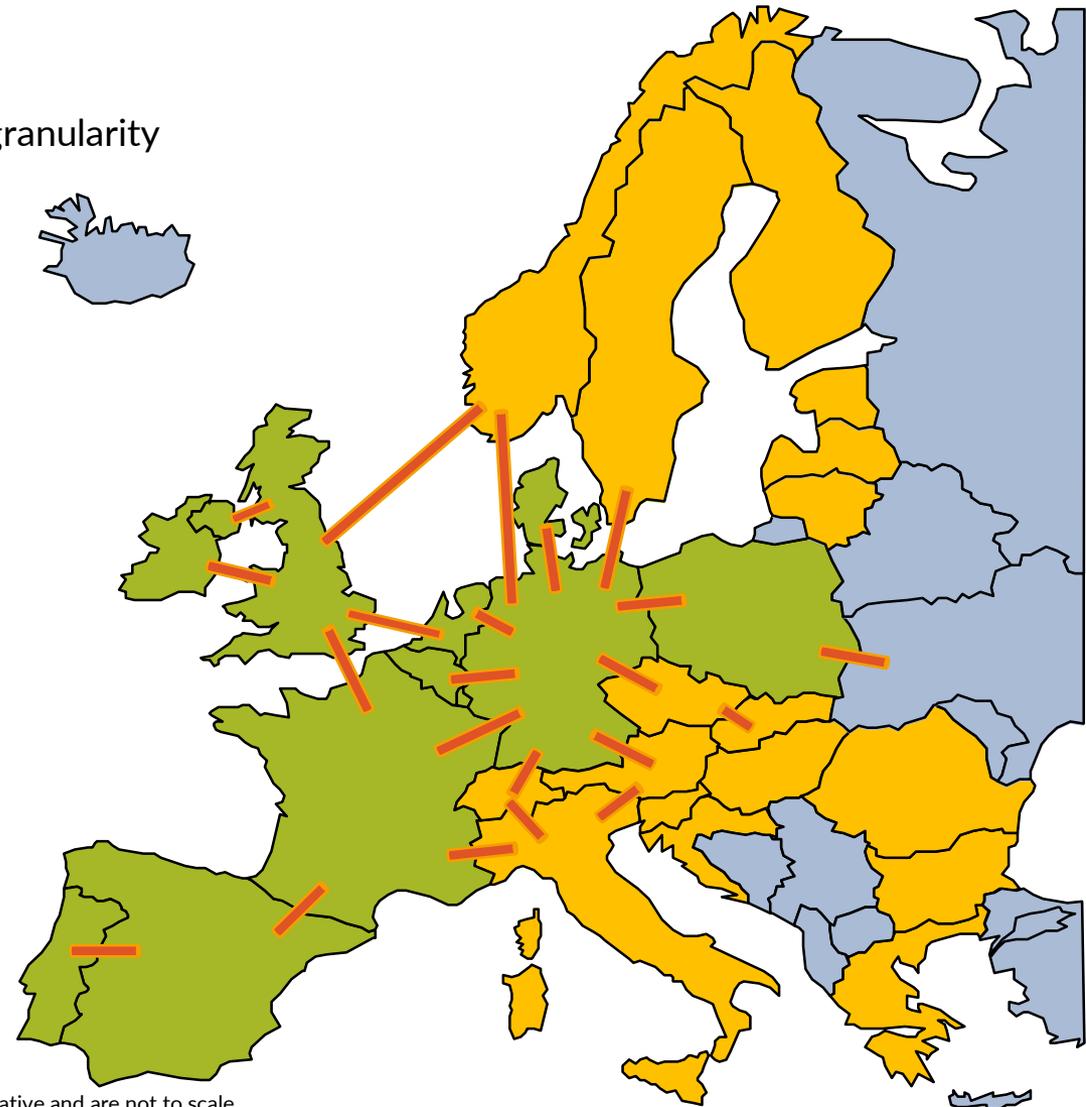
Plant aggregation

Individual plant

Not currently modelled

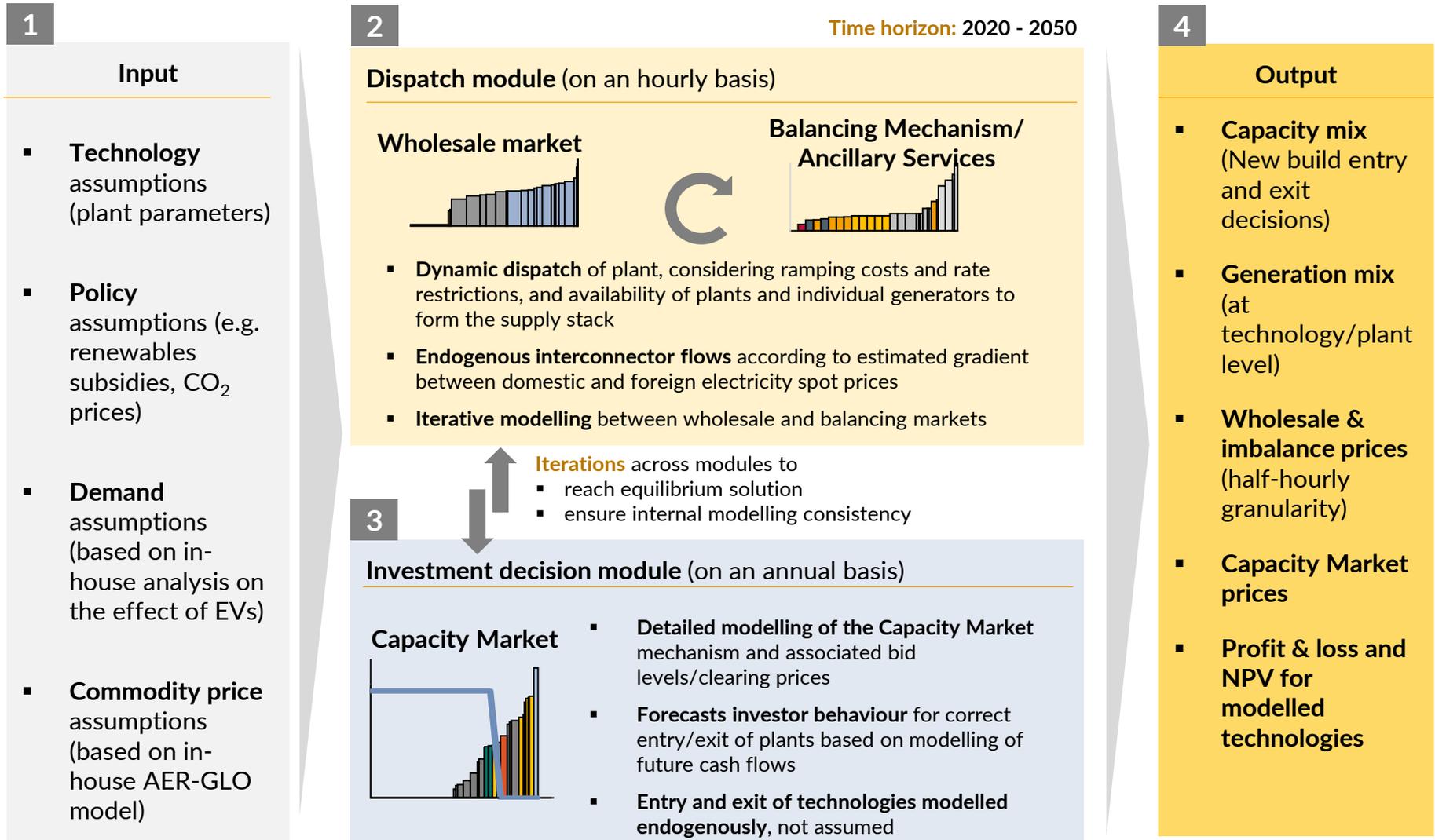
Modelling granularity

- Aurora's EU model currently covers 15 regions
 - 10 regions are modelled at the level of individual plants
 - 5 regions aggregate plants into technology classes
- Even in aggregated regions, a single technology class may contain several discrete technologies (e.g. high/mid/low merits CCGT)
- Bi-directional interconnector flows are determined by power price differentials between countries accounting for ramping restrictions, imperfect market integration and flow rate change costs



*Note: sizes and lengths of interconnectors are for visual representation only, illustrative and are not to scale

The model iterates between dispatch and investment decision to find an equilibrium set of prices and capacities



1. See Appendix 1 for further details of the modelling methodology

Input assumptions include technology, policy, demand and commodity prices



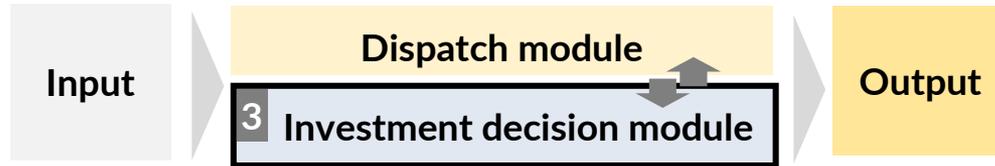
<p>Technology assumptions</p>	<ul style="list-style-type: none"> • Plant efficiencies (incl. efficiency improvement over time) • Plant availabilities • Plant costs: fixed & variable O&M costs, capex, refurbishment cost, mothballing cost 	<ul style="list-style-type: none"> • Ramping costs and speeds • Subsidised/un-subsidised mode of dispatch • Discount rate by revenue stream (for NPV calculation) • (other technical parameters)
<p>Policy assumptions</p>	<ul style="list-style-type: none"> • Carbon cost regime (e.g. Carbon Price Support in GB) • Mandated plant closure (e.g. coal) 	<ul style="list-style-type: none"> • Renewables outlook based on RO/FiT/CfD support schemes • (other policy parameters)
<p>Demand assumptions</p>	<ul style="list-style-type: none"> • Annual demand time series, which is processed into half hourly data including noise as a proxy for 	<ul style="list-style-type: none"> • stochastic availability • Number of EVs and heat pumps, also processed to half hourly profile
<p>Commodity price assumptions</p>	<ul style="list-style-type: none"> • Coal price forecast • Gas price forecast • EU-ETS price forecast • Commodity prices are typically 	<p>derived from separate Aurora CGE modelling, though can also be user-defined</p>

Based on user-defined inputs, the dispatch model optimizes plant behaviour to minimize costs



- Regional dispatch is optimized to minimize costs while accounting for:
 - Gross production and demand, including losses
 - Interconnector imports and exports
 - Ramping constraints
 - Loss of load
 - Spilled power
 - Plant availability and outages
 - Any additional user-defined constraints (e.g. emissions)
- Costs include
 - Capex, fixed and variable
 - Ramping
 - Spill and loss of load
 - Mothballing and refurbishment

Capacity investment decisions are based on plant economics



- In regions like GB which have a Capacity Market:
 - Annual procurement targets are set by the user
 - The model finds the cheapest plants to meet the target de-rated capacity and outputs a Capacity Market price
 - Already existing plants receive 1-year contracts
 - New building plants can receive multi-year contracts
 - Each technology has a specific de-rating factor (i.e. how much can 1MW of each tech count towards the target)
 - The model iterates between the dispatch and investment decision modules until it reaches a consistent, equilibrium set of prices and capacities such that each asset is just able to make its required level of return

Input assumptions include technology, policy, demand and commodity prices



<p>Annual data (plant-level)</p>	<ul style="list-style-type: none"> Capacity details Short-run marginal cost Capture price Production (net and gross) Fuel use and CO2 production Fraction of capacity curtailed Wholesale, balancing and capacity market revenues and profits
<p>Annual data (regional level)</p>	<ul style="list-style-type: none"> Total capacity Demand and embedded demand Baseload and peakload power price Energy unserved/spill Export and import Fuel and commodity prices and use
<p>Half-hourly data</p>	<ul style="list-style-type: none"> Plant short-run marginal cost Marginal plant and system marginal costs Wholesale and balancing prices Capacity margin Gross and net production Curtailement volume Storage and pump production details Energy unserved Transmission data Spread Embedded demand

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