

# PPSGen : Power Model

januari 2021



**eRisk Group**  
*Energy & Finance*

1. PPSGen Power Model
2. eRisk Group scenarios

## PPSGen: Model components

### PPSGen-Data

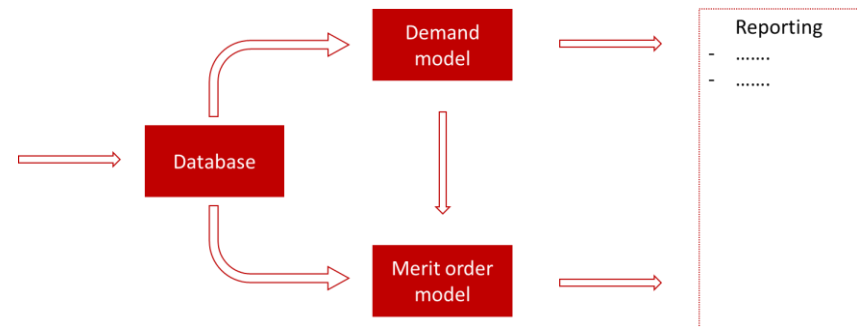
- The database contains the following data: all conventional power plants (> 5 MW) per country, capacity development of inter-connections, renewable energy, and new technologies (e.g., heat pumps, EV). Hourly demand, normalised wind and PV generation data, and weather data.
- Six scenarios to 2050 are defined about probable future developments, including economic growth, and electricity and heat saving scenario's

### PPSGen-Demand

- The demand model uses the data to calculate the net hourly electricity demand and adjusts that demand for the dispatch of flexible assets such as demand response (e.g., electric boilers), hydrogen production and non-core region cross border optimisation, resulting in a final net demand

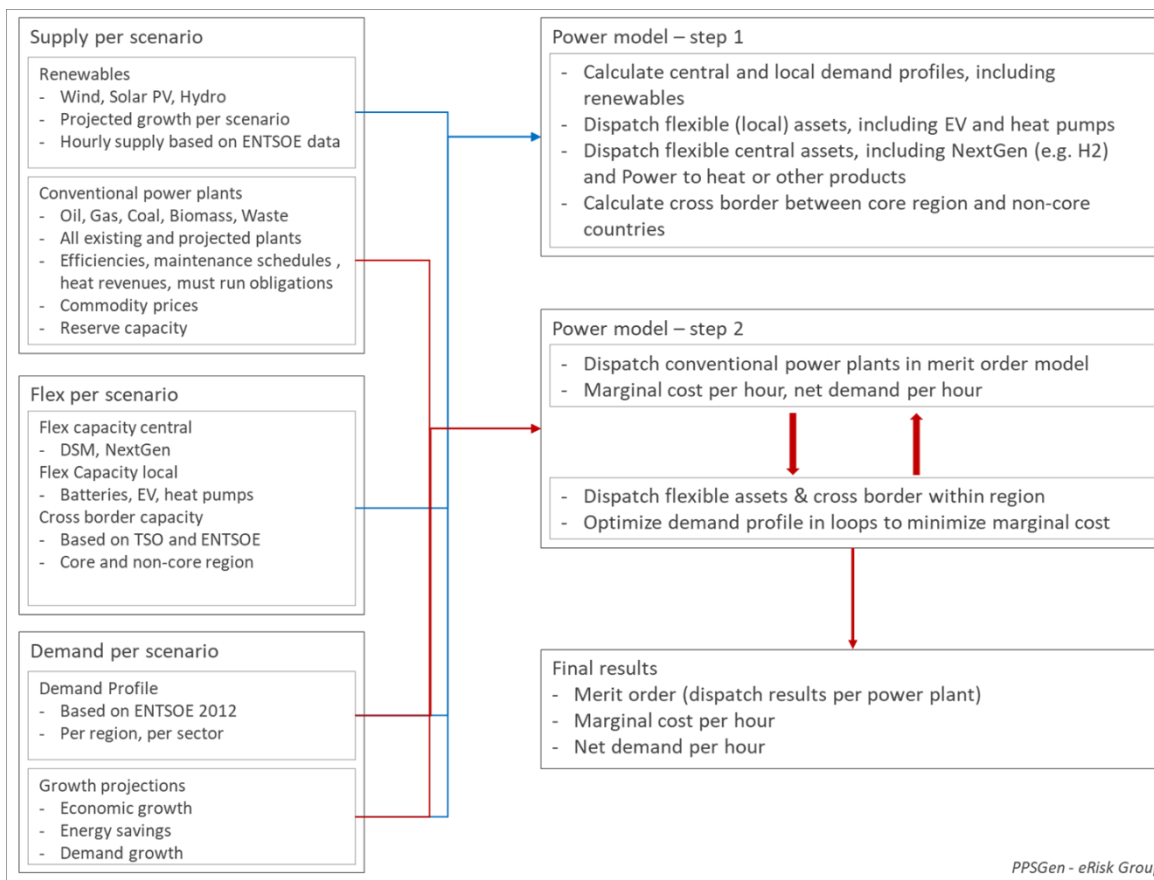
### PPSGen-MeritOrder

- In the merit order model, the optimal dispatch to minimise dispatch costs of available power plants, flex capacity and cross border capacity versus a given net demand is calculated, resulting in hourly electricity prices and loads per generating technology per year, per country and scenario



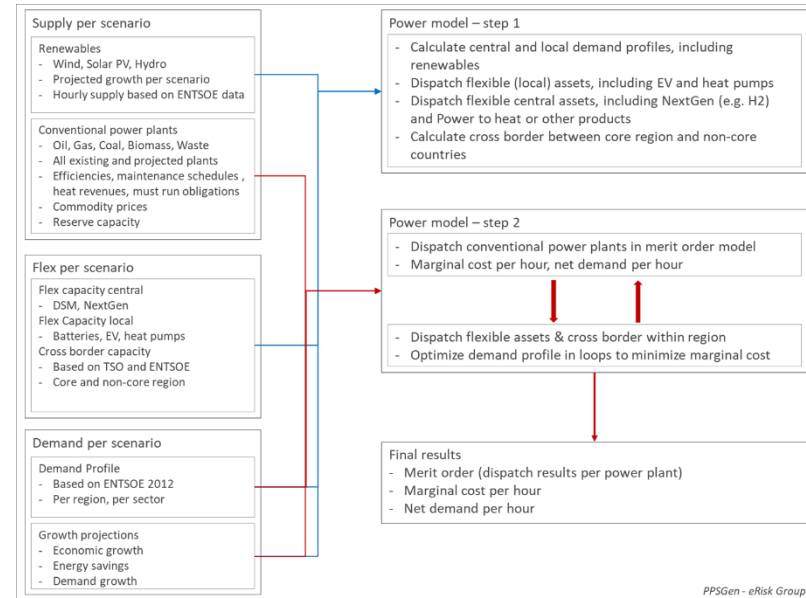
**The model uses data which are modelled using statistical and linear modelling technology**

PPSGen is a fundamental merit order model of the North West European electricity markets. The method is based on basic economic principles of supply and demand describing price dynamics and modelling the impact of the main physical and economic factors determining the market equilibrium price of electricity



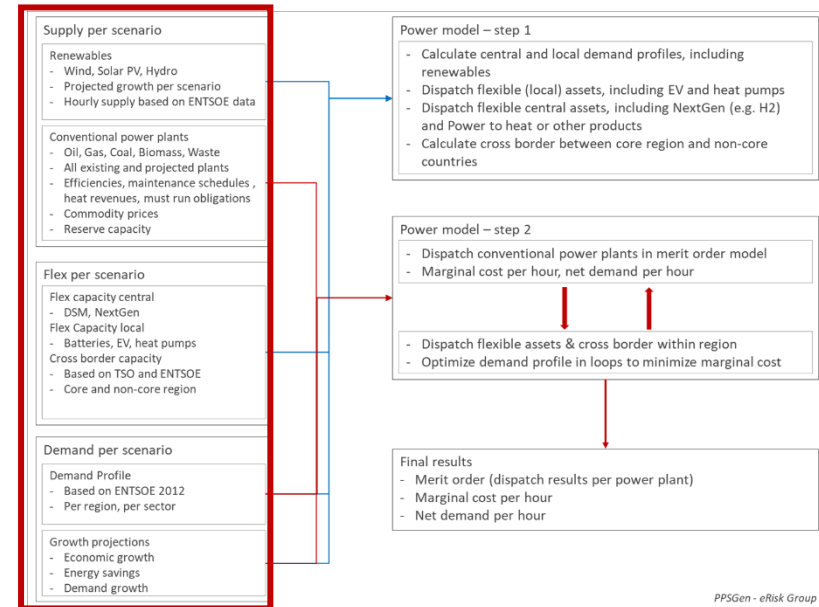
## PPSGen: model principles

- Prices are determined by supply and demand principles
- Replicates actual market design and intended behaviour meeting economic and operational constraints
- Captures technical constraints on physical assets operating within the market
- Includes various scenario analyses for possible future development
- Includes optimisation of other requirements such as start / stop cost of power plants, storage and demand response services and district and industrial heating load
- Produces results (i.e., power price scenarios, hourly fuel use plants, CO2 emissions, hourly dispatch cost and load curves) that reflect future structural changes e.g., fuel/carbon prices impact, changes to renewable and conventional generation capacity and changes in flexible power sources (power plants, demand response and storage)
- The basic goal of the model is to determine the least dispatch costs of generating resources to meet a given power demand



## Scenario input (generation & demand)

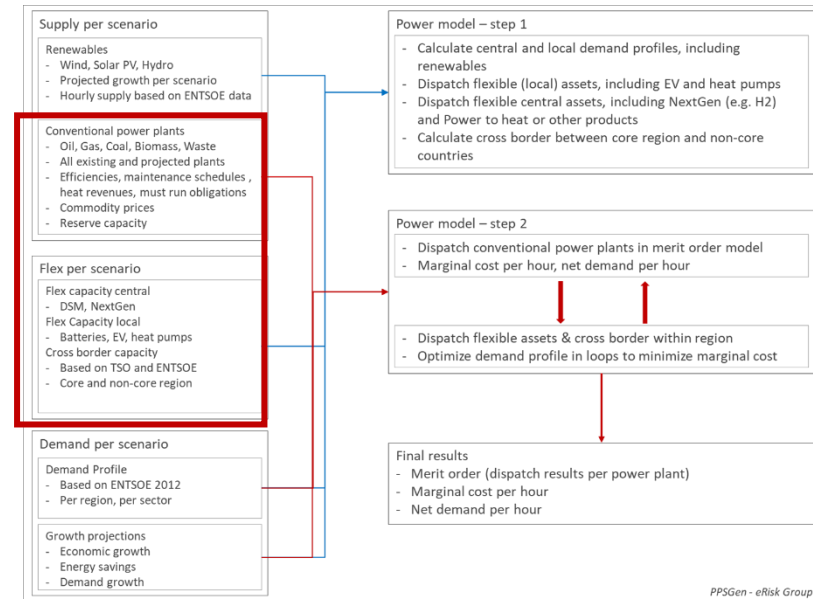
- eRisk Group has developed several distinct scenarios
- Each scenario is based on a consistent set of potential future supply and demand developments per country
- Main scenario input variables for conventional generation are:
  - Development of conventional generation capacity, commissioning and decommissioning schedules, conventional plants, biomass generation and co-firing, plant with CCS and Next Gen
  - Development of fuel prices (coal, natural gas, oil and biomass), CO2 and green certificates prices
- Main scenario input variables for demand are:
  - Economic growth and energy savings rates per sector (residential, commercial, and industrial)
  - Capacity development
    - Wind and solar PV
    - EV (Electric Vehicles) and heat pumps
    - Storage (pump storage, lithium-ion or other storage technologies) and demand response capacity
  - Heat demand



**PPSGen generates future merit orders based on different scenarios creating the possibility to analyse the impact of different energy transitions on business activities**

## Power plant database

- The database of conventional power plants is developed internally
- The database is up to date and includes efficiencies, maximum and minimum load requirements per technology, O&M cost per technology, transport cost per fuel and per region and recent outlooks for commissioning and decommissioning
- Plants with must-run obligations are defined and provided with relevant must run and additional flex profiles depending on their purpose: industrial, district heating, greenhouses.
- Plants with biomass obligations are defined and provided with relevant efficiencies and max. and min. load requirements
- Plants with TSO reserve requirements are defined and provided with relevant efficiencies.
- Database is based on
  - Elia, TenneT, RTE, DECC and Deutsche Bundesnetzagentur
  - CITL
  - Company websites
  - Internal research



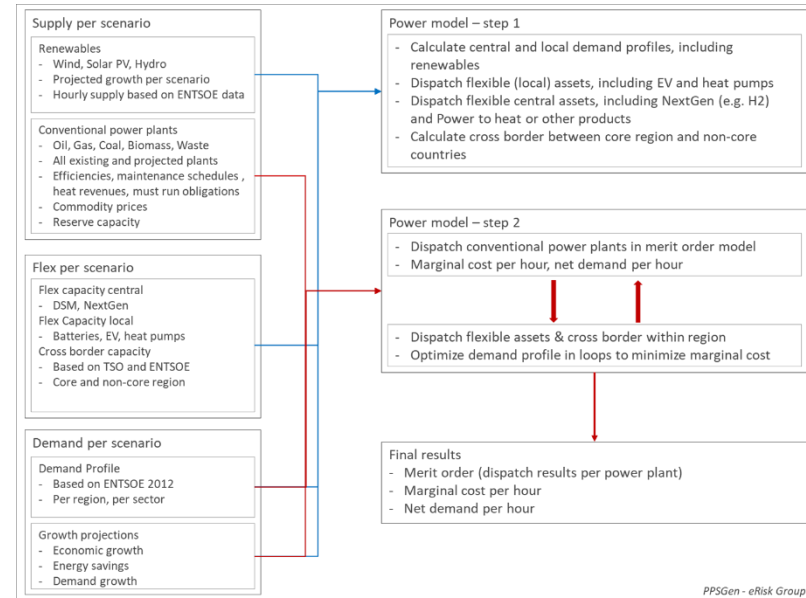
**The model includes an up-to-date and extensive database of power plants in the Benelux, United Kingdom, France, and Germany**

## Net Hourly Demand is derived from gross demand

- Gross hourly demand is based on real 2012 ENTSO-E hourly demand data, fitted to recent real demand totals
  - The 2012 hourly demand is fitted to the demand per sector (retail, commercial and industrial)
  - Future hourly demand is derived from the 2012 data and based on assumptions about future economic growth and energy savings
  - Demand data is adjusted to include own consumption of industrial CHPs and grid losses
  - Additional demand from new applications such as heat pumps and EV is modelled separately based on specific expected load profiles and scenarios
- From gross to final demand in two steps

### Step one: Calculation net local demand:

- Deduction of the hourly renewable production (PV). Hourly production of local (built environment) solar energy is based on actual 2012 weather data for various locations per country and capacity assumptions per country and scenario
- The net local (built environment) hourly electricity demand including additional demand from new applications such as heat pumps and EV is modelled separately based on specific expected load profiles and scenarios
- Adjustments for the rational application of demand side management, batteries and electric vehicles on the hourly load



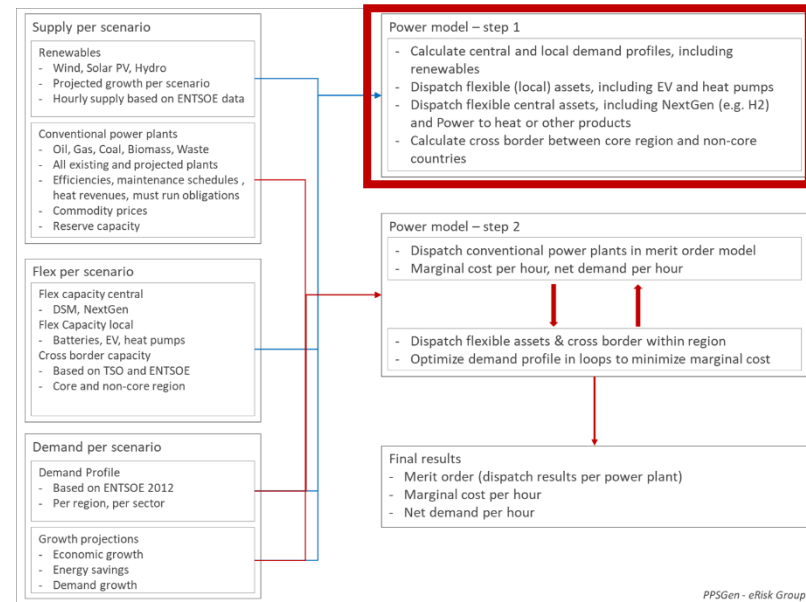
**The demand model generates smoothed hourly demand profiles per year, country, and scenario**



## Hourly demand calculation

### Step two: calculation final demand:

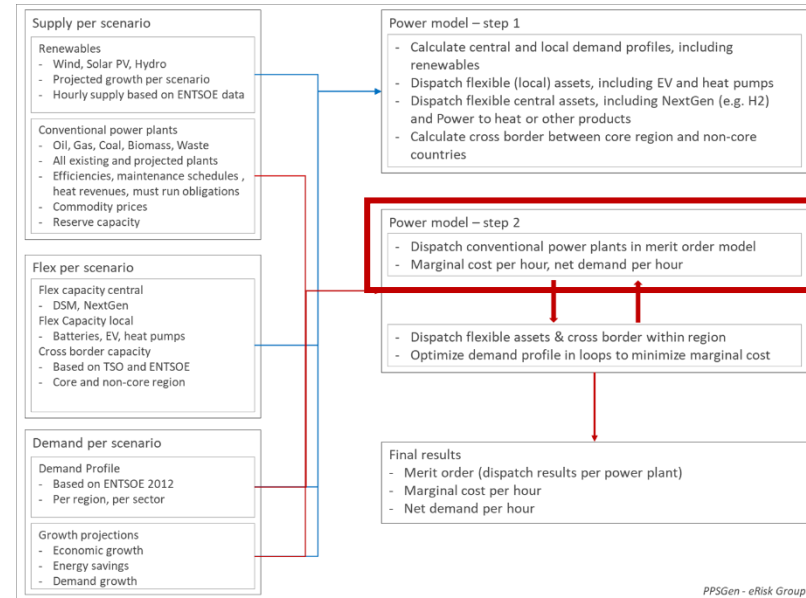
- Deduction of the hourly renewable production (remaining PV and wind). Hourly production of PV and wind energy is based on actual 2012 weather data for various locations per country and capacity assumptions per country and scenario
  - The net final net demand by including the central (remaining) hourly electricity demand including additional demand from new applications such as industrial heat pumps and hydrogen production modelled separately based on specific expected load profiles and
  - Adjustment for the hourly production of Hydro and Run-of-the-River plants (RoR) plants per country and scenario based on national grid data sources
  - Adjustments for the hourly cross border flows with non-core countries per country and scenario
- The flexible assets such as heat pumps and EV are dispatched within their generic constraints such as reservoir levels and efficiency and based on the regular demand for heat, mobility profiles and/or charge/discharge cycles
  - The flex assets are dispatched when defined deviations from future average demand levels occur
  - Dispatch of the cross-border capacity of countries from the non-core region based on deviations from future average demand levels and fitted according to historical cross border use



**Net demand is the starting point for the hourly merit order calculations**

## Hourly merit order calculation

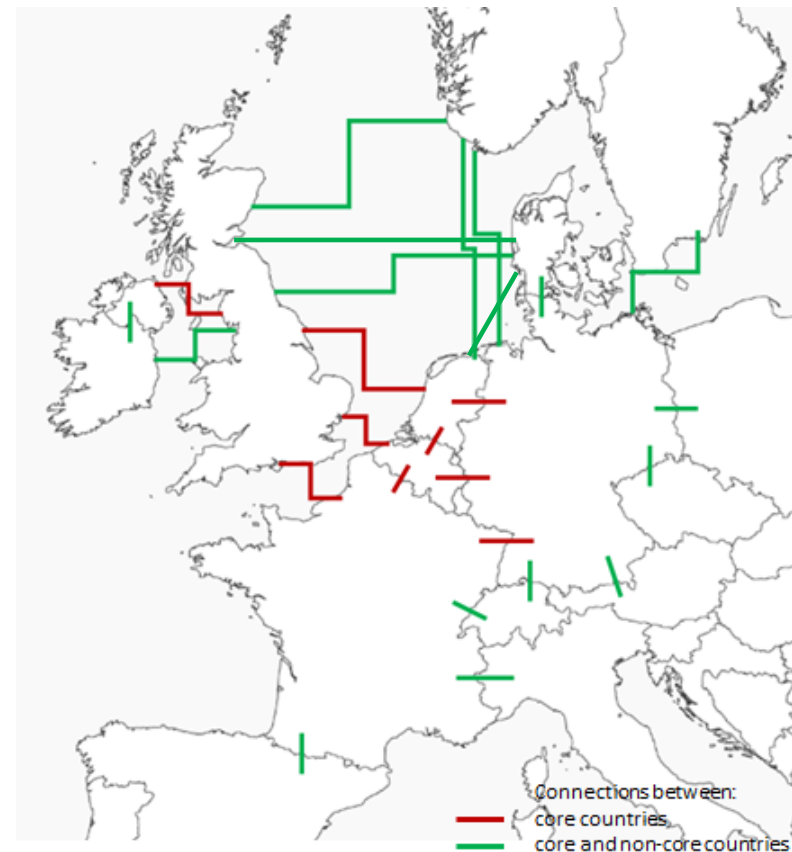
- The function of PPSGen is to minimise dispatch (marginal) costs of the electricity supply in the core region.
- The basis for the dispatch calculations is the unit cost of generation in €/MWh (short run marginal costs or SRMC), for each plant and the optimal dispatch of the available flexible capacity per MWh.
- The model minimises the dispatch costs subject to the following constraints:
  - Energy supply and consumption must be balanced in every hour in every region
  - Power exchange within the modelled core region and between the modelled non-core countries is limited by interconnection capacity
  - Technical and economic constraints for power plants, flex capacity and renewable energy sources.
  - PPSGen does not optimise for the lowest marginal costs, it performs calculations based on the input provided and takes these “as is”
  - PPSGen runs a number of iterations to approximate an optimisation to take start/stop costs and a number of flexible assets into account



**PPSGen merit order calculations are based on specific inputs and allow a detailed analyses of the specific merit order impact of different conventional generation technology**

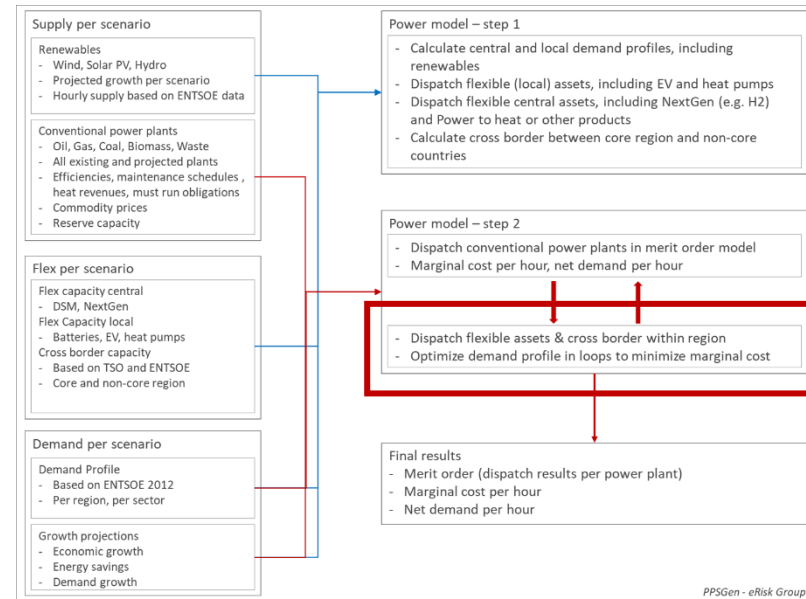
## Production to meet final demand and the impact of cross border flows

- **Cross border flows between the countries in the core region**
  - Final net hourly demand minus the relevant hourly cross border capacity determines the hourly minimum generation capacity to be dispatched per country and per scenario
  - The remaining hourly demand for the core region per year and per scenario is met by the merit order of remaining and aggregated generation capacity of the core region
  - The allocation of the aggregated core region dispatched production capacity per country is based on available import per country and scenario
- **Cross border flows between the core region and other countries**
  - The application of cross border capacity between the core region and other countries is determined by their expected behaviour and adjusted for a certain import/ export threshold
  - In the demand model the demand profile calculated is adjusted for the application of non-core cross border capacity
- The actual and future growth assumptions of cross border capacities and flows per scenario and country are based on actual (NTC) capacity data and information from TSO's and ENTSO-E



## Minimize dispatch costs of available power plants

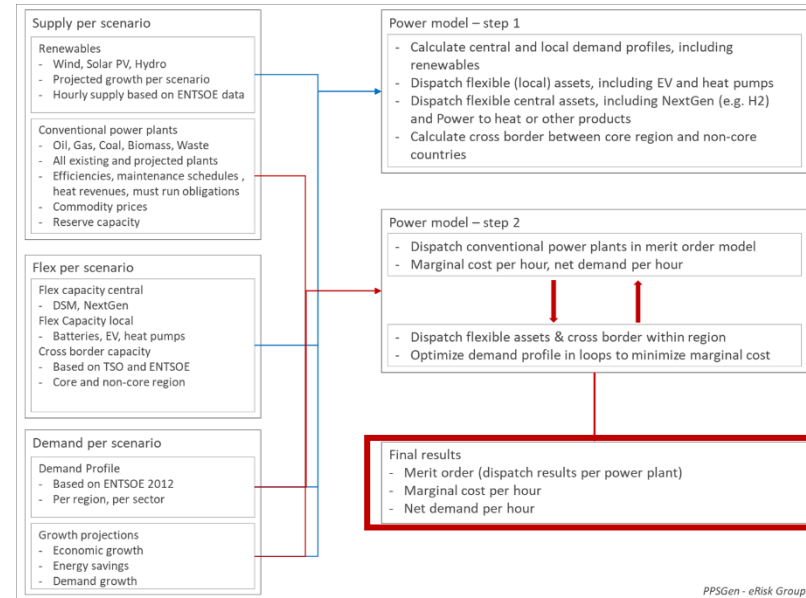
- The flexible assets, including their specific parameters such as round-trip efficiency, reservoir capacity, charge/discharge capacity, have been defined and are used as input to dispatch the flexible assets based on information, notably the merit order, power prices and demand, generated by PPSGen
- The flexible assets (pump storage, batteries, water pumps and industrial flex) are dispatched when defined price spreads per flex asset in relation to future prices generated by PPSGen can be realized within given conditions and parameters per flexible asset
- A flex merit order based on the efficiency of the flexible assets is used to determine in which order the capacity of the flexible assets is dispatched
- To prevent the dispatch of flexible assets that potentially cause market disruptions, a function is included which observes the generated merit order and finds the maximal admissible dispatch of flexible capacity that does not disrupt the market.



**Flexible assets are used to minimise cost of conventional production capacity**

## The PSGen tool

- The final calculations including the dispatch of flexible assets result in the following output for every country, year and scenario:
  - Hourly power prices
  - Plant / portfolio valuation
  - Plant hourly dispatch
- Analyses can be performed by changing the (key) variables
- The above allows for hourly merit order calculations for different scenarios
- Consequently, it makes PSGen an ideal tool ideal to perform sensitivity analyses with respect to regulatory and other changes impacting the market environment such as the commissioning or decommissioning of power plants, the penetration of renewable energy and fuel and CO2 price developments



**PPSGen is a flexible and transparent tool which can be used for multiple analyses, including the impact of market changes and regulation on prices, portfolio value, and plant dispatch**

1. PPSGen 3.0
2. eRisk Group scenarios

## PPSGen-Data stores 6 scenarios

- Two base case scenarios are constructed that mirror the existing and planned policies scenarios of the IEA (see next slide for more detail)
- Four other scenarios can be defined, either as sensitivities on the two base case scenarios or completely different scenarios
- All variables can be defined differently in all scenarios. Power plants construction or mothballing dates, new technologies (e.g., more nuclear power plants) stronger or slower growth rates of heat pump or EV, etc.
- Different scenarios allow for specific analyses, e.g., on the impact of policy changes, minimum CO2 prices in a country, or a faster or slower “kohleausstieg”

# Main characteristics of two basis scenarios

	Current Policies	Planned Policies
Economy	Modest growth	Modest growth
Demand general (methodology)	<i>Year on year demand growth (or decline) is correlated with economic growth and different for Retail, Commercial and Industrial demand. Demand changes are different for existing demand and demand for new appliances (e.g. E.V., Heat Pumps etc.).</i>	
Demand Electricity	Strong growth. Planned Policies even stronger growth	
	<ul style="list-style-type: none"> <li>- more demand: heating and transport</li> <li>- lower demand (-1%yoy): energy savings and more efficient appliances)</li> </ul>	
Heat Demand	Energy needed for heat demand remains stable despite growing demand because of energy savings and more efficient technologies.	Energy needed for heat demand remains stable despite growing demand because of energy savings and more efficient technologies.
Conventional Generation	Coal and Lignite generation capacity is phased out according to various country plans.	Coal and Lignite generation capacity is phased out according to various country plans.
Biomass Generation	Biomass cofiring phased out before 2030.	Biomass cofiring phased out before 2030.
Renewable Generation	The countries existing renewable plans (2020) are fully executed towards 2030. Future growth of renewable capacity extrapolated based on 20s growth%.	The countries anticipated renewable plans (2020) are fully executed towards 2030. Future growth of renewable capacity extrapolated based on 20s growth%.
Market Prices	Gas and CO2 prices significantly higher. Uranium, Coal, and Lignite prices modest growth. Hydrogen prices (including subsidies) assumed to be 10% below CO2 compensated gas prices.	Gas and CO2 prices significantly higher. Uranium, Coal, and Lignite prices modest growth. Hydrogen prices (including subsidies) assumed to be 10% below CO2 compensated gas prices.
Electricity Prices	<i>Electricity prices are calculated by PPSGen and as such not an input. European electricity wholesale prices tend upwards despite the abundant supply of low marginal cost solar and wind power. The upward trend is mainly caused by high gas/CO2 prices and high marginal cost (power plants typically run only a few hours each time causing high start/stop related costs)</i>	





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