



**NEP2019: OVERVIEW OF MARKET MODEL BID3**  
January 2019

---

# AGENDA

- Introduction
- Overview of BID3
- BID3 key features

# INTRODUCTION

**This pack gives an overview of the market model used in the NEP2019, BID3. It is not a comprehensive technical description, but an overview of the key principles and main features in the model**

- The Grid Development Plan 2019 (NEP2019) deals with the expansion requirements of the German onshore energy transportation network and is based on the legal requirements as stipulated by the German Energy Management Act (Section 12a-d). The transmission system operators are planning, developing and building the grid of the future and the NEP2019 is used to show how power generation in Germany can successfully be restructured and renewable energy can be integrated within ten and twenty years.
- Following the ruling of the German Bundestag in August 2011, the transmission system operators have been tasked with compiling a plan for the development of the transmission network every two years to allow for changing conditions in the energy industry. The result of all this work is the NEP2019.
- To carry out the NEP2019, simulations of the market and of the transmission network are required, and the transmission system operators run the simulation of a series of scenarios of the European market for the NEP2019, using Pöyry's bespoke market model called BID3.
- This document gives an overview of BID3 and expands upon the details laid out in the Grid Development Plan report.



---

# AGENDA

- Introduction
- Overview of BID3
- BID3 key features

# WHY BID3



**BID3 is the leading electricity market simulation software – combining powerful simulations with user-friendliness**

**Buying BID3 means buying into Pöyry's market knowhow**

BID3 is used everyday by Pöyry to provide services to utilities, investors, banks, and projections using it underpins all our market reports and valuation services

**Extensive client base**

BID3 is already used by TSOs, energy companies and regulators, as well as extensively by Pöyry

**User-friendly**

BID3 has been designed to be very user friendly, meaning that the training and implementation time is very low

**High quality datasets available**

Our datasets come fully benchmarked with a high-quality backcast of 2012-17. Datasets are taken from the data use ourselves for our modelling work, guaranteeing the highest quality

**Detailed hydro, wind and solar modelling**

We use the model to underpin our extensive modelling work in 'intermittency' including detailed simulations of historical weather patterns, along with sophisticated hydro modelling

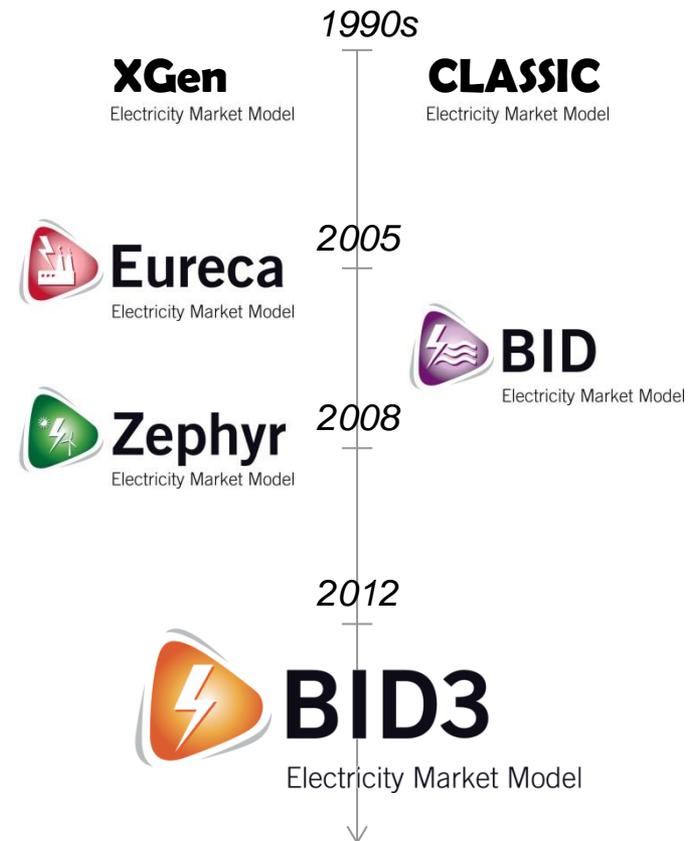
**Fast and powerful**

Designed to allow computing power to be focused where it is needed, and handles modelling of 8760 hours with large numbers of countries, power stations, renewables, hydro and demand-side management with ease.

# PÖYRY EXPERTISE IN POWER MARKET MODELLING

## Poyry has a long experience of market modelling, dating to the beginning of liberalisation

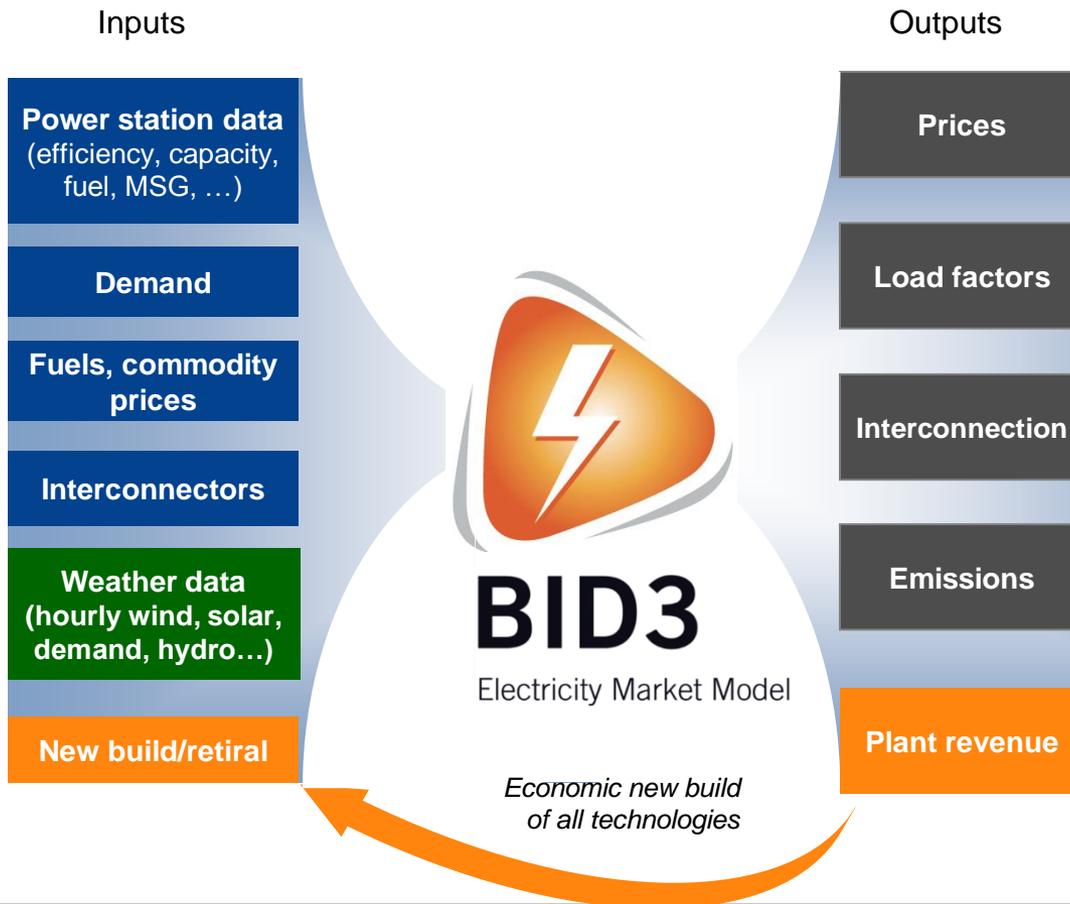
- In the 1990s we used Excel/VBA-based 'stack models' to model single markets
- Since 2005, we have used optimisation and mathematical programming to ensure our models are the best available
  - BID explored the interaction between the Nordics and the Continent
  - Zephyr explores the impact of intermittent renewables in thermal markets
- In 2012, Pöyry undertook a major redevelopment of its modelling platform, called BID3
  - merging expertise from all models, for unparalleled speed, quality and robustness
  - implementing a very user-friendly interface



# BID3 – PÖYRY'S ELECTRICITY MARKET MODEL

BID3 projects physical operation (generator output, electricity flows, emissions) and economic behaviour (electricity prices, revenues)

## Inputs and outputs of BID3



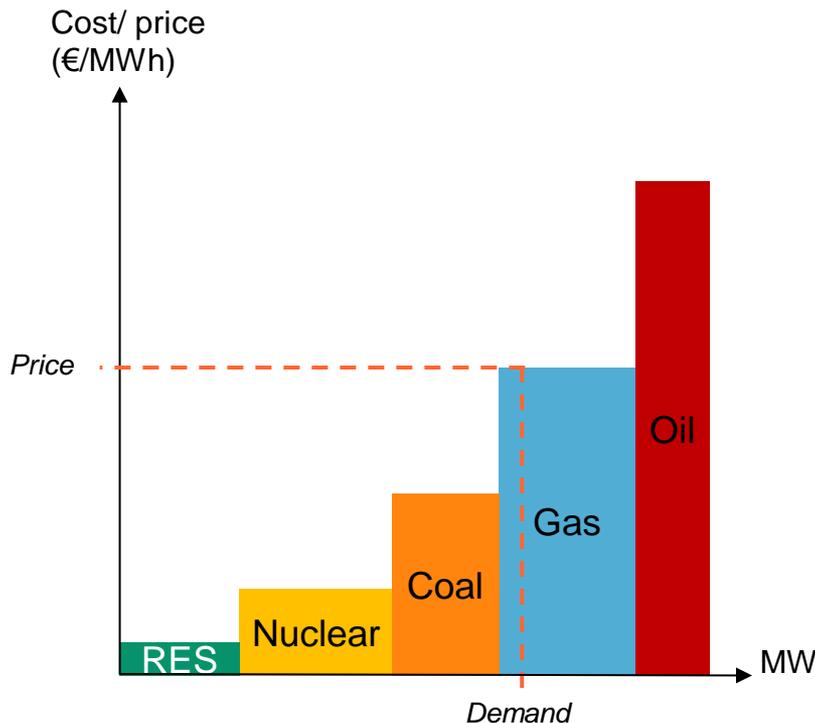
## Basics of BID3

- BID3 is an optimisation which minimises the system cost in a year subject to constraints
- It models all 8760 hours of the year and accounts for varying renewables, demand-side management, hydro and pumped/battery storage
- It has the following key plant dynamics
  - Start-up, Part-loading (no-load), Minimum Stable Generation
  - Minimum on- and off-times
  - Temperature dependent start cost
  - Ramping
  - CHP and co-firing
- It also models
  - Intermittency of wind/solar
  - Reserve constraints
  - Capacity expansion (new build and retiral)
  - Flow Based Market Coupling

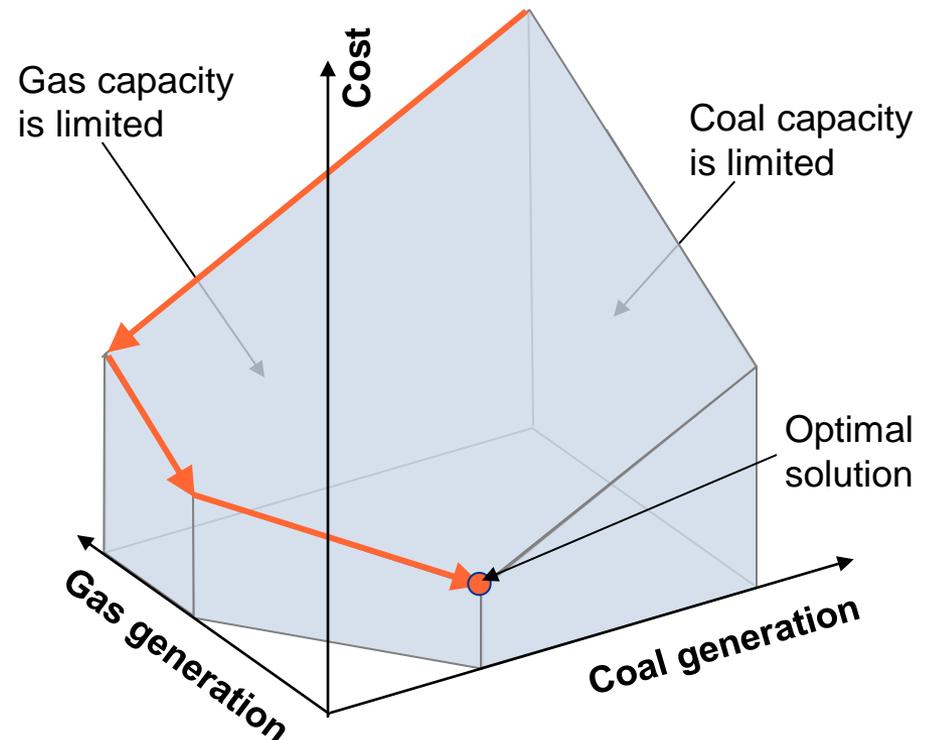
# UNDERLYING PRINCIPLES: LINEAR OPTIMISATION

BID3 uses linear or mixed integer linear programming (MILP) to optimise the dispatch. This is similar to a merit order ('stack'), but more accurate

Merit order

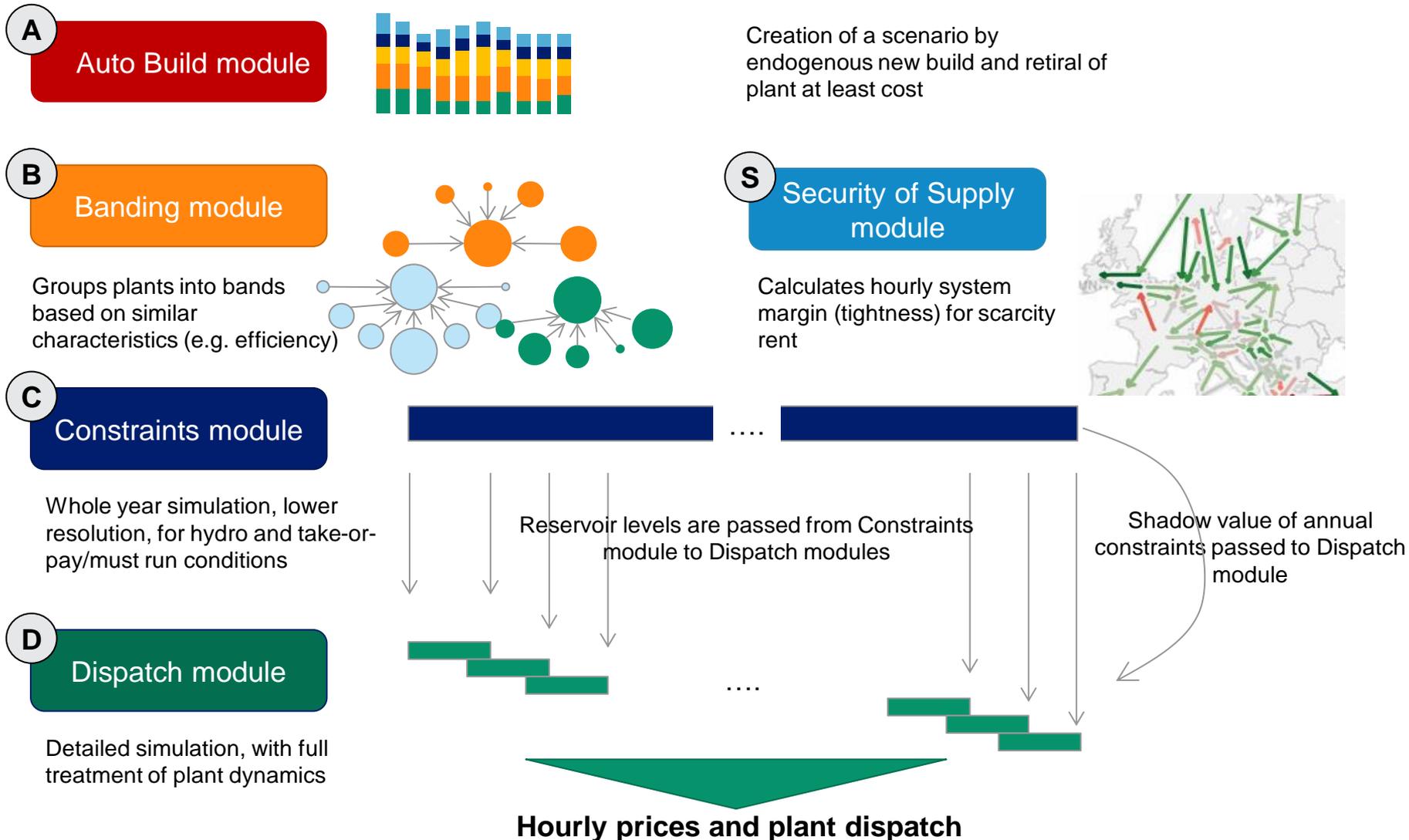


Linear optimisation (merit order adjusted for constraints)



Unlike a simple merit order stack, linear or MILP optimisation allows the inclusion of inter-temporal constraints (start-up costs, pumped storage, hydro etc.) and multiple zones

# THE HEART OF BID3 IS IN FIVE MAIN MODULES



# INTERFACE EXAMPLES

### Start screen

### Tracks - annual building blocks

- Plant tracks: List, Batch edit
- Demand tracks: List, Batch edit
- IC tracks: List, Batch edit
- Fuel tracks: List, Batch edit

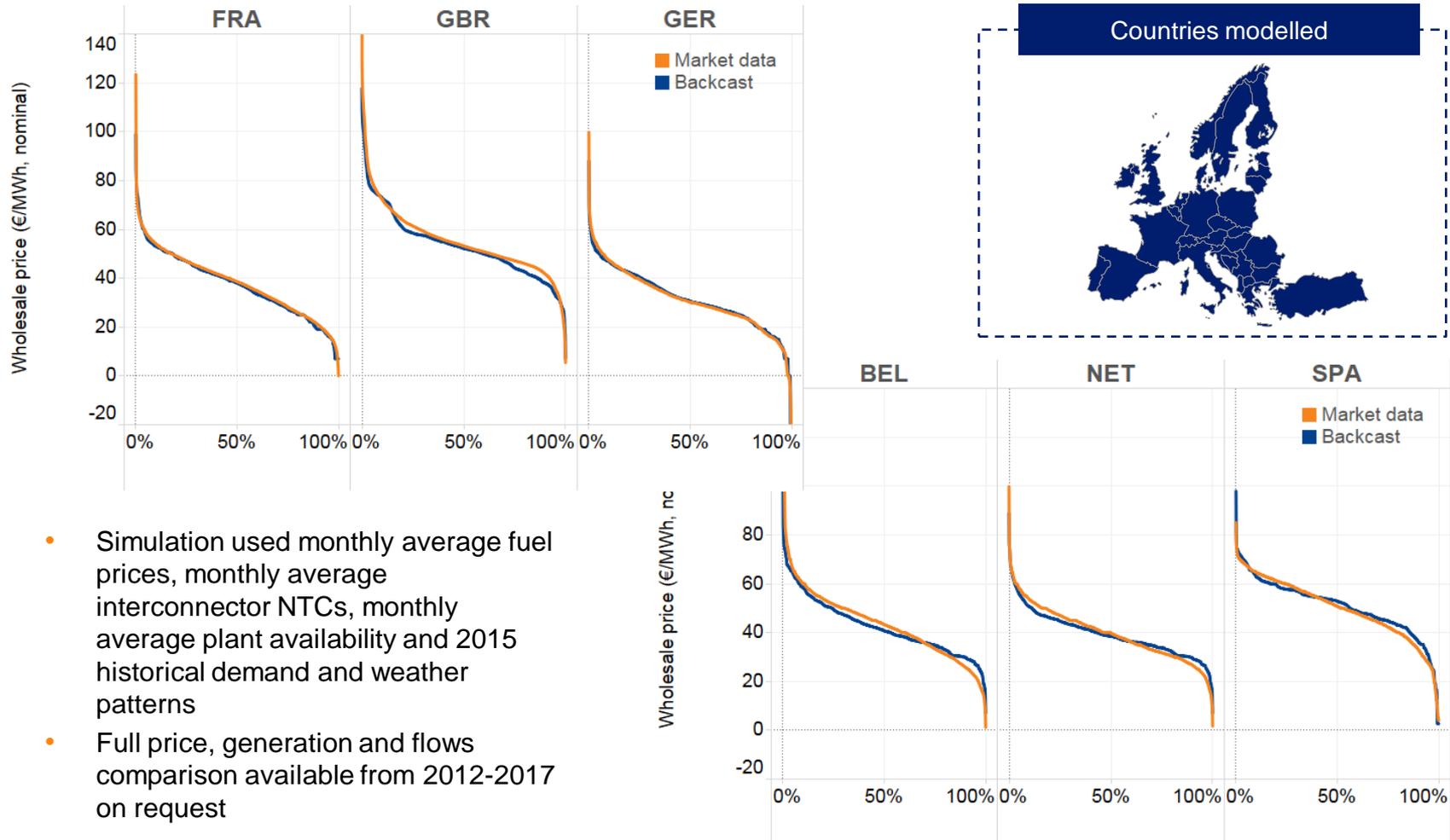
### Maps

### Flexible pivot tables/charts

Year	Week	AUS	BEL	DEU	FRA
2020	1		54.43	53.20	57.15
2020	2		57.21	58.00	54.56
2020	3		52.74	53.33	49.52
2020	4		58.56	57.23	63.99
2020	5		62.84	59.46	65.97
2020	6		52.56	56.10	50.49
2020	7		53.83	54.59	45.99
2020	8		53.23	54.15	46.25
2020	9		57.24	58.01	60.70
2020	10		53.73	56.60	56.03
2020	11		59.74	59.02	65.71
2020	12		51.41	52.14	49.09
2020	13		34.88	25.43	30.46
2020	14		36.23	35.47	35.65
2020	15		39.83	41.94	37.15

# MODEL ACCURACY CAN BE DEMONSTRATED VIA 'BACKCASTS'

Comparing historical prices against BID3 price duration curves for 2015 shows that it produces accurate prices and a convincing price shape.



# LIST OF FEATURES

## BID3 is simple and user-friendly, but has many advanced features

### General features

- Modelling of 8760 hours per year
  - Across many weather/stochastic series for each 'future year' modelled
- Interface designed to allow an easy setup of sensitivities
- User-friendly, but detailed and powerful interface
  - Pivot-table/pivot-chart system, highly flexible,
  - Easy interaction with Excel
  - Several levels of outputs, from most aggregated to most detailed
- Investment analysis
  - Plant-by-plant profitability analysis
  - Capacity payment, need for other revenue streams
  - System indicators: costs, emissions, loss of load, capacity margin
  - Auto Build module: optimal long-term evolution of the mix
- Mapping capabilities

### Dispatch thermal plants

- Comprehensive set of plant dynamics
  - Start-up costs, dependent on plant temperature
  - Minimum stable generation
  - Minimum On- and Off- time
  - Start-up ramp rates
- Advanced treatment of CHP plants
  - Hourly heat demand
  - Possibility of backup boiler
  - Electric generation limit as a function of heat demand
- Possibility of Mixed Integer Programming
  - Plants either ON or OFF, required for detailed dispatched patterns
- Many other features
  - Co-firing
  - Contractual/regulation limits on operations
  - Ambient profile temperature effect

### Dispatch

- Hourly renewables generation
  - Detailed analysis of satellite data, many historical weather patterns
- Optimisation of reservoir hydro using Stochastic Dynamic Programming
  - Dispatch under uncertainty of future inflows for the Nordics
  - Dispatch of reservoirs with annual constraints for the Continent
- Demand-side management
  - Load-shifting and smart grids
  - Electric vehicles, heating, power intensive industry, etc.
- Interconnectors
  - Flow-based allocation of interconnectors
  - Ramp rates on DC links
- Reserve holding within 'spot' simulation, with different products and timeframes

---

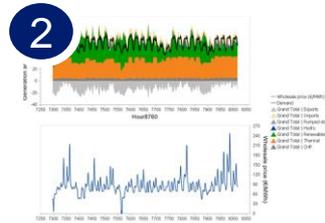
# AGENDA

- Introduction
- Overview of BID3
- BID3 key features

# KEY FEATURES OF BID3



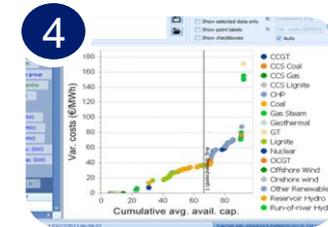
1 Detailed power station database



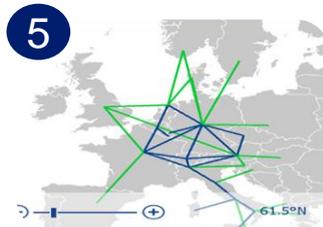
2 Flexible charting and pivoting of any data



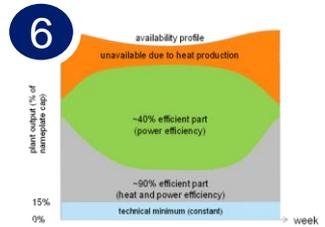
3 Mapping



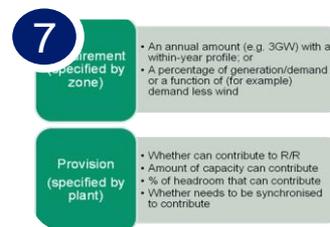
4 Supply curves



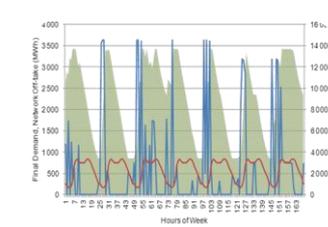
5 Flexible zones and interconnections



6 Detailed CHP modelling



7 Reserve and response



8 Demand-side management



9 Load flow model integration

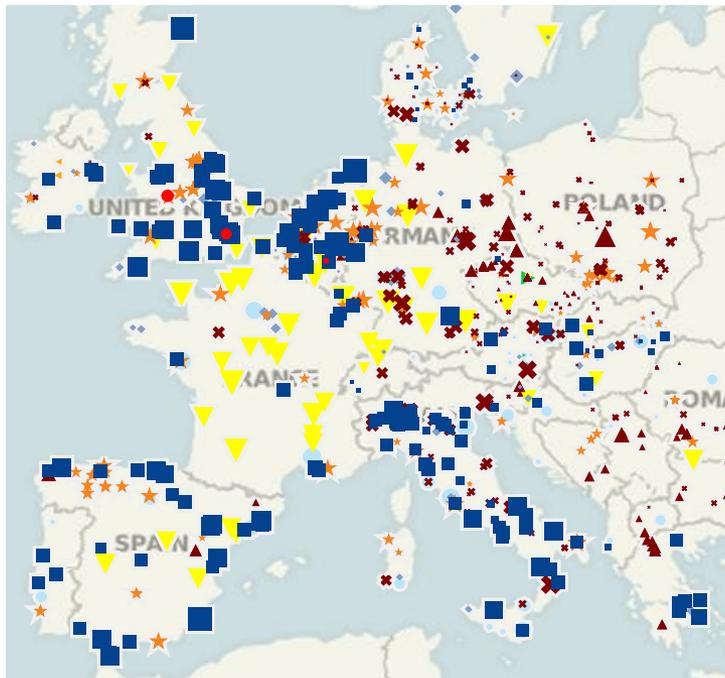


10 BID3 building blocks

# 1 DETAILED POWER STATION DATABASE

Different categories of plant exist (hydro, storage, thermal, renewable and CHP) with detailed parameters for each type. Different phases can be used for shifts in technology (e.g. change in efficiency, change of fuel)

All European power stations



Interface example: nuclear

Basic plant information

Plant Name: BELLEVILLE 2 Info 1: Nuclear  
Zone: FRA Info 2: Nuclear  
Status: In operation Info 3: Nuclear  
Site: BELLEVILLE (47.50978/2.875...)  
Comments: Example data

Spec: Thermal

Properties	Phase 1	Phase 2
Type	Nuclear	Nuclear
Fuel type	Nuclear	Nuclear
Technology	Nuc	Nuc
Availability	FR_PWR	FR_PWR
Efficiency	99.00 %	99.00 %
Min instant LF	0.00 %	0.00 %
Min annual LF	0.00 %	0.00 %
Max annual LF	100.00 %	100.00 %
FuelTrans (€/MWh of fuel)	0	0
FGDX	No	No
Cofires	No	No
Cofire fuel		
Cofire percent	0.00 %	0.00 %
Cofire efficiency	99.00 %	99.00 %
Force cofiring	No	No

Capacity (MW):

Track	Phase	2014	2015	2016	2017	2018	2019	2020	2021	2022
Central	1	1310	1310	1310	1310	1310	1310	1310	1310	1310
High	1	1310	1310	1310	1310	1310	1310	1310	1310	1310
Low	1	1310	1310	1310	1310	1310	1310	1310	1310	1310

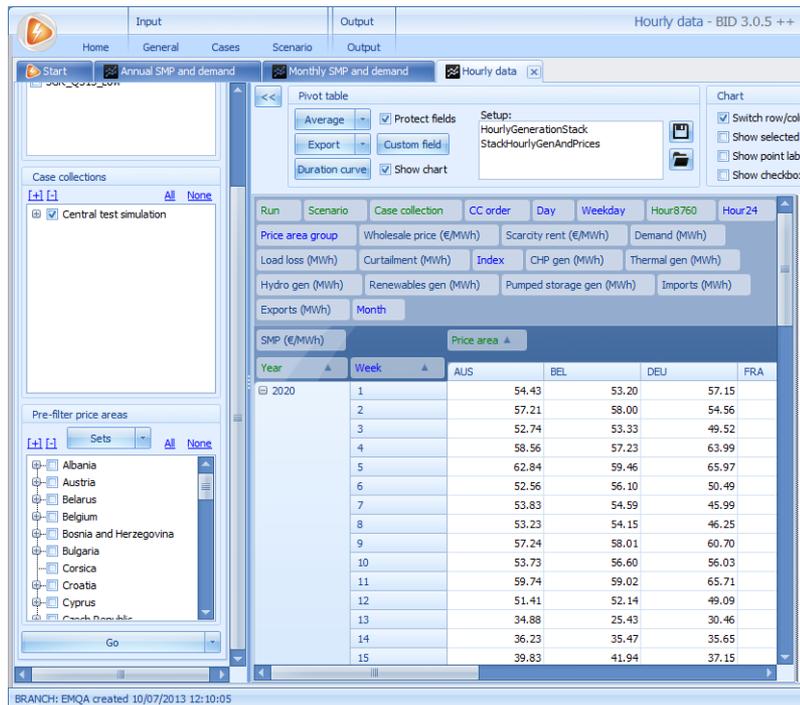
- BID3 datasets hold data on all power stations in Europe, including detailed technical parameters

## 2

# FLEXIBLE CHARTING AND PIVOTING OF ANY DATA

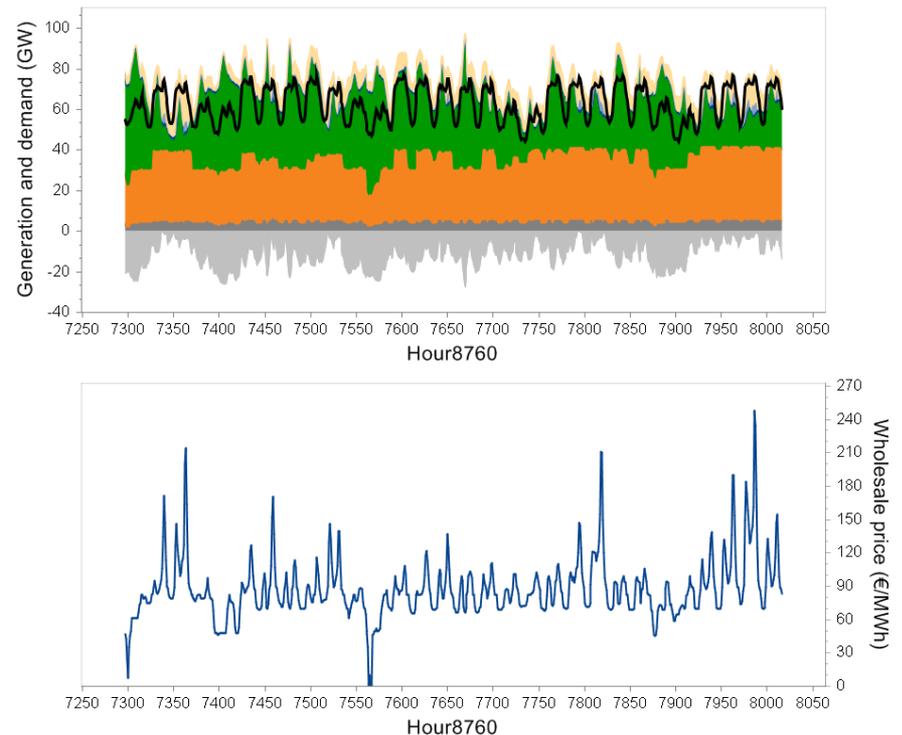
BID3 uses the latest visual environment to allow pivoting and charting of data, quickly and flexibly

Any outputs can be pivoted instantly understand data



- Standard set-ups can be saved and instantly restored
- Pivot grid allows duration curves
- Custom fields can be specified for bespoke calculations

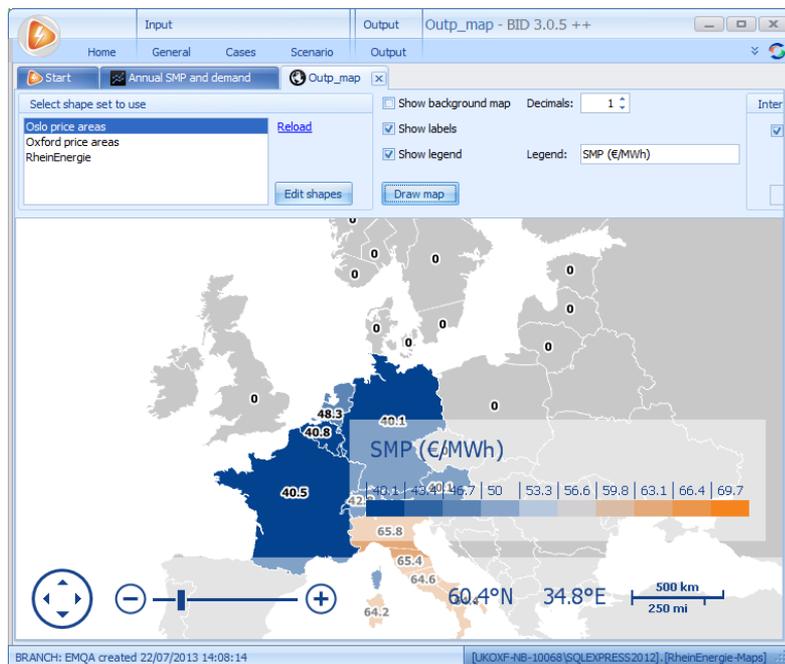
Any data can be visualised quickly and flexibly, and graphs customised to corporate colours/fonts



### 3 MAPPING FUNCTIONALITY

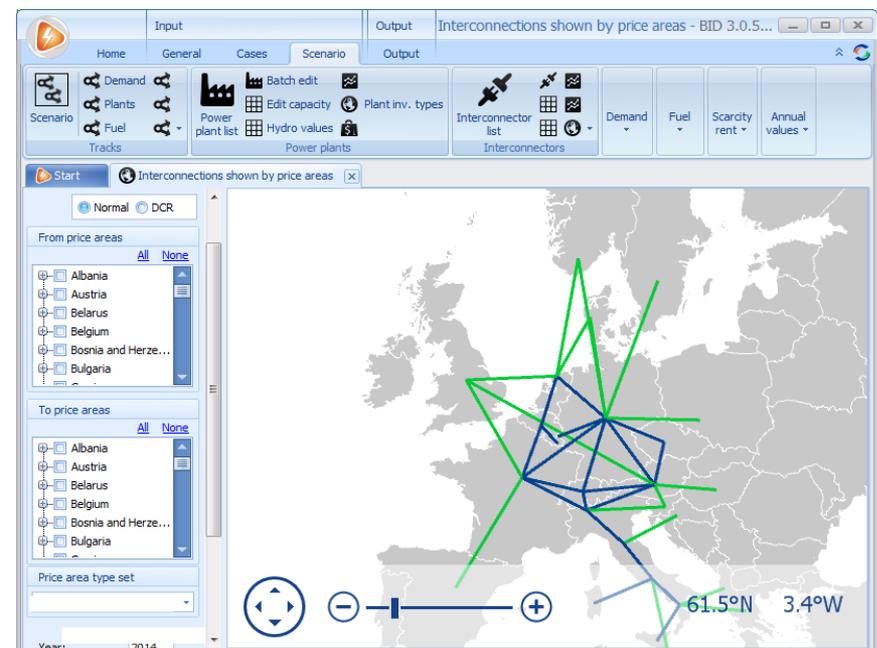
BID3 allows mapping of key data, allowing instant visualisation and presentation-ready slides

Any output data can be plotted on a map



- Example shows System Marginal Prices for one year
- Typical uses include wholesale prices, share of renewable generation, carbon emissions

Key input data can be visualised ensuring that mistakes are spotted

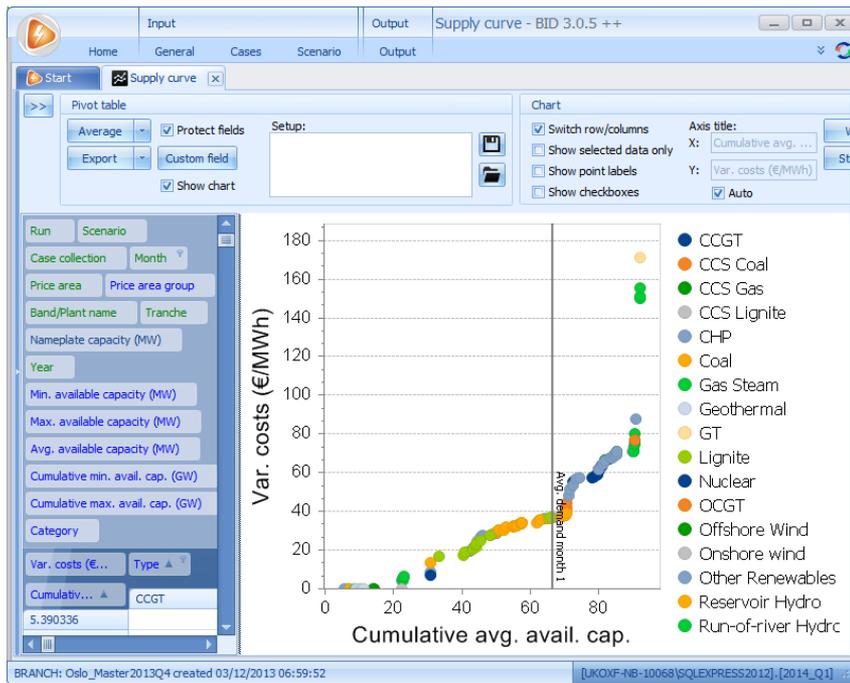


- Example shows map of which areas are optimised (blue), areas that have fixed flows (green)
- This ensures that the model set-up covers the regions required

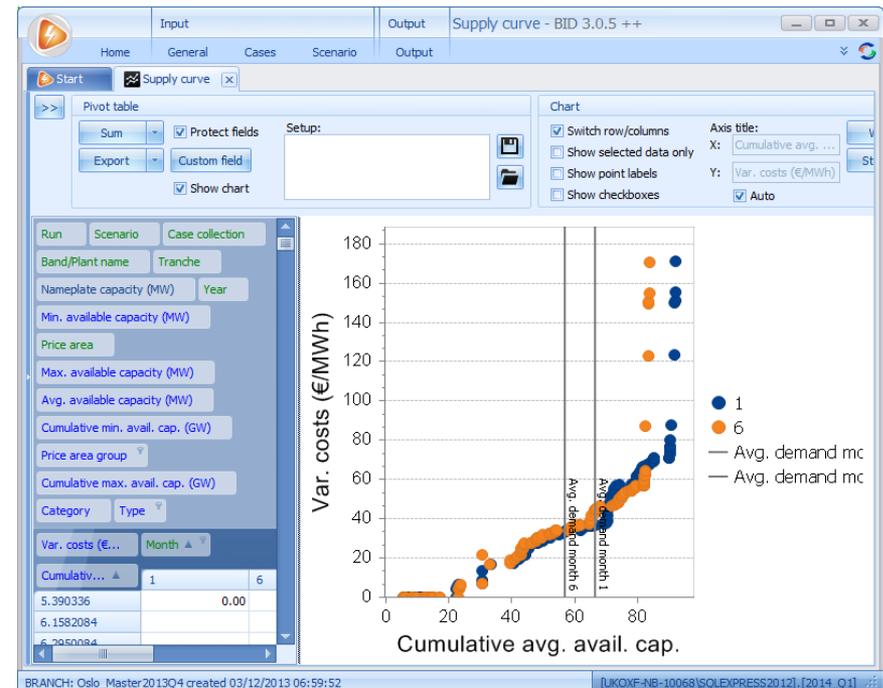
## 6 SUPPLY/DEMAND CURVES

Supply/demand curves can be generated quickly and easily, allowing instant understanding of price formation

Supply curve by type



Supply curve comparing Jan and June

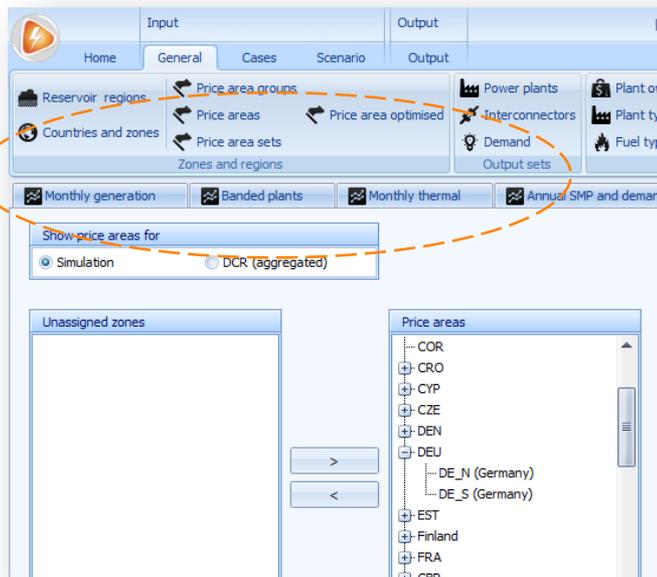


- The interface can generate supply/demand curves at a monthly resolution, for any number of price areas simultaneously
- The supply curve can be plotted down to the individual plant

## 6

# FLEXIBLE ZONES AND INTERCONNECTIONS

The model allows any specification of pricing areas and these to be combined or split. In addition, the user can choose between fixing flows or optimising



— Fixed flows  
— Optimised

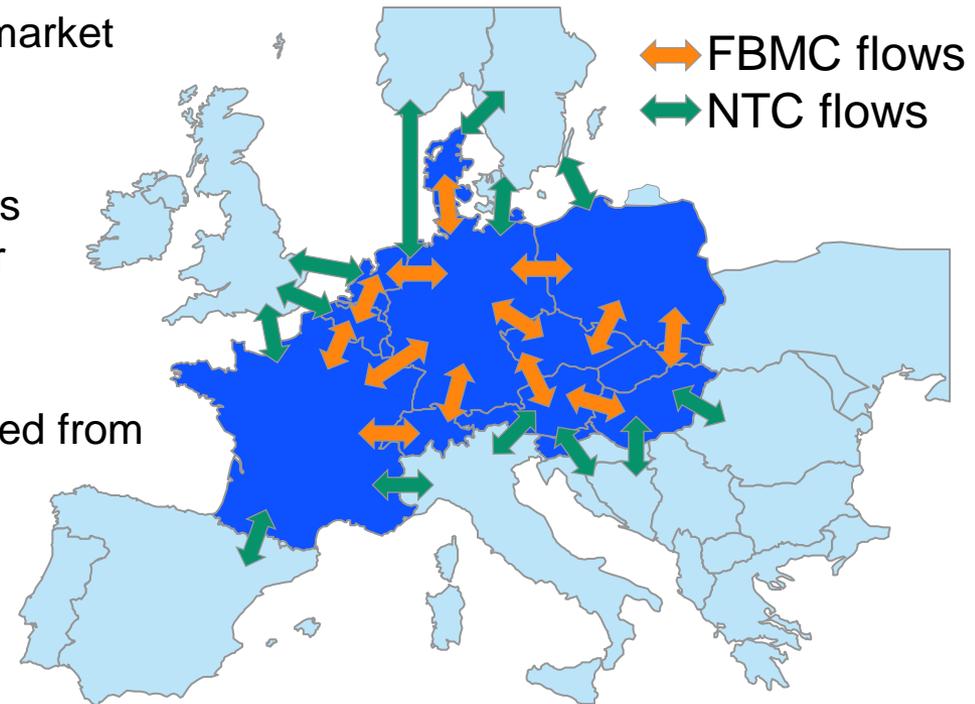
- Zones (e.g. Norway NNO) level of resolution of all of the input data
  - Price areas (e.g. Norway NNO + NFI = Norway NO4)
    - transmission constraints ignored within group of zones
    - only one price created per price area, lower run time
  - Country level irrelevant for the model, practical for filtering data
1. Fixed flows based on a profile. This involves specifying an annual value and a profile. BID3 will then 'lock' a certain amount of interconnector flow
  2. Fixed flows based on a previous run. This allows you to do (say) an overnight run with a large area (e.g. all Europe), but then use that run as the basis for fixed flows for a smaller area

## 6

## FLEXIBLE ZONES AND INTERCONNECTIONS

**BID3 includes the ability to model Flow based Market Coupling (FBMC) for the countries in the FBMC zone (or another defined FBMC set of countries).**

- AC Flows between countries within the FBMC domain are allocated using flow-based market coupling.
- Flows between these and other countries use the NTC approach, and do not enter into the FBMC calculations
- Flows on DC interconnectors are excluded from the FBMC calculations (eg DE-SE), and use the NTC approach



## 6 LINEAR AND MIXED INTEGER MODELLING

For each scenario, there are two runs using BID3, increasing the resolution of the run to hone in on Germany



### Pan Europe

Pan-European model run covering the entire ENTSO-E region. Linear programming version used, with simplified intertemporal dynamics and some grouping of power plants. Main output is border flows (between countries) for the Germany Plus run



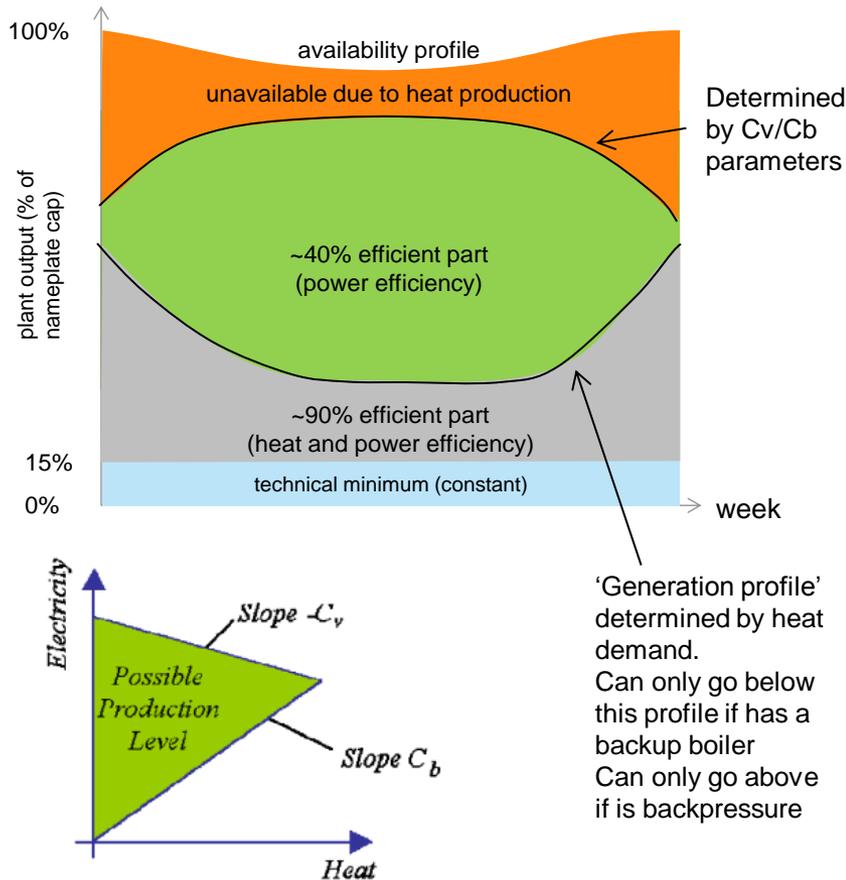
### Germany-Plus

A full resolution, mixed integer programme run of BID3 with full intertemporal dynamics, including temperature dependent starts, reserve co-optimisation, with all plants treated individually

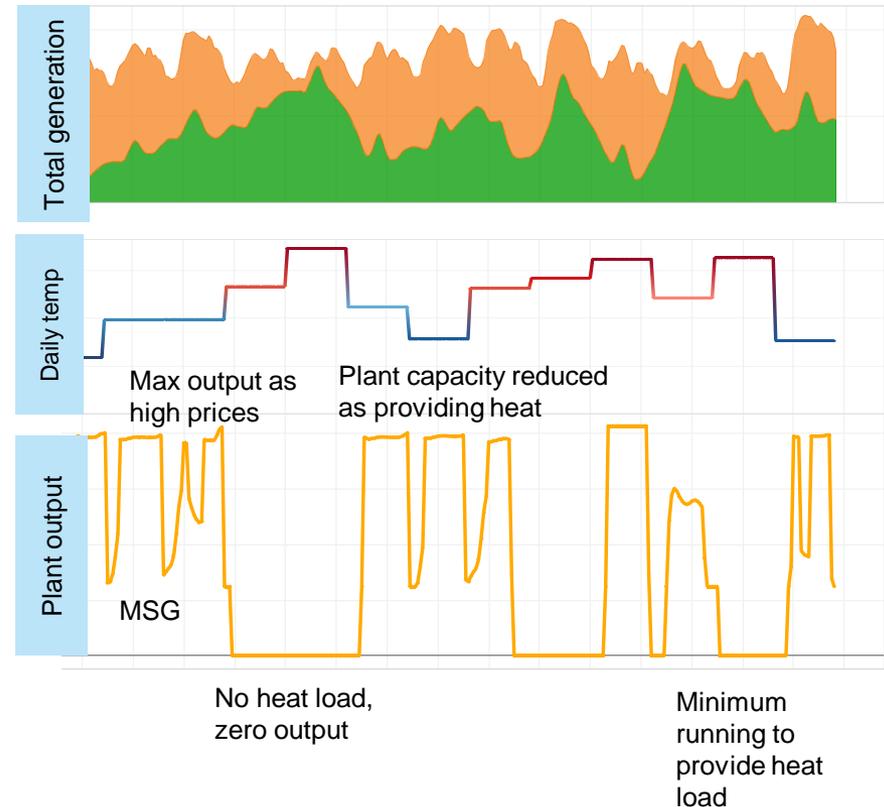
# 7 DETAILED CHP MODELLING

BID3 allows sophisticated specification of CHP, including capturing the heat load, varying efficiencies, backpressure or extraction types and backup boilers

## CHP parameters



## Example for a CCGT with heat load



## 9 RESERVE AND RESPONSE

**BID3 models the holding (not the activation) of any type of reserve/response (primary to tertiary ancillary services)**

### Generic specification of reserve/response

#### Requirement (specified by zone)

- An annual amount (e.g. 3GW) with a within-year profile; or
- A percentage of generation/demand or a function of (for example) demand less wind

#### Provision (specified by plant)

- Whether can contribute to R/R
- Amount of capacity can contribute
- % of headroom that can contribute
- Whether needs to be synchronised to contribute

- BID3 allows the specification of any number of types of reserve/response, although typically three are used – primary, secondary or tertiary
- BID3 requires the specification of both the requirement (the need for reserve/response) and the provision (what is providing the reserve/response).

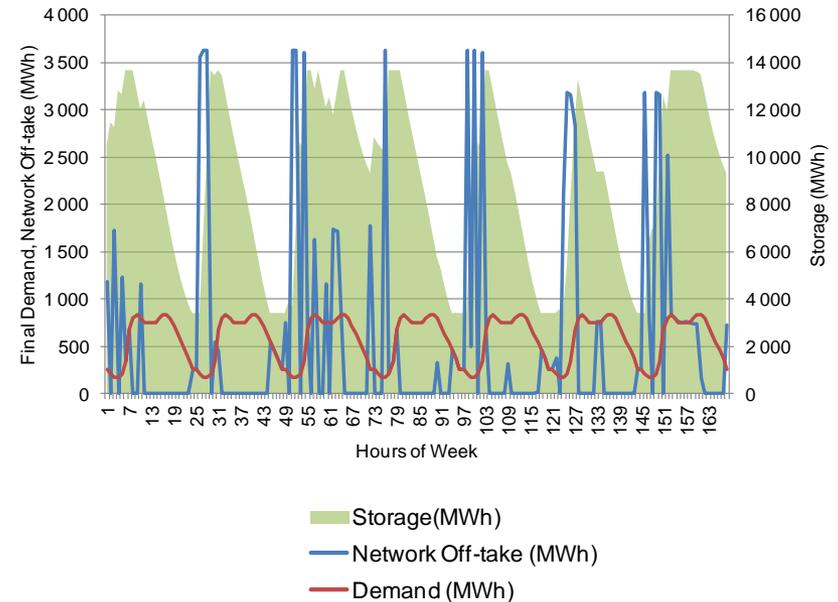
# 10 DEMAND SIDE MANAGEMENT

BID3 allows any type of demand side management (such as Electric Vehicles or flexible heat) to be modelled by specifying a number of generic parameters.

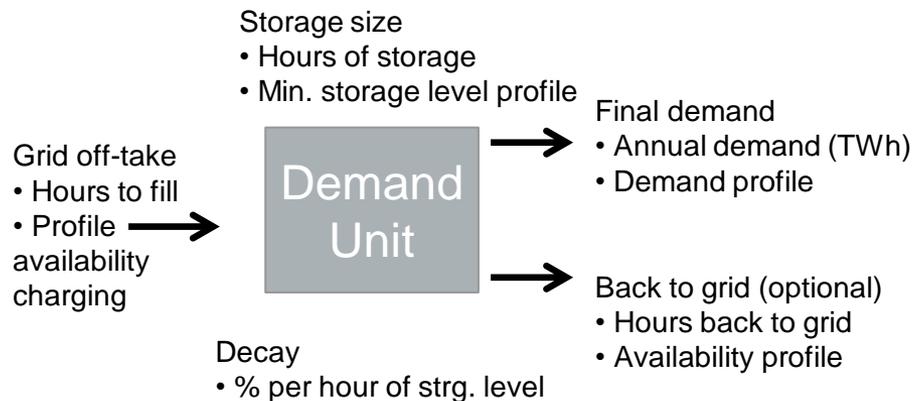
Screenshot of BID3

demGrpID	Demand group	Is flexible	Hours of storage	Hours to fill	Avail. profile def. filling	Decay rate	Minimum storage level profile def.	Back to grid
1	All	<input type="checkbox"/>	3		Not set		Not set	<input checked="" type="checkbox"/>
5	EV_backToGrid	<input checked="" type="checkbox"/>	24	6	Flat	0	Flat - 0.25	<input checked="" type="checkbox"/>
2	EV_LeafHomeCharge	<input checked="" type="checkbox"/>	24	3	EV - charging availability	0	Flat - 0.25	<input type="checkbox"/>
3	EV_LeafQuickCharge	<input checked="" type="checkbox"/>	24	1	EV - charging availability	0	Flat - 0.25	<input type="checkbox"/>
4	HEAT	<input checked="" type="checkbox"/>	24	10	Flat	0.01	Flat - 0.25	<input type="checkbox"/>

Example for Electric Vehicles



Generic specification of DSM



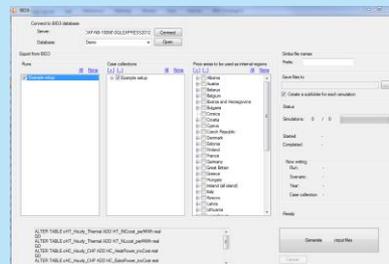
# 11 INTEGRATION OF BID3 WITH LOAD FLOW MODELS

BID3 has been integrated to allow a smooth transfer of data to the load flow model, Integral



- Hourly generation for each plant
- Flows between countries
- Merit order (short-run marginal cost)

BID3/load flow model interface



- Takes BID3 data and writes appropriate csv files in required form for the DC LF model

Integral

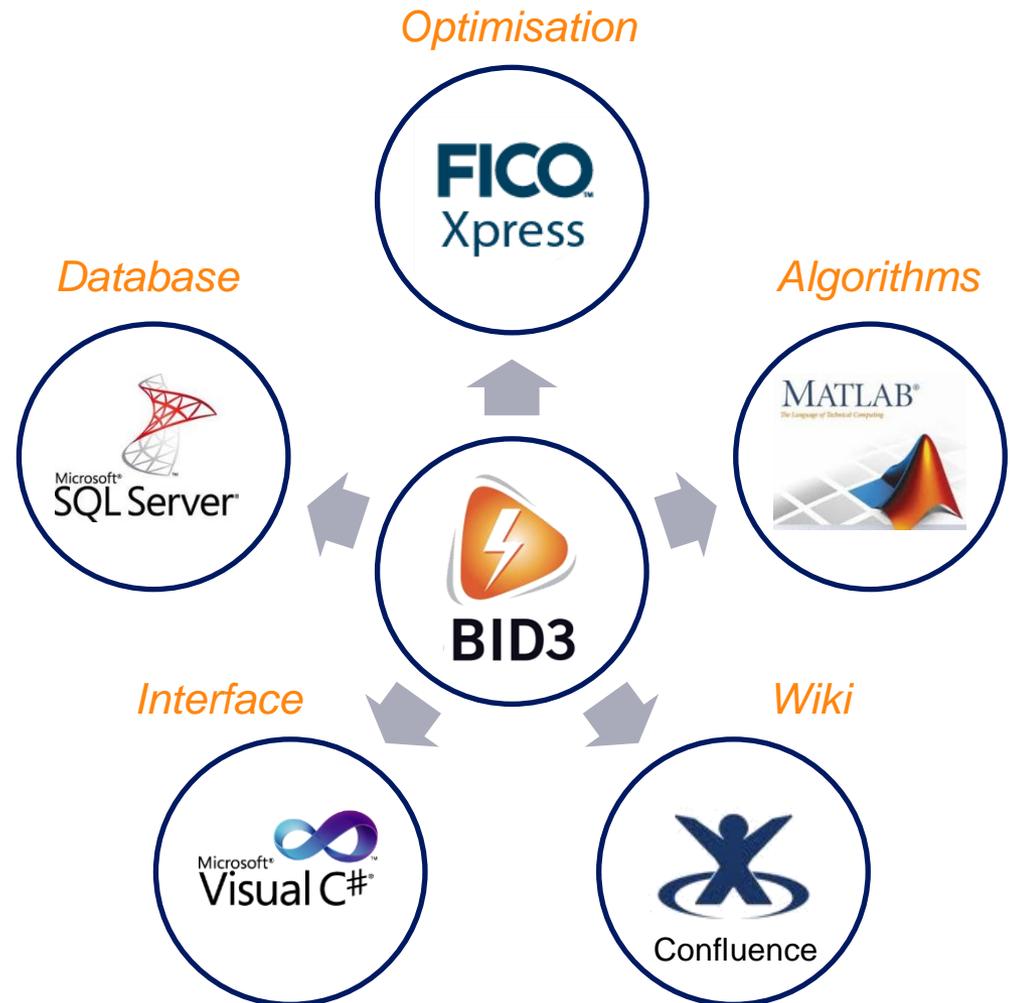
TRANSNET BW



## 12 BID3 BUILDING BLOCKS

### BID3 uses professional software, with a flexible and modular structure

- BID3 uses the most powerful technologies
  - *Xpress* optimisation software, for power market simulation
  - *Matlab* for optimisation of hydro reservoir under uncertainty
  - *SQLserver* for robust storing of data
- BID3 is designed for the maximum ease of use
  - User-friendly interface developed in professional language *C#*
  - Structure is designed for powerful, yet easily set-up analysis
  - Input, output and processing all encompassed into the same interface
  - Dynamic documentation in *wiki* format





*The leading advisor to the world's capital and resource intensive industries.  
Clients choose us for the sharpness of our insight, deep industry  
expertise and proven track record – because results count.*

**Pöyry Management Consulting**