The European Commission's science and knowledge service

Joint Research Centre

European Commission

The POTEnCIA model

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POTEnCIA

Policy
Oriented
Tool for
Energy and
Climate change
Impact
Assessment

Actuality is to potentiality, Aristotle tells us, as "someone waking is to someone sleeping, as someone seeing is to a sighted person with his eyes closed, as that which has been shaped out of some matter is to the matter from which it has been shaped" (1048b1–3).
http://plato.stanford.edu/entries/aristotle-metaphysics/#ActPot

El ser no sólo se toma en el sentido de sustancia, de cualidad, de cuantidad, sino que hay también el ser en ***potencia*** *y el ser en acto, el ser relativamente a la acción.(Aristóteles, Metafísica, libro IX, 1).*
http://www.webdianoia.com/aristoteles/aristoteles_meta_4.htm

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OUTLINE

Brief description and current status

Motivation and main features of the tool

- Demand side
- Power sector
- Behavioural aspects

Policy assessment

Next steps

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The Tool

POTEnCIA is a mathematical model designed to represent the economically driven functioning of the European energy markets

- Assessing the impacts of strategic EU energy-related policy options while dealing with the **radical changes and new challenges** experienced
- Coping with the **increasingly complex structure** of the energy market and related policies

The methodological approach

- **Hybrid partial equilibrium**
  - behavioural decisions
  - detailed techno-economic features
- **Discrete choice modelling** applies for energy actors decisions

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THE CURRENT STATUS

Geographical coverage

- EU Member States

Time horizon

- 2050 (and beyond) in annual steps

Validation

- Technical peer review exercise (documents available in the POTEnCIA website)
- Stylised policy scenarios developed and analysed within the Commission Services
  - Testing the model properties
  - Analysing the quality and robustness of results

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The Questions

How does the policy framework affect

… the way in which energy is used

… the investment decisions in new energy equipment

… technology progress

… the role of non-energy using equipment options

… and thus the amount of energy used, related CO_2 emissions and costs

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The Challenges

Identifying the domain for **policy action**

Capturing **technology dynamics**

Addressing **radical changes**

Dealing with **increasing complexities**

Reflecting **uncertainties**

… while fully accounting for
behavioural responses

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WE CONSUME ENERGY TO MEET OUR NEEDS

SERVICE

An industrial product

Mobility

Indoor temperature

WE CONSUME ENERGY TO MEET OUR NEEDS

DRIVERS

Economy

Behaviour

Achieved comfort level

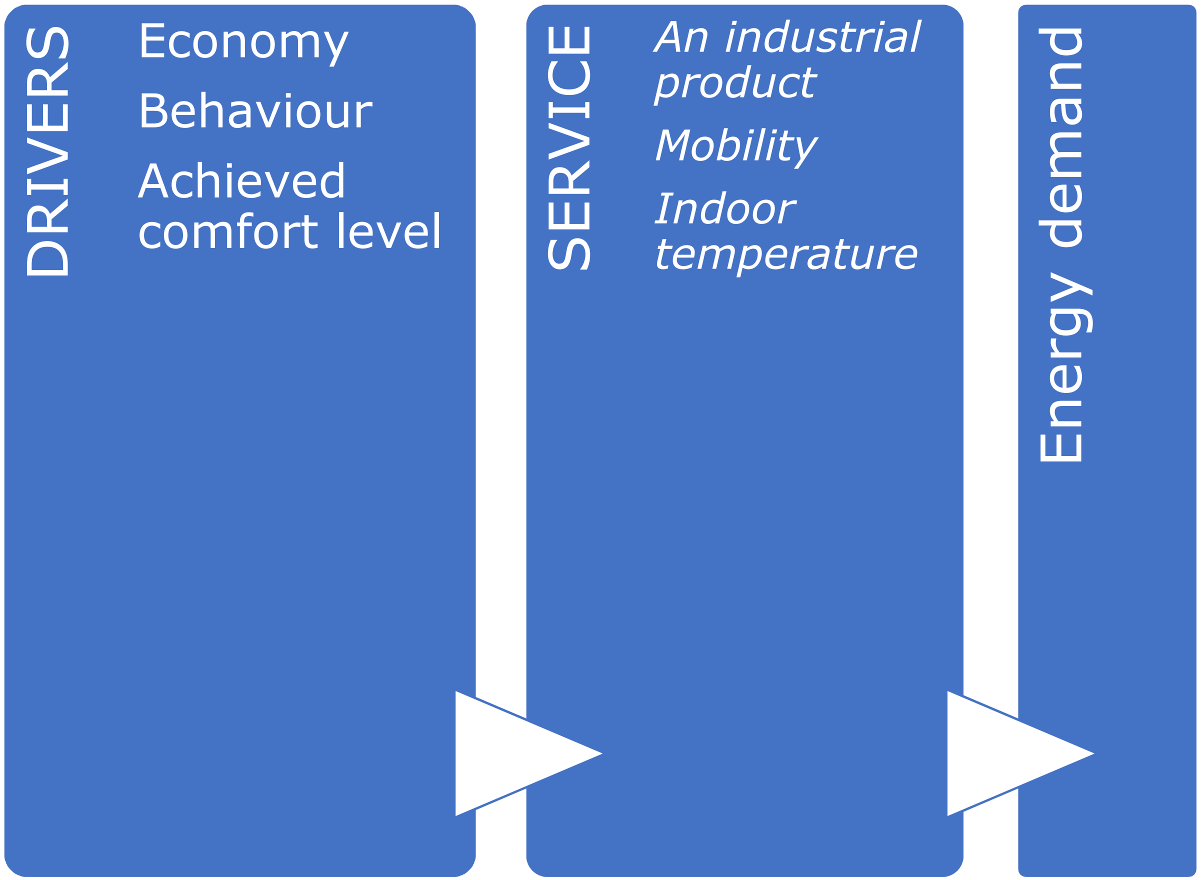
SERVICE

An industrial product

Mobility

Indoor temperature

We consume energy to meet our needs



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We consume energy to meet our needs

DRIVERS

Economy

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Achieved comfort level

SERVICE

An industrial product

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Indoor temperature

Policy Context

Energy demand

Equipment

- type
- characteristics
- size

Use

- equipment
- preferences

How the Policy Context affects Energy Demand

Energy equipment limits flexibility

- Technology types
- Vintage specific characteristics

Number of individual units explicitly identified

Operation of equipment may deviate from optimality

- Size forms a constraint
- Response to policy dependent on equipment and purpose of service
  - ➢ *multiple decisions*

Enhanced **economic** response mechanisms

- Investment in non-energy equipment
- Premature replacement of equipment
- Structural responses

Explicit accounting for incurred stranded costs; idle stock; scrapped equipment

We **invest** to meet our service needs

- Explicit number of units identified
- Combined to non-energy using options

reflected on size of energy equipment

Technology dynamics

- depend on the existing equipment stock (structure and age)
- relate to the need for new equipment
- link to prevailing policy conditions

through

- level of deployment
- pace of progress
- technical/physical limits

Technology characteristics are country specific

Related costs link to projected dynamics

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Model Detail in the demand side

Industry	11 sectors 21 subsectors +agriculture	6 to 11 processes per subsector	~14 end-uses ~44 technology options per subsector
Residential	9 household types 9 appliances types	43 combined space and water heating types	135 technology options
Services	4 thermal uses 6 appliances types		47 technology options
Transport	4 modes +pipelines;+*bunkers*	16 transport means	2 to 5 engine types 6 to 27 technology options per mean

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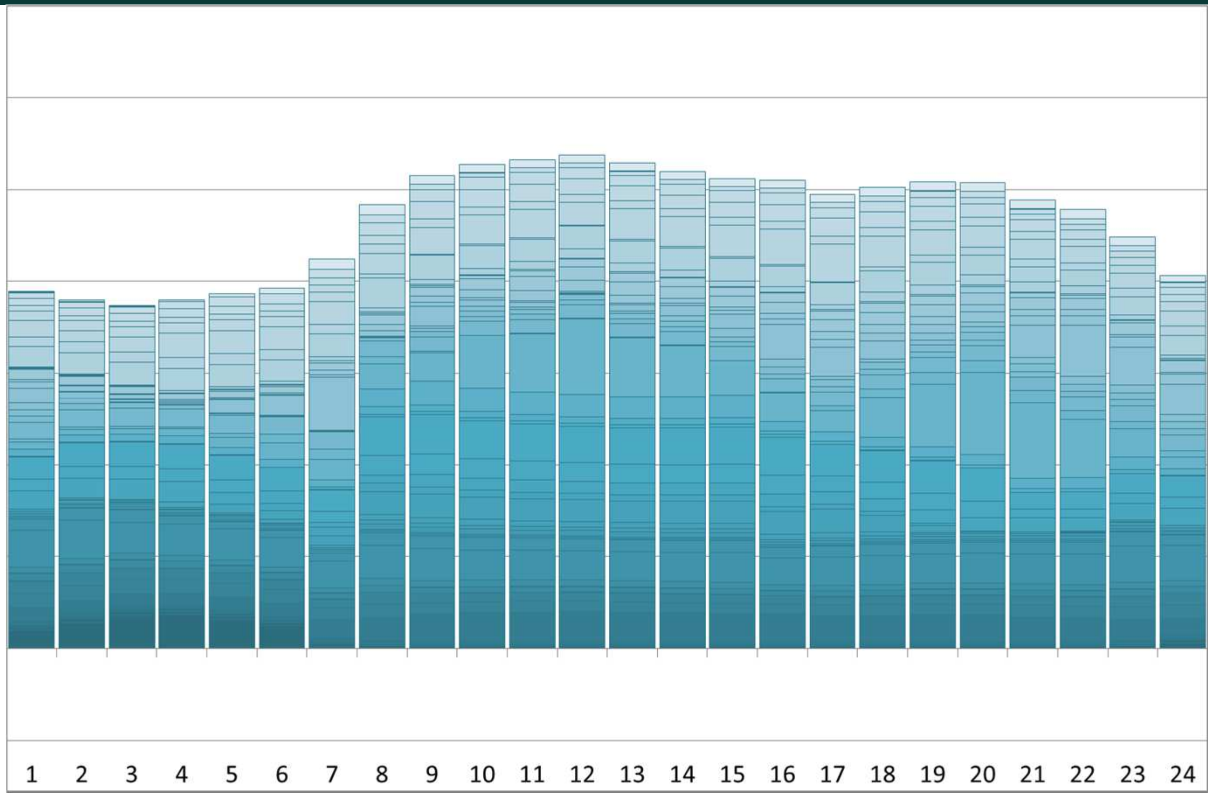
ADDRESSING POWER SECTOR'S COMPLEXITY

Chronological load curve derived from almost 300 energy uses

- with specific load profiles
- dynamic evolution of shape
- fully capturing policy effects



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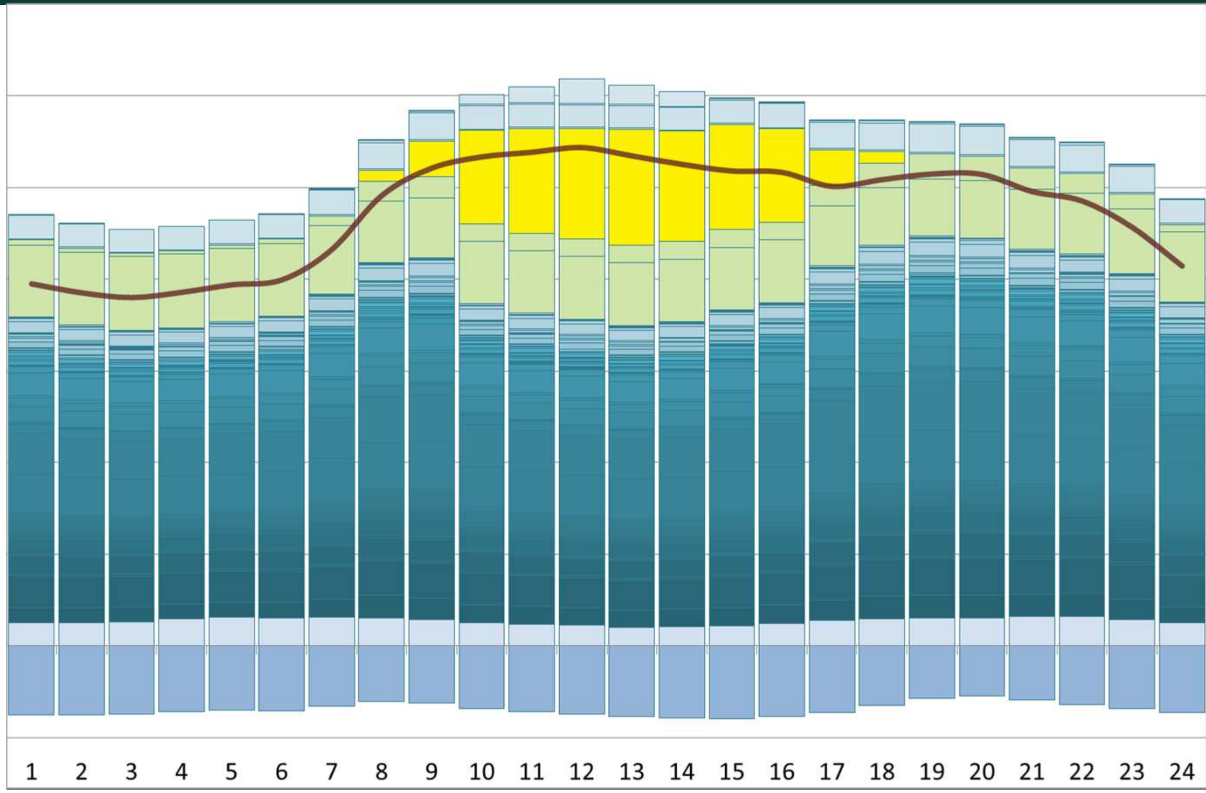
ADDRESSING POWER SECTOR'S COMPLEXITY

Chronological load curve derived from almost 300 energy uses

Trade of electricity takes place as to optimise the power system

- Simultaneous imports and exports of electricity across countries
- Interconnection constraints fully respected



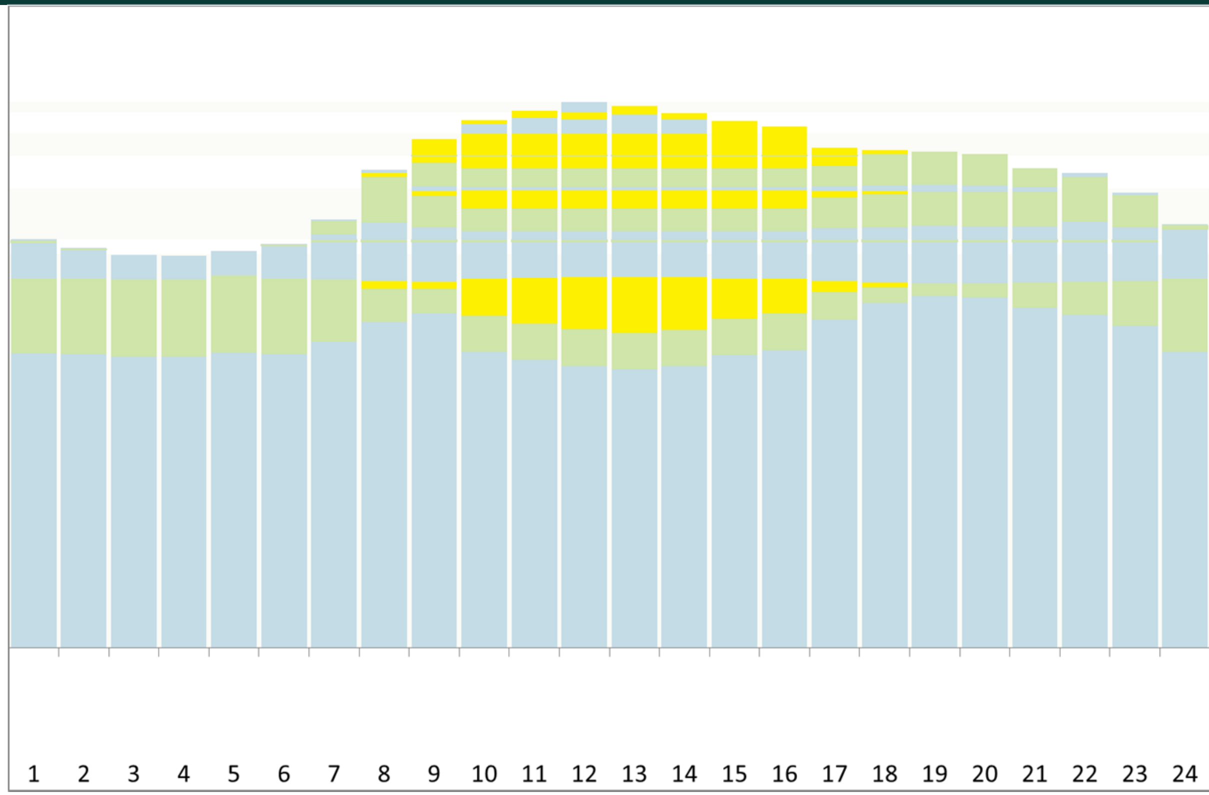
ADDRESSING POWER SECTOR'S COMPLEXITY

Chronological load curve derived from almost 300 energy uses

Trade of electricity takes place as to optimise power generation

Power plants operation addressed at the level of units

- Dispatching in multiples of unit sizes
- Capturing operation related effects
- Integrating high shares of variable renewable energies
- Accounting for opportunity costs induced across competing technologies
- Respecting resources availability constraints
- Addressing system stability



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Addressing power sector's complexity

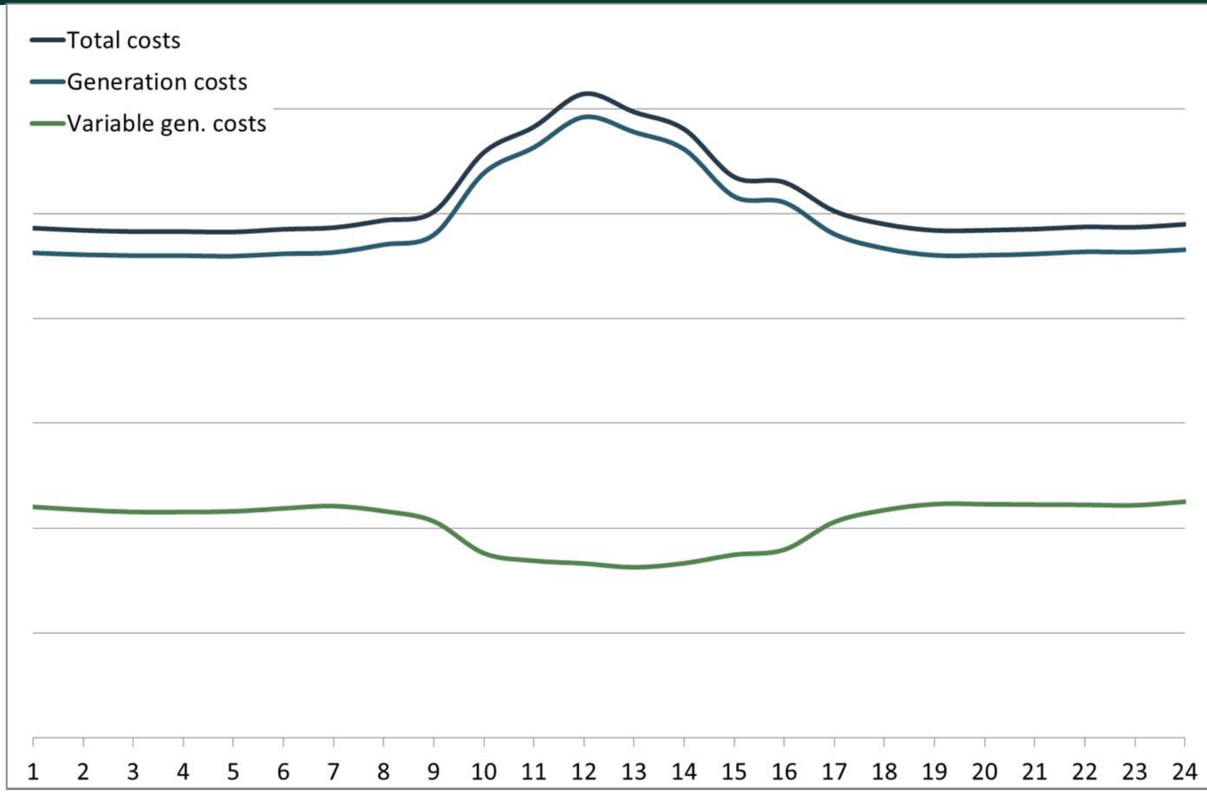
Chronological load curve derived from almost 300 energy uses

Trade of electricity takes place as to optimise power generation

Power plants operation addressed at the level of units

Capturing **generation cost fluctuations**

- Average and marginal cost on hourly basis
- Correctly identifying the cost of different uses
- Identifying the scope for Demand Side Management



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Addressing power sector's complexity

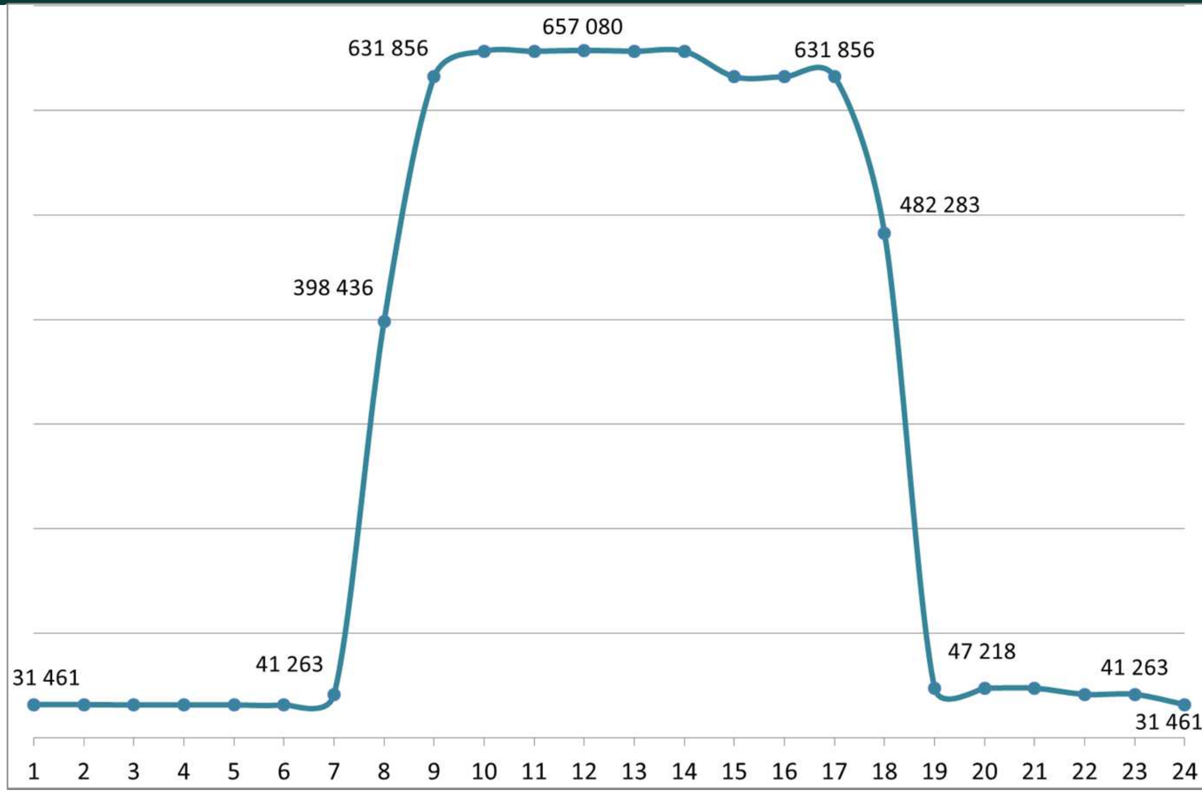
Chronological load curve derived from almost 300 energy uses

Trade of electricity takes place as to optimise power generation

Power plants operation addressed at the level of units

Capturing **generation cost fluctuations**

… while quantifying **the number of units in operation**



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Addressing power sector's complexity

Chronological load curve derived from more than 300 energy uses

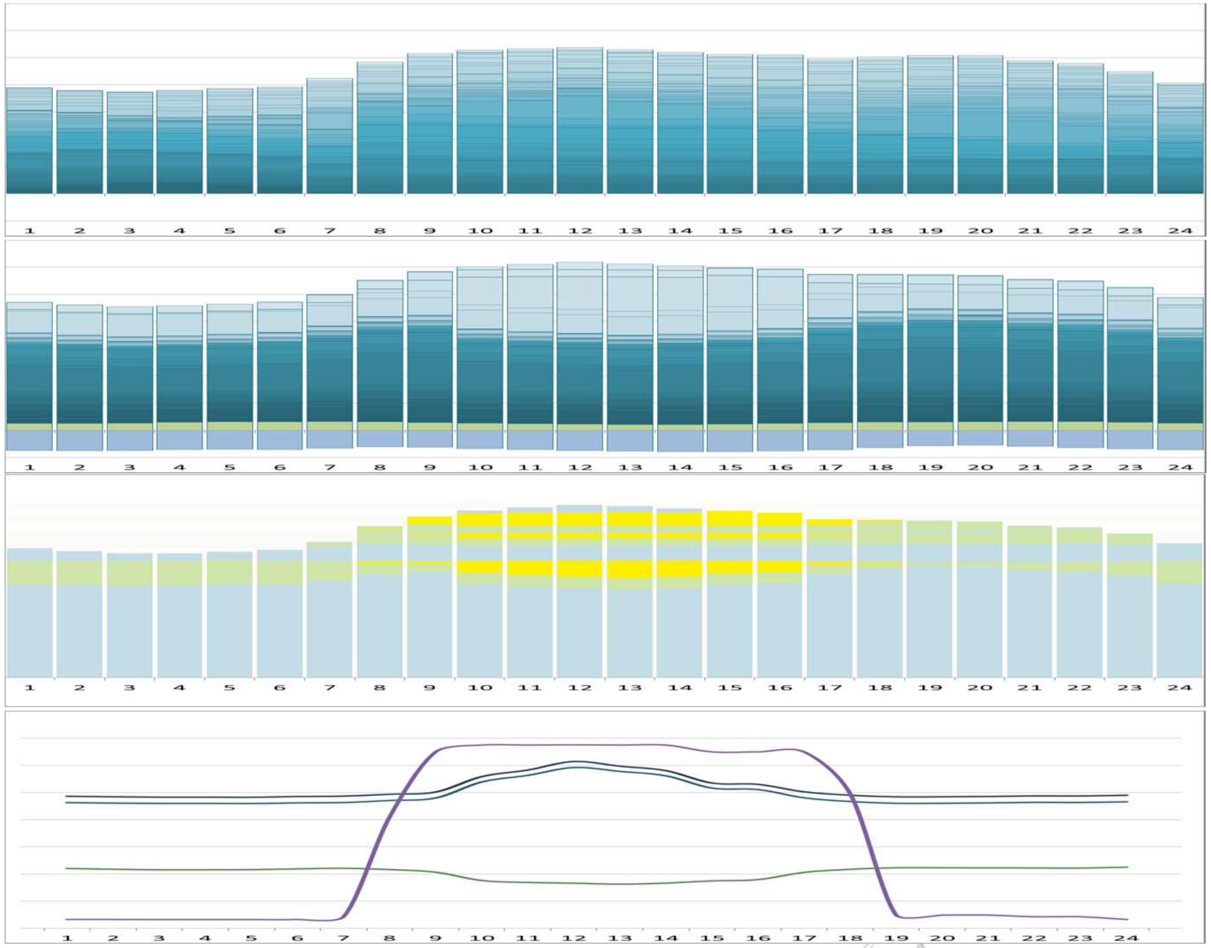
Trade of electricity takes place as to optimise power generation

Power plants operation addressed at the level of units

Capturing **generation cost fluctuations**

… and identifying the **number of units in operation**

… as to better mimic real life power plants operation



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INVESTMENT DECISIONS IN THE POWER SECTOR

Respecting system and power plants factual characteristics

- Investments take place in typical sizes of units
- System stability accounted for

Different types of investors considered

- From small power generators that act primarily towards satisfying their own needs …
- to large utilities that seek to optimise the operating characteristics of the overall system

Coping with uncertainties

- No perfect foresight
- Recursive myopic foresight
- Divergent future expectations
- Failures in meeting capacity needs may occur

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Accounting for behavioural responses

We do not behave in the same way

Our decisions are characterised by suboptimality

- the economic environment
  - access to capital and/or
  - budgetary constraints
- rationality

Our **rationality** is defined by our

- Perception (understanding)
- Preferences

Policies can increase our rationality

- fostering economic awareness
- removing asymmetric information
- improving risk perception

but also through

- exploiting learning-by-adopting effects
- influencing individual preferences
- triggering collective "societal" appreciation / collective behaviour effects

Modelled through a dynamic non-linear formulation that allows endogenously shifting

- from a portfolio of (suboptimal) decisions
- towards the economically optimal one

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What For?

Analysing the main energy system related policy pillars:

Energy efficiency	Renewable energies	Climate change	Market integration

through

Price signals	*Subsidies; premium tariffs*	Technology standards	*Eco-design, CO_2 standards for vehicles*
Quantity constraints	*Renewables quota; ETS cap; minimum fuel blending*	Non-energy measures	*Building codes*
Behavioural policies	*Labelling; Awareness campaigns*	Market conditions	*Liberalisation; decentralisation*

Constrained by

Sectoral detail	Time step	Policy impacts on the economy	Spatial dimension
engineering analysis performed at the level of technology groups	*fractions of an annual step addressed through snapshots*	*link to appropriate modelling tools*	*network related volumes and costs still captured*

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ANALYSING POLICIES WITH POTENCIA

POTEnCIA is designed to perform **comparative** analysis of scenarios

"Projections are not forecasts"

A "**central**" scenario needs to be defined

- *Reflecting a plausible evolution of the energy system, while*
- *incorporating policies and measures in place*

The internal coherence of the model enhances robust scenario analysis

minimising the need for exogenous interventions

Assessment of the impact of specific (policy) assumptions with respect to the "central" scenario

- POTEnCIA can address both explicitly defined policies and those that are met through policy signals
- Different ways of representing policies and targets
  - *Year specific and/or cumulative*
  - *Quantity based and/or cost based*
- Multiple targets can be addressed simultaneously

  Involving "equivalent" effort or prioritising scopes
- The geographical/sectoral scope is also flexible

  From sector and country specific to simultaneous EU wide solutions

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DEVELOPING THE "CENTRAL" SCENARIO

… requires continuous interactions

between JRC, policy DGs and Member States experts

- decomposition of historical data (JRC-IDEES database)
- incorporation of country specific policies in place
- inclusion of on-going investments plans
- reflection of envisaged evolution of national energy systems in a European wide context
- agreeing in key future assumptions (macro-economy, demographics, policy context)

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Next Steps

Interactive process initiated

- validation of the JRC-IDEES database
- technical workshops on POTEnCIA model
- establishment of contact links between Member States, the policy DGs and the POTEnCIA team

First priority: the development of the "central" scenario

which will be initially used as to

- to assess the combined impact of Member States' National Energy and Climate Plans (NECPs)
- policy assumptions captured in the NECPs to be discussed with Member States and policy DGs

Ensuring transparency and accessibility

An online platform to be established that will eventually allow access to

- Documentation on POTEnCIA
- POTEnCIA input database
- Detailed results of selected (and agreed upon with the policy DGs) scenarios

  enhanced by visualisation tools
- The tool will be made accessible

  including the model code

POTEnCIA scenario output

Model assumptions

- *Macroeconomic drivers*
- *Demographics*
- *International fuel prices*
- *Policy assumptions*

Activity levels and use of stock

- *Industrial production levels, transport activity by mode, etc.*
- *Rates of use*
- *Investment in new equipment*
- *Idle equipment*
- *Prematurely replaced equipment*

Techno-economic characteristics of installed equipment

Distinguishing per vintage

- *Typical sizes*
- *Efficiencies*
- *Costs (capital, fixed, variable)*

Energy use and CO_2 emissions

- *from aggregates at sectoral level to end-use specific*
- *fuel disaggregation in line with EUROSTAT nomenclature*

Cost elements

Energy system costs

- *Energy equipment related*
- *Policy related*
- *Stranded costs*
- *Infrastructure related*

Fuel prices

- *Sector specific*
- *Production, transmission and distribution costs accounted for*
- *Price elements considered*
- *pre-tax prices, excise taxes and VAT, end-user prices*

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Thank you for your attention

JRC Science Hub –POTEnCIA:
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