The European Commission's science and knowledge service

Joint Research Centre

European Commission

The POTEnCIA modelling tool

Overview and process
Key features and structure

MEMBER STATES EXPERTS' WORKSHOP ON THE POTENCIA MODEL

Brussels, 26 February 2018

European Commission

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

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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
- Accounting for **behavioural responses** to policy context

The methodological approach

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

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 scenarios developed and analysed within the Commission Services
  - Testing the model properties
  - Analysing the quality and robustness of results

High-level launch event of POTEnCIA (Oct 11 2017)

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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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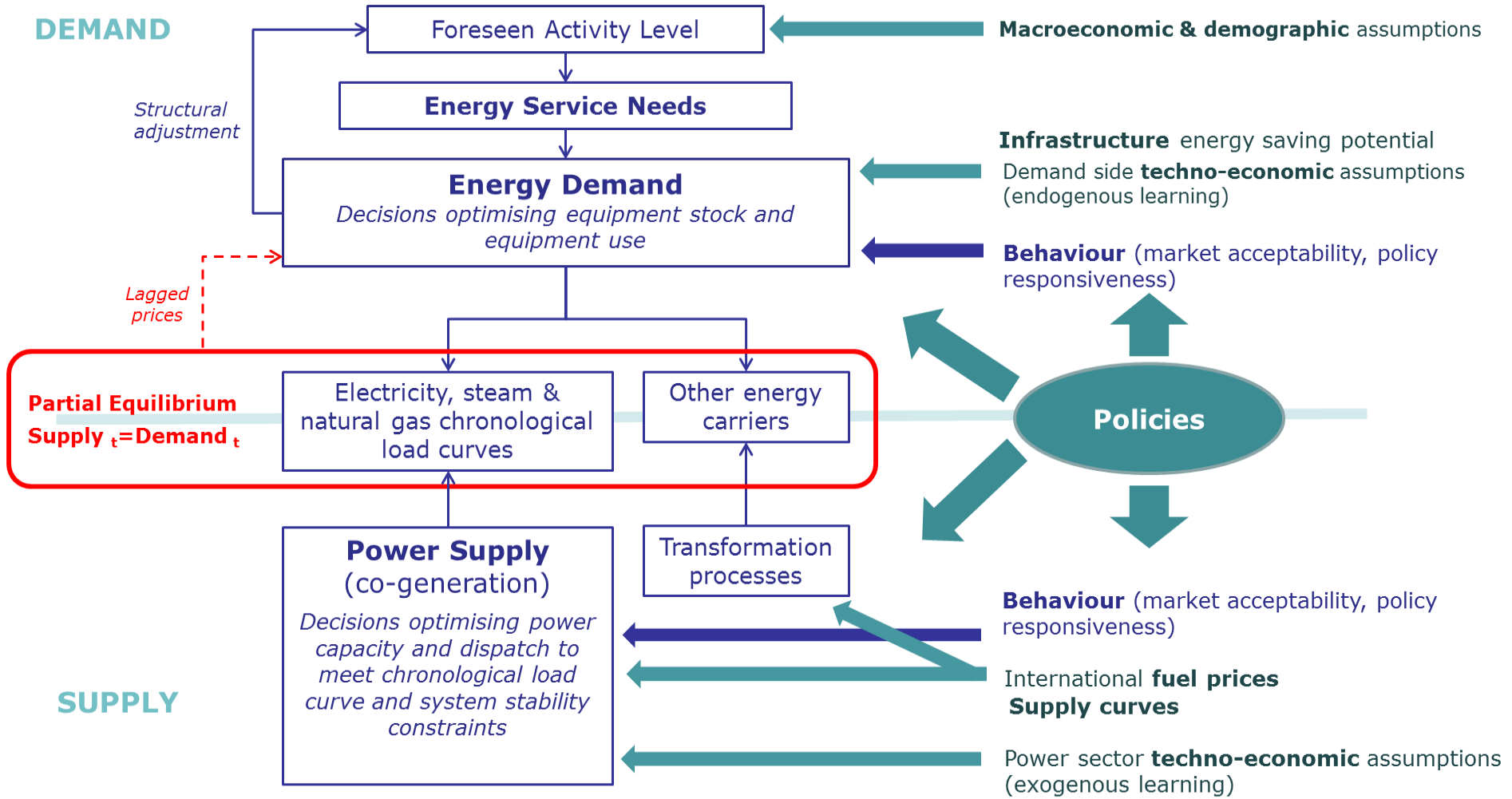
The Model Structure



Input

- ***JRC-IDEES***
- Demographics (EUROSTAT)
- Macroeconomic assumptions (GEM-E3, DG ECFIN)
- International fuel prices (POLES)
- Power generation technology characteristics

Output

- Energy balances and related CO_2 emissions (ETS explicitly addressed)
- Energy system costs and prices
- Activity indicators and related process CO_2 emissions
- Installed equipment capacities, characteristics and rate of use
- Dynamic technology improvements

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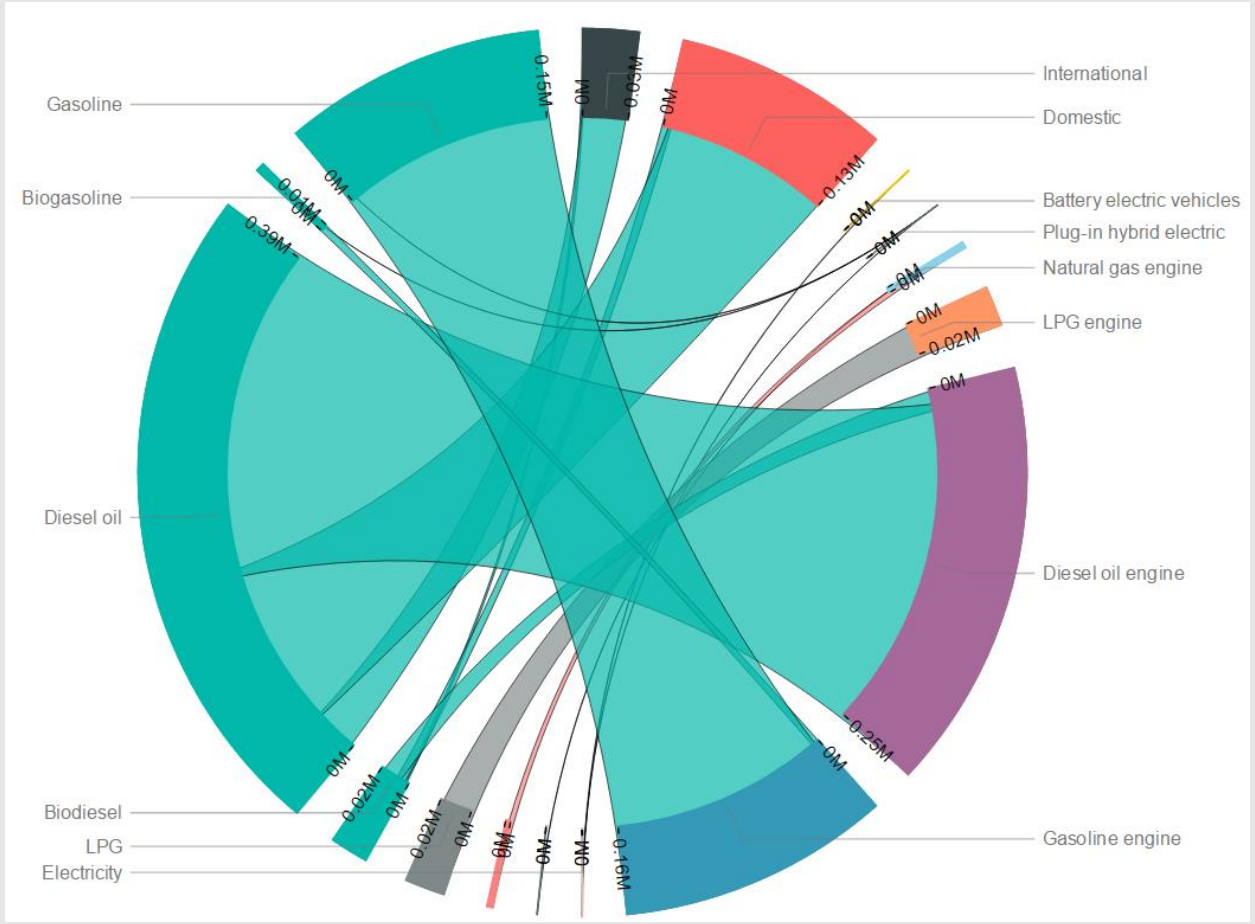
JRC-IDEES

Integrated
Database of the
European
Energy
System



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Motivation

All modelling tools need to put together the statistical data that they use

Decomposition of data applies as to match the level of detail represented in the model structure

JRC-IDEES forms **an integral part** of the POTEnCIA model

- *reflecting the current structure and properties of the energy system*
- *identifying existing equipment vintages and characteristics*
- *capturing behavioural aspects with regards to the use of equipment*

JRC-IDEES DATABASE

An **open source** complete database of the energy system and all associated factors

- EUROSTAT compliant
- Time horizon: 2000-latest statistical year on an annual basis (currently: 2015)
- Geographical coverage: EU Member States

FIRST-OF-ITS-KIND

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*

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

POLICY ANALYSIS WITH A MODELLING TOOL

… requires continuous interactions

between European Commission and Member States' experts

- Understanding and correctly reflecting the past

  JRC-IDEES database

  → Exchanges with national experts on-going

- Agreeing in **key future assumptions**

  → macro-economy and demographics

  → international fuel prices

  → technology characteristics

  → envisaged activity levels

- Understanding the model features and scope

  → illustrative **"Entry-point"** stylised scenario

- Addressing **country specificities**

  → 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

ENSURING TRANSPARENCY AND ACCESSIBILITY

An online platform has been 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 MODEL 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.*
  - introduced as assumptions (envisaged levels)
  - revised endogenously as a function of the policy context (costs, technology dynamics etc.)
- *Rates of use*
- *Investment in new equipment*
- *Idle equipment*
- *Prematurely replaced equipment*

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*

Techno-economic characteristics of installed equipment

Distinguishing per vintage

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

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A macro overview of the agricultural sector: Key Performance Indicators and map-based visualisation for comparison with the european average

Country

DE Others

Time slider

01/01/2000 01/01/2015

Variable

Energy intensity of value added

Category	Subcategory	As of Date	Variable	Current Value	Growth over period	Comparison Value	Trend
Quantities	Macro	2015	Value added (M€2010)	191,464.51	-17.17 %	231,161.59	
	Energy or emissions	2015	Final energy consumption (ktoe)	26,493.49	-15.03 %	31,179.17	
		2015	Useful energy service (ktoe)	10,606.89	-7.80 %	11,504.37	
		2015	CO2 emissions (ktCO2)	57,268.15	-22.60 %	73,993.59	
Intensities	Energy or emissions to macro	2015	Energy intensity of value added (toe / M€2010)	138.37	+2.59 %	134.88	
		2015	Carbon intensity of value added (tCO2 / M€2010)	299.11	-6.56 %	320.09	
	Energy or emissions to energy or emissions	2015	Carbon intensity of final energy (tCO2 / toe)	2.16	-8.92 %	2.37	
		2015	System efficiency (toe useful energy / toe final energy)	0.40	+8.51 %	0.37	

Max Year (default variable: value added per emplo...

Min Year (default variable: value added per employ...

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Analysis at the household level: energy consumption ans emissions

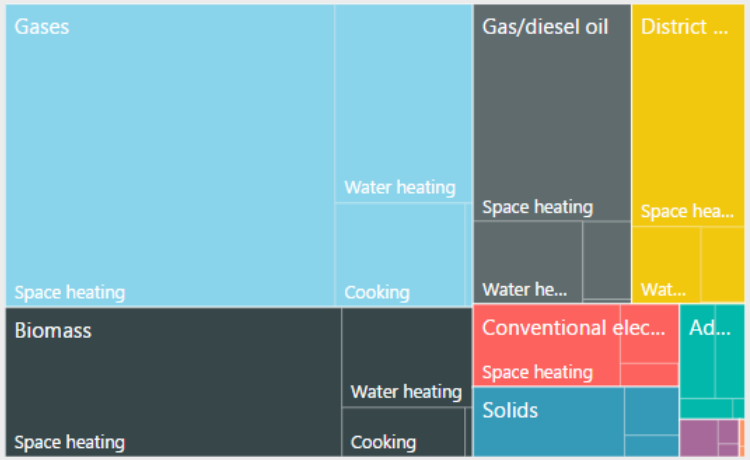
Country: DE | Others

Select a single year: 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | **2015**

Measure: Difference: None | Ref 2000 | Year-to-Year

Measure: Compare: No | Over 2000 | Over EU

Final energy consumption (ktoe) by Household type and End-use



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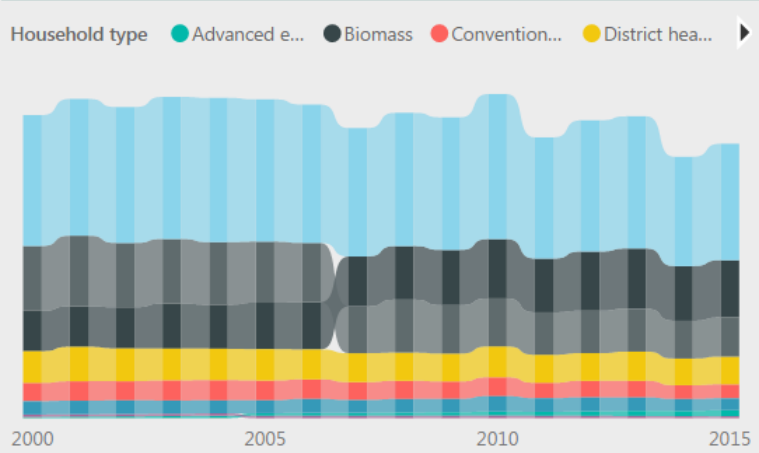
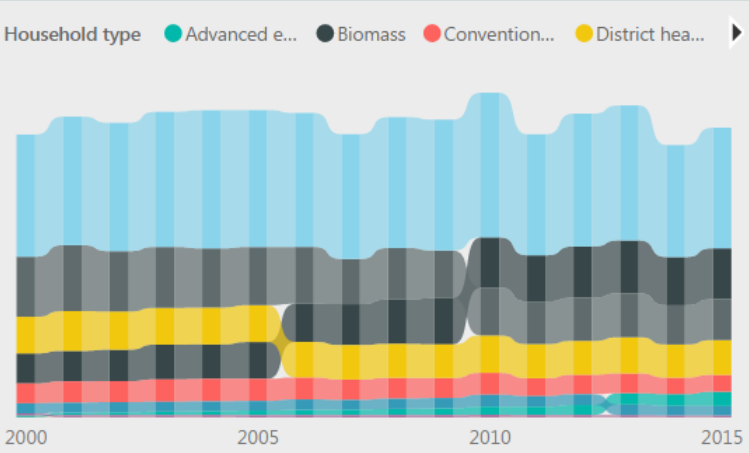
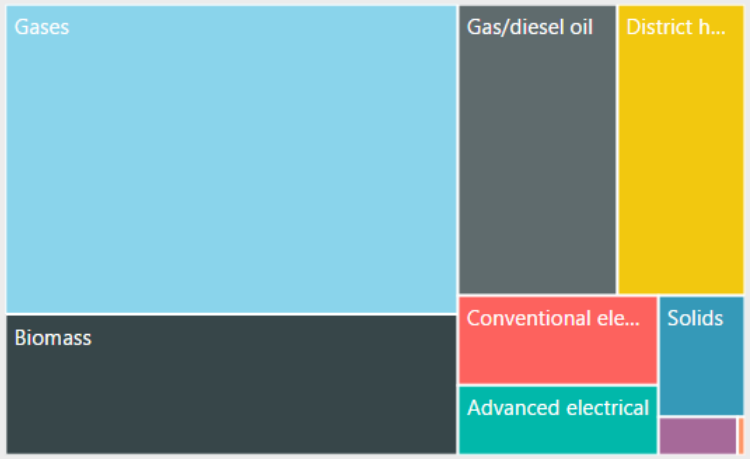


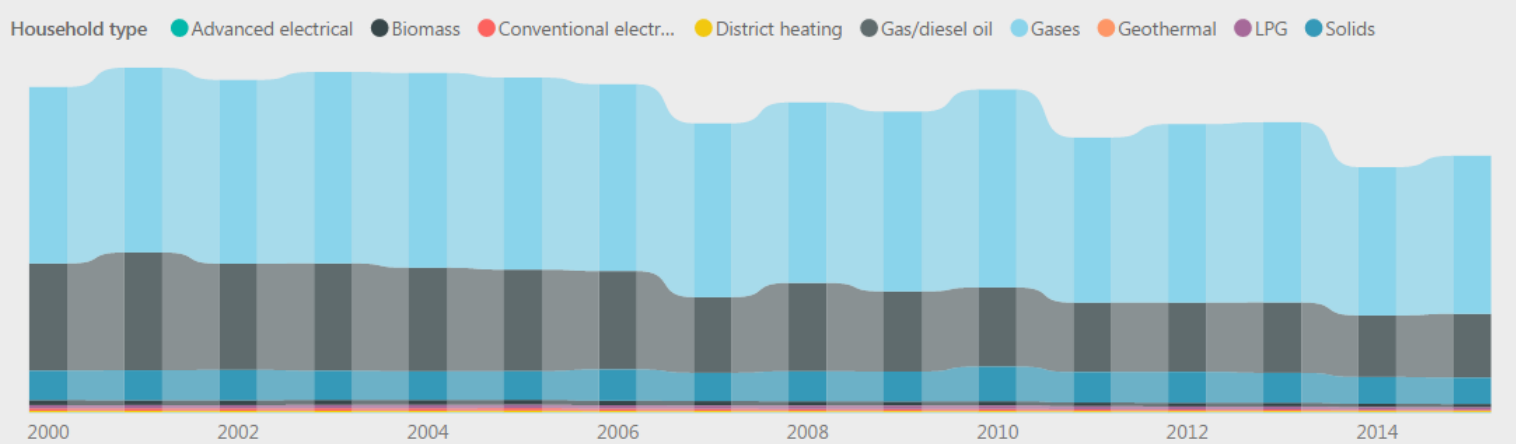
Useful energy service (ktoe) by Year and Household type



Number of households equipped by Household type



CO2 emissions (ktCO2) by Year and Household type



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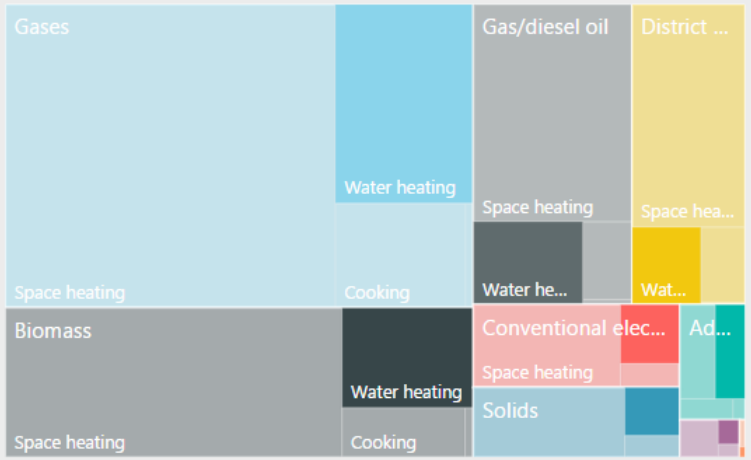
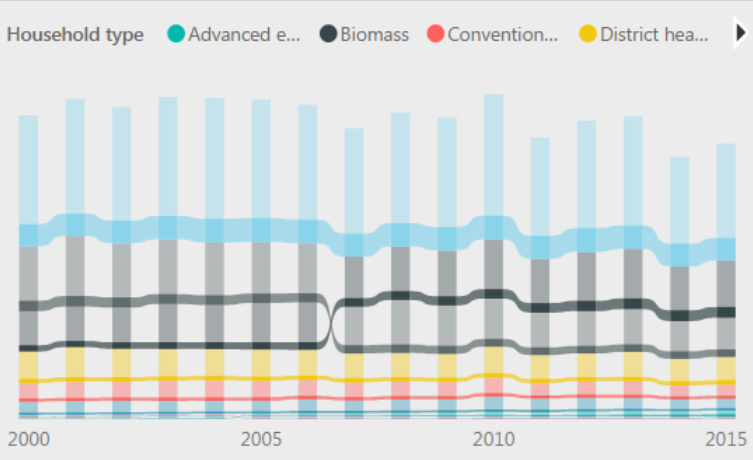


Final energy consumption (ktoe) by Year and Household type



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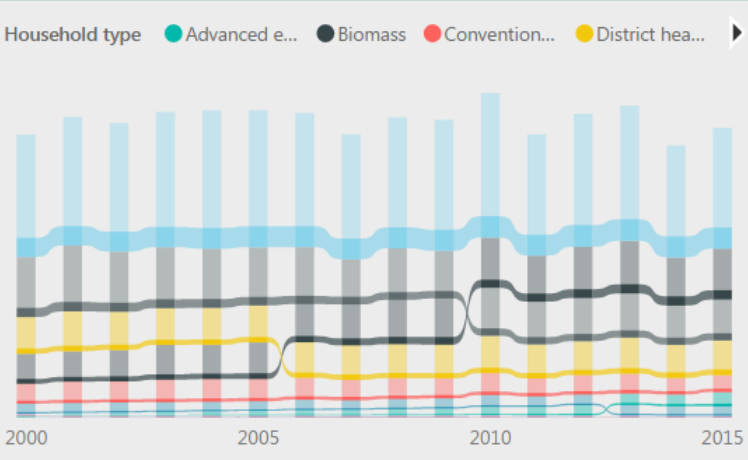

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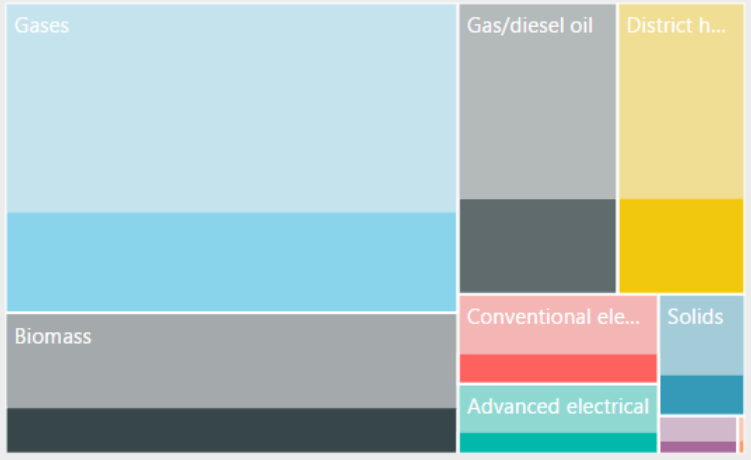

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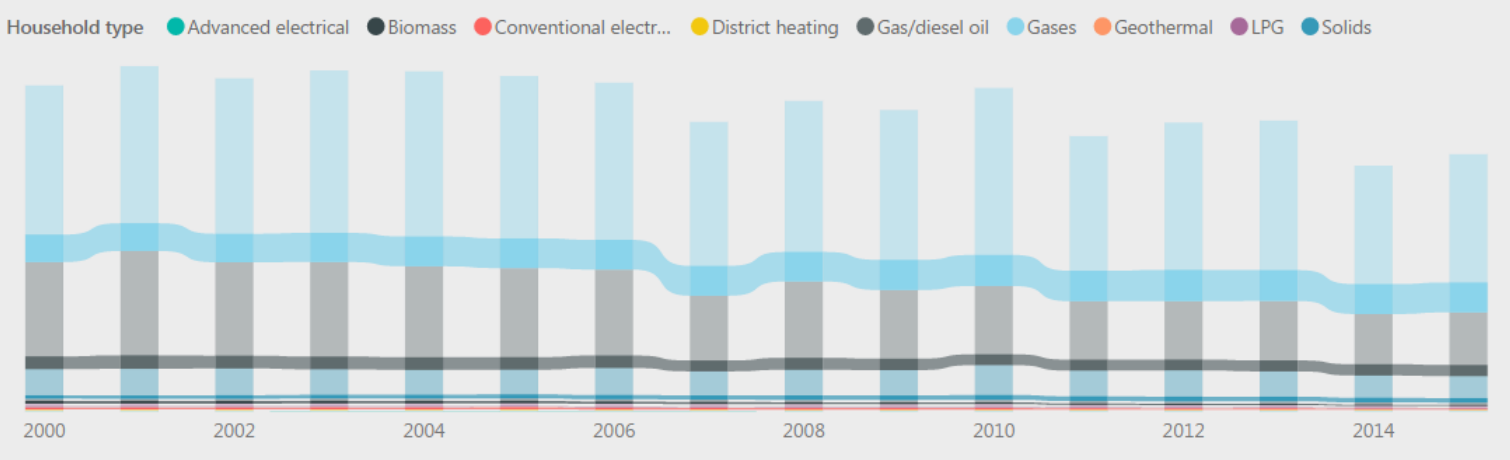

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Specific analysis of energy consumptions - Sankey Chart 2: End-uses -> Technologies -> Useful energy provided by technologies

Country: DE | Others

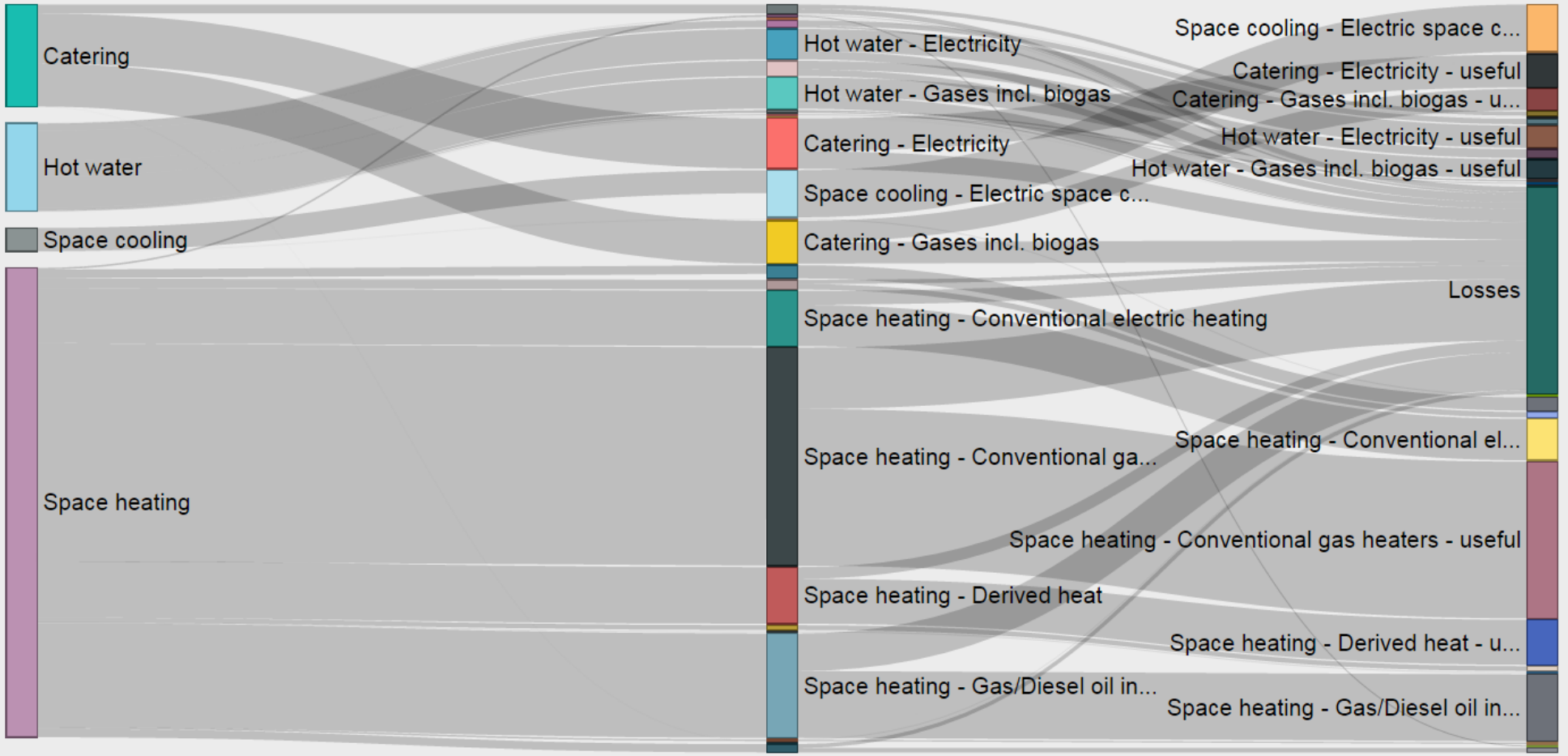
Technology: Catering - Biomass and wastes | Catering - Electricity | Catering - Gases incl. biogas | Catering - Liquified petroleum gas (LPG) | Hot water - Biomass and wastes | Hot water - Derived heat | Hot water - Electricity | Hot water - Gas/Diesel oil incl. biofuels (G... | Hot water - Gases incl. biogas

End-use: Catering | Hot water | Space cooli... | Space heati...

Animate or select single year

Year

ktoe



Origin node
- Technology option
- Use

Destination node
- Energy service
- Technology option

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Analysis at the mode level (freight): intensities

Country: DE | Others

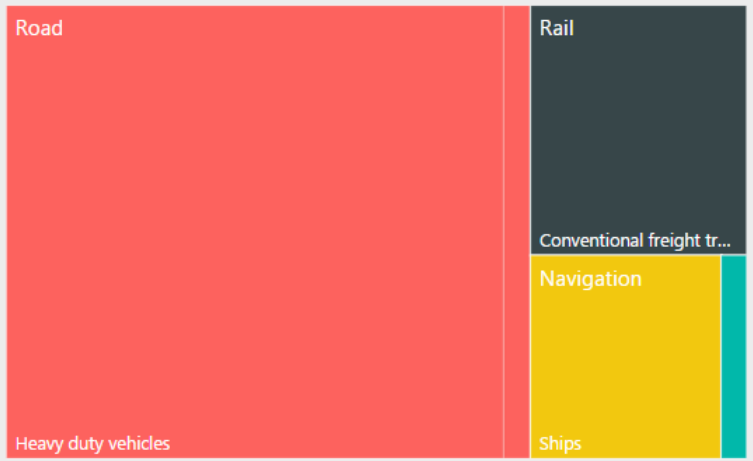
Select a single year: 2000 | 2001 | 2002 | 2003 | 2004 | 2005

Decomposition level: **CO2 emissions** | Energy

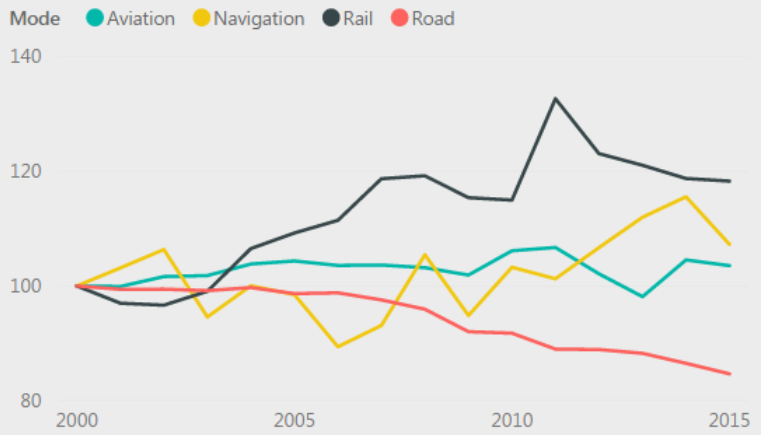
Measure: Difference: None | Ref 2000 | Year-to-Year

Measure: Compare: No | **Over 2000** | Over EU

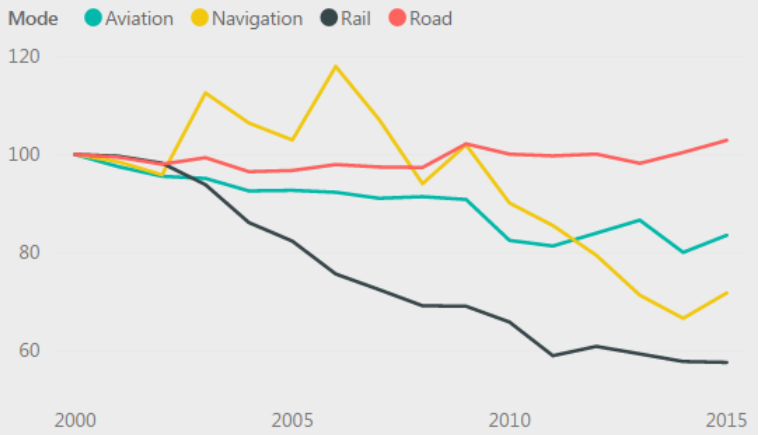
Freight activity (mio tkm) by Mode and Mean



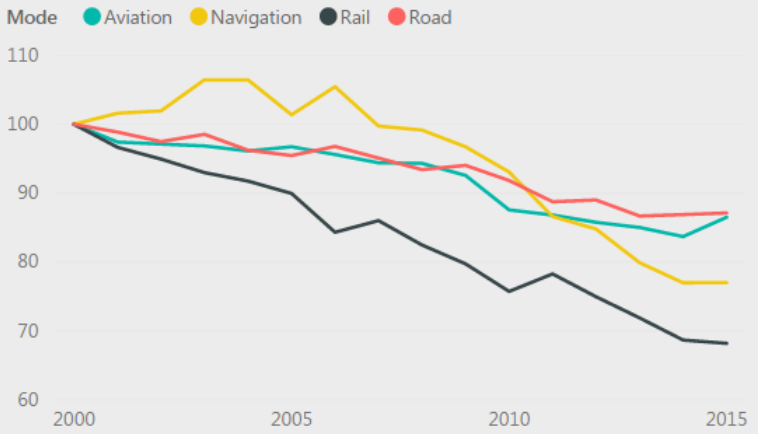
Tonnage per movement (t / mov) by Year and Mode



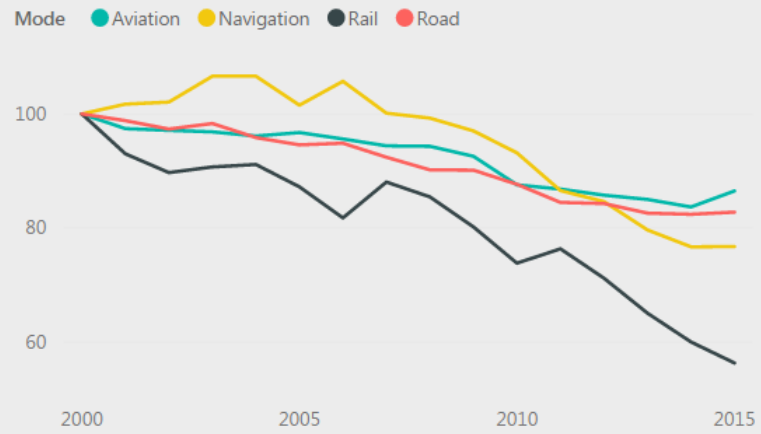
Energy intensity of freight activity (toe / mio tkm) by Year and Mode



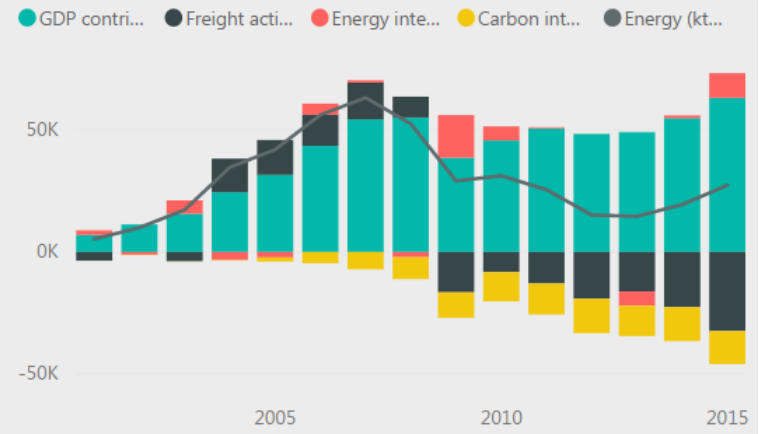
Energy efficiency overall (kgoe / 100 km) by Year and Mode



Carbon intensity overall (gCO2 / km) by Year and Mode



Decomposition analysis



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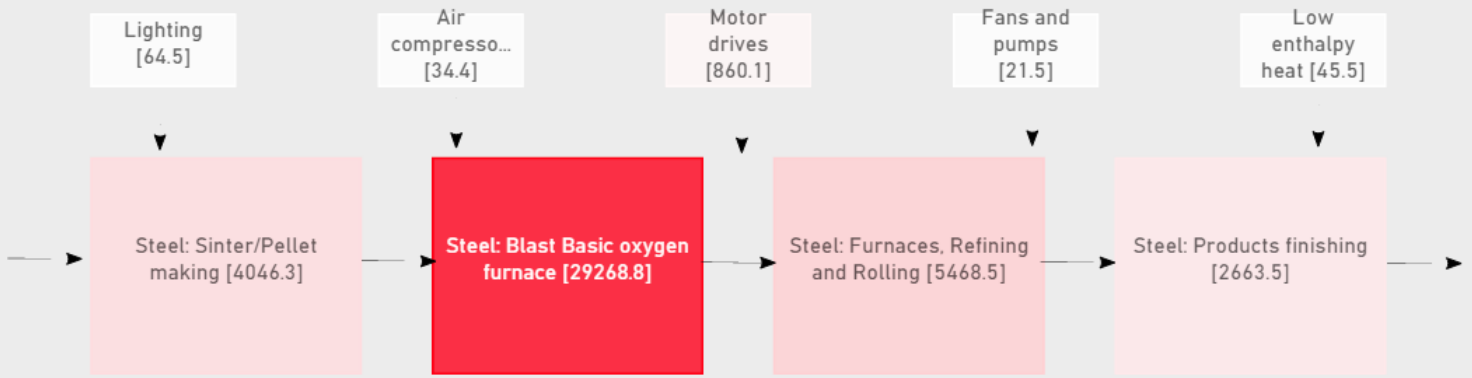
Process-level analysis: Integrated Steelworks

Country: DE | Others

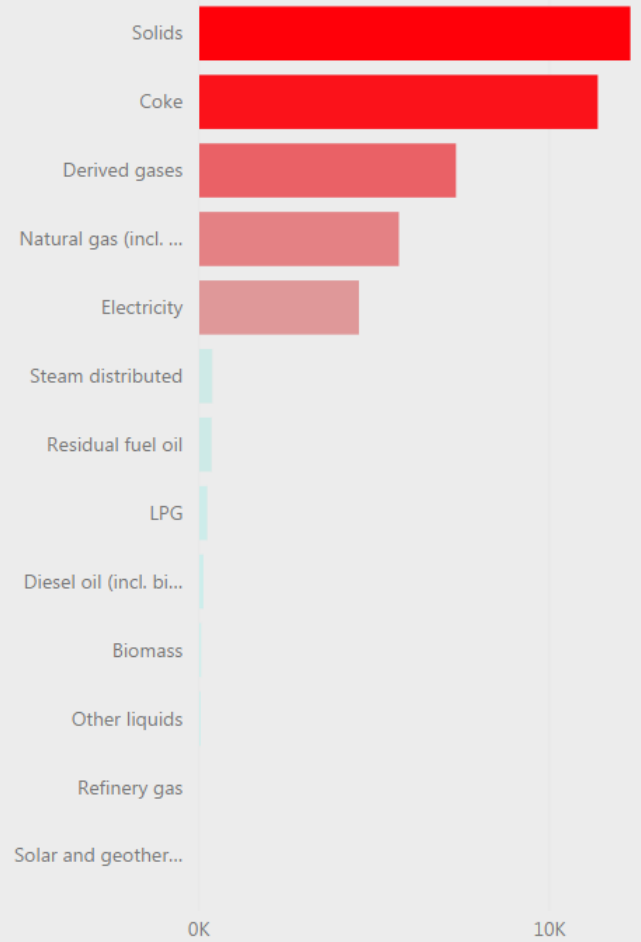
Variable: CO2 content of final energy | CO2 emissions | Efficiency | Final energy | Useful energy

Year: 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015

Process flow diagram (default value: final energy consumption)



Measured value (default value: final energy consumption)



Measured value - absolute (default value: final energy consumption)

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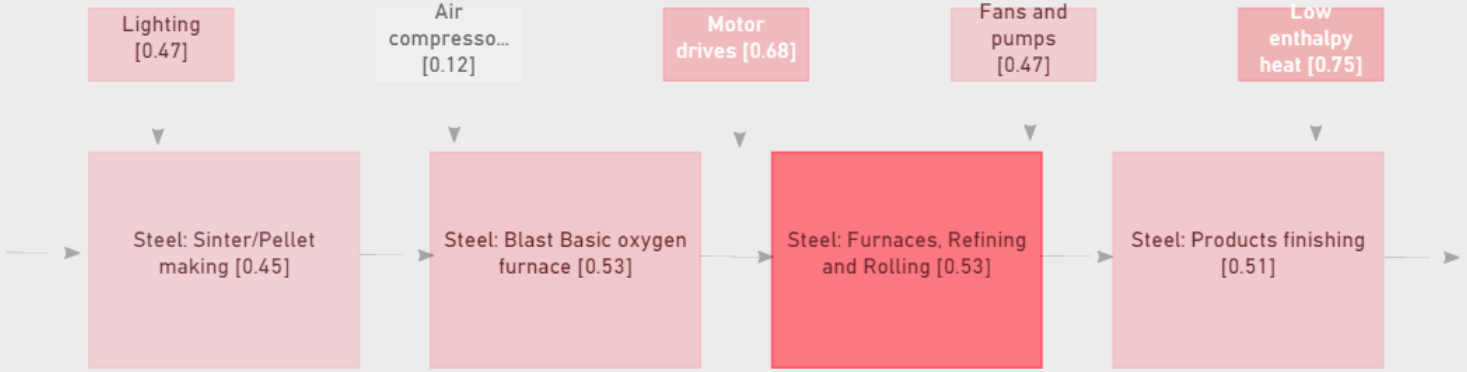

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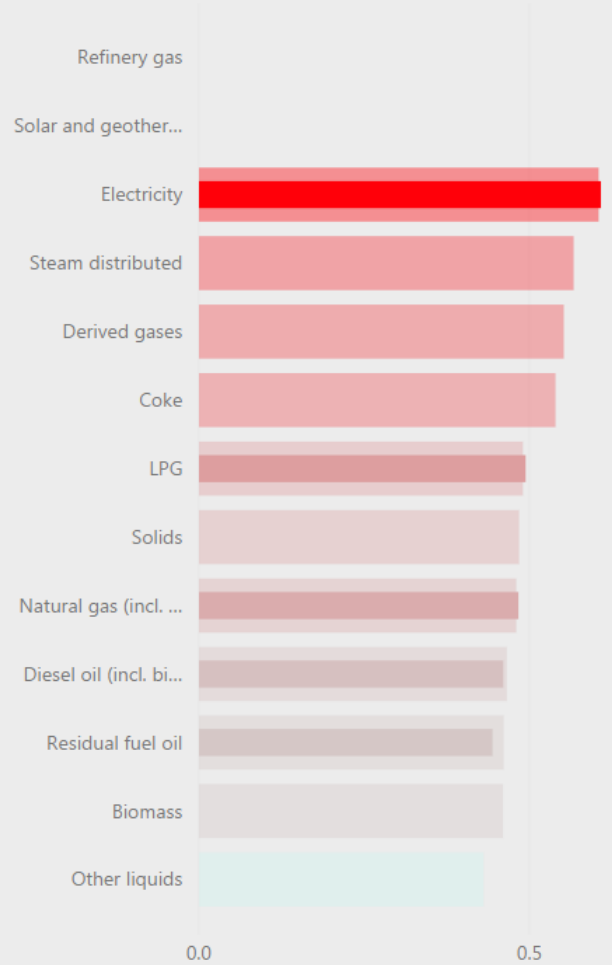

Measured value - absolute (default value: final energy consumption)

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Detailed analysis of power generation technologies : gross & net capacities, number of units and average unit size

Country

DE Others

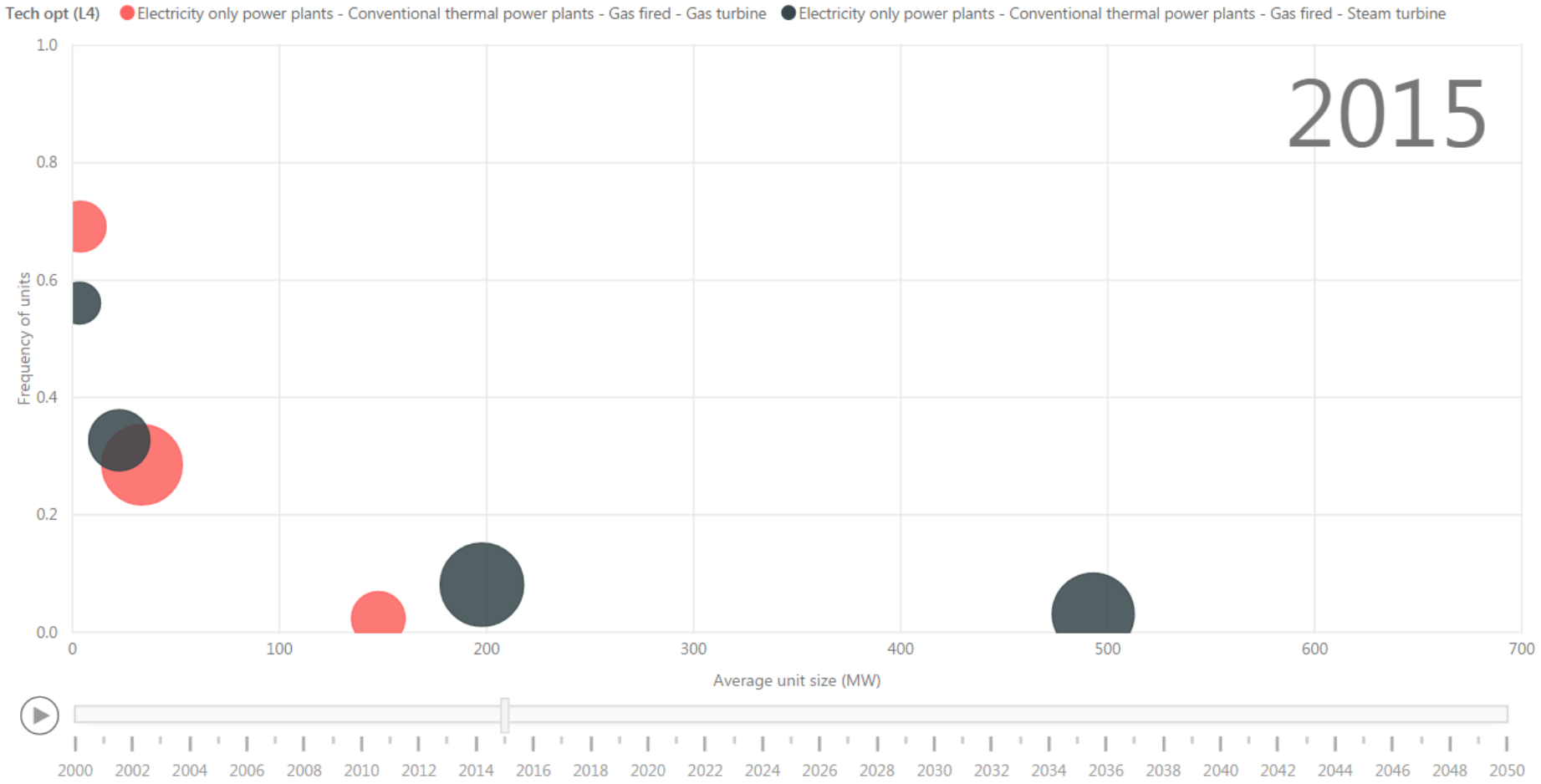
Units

Decommissioned units | New units | **Stock**

Navigate

- Electricity only power plants
  - Conventional thermal power p
    - Coal fired
      - Fluidized bed combustio
      - Integrated gasification cc
      - Steam turbine
      - Supercritical steam turbir
    - Derived gas fired
    - Diesel oil fired
      - Gas turbine
      - Gas turbine combined cy
      - Internal combustion engi
      - Steam turbine
    - Fuel Oil fired
      - Integrated gasification cc
      - Steam turbine
      - Supercritical steam turbir
    - Gas fired
      - Gas turbine
      - Gas turbine combined cy
      - Internal combustion engi
      - Steam turbine
    - Lignite fired
    - Refinery gas fired
    - Solid biomass and waste fir

Analyzing sizes of units



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REPRESENTING THE SECTORAL STRUCTURE

Formulated by means of a **nested-tree structure**

flexible implementation across the different sectors

Decomposing energy use at the level of

- processes
- energy end-uses
- technology options,
- technology types, and
- associated energy forms

Reflecting the energy equipment installed as to satisfy the service needs of energy consumers

The representative agents' investment decisions are obtained through a **nested multinomial logit formulation**

The drivers for the decision making at each level of the tree are

- the techno-economic characteristics of the alternative options
- their market acceptance factor
- the size of equipment installed
- the level of operation of the equipment

The explicit characteristics of an installation span the whole tree

Substitutability/complementarity of the options available at each level is explicitly addressed

Behavioural equations apply as regards the operation and use of energy related equipment

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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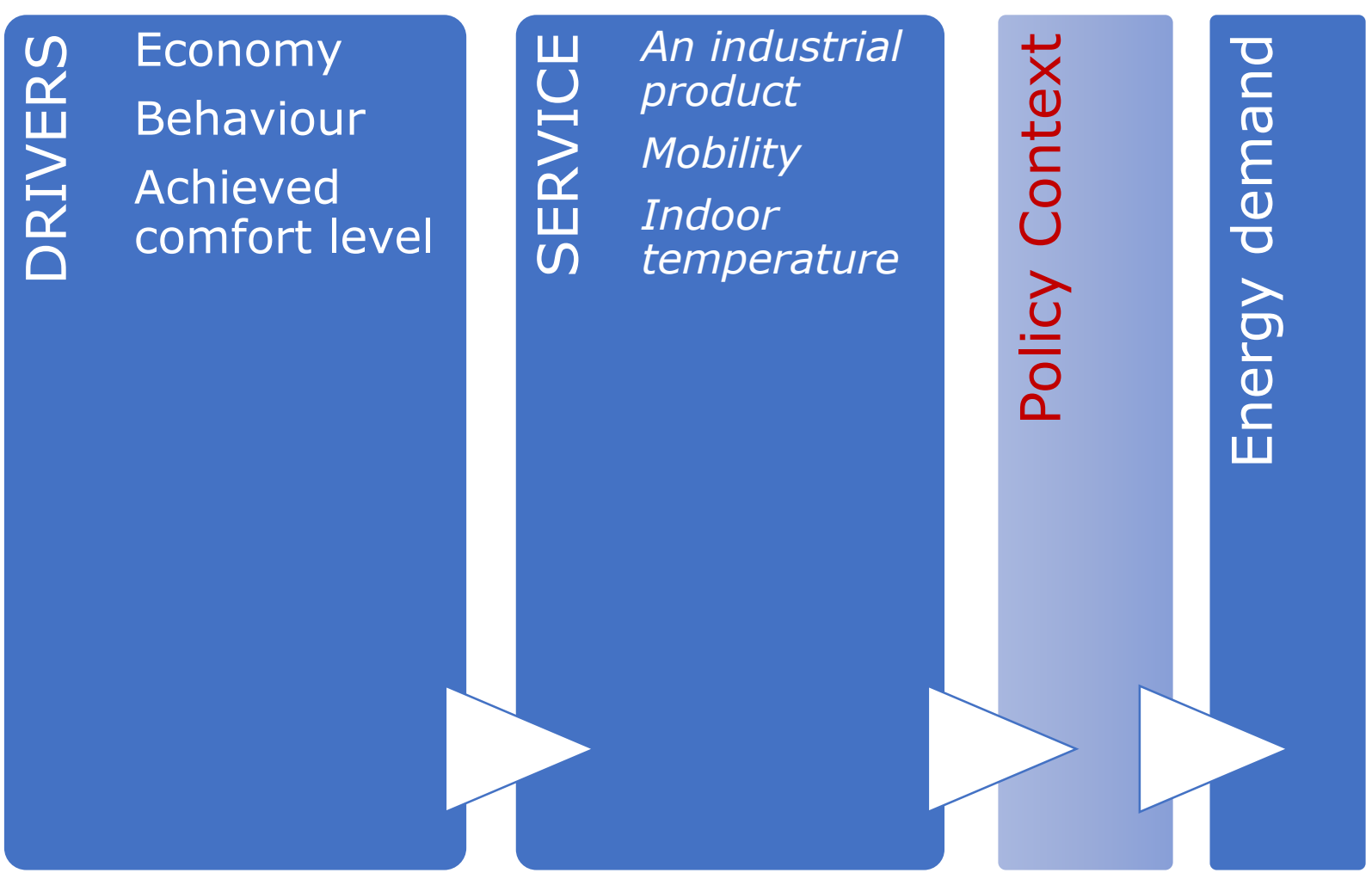
We consume energy to meet our needs



Equipment
- type
- characteristics
- size

Use
- equipment
- preferences

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How the Policy Context affects Energy Demand

Energy equipment limits flexibility

Representative consumption unit

- An industrial installation needed to produce one unit of output
- A building installation for thermal uses
- A unit or a representative configuration of units for electrical equipment
- A vehicle for private transport
- A representative vehicle configuration for other transport modes

Multiple options of installations are available within a vintage

Replacement of different components in line with the corresponding technical lifetime

Dynamically evolving technoeconomic characteristics

Explicit representation of idle equipment or installations

- Avoiding erroneous allocation of equipment
- Allows identifying the domain for policy implementation

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How the Policy Context affects Energy Demand

Energy equipment limits flexibility

- Installation types
- Vintage specific characteristics

Number of individual units explicitly identified

Operation of equipment may deviate from optimality

The way we use the energy related equipment is dependent on

- the prevailing policy conditions
- the vintage specific equipment characteristics
  - Size / Technical characteristics
- the purpose of use

Affecting the level of satisfying our service needs

Flexibility to adapt is explicitly considered

Not applicable for industrial sectors

Also acting on vehicles loads for transport

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

Infrastructure improvements are vintage and energy use specific

- non-linear cost formulation applies
- accumulation of consecutive investment in the vintage specific characteristics
- underutilisation of energy equipment captured

Premature replacement of equipment

- within each vintage
- applicable at the level of equipment clusters
- stranded costs and scrapped equipment quantified

Policy initiatives can be explicitly addressed

Structural responses

- changes in activity volumes
- revisions of comfort standards
- reallocations of service needs

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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

How the Policy Context affects Energy Demand

Envisaged level of use

- *reflects the comfort standard ("welfare target")*
- *links to macroeconomic and demographic assumptions*
- *it also takes into account*
  - *the penetration rate of the equipment*
  - *possible saturation limits*

We **invest** to meet our envisaged service needs

Realised level of use

- *adjusts the envisaged level in response to the policy framework*
- *agents flexibility to adapt is explicitly considered*
- *vintage and energy equipment specific*

describes the operation of the installed equipment

Each choice is treated as a physical entity (installation)

Explicit number of new installation quantified

Non-energy using options form an integral part of the investment decision

How the Policy Context affects Energy Demand

Energy equipment limits flexibility

- Technology types
- Vintage specific characteristics

Number of individual units explicitly identified

We **invest** to meet our envisaged service needs

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

reflected on size of energy equipment

Operation of equipment may deviate from optimality

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

Endogenous technology dynamics

Enhanced **economic** response mechanisms

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

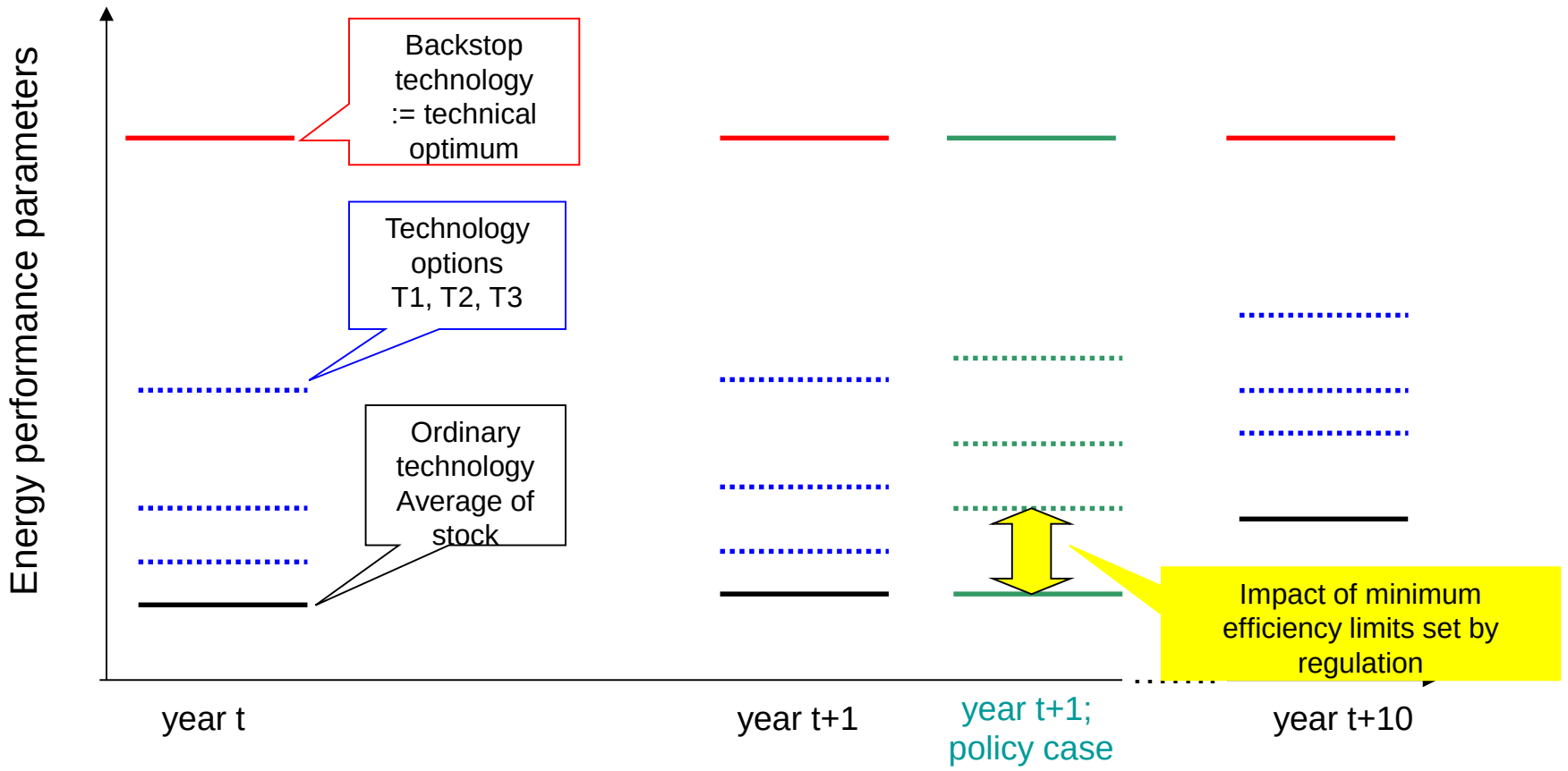
Explicit accounting for incurred stranded costs; idle stock; scrapped equipment

How the Policy Context affects Energy Demand

Initial stock dependent (country specific)

Alternative technology options develop dynamically towards technical optimal

Explicit representation of minimum standards



Endogenous technology dynamics

Techno-economic characteristics

- country specific
- policy dependent evolution

Related costs link to technology dynamics

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

If a technology option becomes unattractive its technology progress slows down

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How the Policy Context affects Energy Demand

Energy equipment limits flexibility

- Technology types
- Vintage specific characteristics

Number of individual units explicitly identified

We **invest** to meet our service needs

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

reflected on size of energy equipment

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

Endogenous technology dynamics

Technology characteristics are country specific

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

Related costs link to projected dynamics *through*

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

Outline

Brief description and current status

Motivation and main features of the tool

- Demand side
- **Power sector**
- Behavioural aspects

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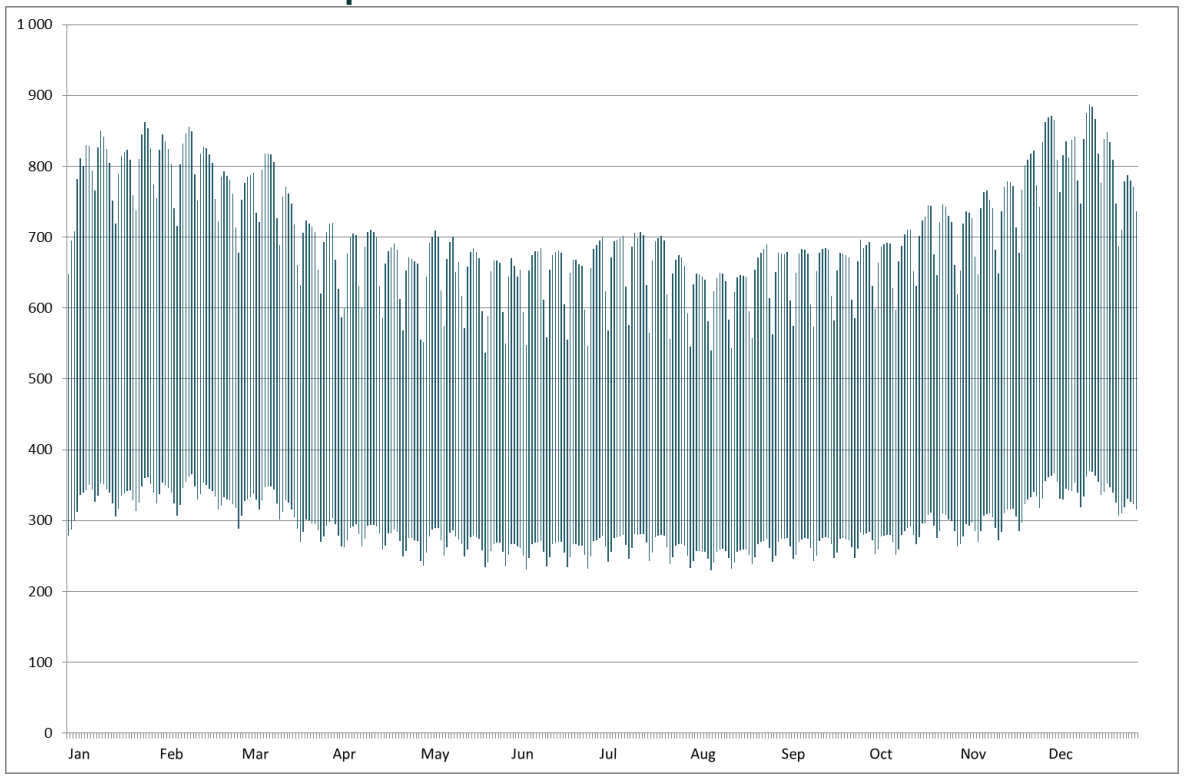
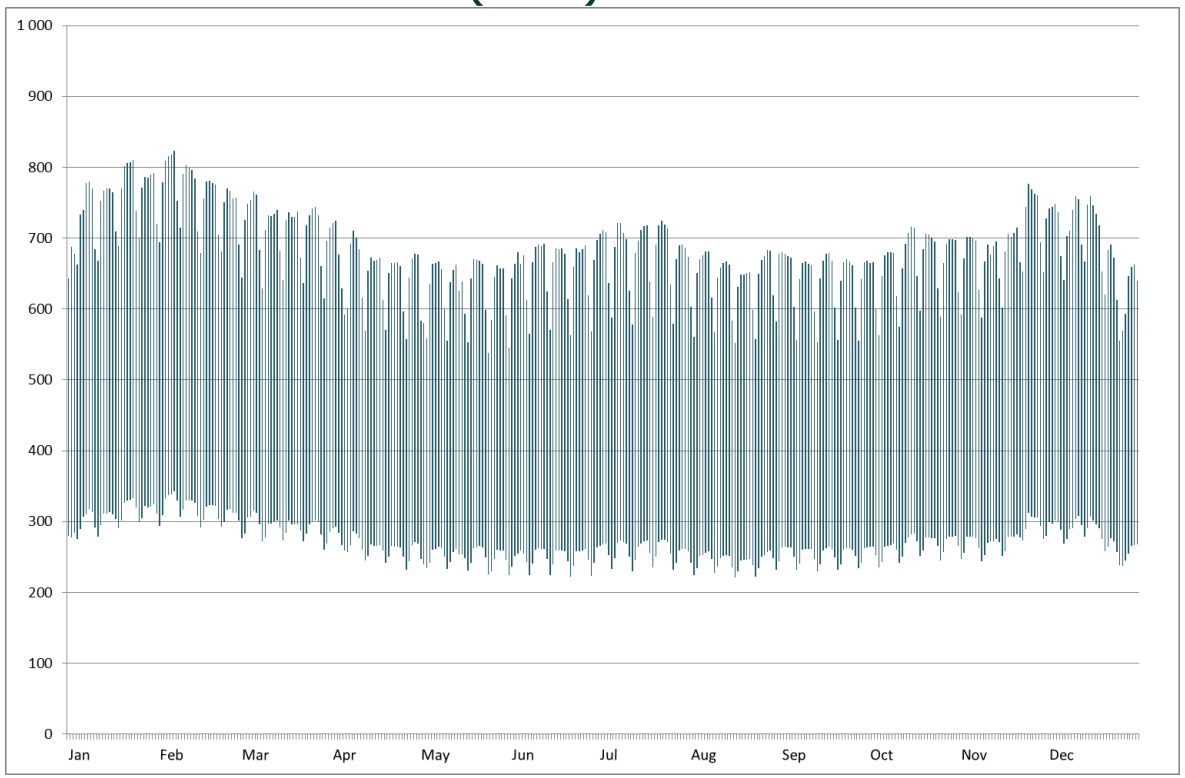
FROM A CHRONOLOGICAL LOAD CURVE …

ENTSO-E provides information on an hourly basis for the load (GW)



2010



2015

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FROM A CHRONOLOGICAL LOAD CURVE ...

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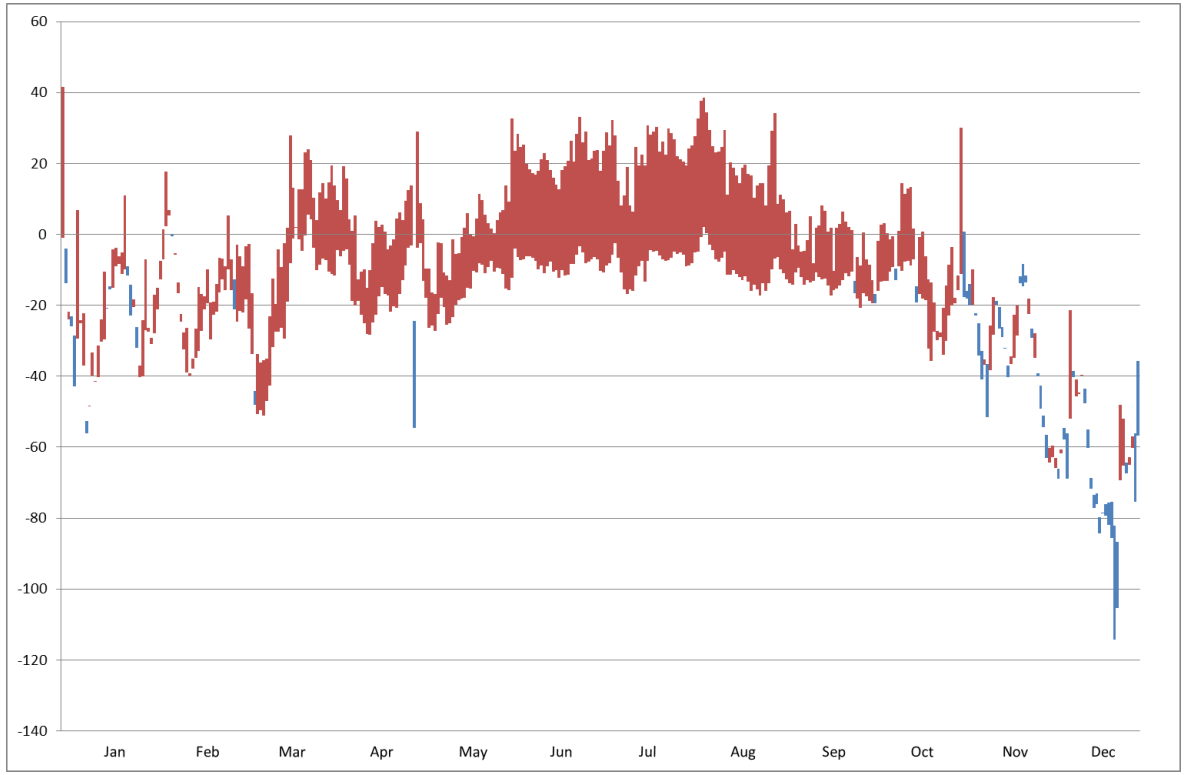
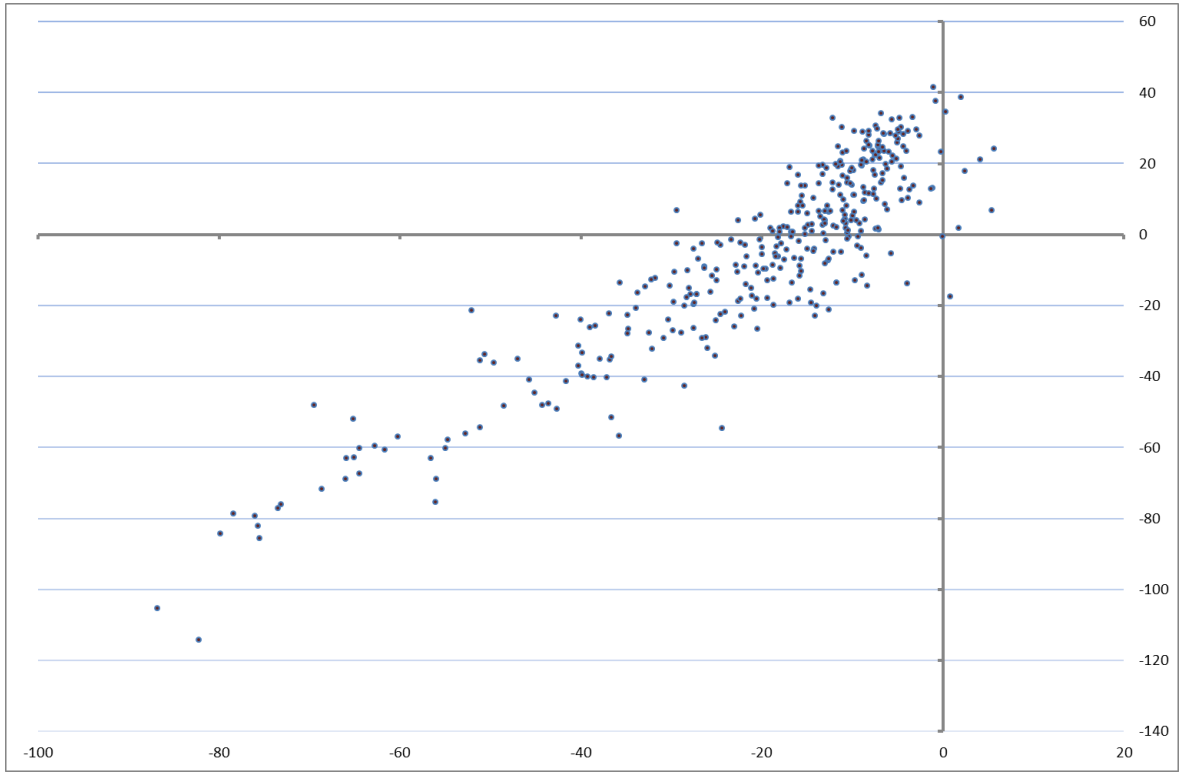


Comparison of daily load 2015-2010



Comparison of daily peak to base load 2015-2010

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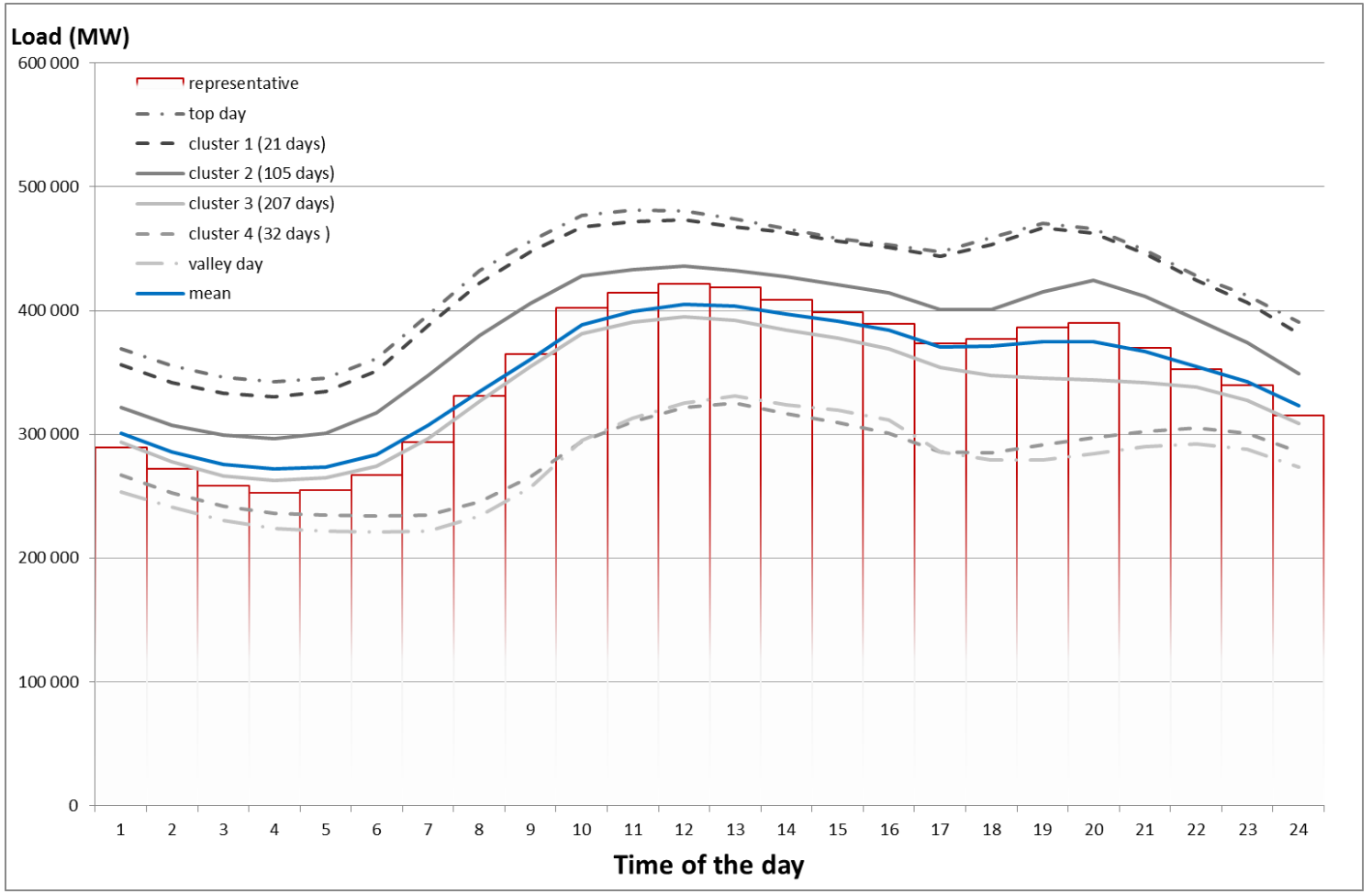
… TO THE REPRESENTATIVE DAY APPROACH

Load curve of a **representative day**

- most likely load pattern for dispatching conditions in one year
- more pronounced peak and valley than in average load curve
- similar concept applies to solar and wind generation
- extreme days can be captured through 'snapshots'

expansion to two representative days foreseen



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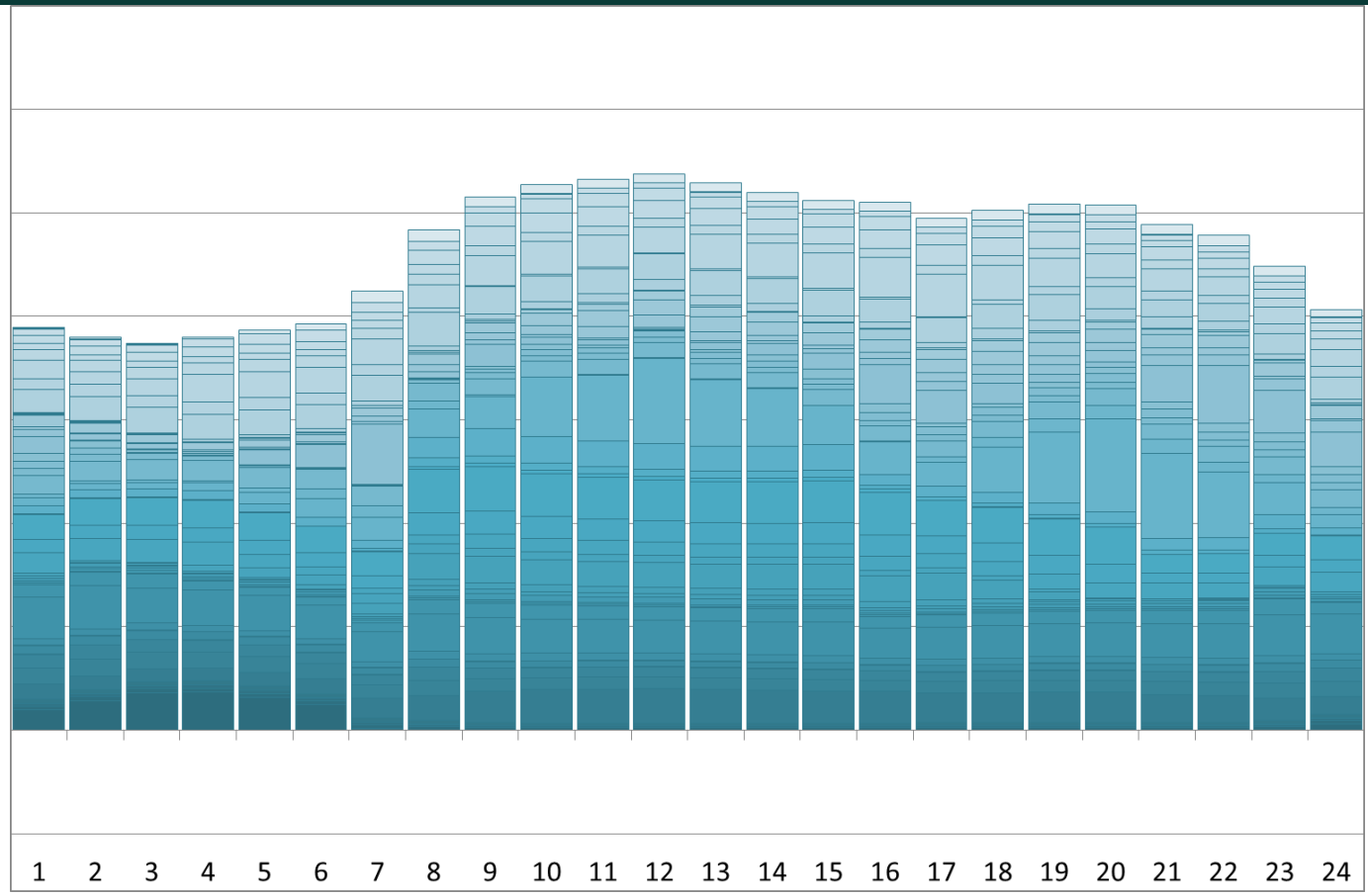
ADDRESSING POWER SECTOR'S COMPLEXITY

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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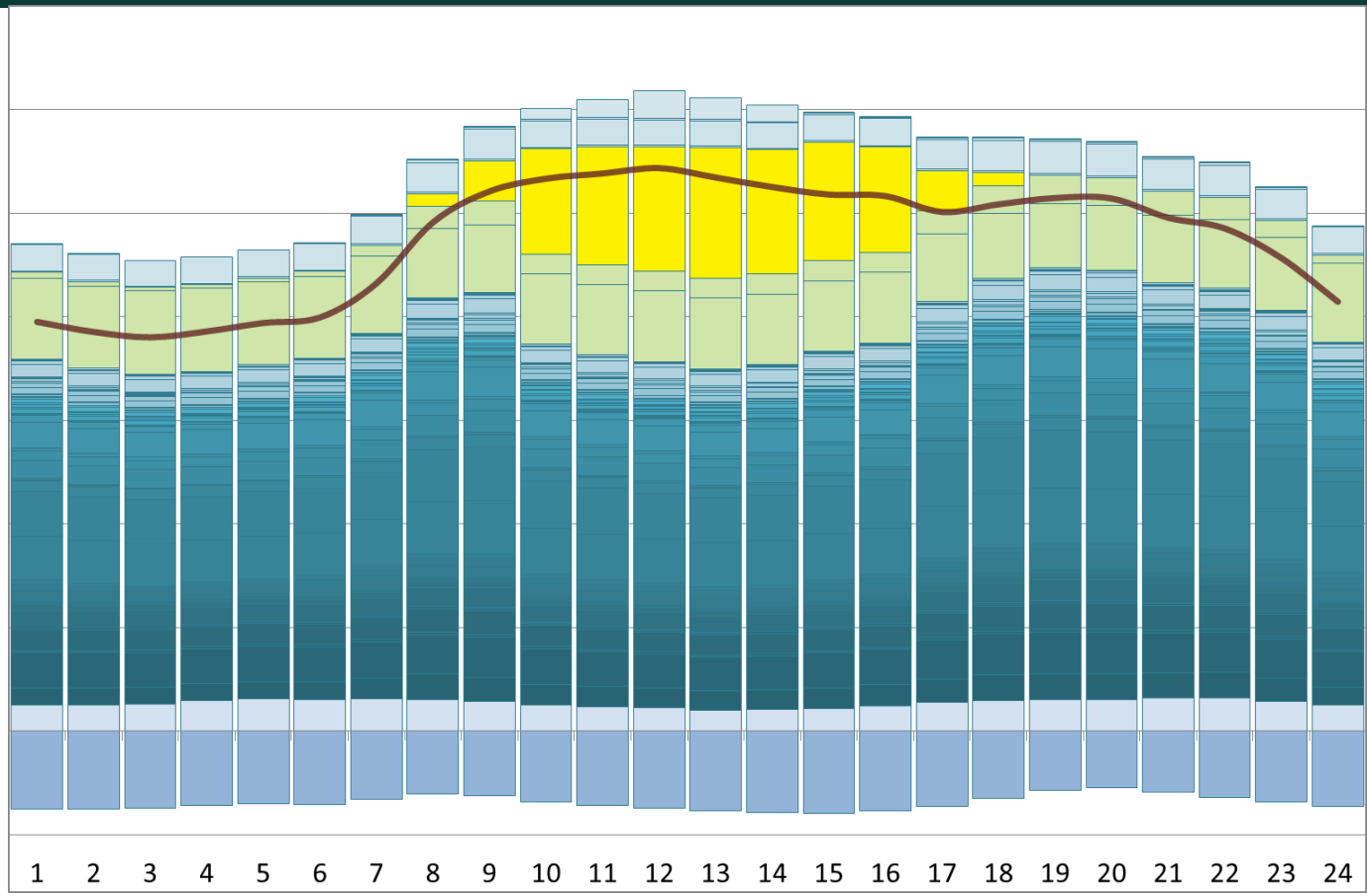
ADDRESSING POWER SECTOR'S COMPLEXITY

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



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Addressing power sector's complexity

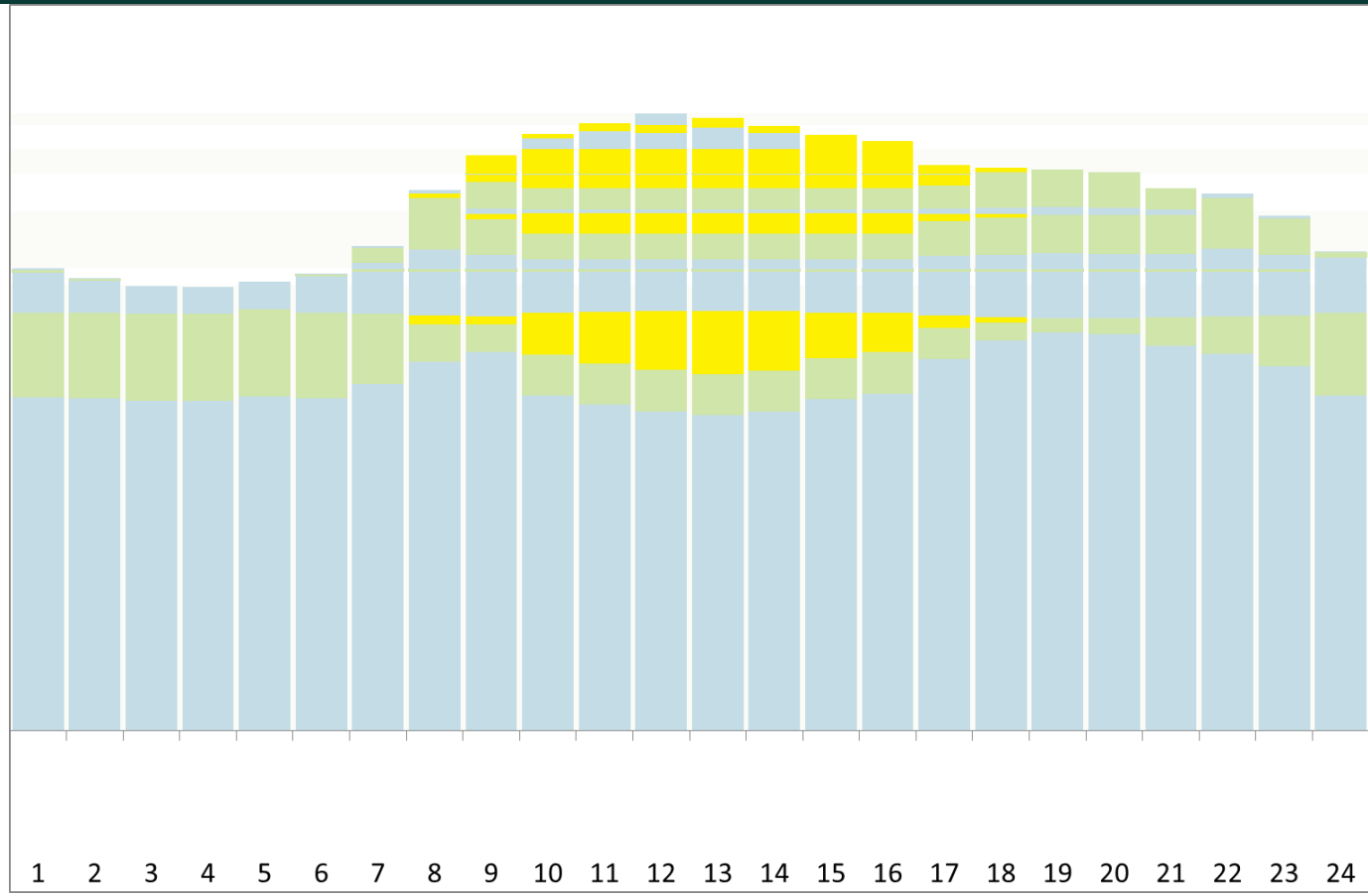
Chronological load curve derived from almost 300 energy uses

Trade of electricity takes place as to optimise power generation

Power plants operation addressed at the level of units

Dispatching in multiples of unit sizes

- *Mimicking mixed integer programming*



Portfolio management approach with dynamic characteristics

European Commission

ADDRESSING POWER SECTOR'S COMPLEXITY

Chronological load curve derived from almost 300 energy uses

Trade of electricity takes place as to optimise power generation

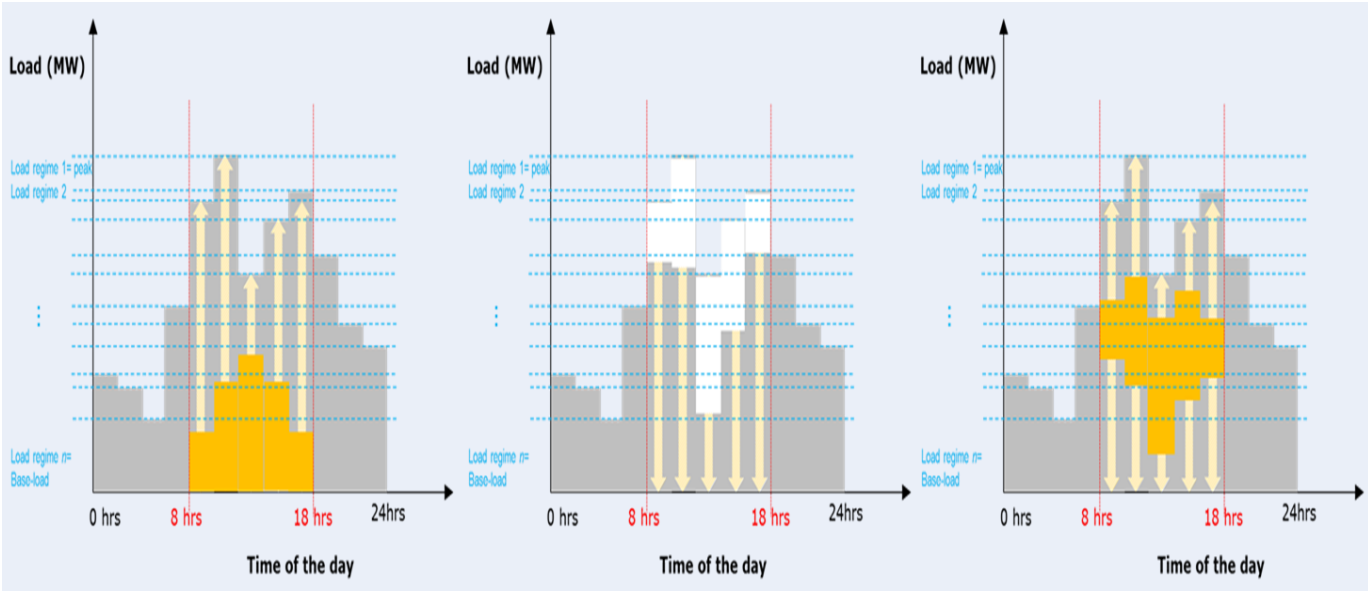
Power plants operation addressed at the level of units

Dispatching in multiples of unit sizes

- *Mimicking mixed integer programming*

Meeting power **and/or** electricity generation

- *Integrating high shares of variable renewable energies*
- *Respecting resources availability constraints*



Strict merit order

Residual Load Curve (RLC)

POTEnCIA

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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

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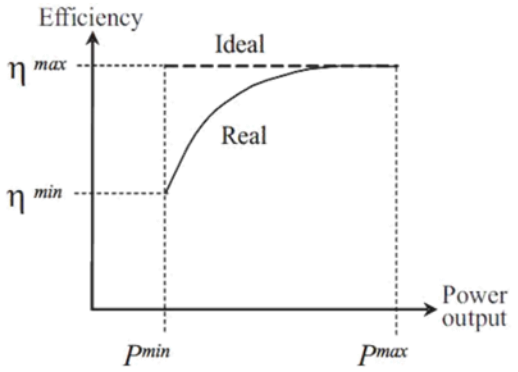
- *Integrating high shares of variable renewable energies*
- *Respecting resources availability constraints*
- *Accounting for opportunity costs induced across competing technologies*
- *Bundling of units is reflected and addressed*
- *System stability is ensured*



Stationary operating costs

Based on nominal techno-economic characteristics of power plant units

- Power plant efficiency
- Rate of own consumption
- Variable operating cost
- Fuel cost
- Policy costs (ETS price, renewable value etc.)

Operating mode related costs reflecting cycling

Part load operation (spinning reserve)

Start-ups and shut downs

- wearing off of equipment effect
- increased own consumption effect

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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

Dispatching in multiples of unit sizes

- *Mimicking mixed integer programming*

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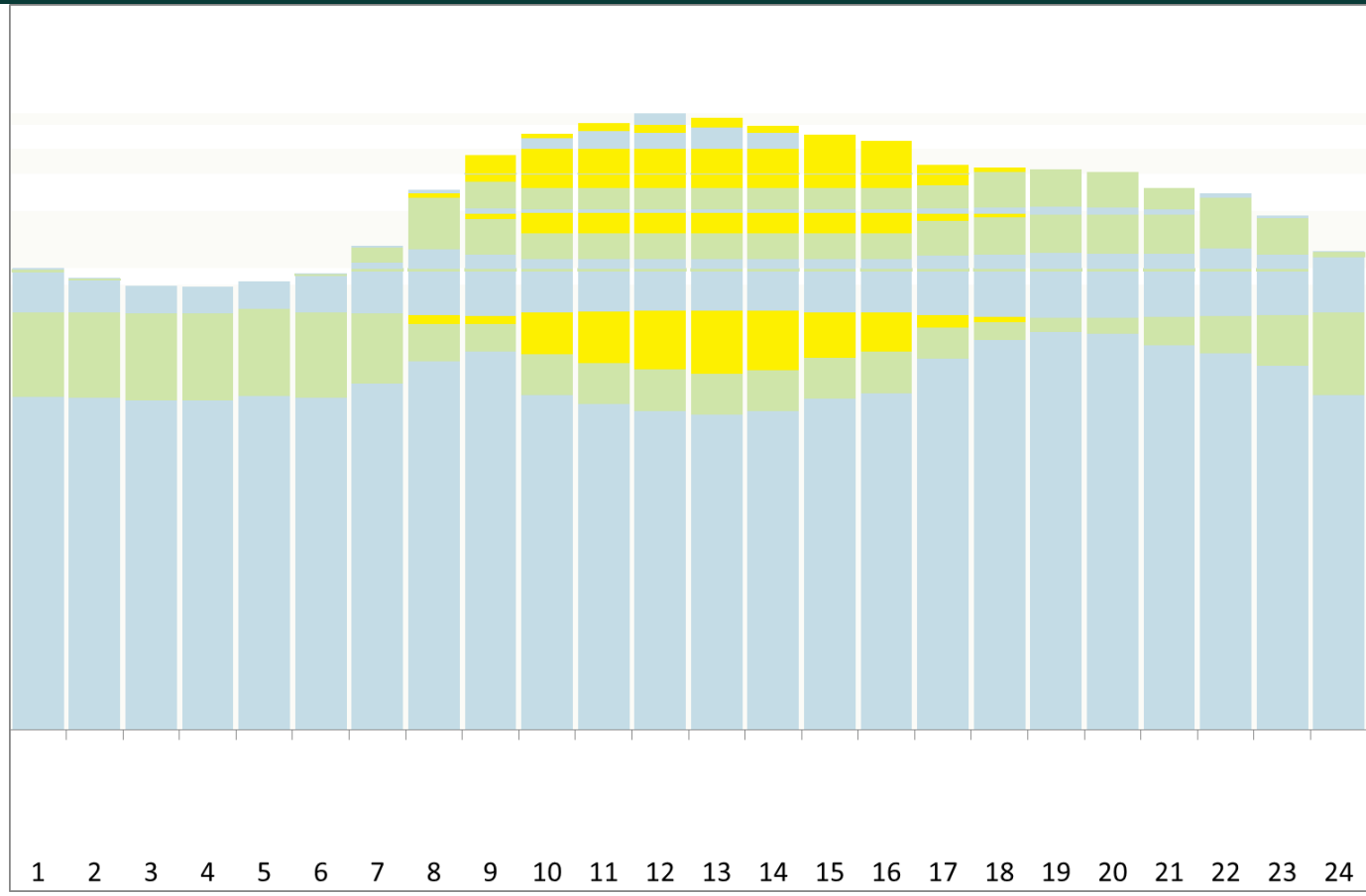
- *Integrating high shares of variable renewable energies*
- *Respecting resources availability constraints*
- *Accounting for opportunity costs induced across competing technologies*
- *Bundling of units is reflected and addressed*
- *Addressing system stability*

Cogeneration plants driven primarily – but not exclusively - by steam demand



Portfolio management approach with dynamic characteristics

European Commission

Addressing power sector's complexity

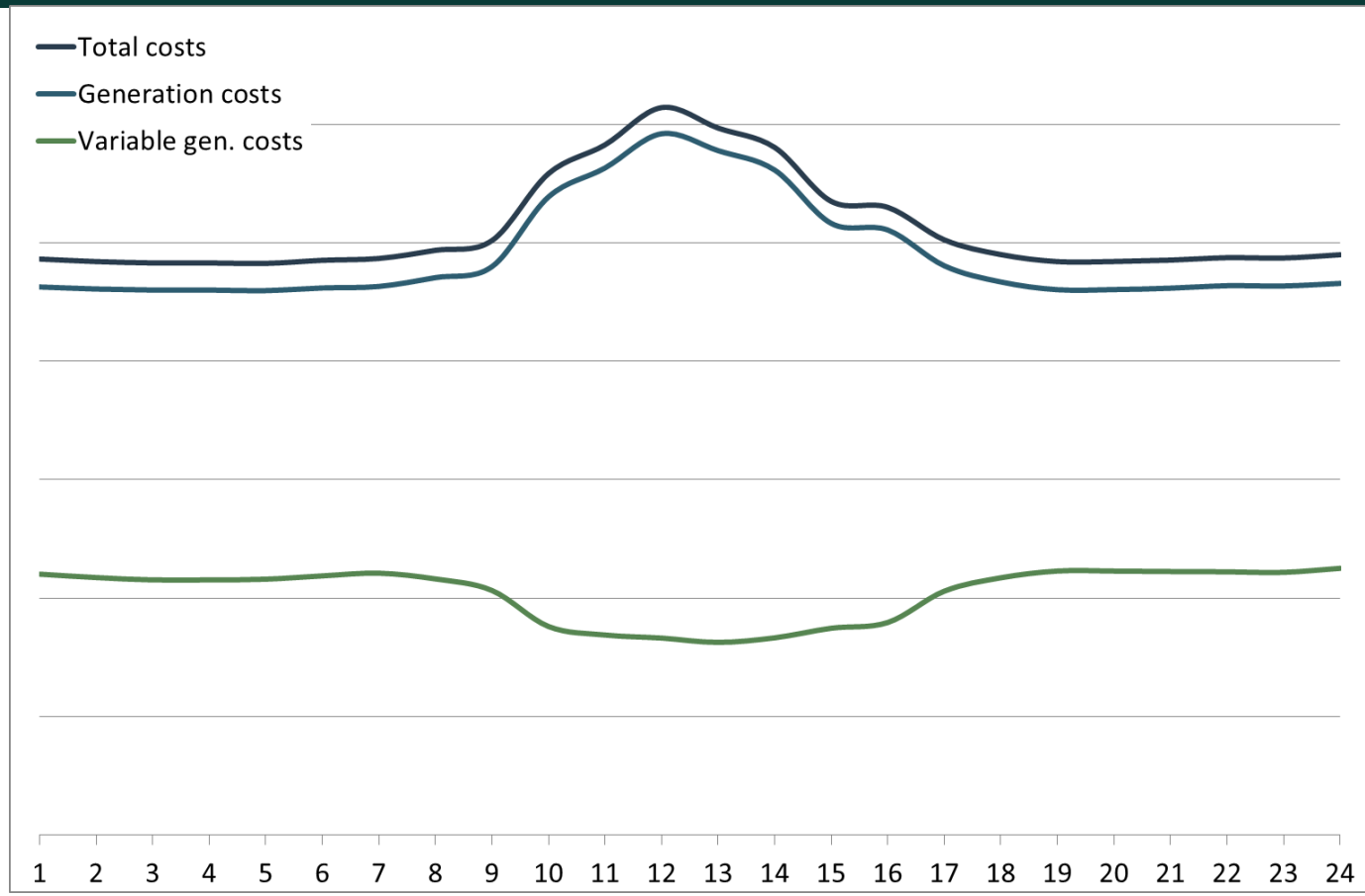
Chronological load curve derived from almost 300 energy uses

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
  - *Endogenous signal to the demand side that can influence load profiles*



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Addressing power sector's complexity

Chronological load curve derived from almost 300 energy uses

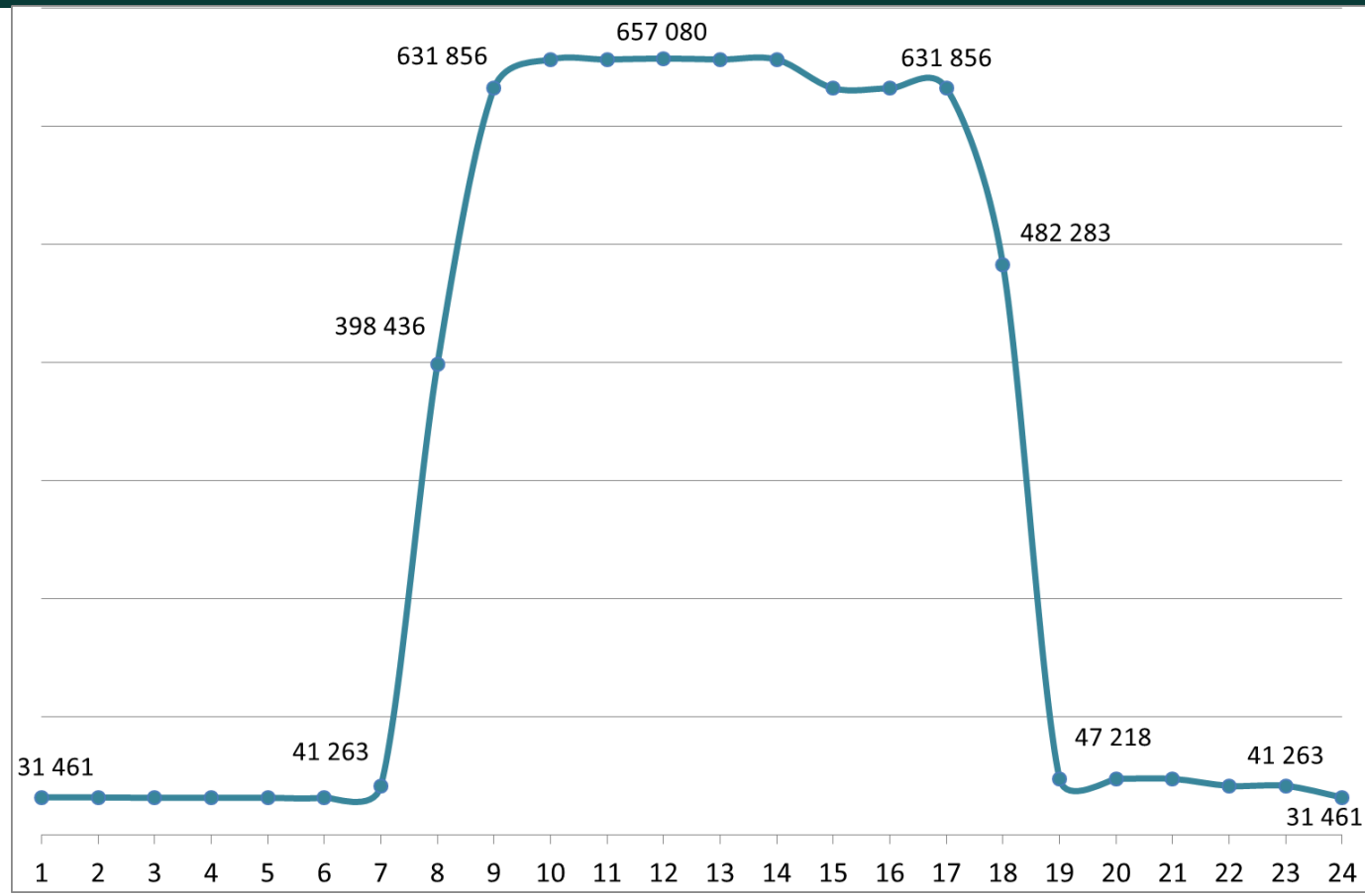
Trade of electricity takes place as to optimise power generation

Power plants operation addressed at the level of units

Capturing **generation cost fluctuations**

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

allowing to understand the complexity of the dispatching problem



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ADDRESSING POWER SECTOR'S COMPLEXITY

Chronological load curve derived from more than 300 energy uses

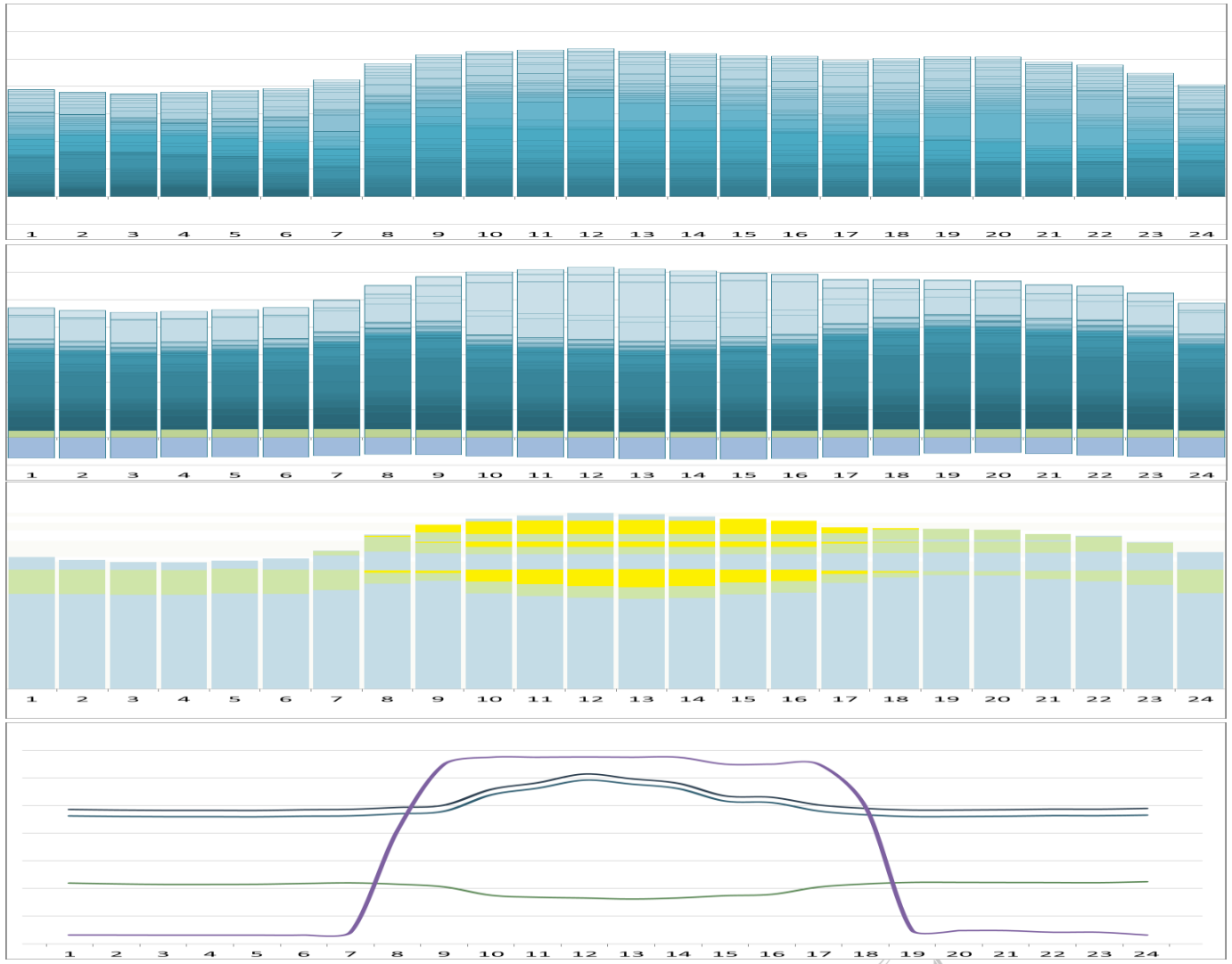
Trade of electricity takes place as to optimise power generation

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

Investments take place in multiples of unit sizes

- Mimicking a **mixed integer programming approach**
- Strongly affecting the evolution of the power plants park, especially for small countries
- Preferences for delaying or advancing investment can be reflected
- Linking to the policy regime
- Underinvestment may occur

The load profile of investment needs reflects

- the load profile of decommissioned capacities, and
- the load pattern of the evolving demand load curve

A **portfolio management approach** applies through a nested multinomial logit formulation

- up to four typical size classes
- technology options
- fuel types
- electricity-only and cogeneration plants
- power plants with/without CCS equipment

272 types

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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

Explicit consideration of **system stability** implemented

Endogenous calculation of the **reserve margin**

- boundary conditions for the total installed capacity versus peak load apply
- the total capacity in use versus the total capacity installed forms another boundary condition

The ***system stability indicator*** provides a signal to the investment decision-making

- defined by means of the capacity in operation compared to peak load
- the attractiveness for power plants that satisfy electricity and not load reduces as the system stability indicator increases

  i.e. investors favour more power plants options that contribute to reliable load

INVESTMENT DECISIONS IN THE POWER SECTOR

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

Dedicated producers: their decision reflects the fulfilment of a specific load pattern

- demand or resource availability driven (IPPs fall in this category)
- weighted distribution of expectations defined at the level of load regimes
- overall decision obtained combining those of the different load regimes

Multiple market agents: individual investment choices in view of the overall load profile

- load regimes decisions form a new problem at the aggregate level
- different expectations dealt with at the aggregate level

Central decision planners: central investment choice in view of the overall load profile

- instead of multiple individual decisions, one single decision that encompasses various assumptions with regards to the different possible evolutions of the system

Investment decisions in the power sector

Coping with uncertainties

- No perfect foresight
- Recursive rational expectations
- Divergent future outlooks
- *Failures in meeting capacity needs may occur*

Capacity planning considers by default **uncertainty** for the policy framework

Dynamic recursive foresight with imperfect information ('rational expectations')

Investors assume **different expectations** on the likely evolution of the policy framework in their decision-making, captured through a probability density function

- The envisaged future policy framework links to
  - prevailing policy assumptions
  - short- and medium term trends in the historic evolution
  - an understanding of the sector's limitations
- The weighted distribution of the decisions of the different market agents (and their divergent expectations) applies on investment decisions

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

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- Power sector
- **Behavioural aspects**

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ACCOUNTING FOR BEHAVIOURAL RESPONSES

We do not behave in the same way

Our decisions are characterised by suboptimality driven by

the **economic environment**

- access to capital and/or
- budgetary constraints

Investment decisions take place on the basis of the perceived cost of capital

The **subjective financing capability**

- Reflects access to capital and purchase power
- Addresses risk factors/asymmetric information
- Links to budget constraints (differentiated per Member State)

Different formulations for the subjective financing capability are available

- from being deactivated
- to being assumed constant and equal across EU Member States

For commercial investors the perceived cost of capital is equivalent to the WACC (weighted average cost of capital)

Investment costs are reported on the basis of the **nominal discount rate**

ACCOUNTING FOR BEHAVIOURAL RESPONSES

We do not behave in the same way

Our decisions are characterised by suboptimality driven by

the **economic environment**

- access to capital and/or
- budgetary constraints

our **rationality**

- perception (understanding)
- preferences

Deviations from economic optimality are captured through **market acceptance factors**, reflecting

- market agents' preferences (cognitive biases)
- market agents' risk considerations
- existing limitations of technical and infrastructure nature

Policies can increase our rationality by

- 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

ACCOUNTING FOR BEHAVIOURAL RESPONSES

We do not behave in the same way

Our decisions are characterised by suboptimality driven by

the **economic environment**

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our **rationality**

- perception (understanding)
- preferences

Economic conditions act on the **perception of investment costs**

Endogenously driven adaptation mechanism that reflects market agents **behaviour response** to policies

Policy driven changes in the **economic rationality** of investment decision making

"Entry Point" Scenario Assumptions

Macro-economy & demographics
international fuel prices
industry

MEMBER STATES EXPERTS' WORKSHOP ON THE POTENCIA MODEL

Brussels, 26 February 2018

European Commission

POLICY ANALYSIS WITH A MODELLING TOOL

… requires continuous interactions

between European Commission and Member States' experts

- Understanding and correctly reflecting the past

  JRC-IDEES database

  → Exchanges with national experts on-going

Agreeing in **key future assumptions**

- Understanding the model features and scope

  → illustrative **"Entry-point"** stylised scenario

- Addressing **country specificities**

  → 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

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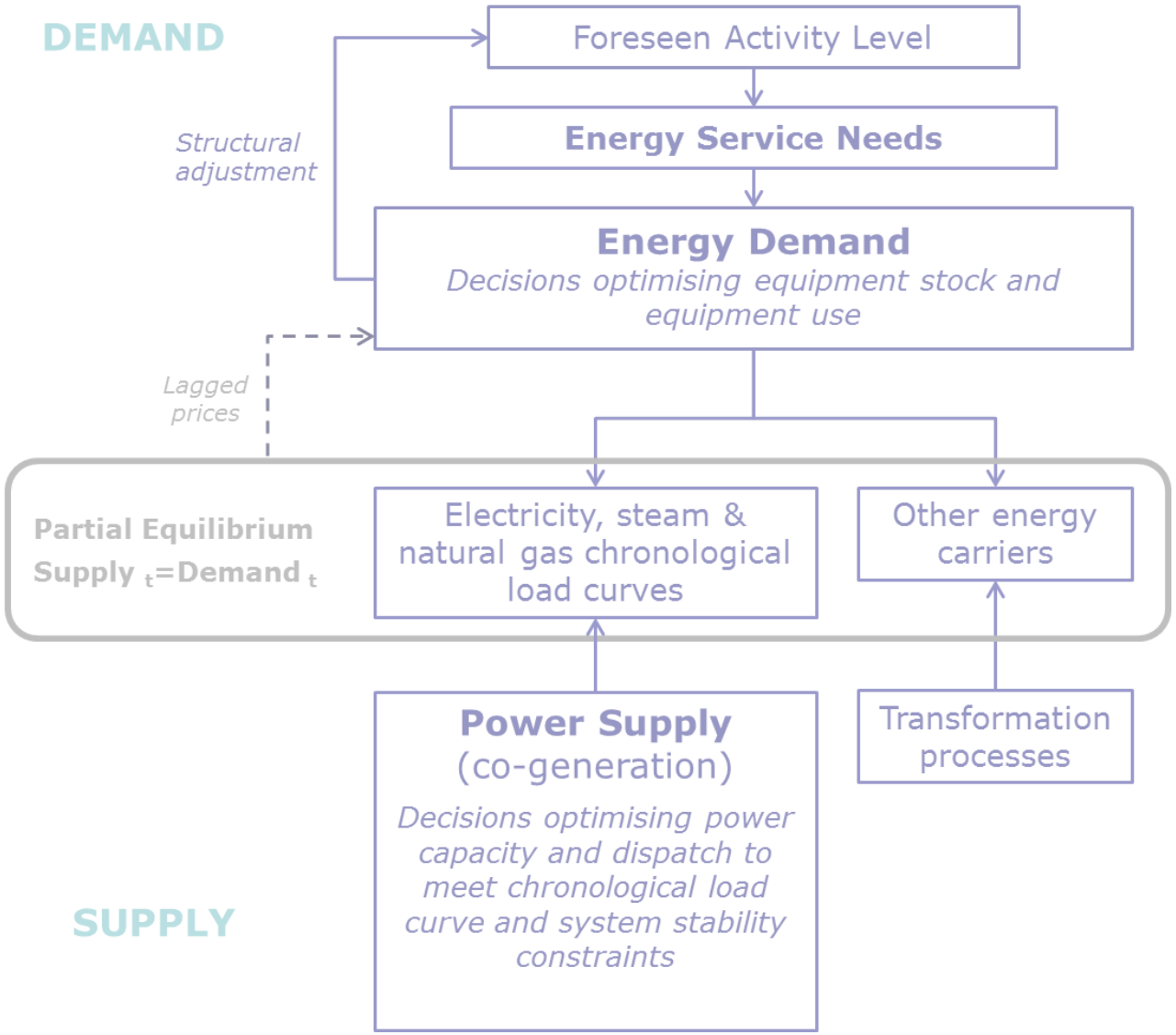
Scope of this presentation



Macro-economic & demographic assumptions

International fuel prices

Industrial activity

Techno-economic assumptions:
Power sector (exogenous learning)

Activity: buildings and transport

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Key Assumptions

Macro-economy and demographics

Population data and Projections

EUROSTAT (2017 Population Projections used)

Macroeconomic data and projections expressed in €2010

EUROSTAT historical data (from 2000 up to 2015-2016)

- **National accounts ESA 2010**
- **SBS statistics**

€2010 obtained from current prices by applying the corresponding deflator

Projection for GDP

- 2017-2019: from the **AMECO database** published forecasts - DG ECFIN

also for gross value added and private consumption expenditure

- 2020 onwards: based on the assumptions of the "2018 Ageing Report" – EPC and DG ECFIN

Projection for sectoral value added (2016 onwards)

- own estimates

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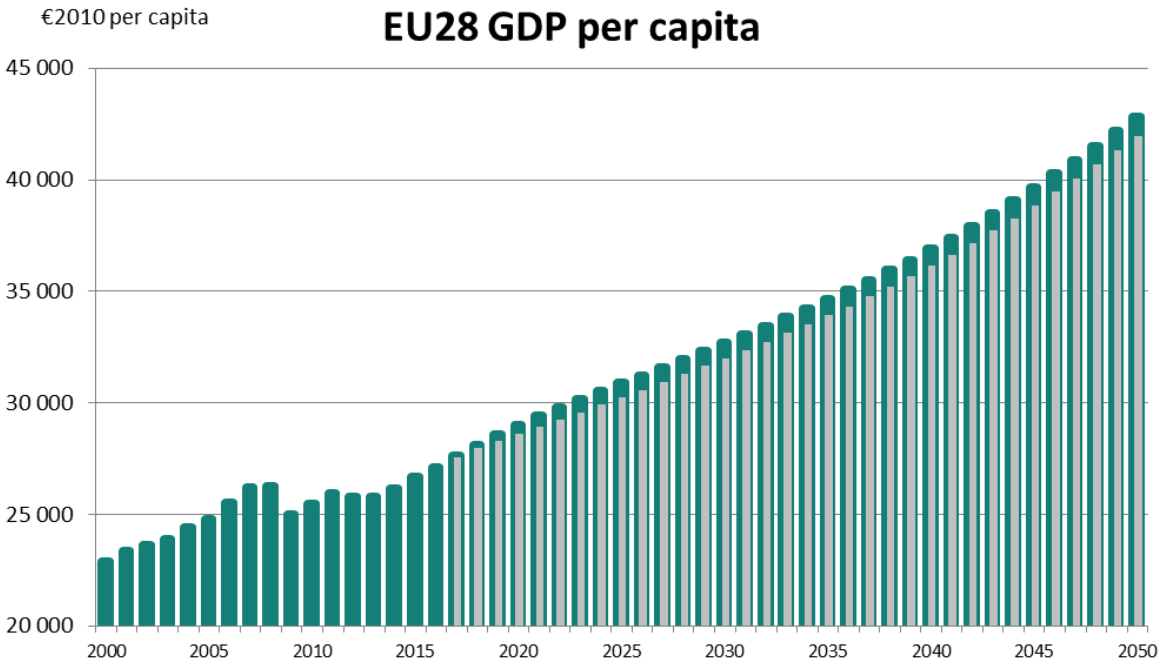
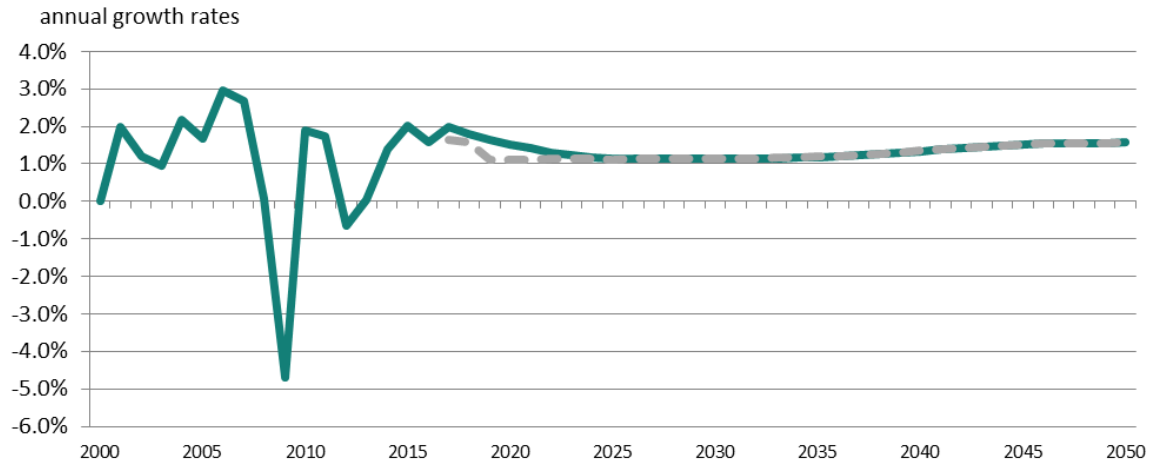
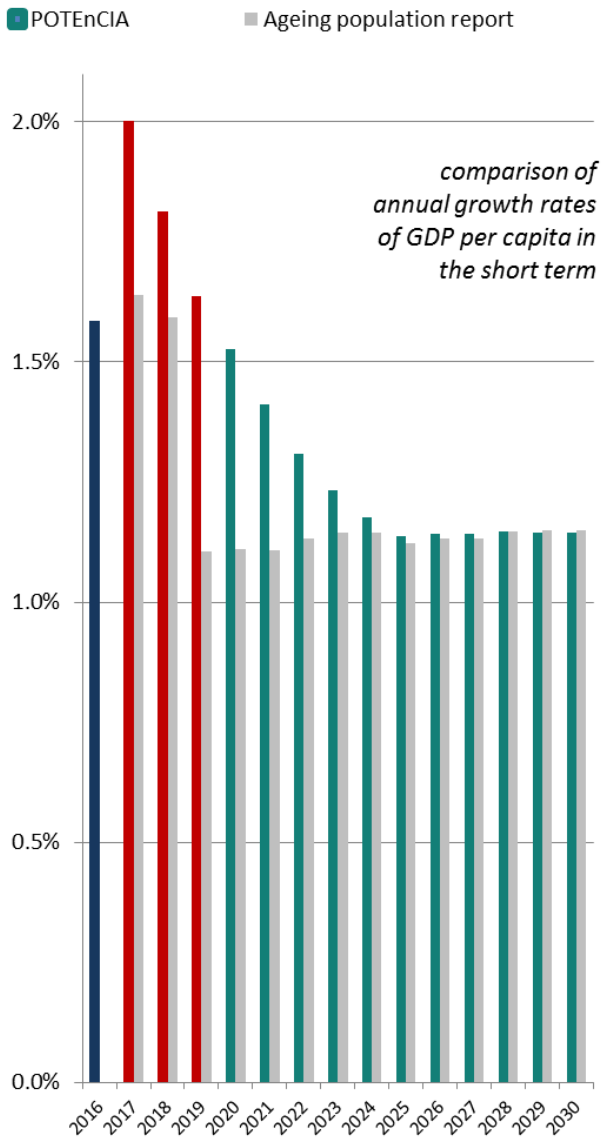
Key Assumptions

Macro-economy and demographics







Adjustments in 2020-2025 apply as to bridge

- AMECO projections to
- Ageing report assumptions

Country specific

GDP per capita grows at an average annual growth rate of

1.36% pa in 2015-2050

(1.31% pa in the Ageing report)

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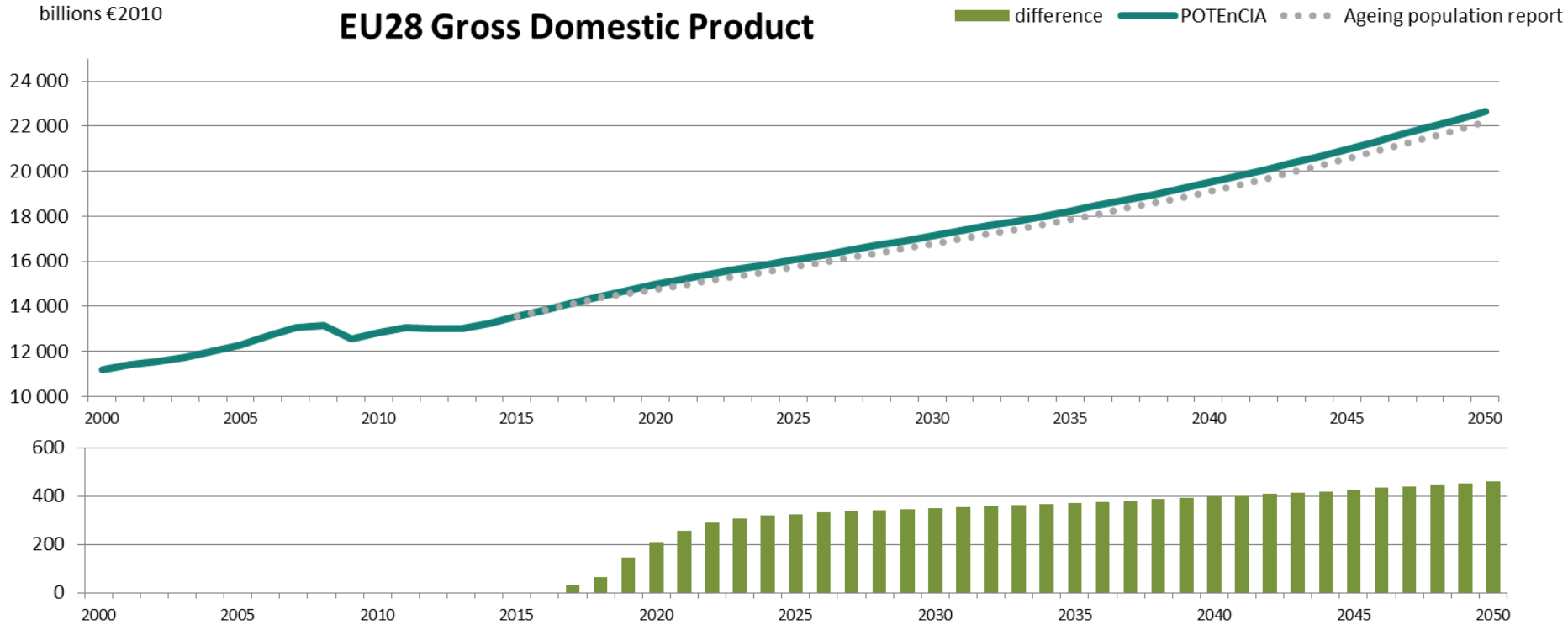
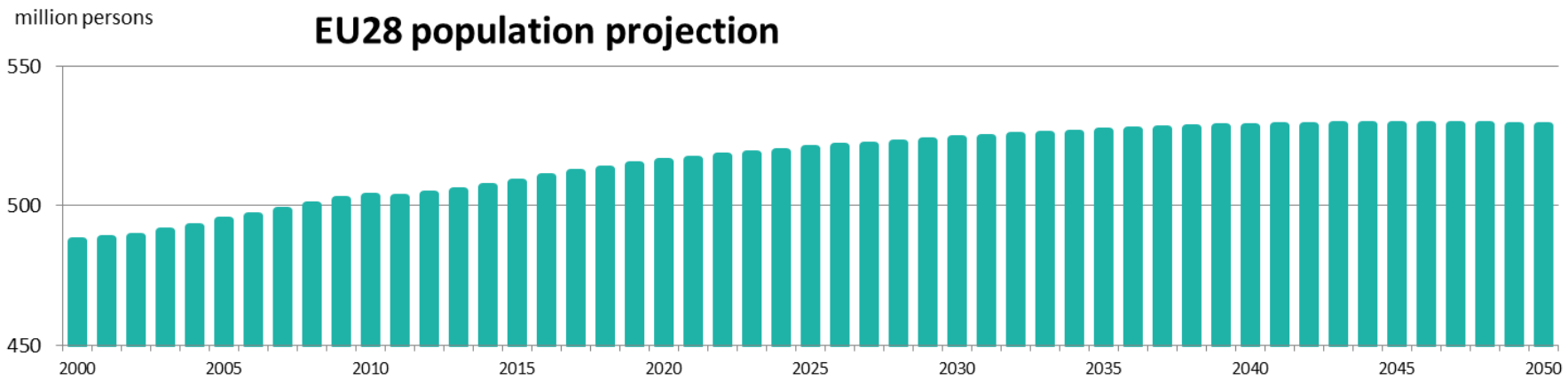
Key Assumptions

Macro-economy and demographics





Total GDP grows by 1.47% pa in 2015-2050

Adjustments lead to an annual increase of the GDP by up to 460 billion €2010

(or 1.9% in cumulative terms)

EU population grows at a rate of 0.1% pa

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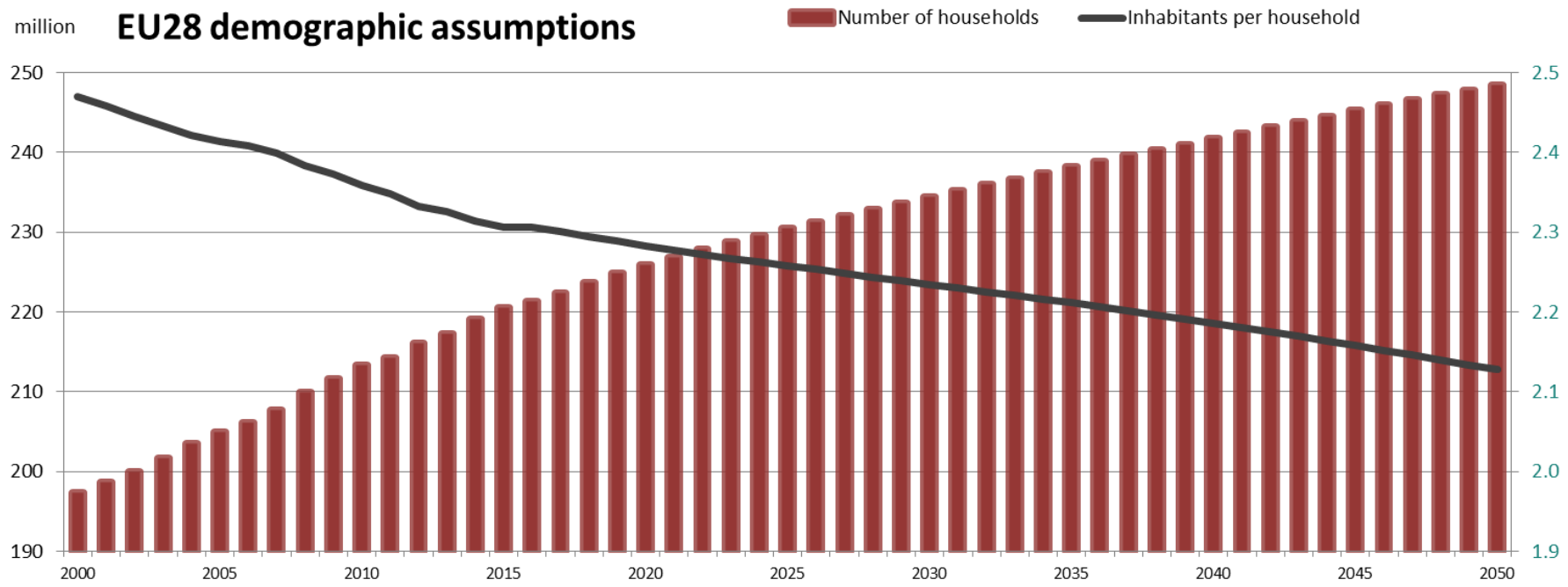
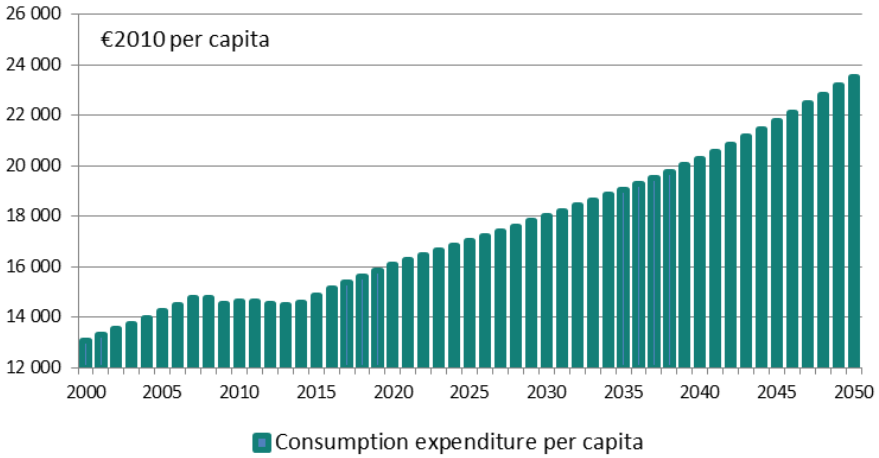
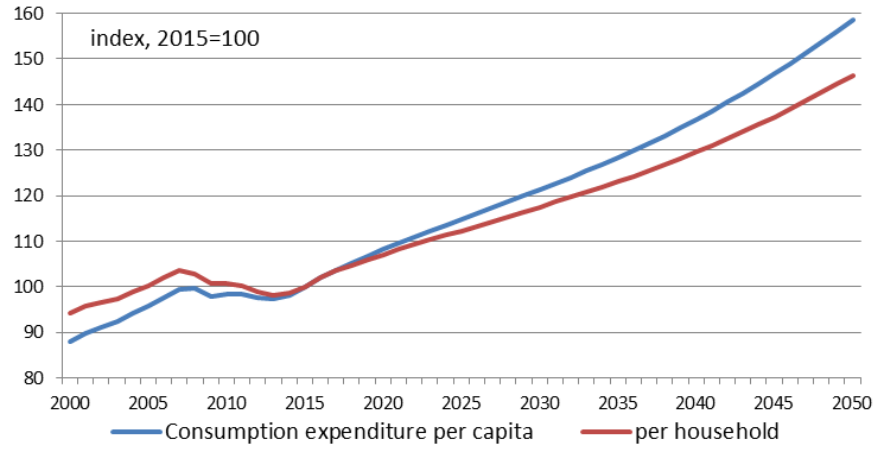
Key Assumptions

Macro-economy and demographics







Households size declines

- 2.31 inh/household in 2015
- 2.13 in 2050

Number of households increases by 0.3% pa

- Income per capita grows by 1.3% pa
- Income per household grows by 1.1% pa

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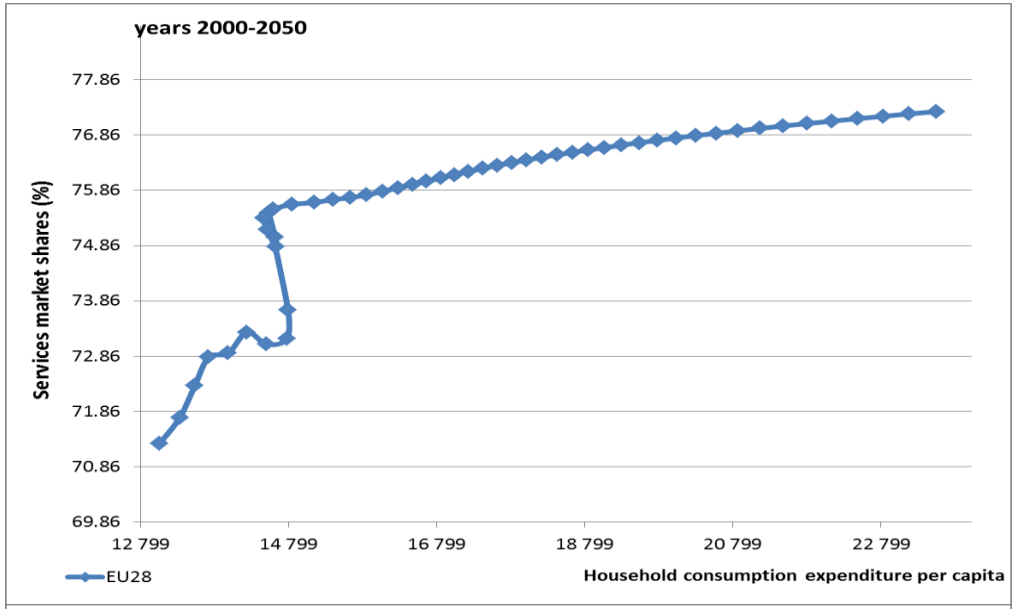
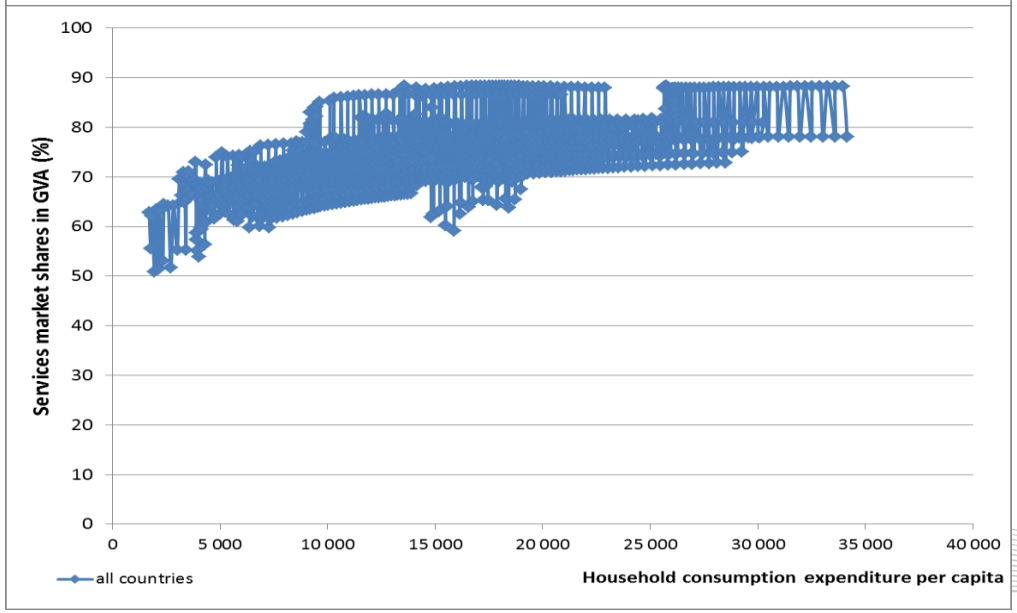
Key Assumptions

Structure of the economy





Key Assumptions

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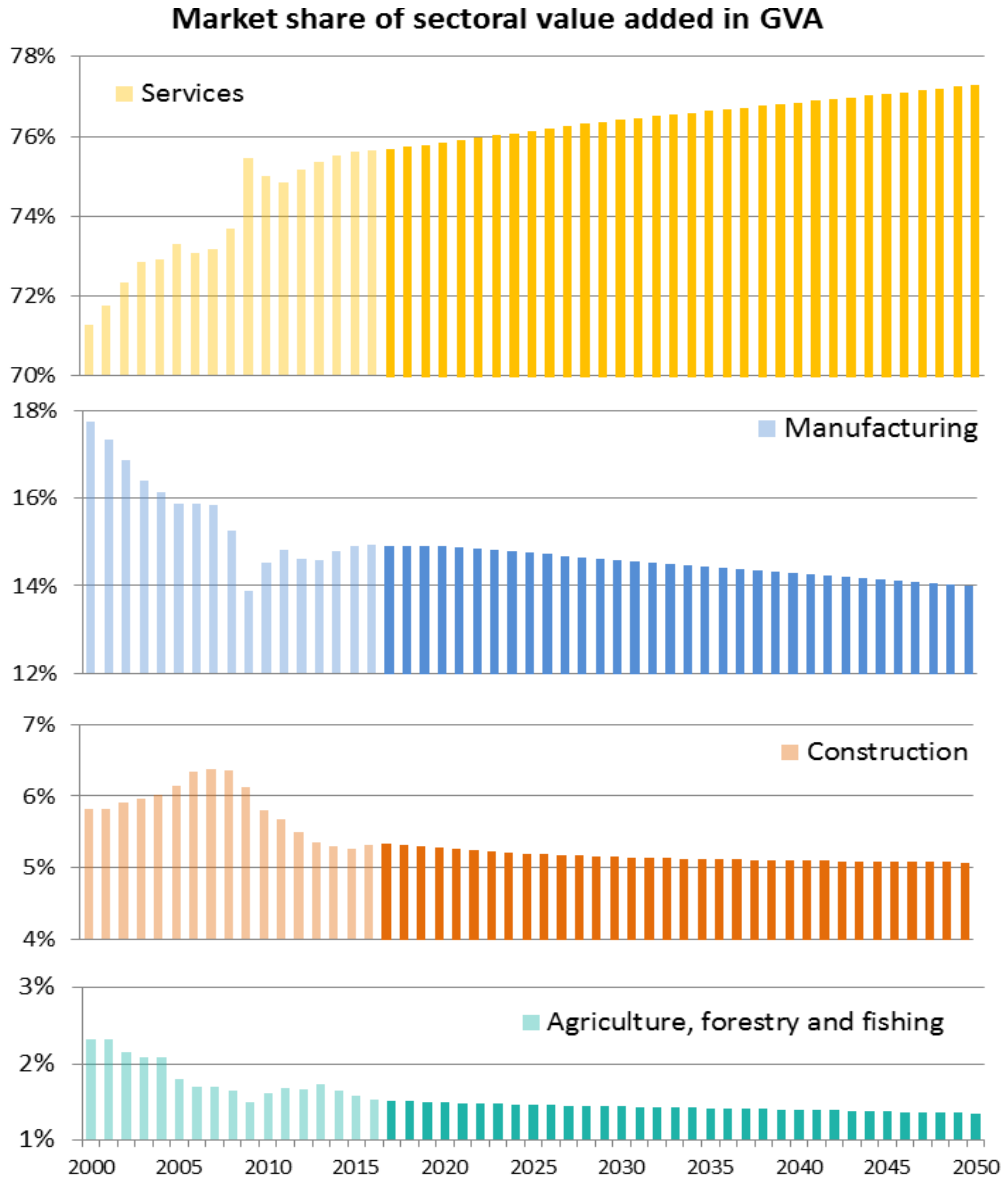

The restructuring of the EU economy continues

- Services reach 77.3% in 2050 (+1.7 percentage points from 2015 levels)
- Manufacturing declines from 14.9% in 2015 to 14.0% in 2050
- Construction and agriculture broadly stabilises (5.3% to 5.1%; 1.6% to 1.4%)

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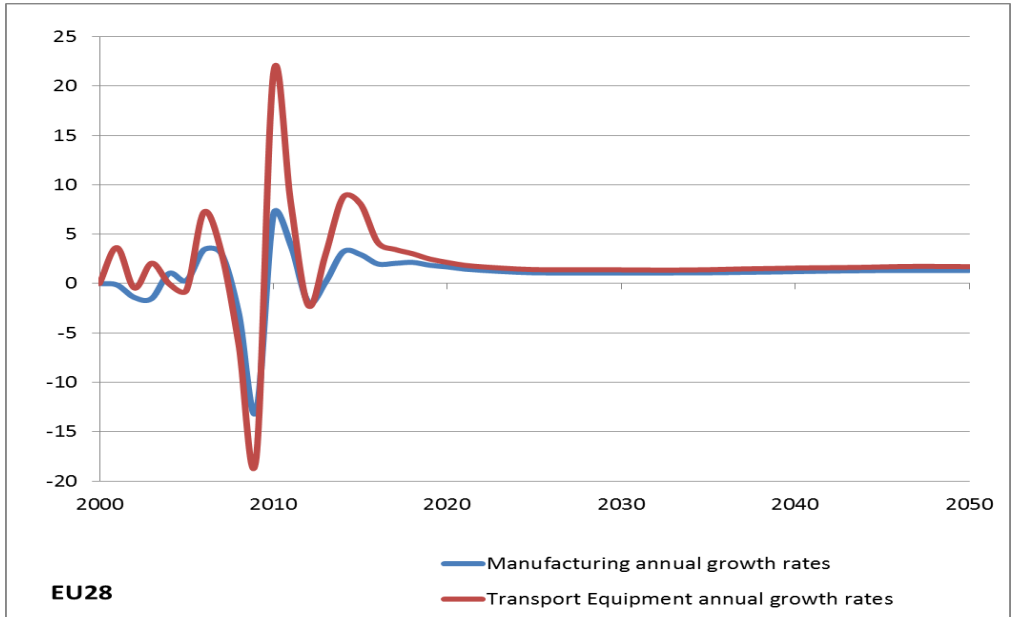
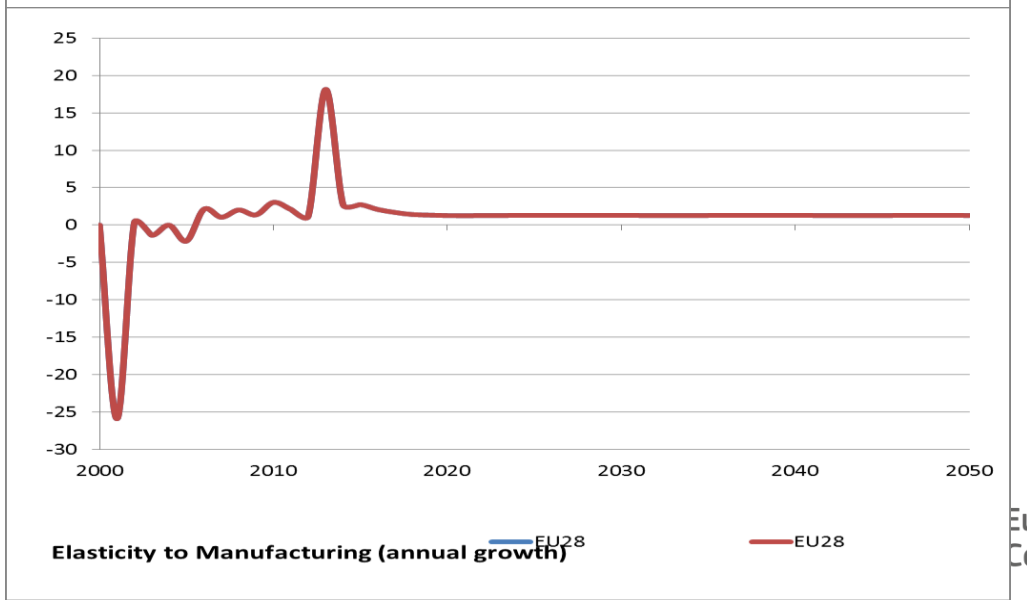
Key Assumptions

Structure of the economy





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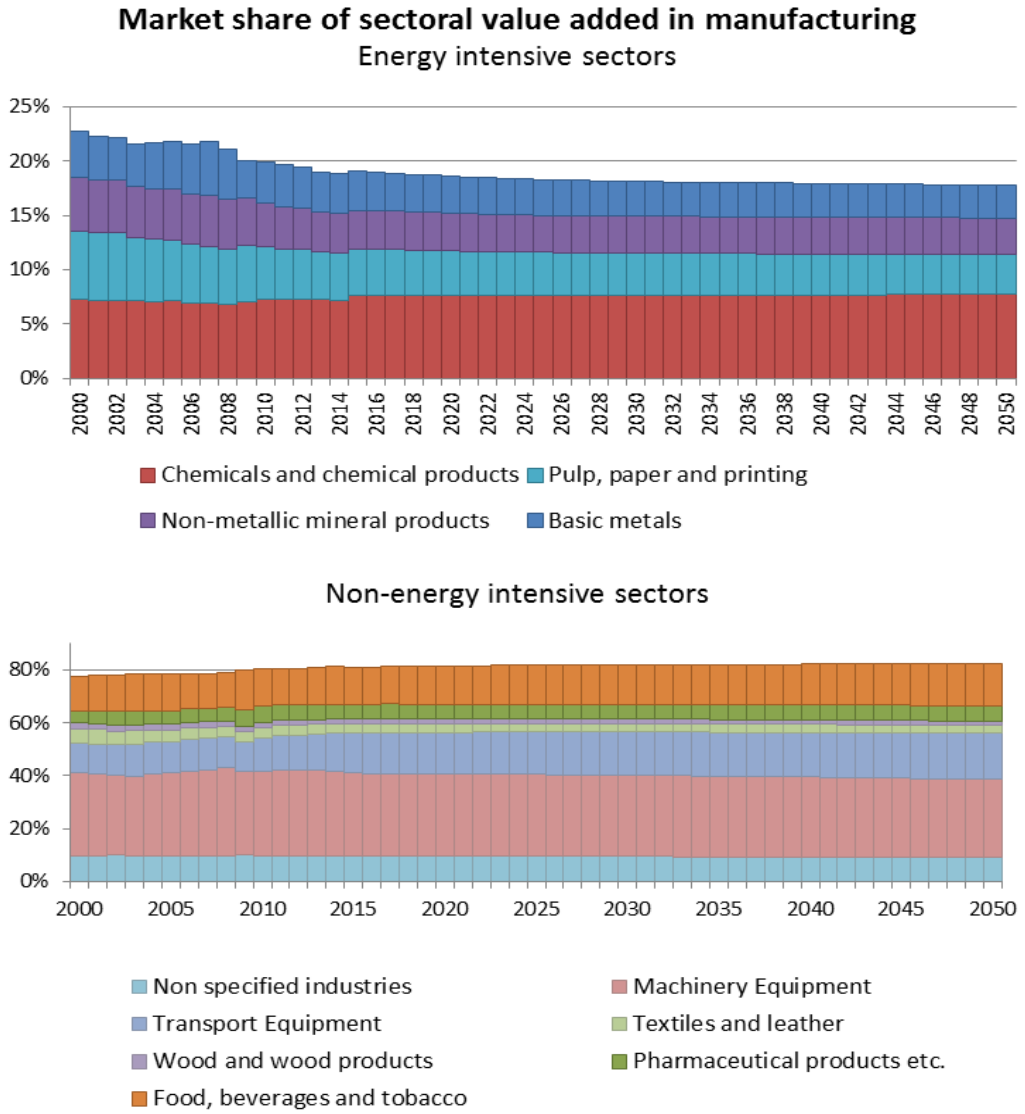
Key Assumptions

Structure of the economy



VA from energy intensive sectors in manufacturing decreases from 19.1% to 17.8%

- Decreasing share of basic metals, pulp, paper and printing
- Stable share of chemicals and chemical products

Fastest growing sectors are

- transport equipment and
- food, beverages and tobacco industries

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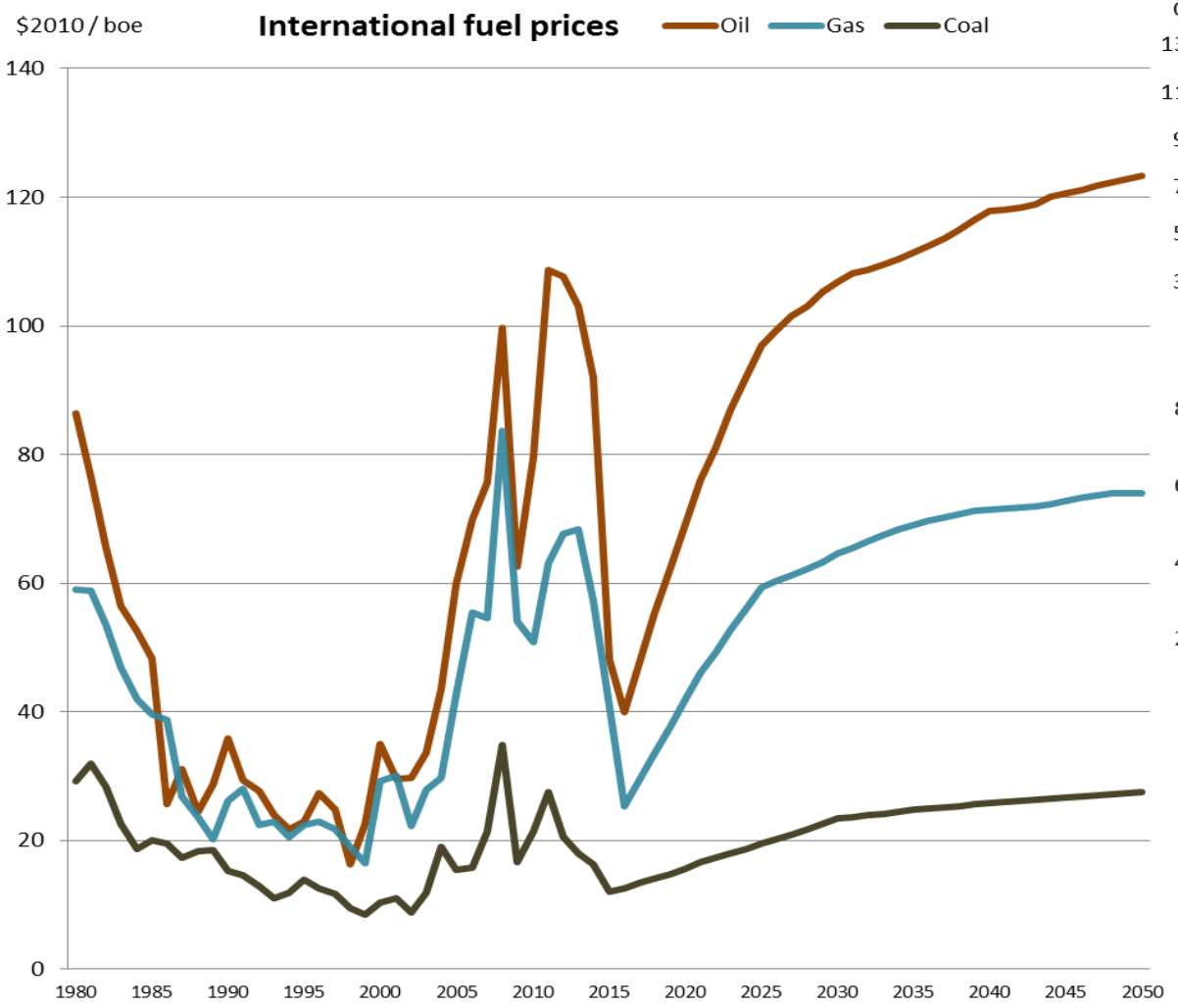
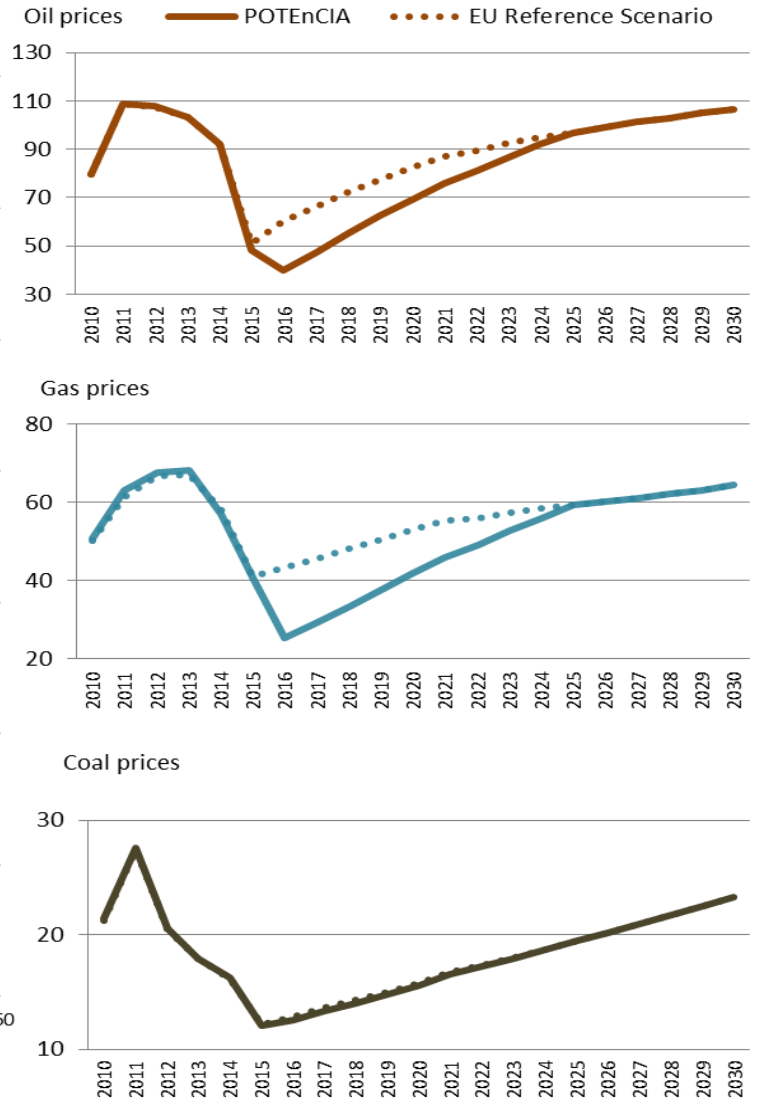
Key Assumptions

International fossil fuel prices





Prices assumptions aligned to the EU Reference Scenario 2016

Updated for historical values up to 2016

- World Bank (Gas and Oil)
- BP Statistics (Coal)

Gradual convergence to the Reference Scenario values is performed from 2017 to 2024

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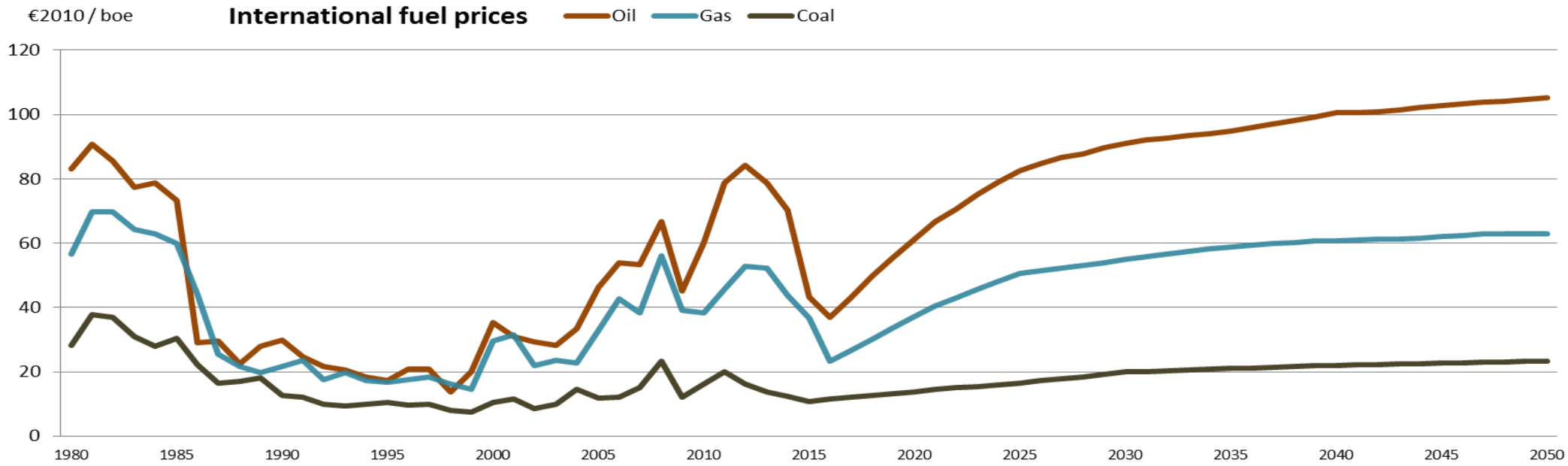
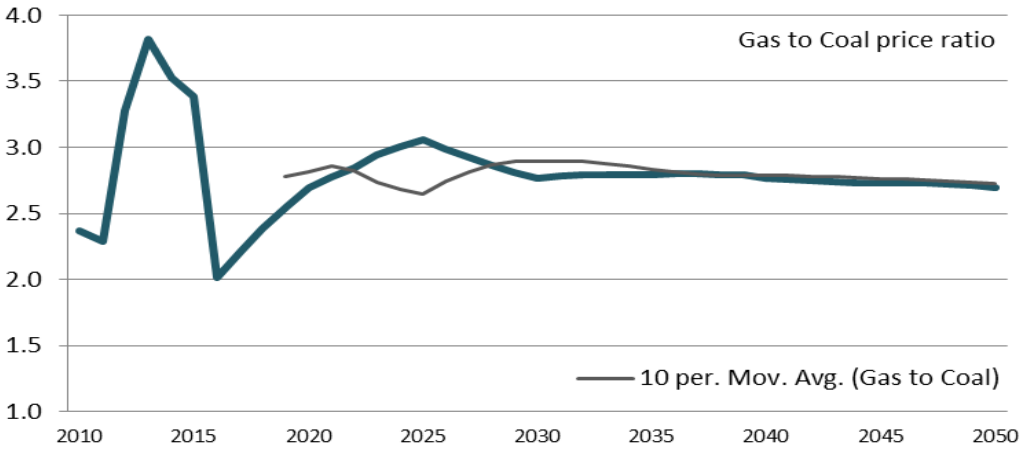
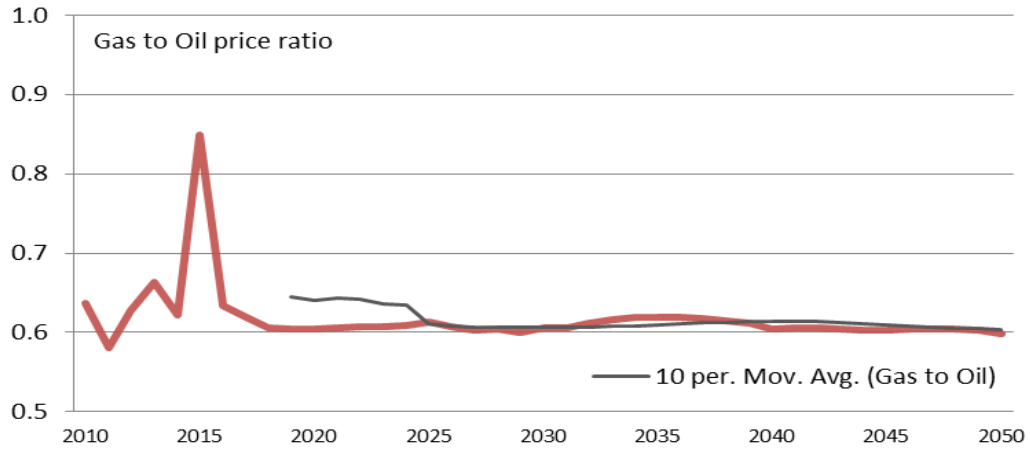
Key Assumptions

International fossil fuel prices







Key Assumptions – industrial activity

Industrial sectors

Energy Intensive

Iron and steel
- Integrated steelworks
- Electric arc

Non-ferrous metals
- Alumina production
- Aluminium primary production
- Aluminium secondary production
- Other non-ferrous metals

Chemicals
- Basic chemicals
- Other chemicals
- Pharmaceutical products etc.

Non-metallic minerals
- Cement
- Ceramics & other NMM
- Glass production

Paper and pulp
- Pulp production
- Paper production
- Printing and media reproduction

Non-energy Intensive

Food, Beverages and Tobacco

Transport equipment

Machinery equipment

Textiles and Leather

Wood and wood products

Other industrial sectors

Including:

Mining and quarrying

Construction

Non-specified industries

Key Assumptions – industrial activity

Industrial sectors

Model Description	NACE code	NACE Description	Source
Gross domestic product	B1GM	Gross domestic product at market prices	EUROSTAT Statistics: nama_gdp
Household consumption expenditure	P31_S14_S15	Household and NPISH final consumption expenditure	EUROSTAT Statistics: nama_gdp
Gross value added	B1G	Gross value added (at basic prices)	EUROSTAT Statistics: nama_gdp
Manufacturing	C excluding C33		
Basic metals	C24		
	C24	Manufacture of basic metals	EUROSTAT Statistics: nama_nace64
Iron and steel			
	C241	Manufacture of basic iron and steel and of ferro-alloys	EUROSTAT Structural business statistics: sbs_ind_co
	C242	Manufacture of tubes, pipes, hollow profiles and related fittings, of steel	EUROSTAT Structural business statistics: sbs_ind_co
	C243	Manufacture of other products of first processing of steel	EUROSTAT Structural business statistics: sbs_ind_co
	C2451	Casting of iron	EUROSTAT Structural business statistics: sbs_ind_co
	C2452	Casting of steel	EUROSTAT Structural business statistics: sbs_ind_co
Non ferrous metals			
Alumina production			
Aluminium production			
Other non-ferrous metals			
	C2442	Aluminium production	EUROSTAT Structural business statistics: sbs_ind_co
	C2453	Casting of light metals	EUROSTAT Structural business statistics: sbs_ind_co
	C2441	Precious metals production	EUROSTAT Structural business statistics: sbs_ind_co
	C2443	Lead, zinc and tin production	EUROSTAT Structural business statistics: sbs_ind_co
	C2444	Copper production	EUROSTAT Structural business statistics: sbs_ind_co
	C2445	Other non-ferrous metal production	EUROSTAT Structural business statistics: sbs_ind_co
	C2446	Processing of nuclear fuel	EUROSTAT Structural business statistics: sbs_ind_co
	C2454	Casting of other non-ferrous metals	EUROSTAT Structural business statistics: sbs_ind_co
Chemicals Industry	C20, C21		
Chemicals and chemical products	C20		
	C20	Manufacture of chemicals and chemical products	EUROSTAT Statistics: nama_nace64
Basic chemicals			
	C2013	Manufacture of other inorganic basic chemicals	EUROSTAT Structural business statistics: sbs_ind_co
	C2014	Manufacture of other organic basic chemicals	EUROSTAT Structural business statistics: sbs_ind_co
	C2015	Manufacture of fertilisers and nitrogen compounds	EUROSTAT Structural business statistics: sbs_ind_co
	C2016	Manufacture of plastics in primary forms	EUROSTAT Structural business statistics: sbs_ind_co
Other chemicals			
	C2011	Manufacture of industrial gases	EUROSTAT Structural business statistics: sbs_ind_co

Key Assumptions – industrial activity

Industrial output: concept

Physical tonnes of output:

- Sectors with a clearly defined product

Iron and steel	t steel
Alumina	t alumina
Aluminium	t aluminium
Cement	t cement
Pulp	t pulp
Paper	t paper

'Equivalent tonnes' of output:

- Relates the production to a clearly defined product
- By means of value added and energy intensity
- Accounting for additional information (if available)

Other non-ferrous metals	t lead eq.
Chemicals	t ethylene eq.
Ceramics & other NMM	t bricks eq.
Glass production	t container glass eq.
Printing and media reproduction	t paper eq.

'Physical output index':

- For non-energy intensive sector
- Proxy – at EU level matches VA
- Product with similar useful energy requirements

Key Assumptions – industrial activity

data and approach

Historical data

- EUROSTAT
- UN databases (UNFCC National GHG Inventory Submissions)
- U.S. Geological Survey Minerals Information Commodity Statistics and Information; European Minerals Statistics of the British Geological Survey
- Industry associations statistics
- Specific studies and reports (EC incl. JRC; IEA etc.)

Projections

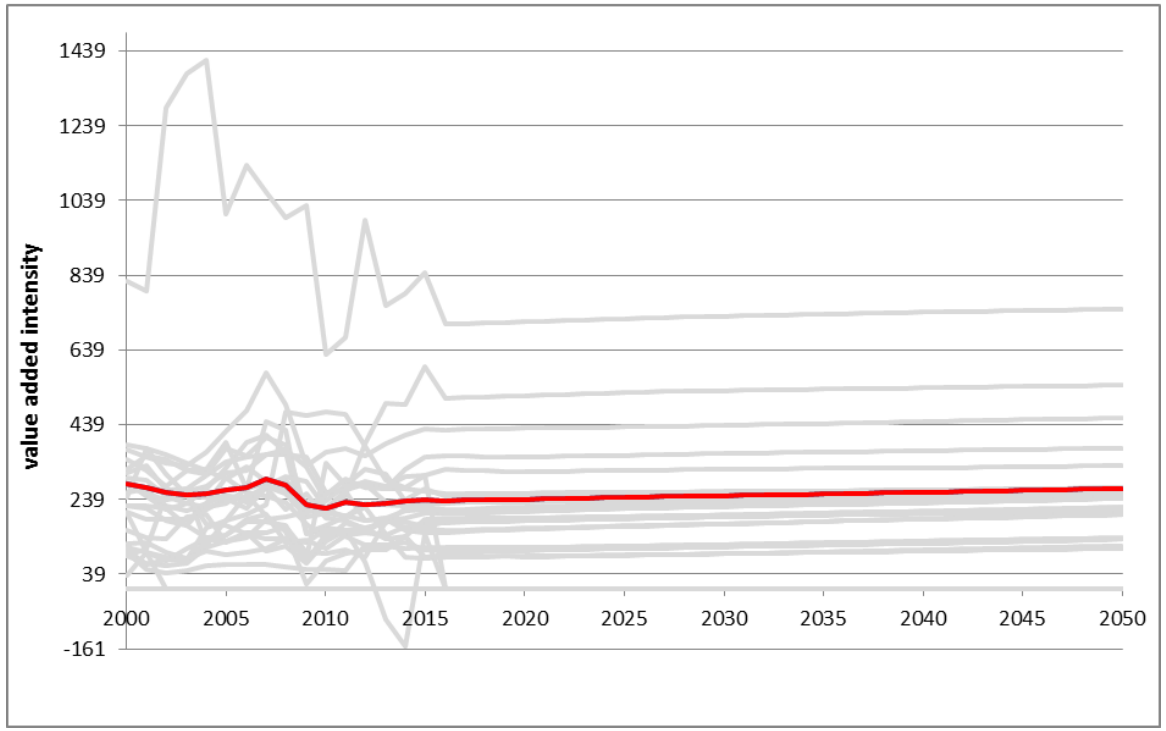
Evolution links to

- wages (household income)
- material costs
- historical trends
- the sector's VA growth rate
- very limited convergence to respect different product characteristics

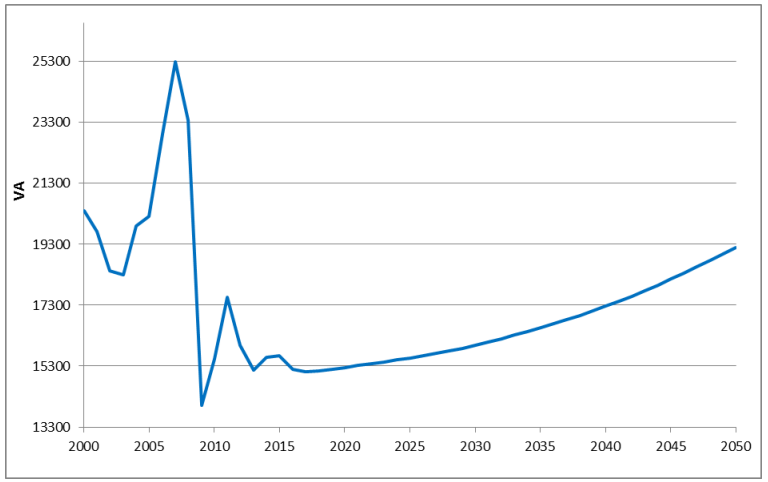
Key Assumptions – industrial activity

Illustration: Iron and Steel - EAF

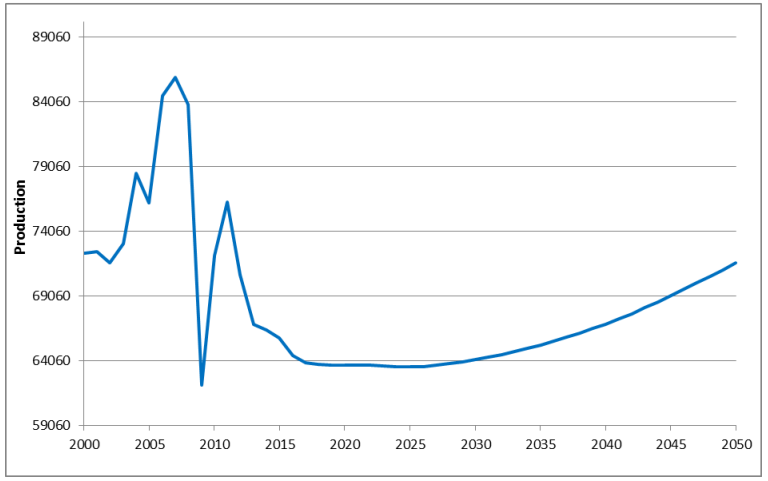
Value added intensity (country in blue, EU28 in red, other countries greyed) (€2010 / unit of prd)



Value added



Production



European Commission

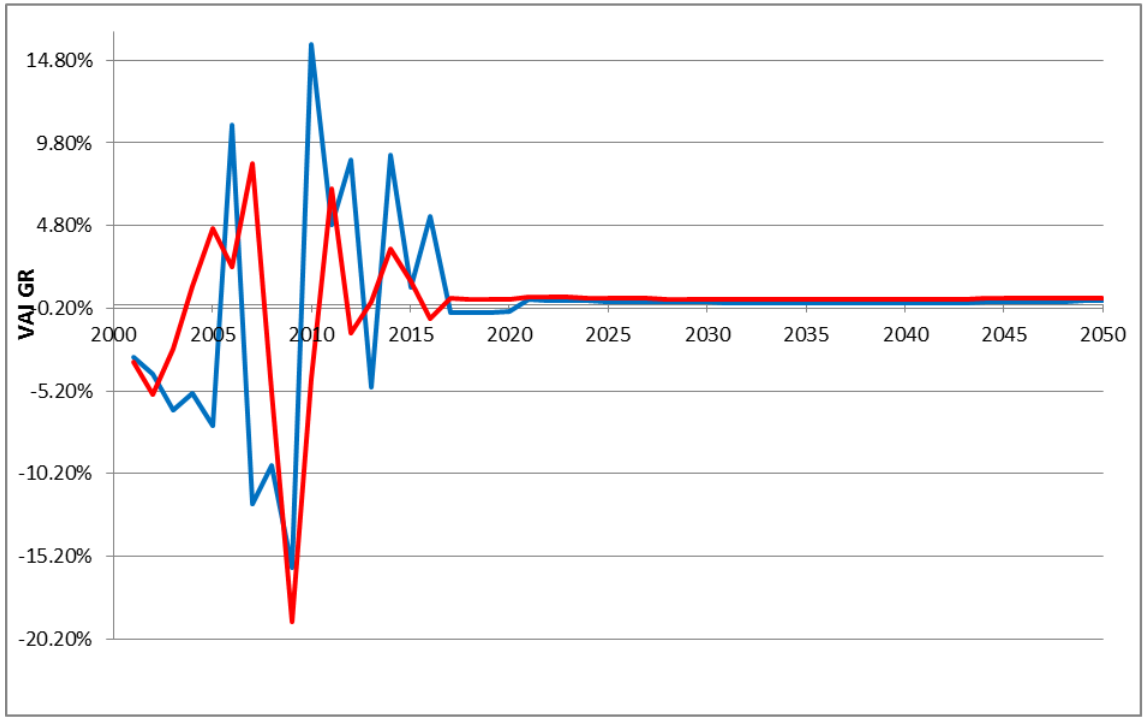
Key Assumptions – industrial activity

Additional information made available

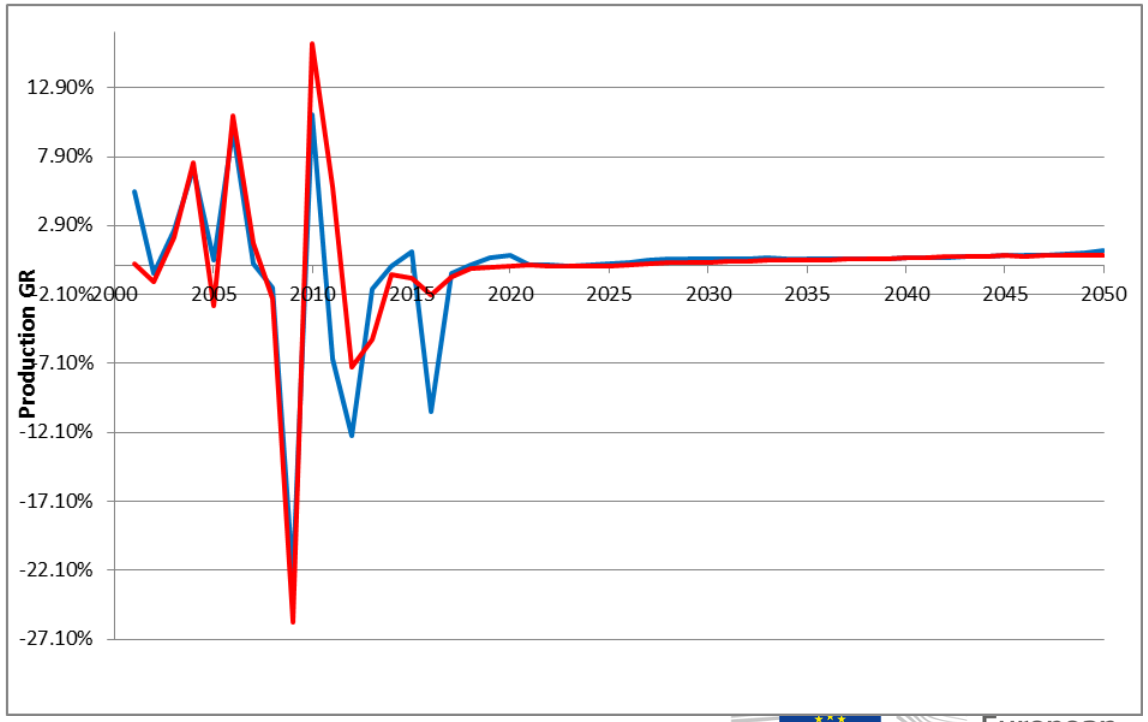
Country comparison to EU28 average

Growth rates of value added, value added intensity and production

Value added intensity (country in blue, EU28 in red) growth rate



Production (country in blue, EU28 in red) growth rate)



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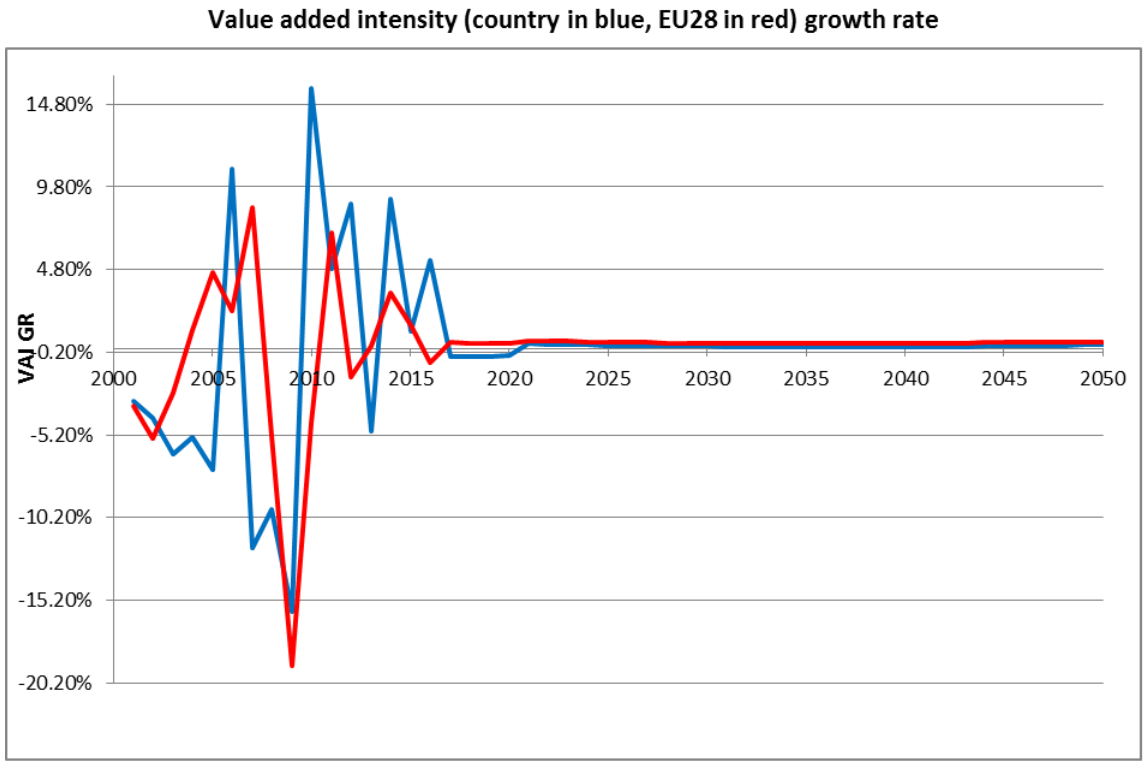
Key Assumptions – industrial activity

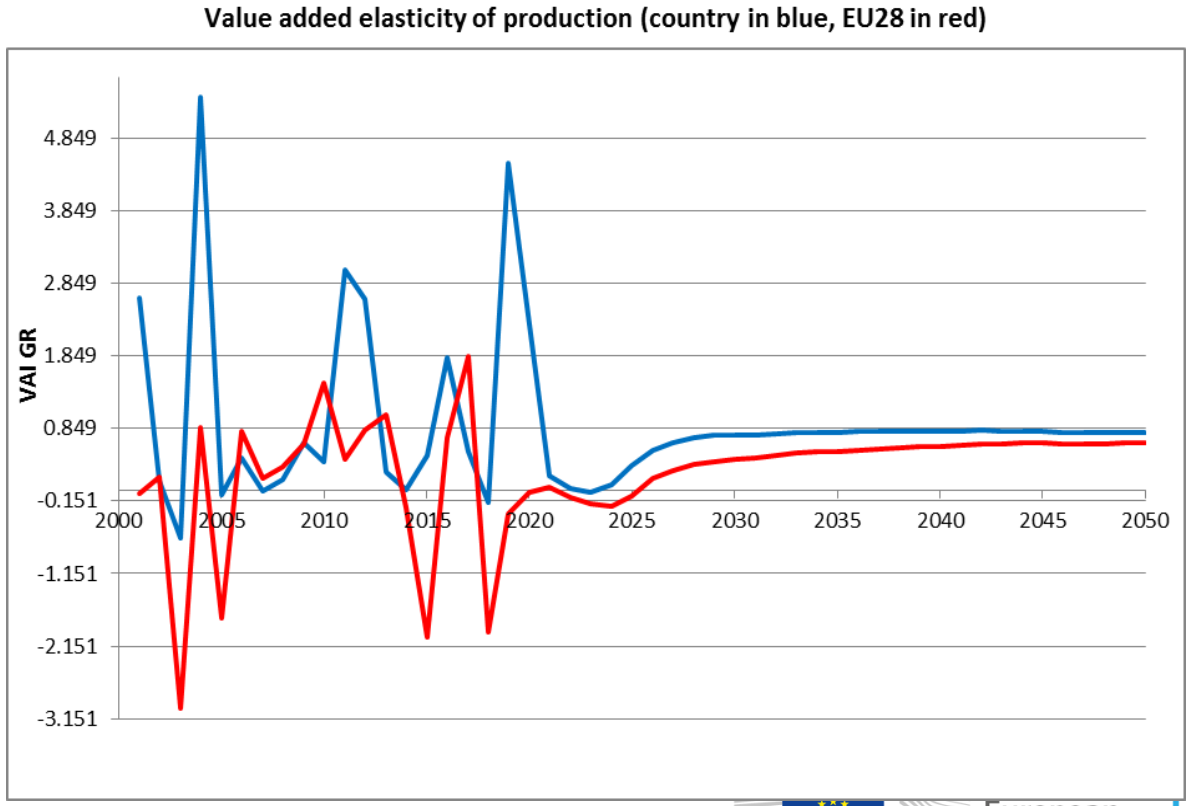
Additional information made available

Country comparison to EU28 average

Growth rates of value added, value added intensity and production

Value added elasticity of production





Data Files

Demographics
- Population
- Number of households
- Inhabitants per household

Macro-economic assumptions
- Gross domestic product
- Household consumption expenditure
- VA by sector

Industry
- Definition file
- Envisaged production volumes
- Value added intensity

accompanied by a series of graphs illustrating trends in
- Absolute figures
- Growth rates
- Elasticities
- Comparison to the EU28

Annual time steps
2000-2050
by **Member State**

Power generation technologies

MEMBER STATES EXPERTS' WORKSHOP ON THE POTENCIA MODEL

Brussels, 26 February 2018

European Commission

Power plant types

- Nuclear
- Conventional thermal – 8 fuel types
  - Each fuel-type split into 3-4 technologies:
    - Steam turbine
    - Fluidized bed combustion
    - Integrated gasification combined cycle
    - Supercritical steam turbine
    - Gas turbine
    - Gas turbine combined cycle
    - Internal combustion engine
- Wind
  - On-shore / Off-shore
- Solar photovoltaics
- Solar thermal
- Geothermal
- Tide, wave and ocean
  - Tidal / Wave
- Hydro
  - Run-of river / Reservoirs (dams)
- Pump storage

- up to 4 size classes
  - *size limits vary among technologies*
- electricity only / CHP
- with/without CCS

272 power plant type groups

TECHNOLOGY CHARACTERIZATION

Each power plant type is characterised by a set of techno-economic parameters, i.e.:

- typical size of a power plant unit
- technical lifetime
- the construction time
- the technical availability (expressing the period of planned maintenance)

- capital cost
- fixed cost
- variable O&M costs

- thermal conversion efficiency
- own consumption ratio (net to gross capacity ratio)
- default steam-to-electricity ratio in the case of co-generation plants
- CO2 emissions capturing rate (for CCS power plants)
- Desired range of operation

ASSUMPTIONS – SAMPLES

- Wind on-shore:

  Capital cost going from

  1200-1650 €/kW in 2015 to

  650-900 €/kW in 2050

- Solar PV:

  Capital cost going from

  1800-2500 €/kW in 2010 and

  1000-1250 €/kW in 2015 to

  450-600 €/kW in 2050

- Nuclear IV available from 2035
- CCS plants available from 2030-2035

- CCS plants become competitive

  from 200-250 €/t of CO2

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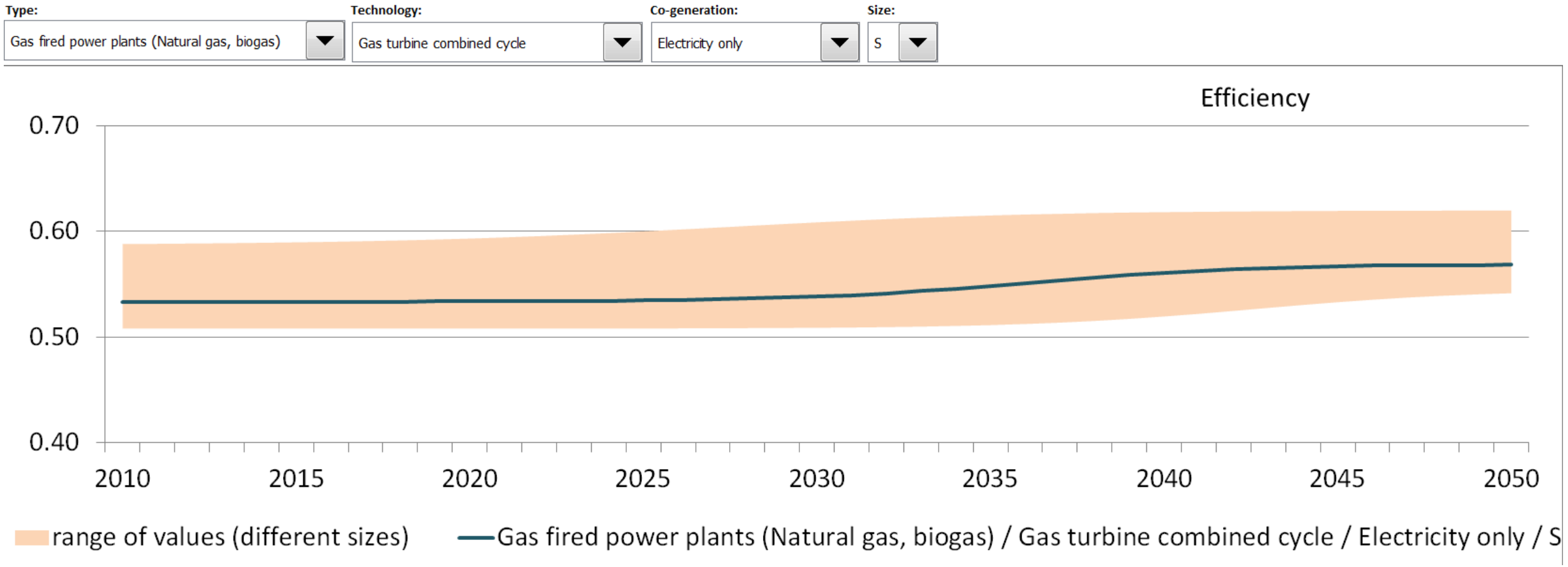
Exogenous evolution – Sample1



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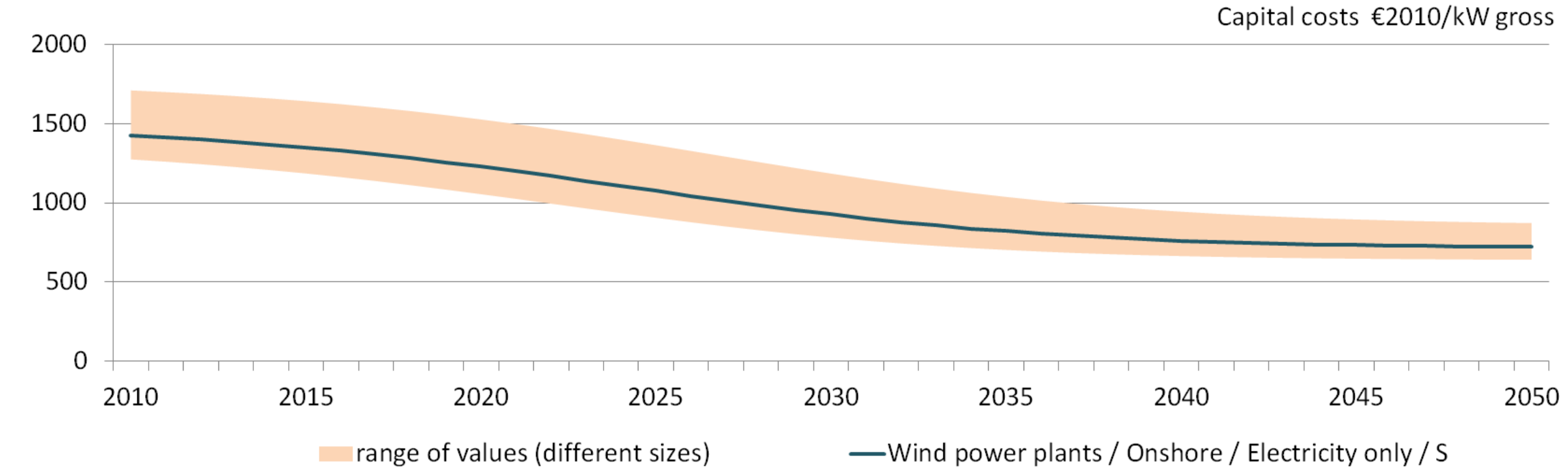
EXOGENOUS EVOLUTION – SAMPLE2

Type:	Technology:	Co-generation:	Size:
Wind power plants	Onshore	Electricity only	S



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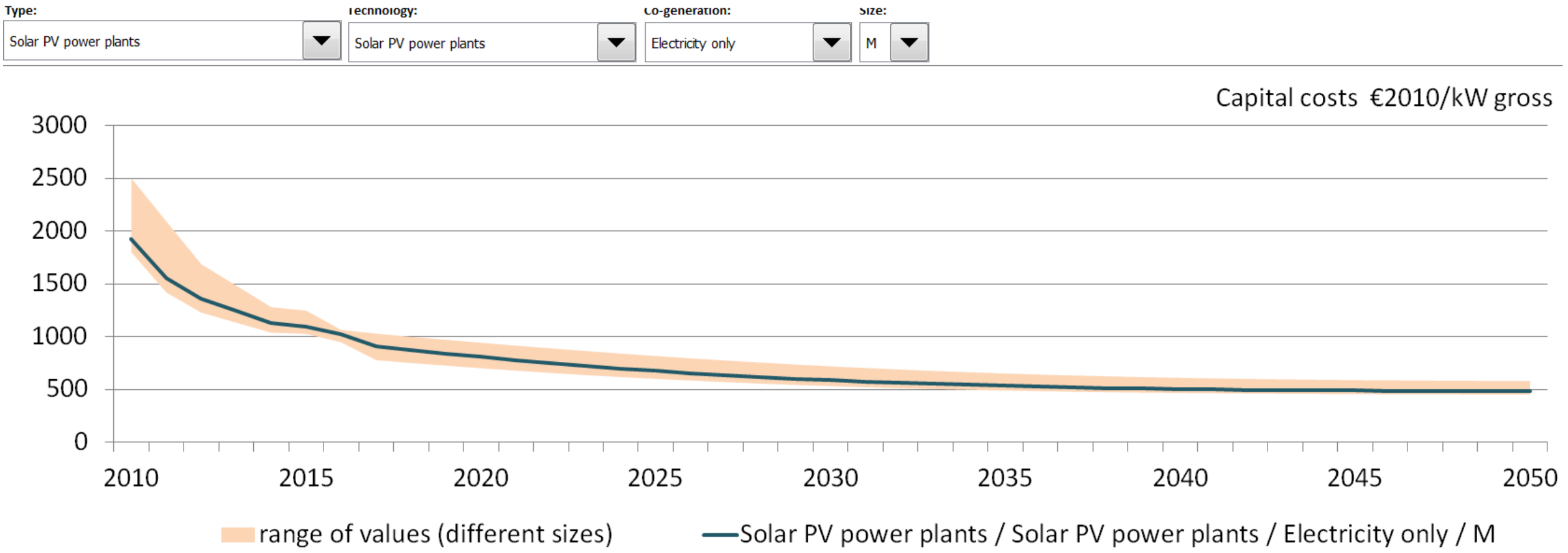
EXOGENOUS EVOLUTION – SAMPLE3



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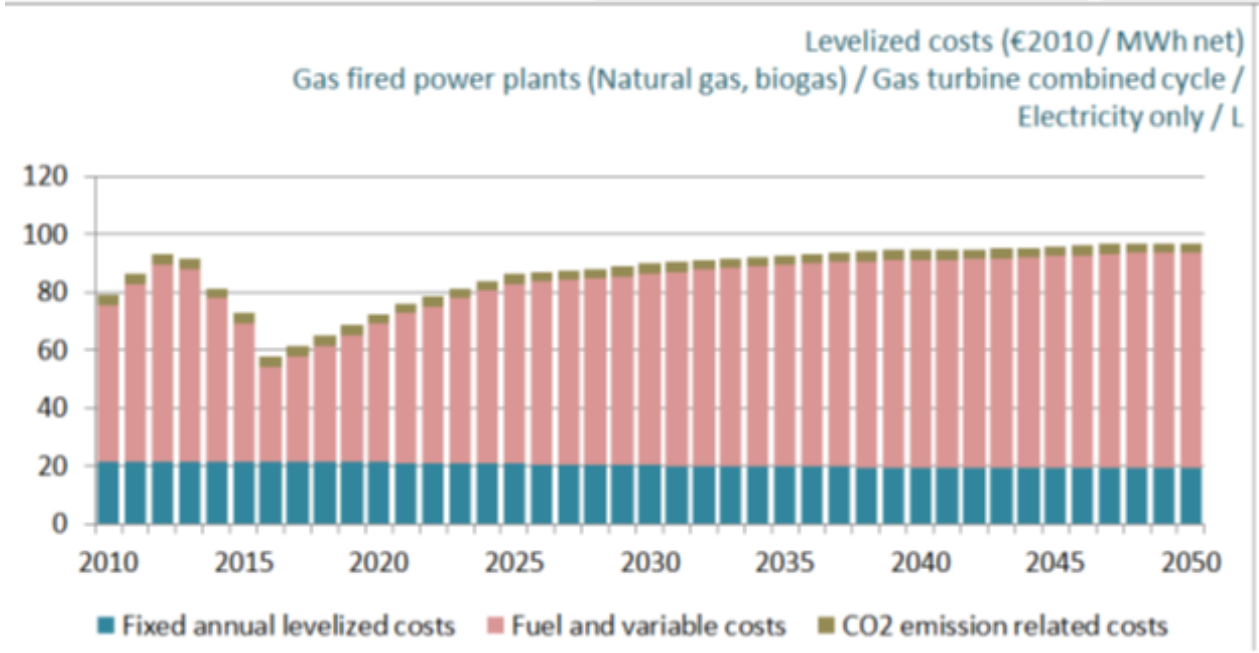
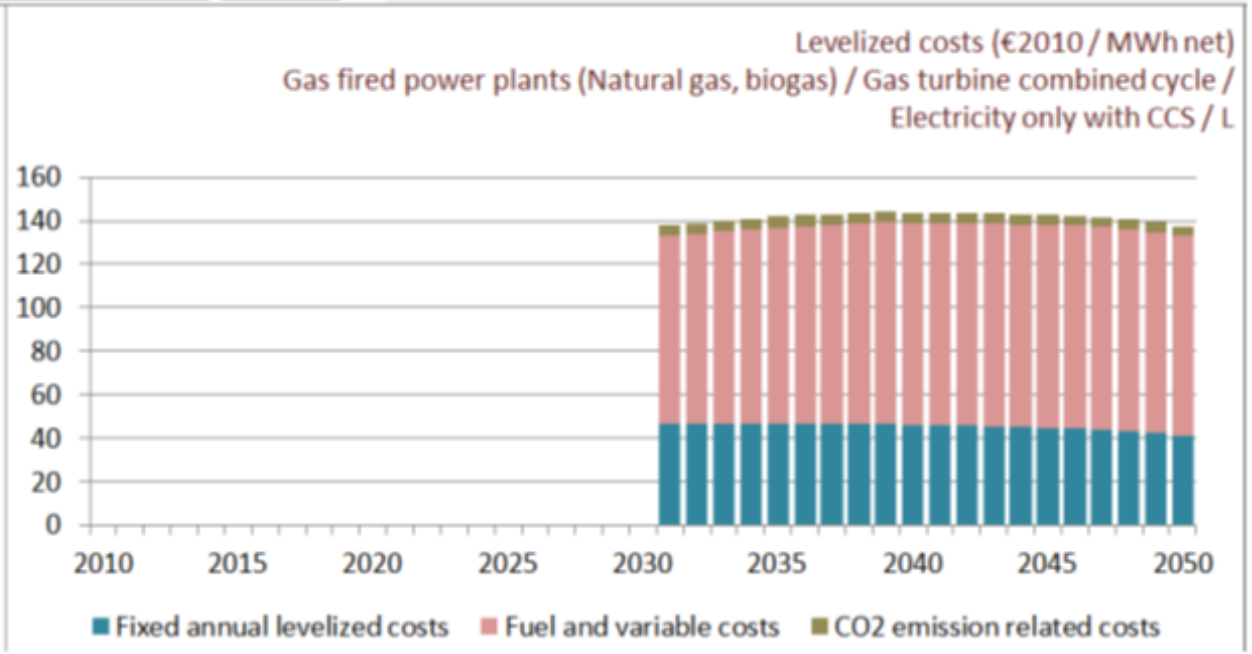
Comparison of levelized costs

Plant type for comparison (left):	Technology:	Co-generation:	Size:
Gas fired power plants (Natural gas, biogas)	Gas turbine combined cycle	Electricity only	L
Plant type for comparison (right):	**Technology:**	**Co-generation:**	**Size:**
Gas fired power plants (Natural gas, biogas)	Gas turbine combined cycle	Electricity only with CCS	L

Parameters to calculate levelized costs

Discount rate (%):	Annual operating hours:	CO2 price (€2010 / t CO2):
8.0%	5000	10
manual (discount rate):		manual (CO2 price):





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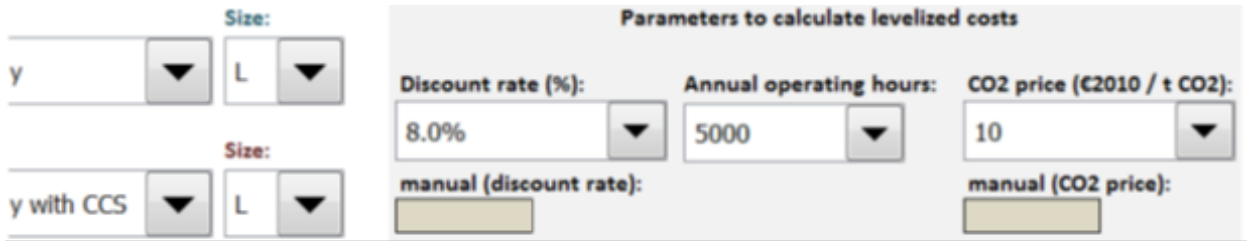
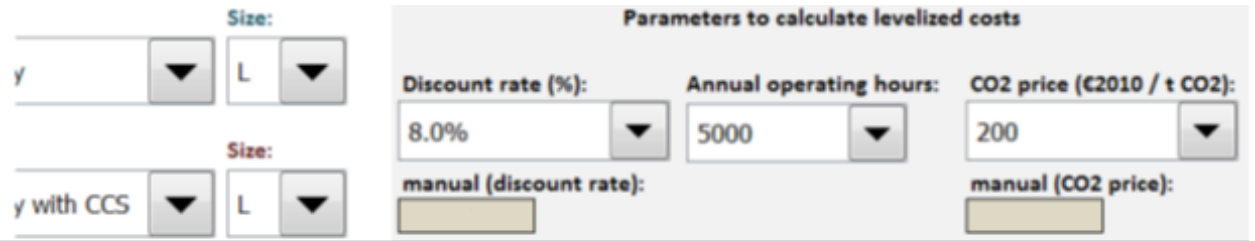
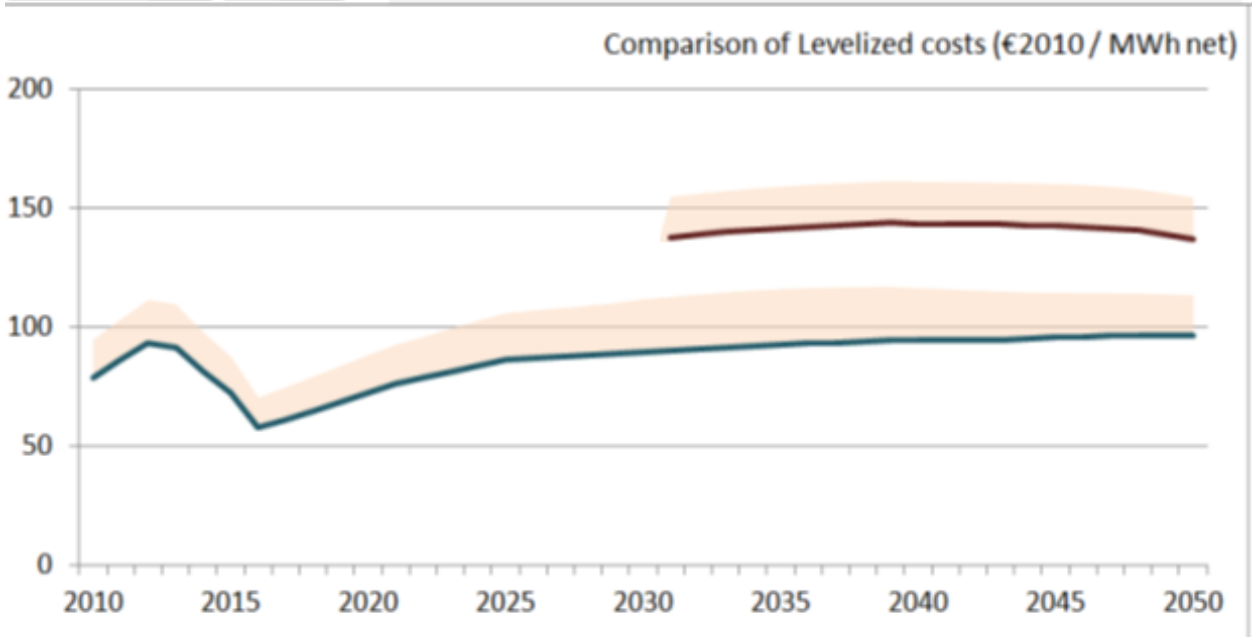
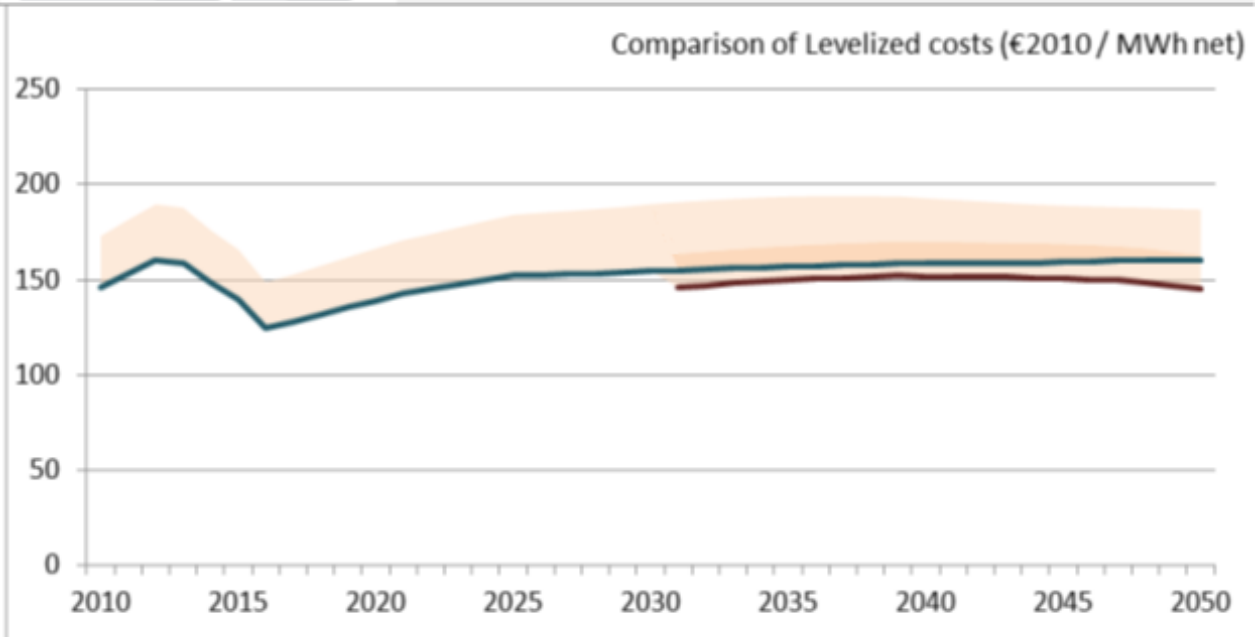
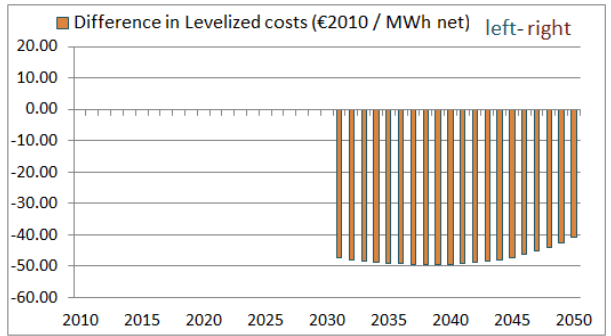
Comparison of levelized costs - scenarios



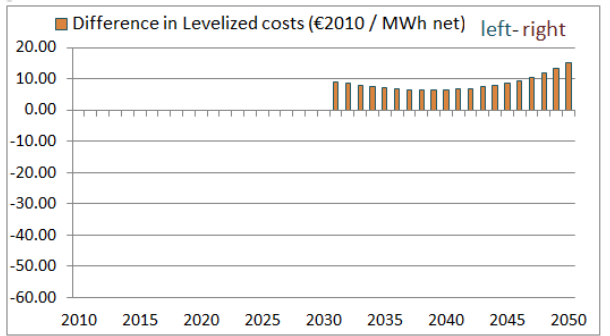








range of values (different sizes)



range of values (different sizes)

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Sources

- Joint Research Centre
  - Energy Technology Reference Indicator
  - SET-Plan European Technology and Innovation Platforms (SETIS)
  - Specific technology studies (PV Status Report, etc.)

- International Energy Agency
- National Renewable Energy Laboratory
- European Technology Platform for Zero Emission Fossil Fuel Power Plants
- Global CCS Institute

"Entry Point "Scenario Assumptions
BUILDINGS

MEMBER STATES EXPERTS' WORKSHOP ON THE POTENCIA MODEL

Brussels, 26 Feb 2018

European Commission

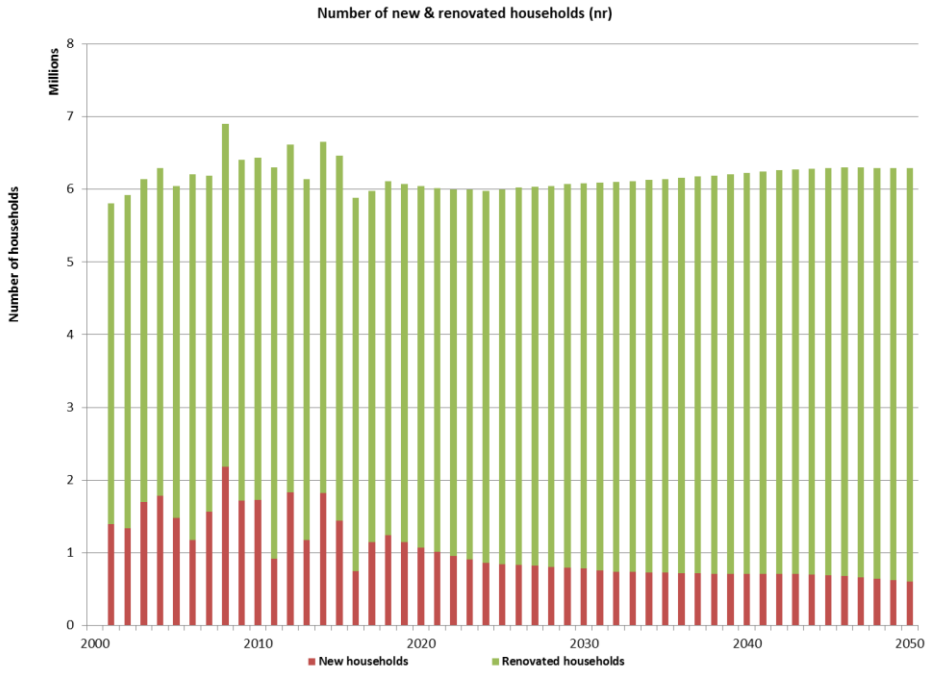
BUILDING CHARACTERISTICS

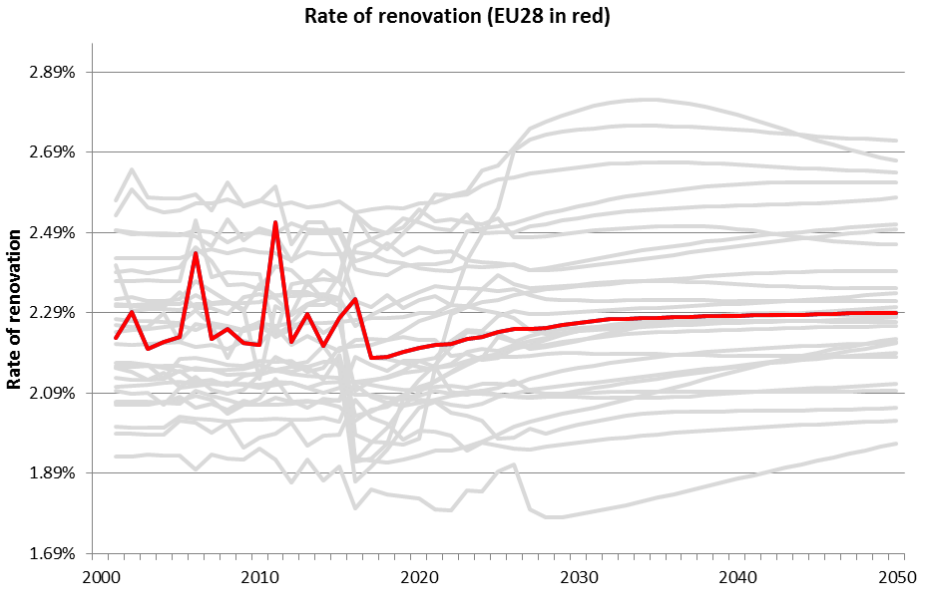
Demographic and **Macroeconomic** *Projections*

→ *Projected* **Number of Households**

Assumptions on **Lifetime of building stock**

→ *Projected* Number of **New** and **Renovated** households





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BUILDING CHARACTERISTICS

Demographic and **Macroeconomic** *Projections*

→ *Projected* **Number of Households**

Assumptions on **Lifetime of households**

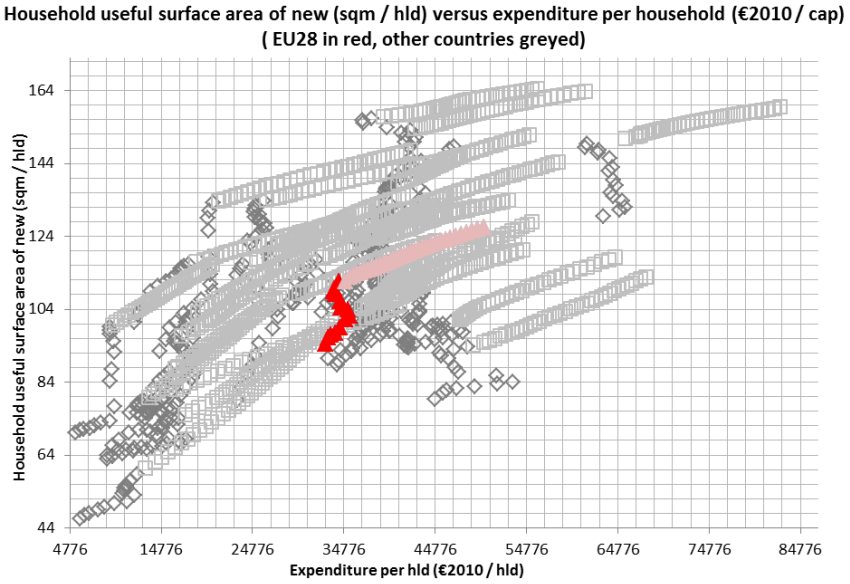
Projected Number of **New** and **Renovated** households

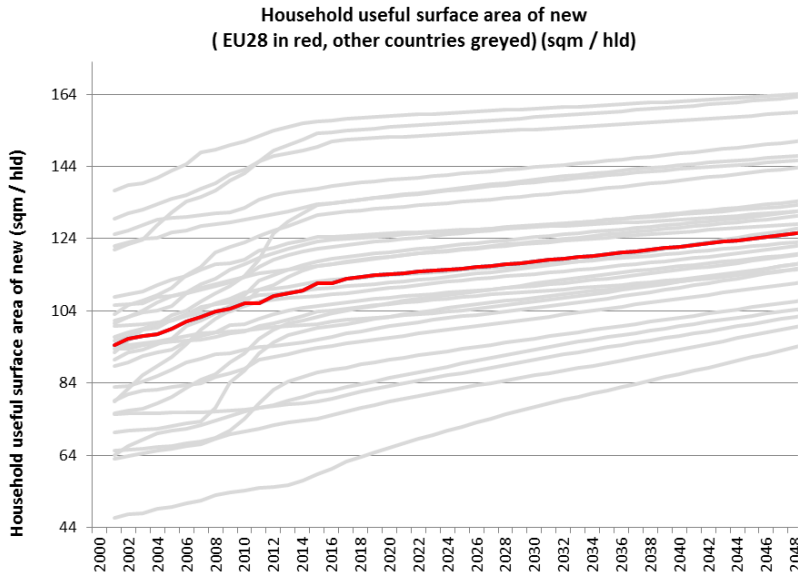
Consumption Expenditure/household

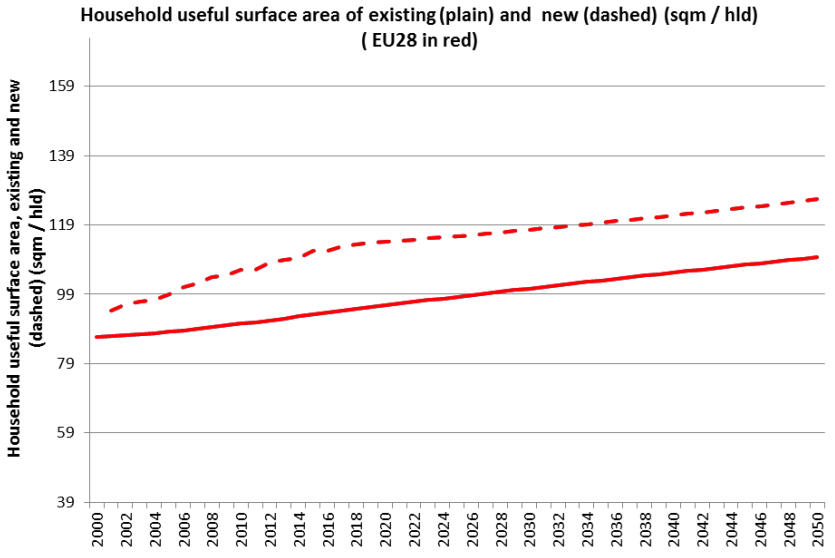
Inhabitants/households

Autonomous trend

→ ***Projected*** **Useful size of new constructions**







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The energy Service Needs

Identified at the level of the representative **consumption unit,** defined by means of

- a **household installation** for thermal uses in the **Residential**
- the **representative building cell** in the **Services**
- an **representative device** for specific electricity uses
  - Appliance (e.g. typical EU refrigerator)
  - Electric device (e.g. ICT equipment)

…a concept that allows for a comparability across the Member States

The Representative consumption unit

Residential

Thermal uses

- Space heating
- Space cooling
- Water heating
- Cooking

Specific electricity uses

- Lighting
- White appliances
  - refrigerators and freezers
  - washing machines
  - tumble dryers
  - dishwashers
- TV and multimedia
- ICT equipment
- Other electric appliances

Lightbulb of 1000 lumens

- 220l of a fridge and 110l of a freezer
- 6kg washing machine
- 6kg tumble drier
- a typical dishwasher

TV set +satellite receiver + Dvd player + playing console + sound system …

1 desktop+1laptop+ share of a printer+ mobile devices

Iron, vacuum cleaner, hair drier, kettle, toaster, grill, mixers etc.

Services

Thermal uses

- Space heating
- Space cooling
- Hot water services
- Catering

Specific electricity uses

- Street lighting
- Building lighting
- Ventilation
- Miscellaneous building technologies
- Commercial refrigeration
- ICT and multimedia

Preparatory studies under 'Eco-design of energy using products regulation' taken into consideration

KEY ASSUMPTIONS

The **envisaged** operation and equipment characteristics

- **Thermal Uses**

Useful energy indicator per m^2 (kWh/ m^2)

Size of equipment

Hours of operation

- **Electricity uses**

Number of units ← Size of equipment incorporated

Hours of operation

European Commission

Thermal Uses

Main **drivers** in projecting the evolution of the energy service needs per m^2

Societal characteristics

- surface area of a representative household

Evolution of the economy

- Private consumption expenditure per capita

Evolution of the households occupancy

- Inhabitants per household

Implicit assumption capturing

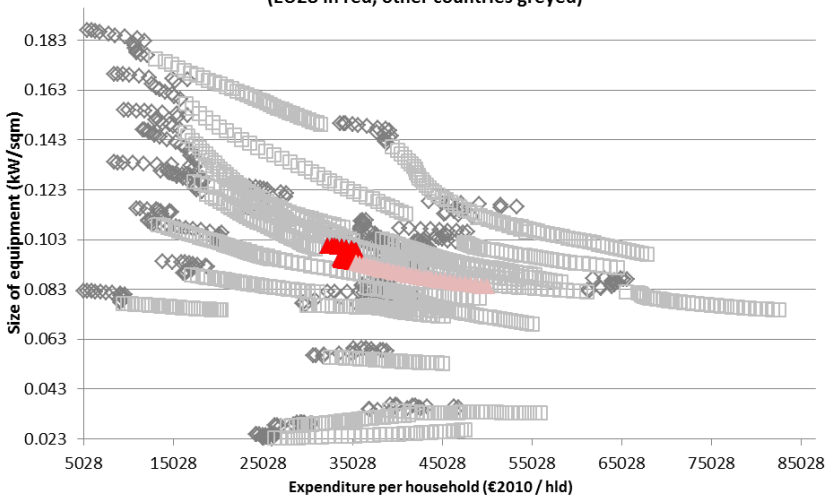
- technology improvements e.g. downsizing of equipment
- systematic assessment of heating needs in new constructions
- building stock characteristics improvements

Converging behaviours as regards the comfort levels

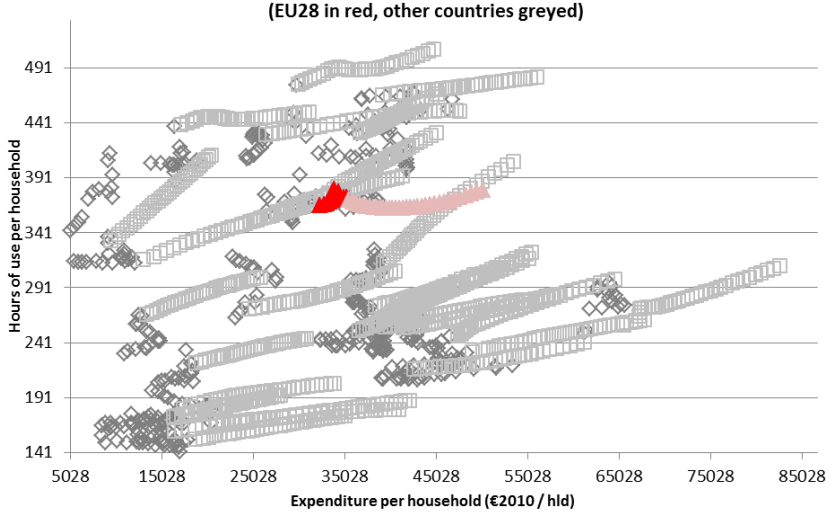
- Addressing discrepancies in service needs
- Accounting for the climatic conditions

Space Heating

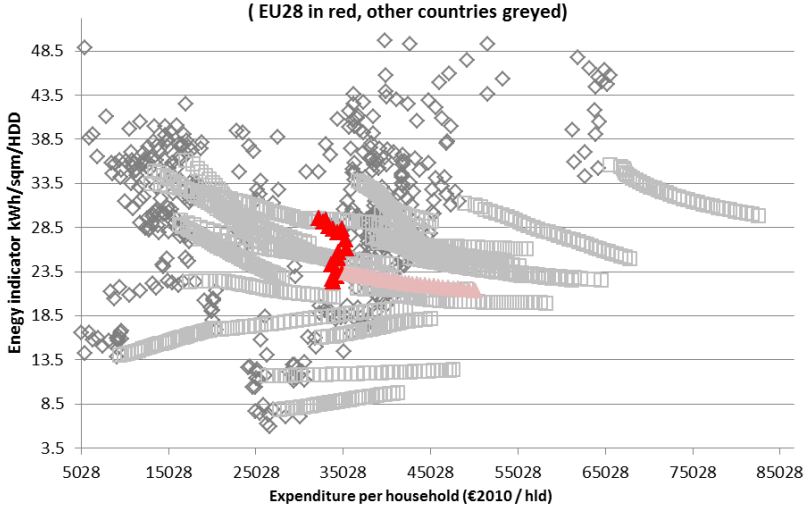
Size of equipment vs Expenditure per household
(EU28 in red, other countries greyed)



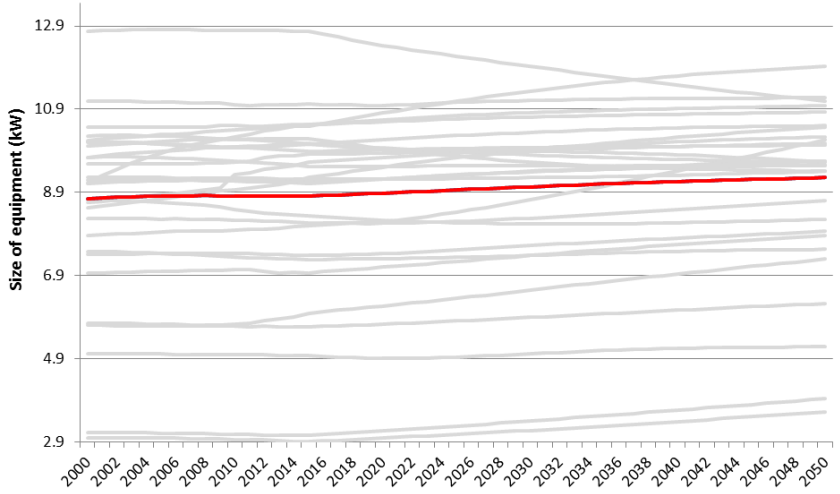
Hours of use per household (hrs / yr) vs expenditure per household
(EU28 in red, other countries greyed)



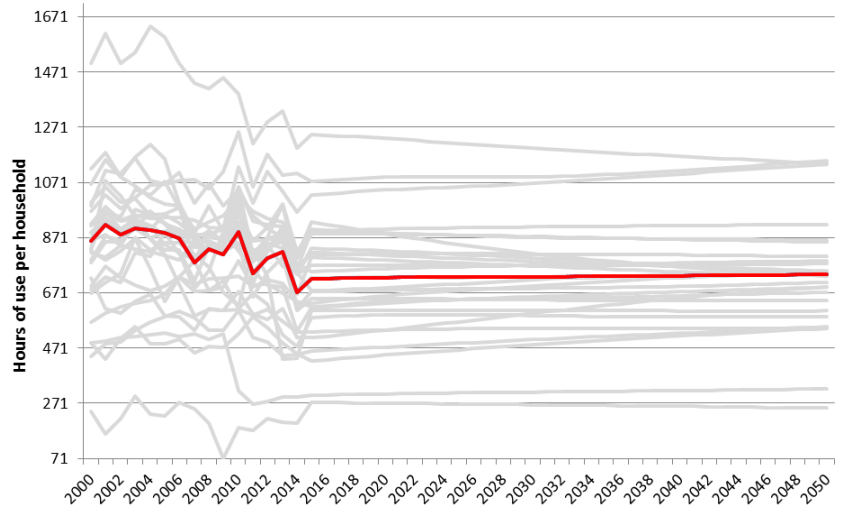
Energy indicator vs expenditure per household
(EU28 in red, other countries greyed)



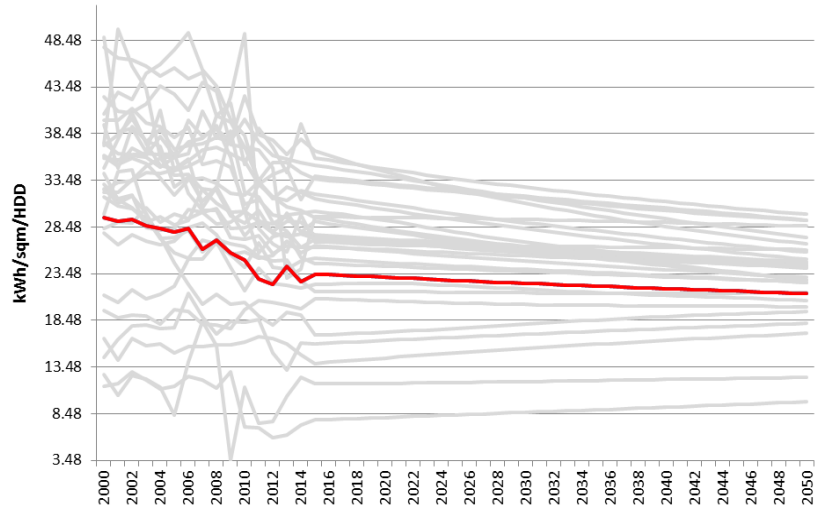
Size of equipment (kW) (EU28 in red, other countries greyed)



Hours of use per household (hrs / yr) (EU28 in red, other countries greyed)



Energy indicator (EU28 in red, other countries greyed)



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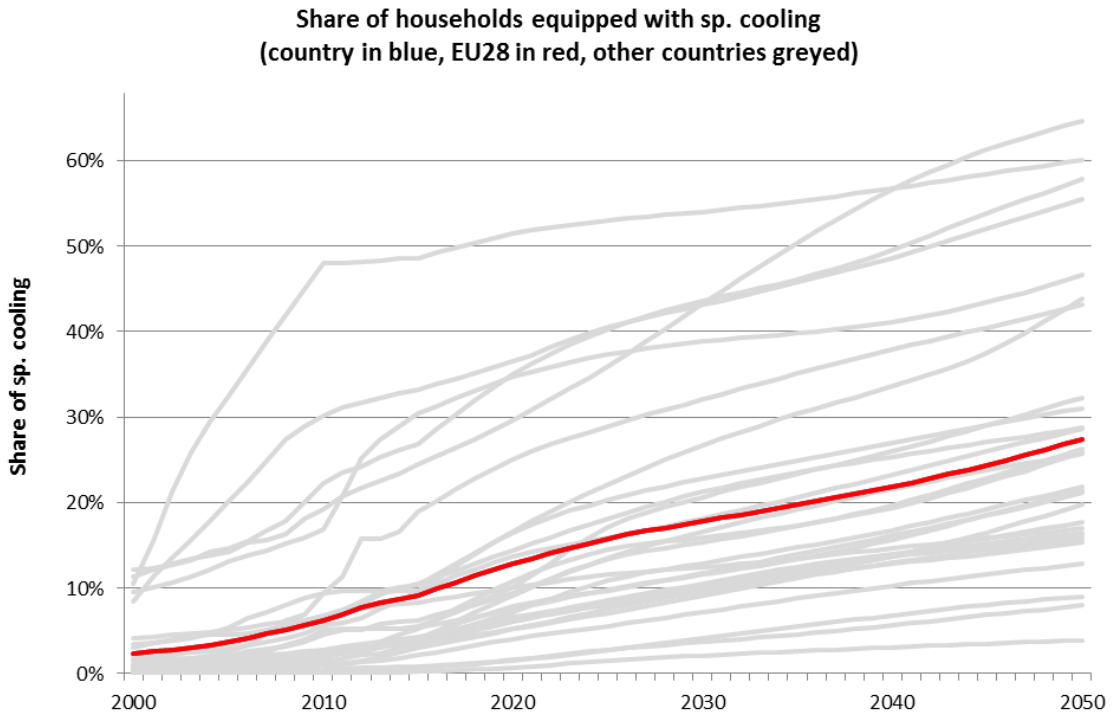
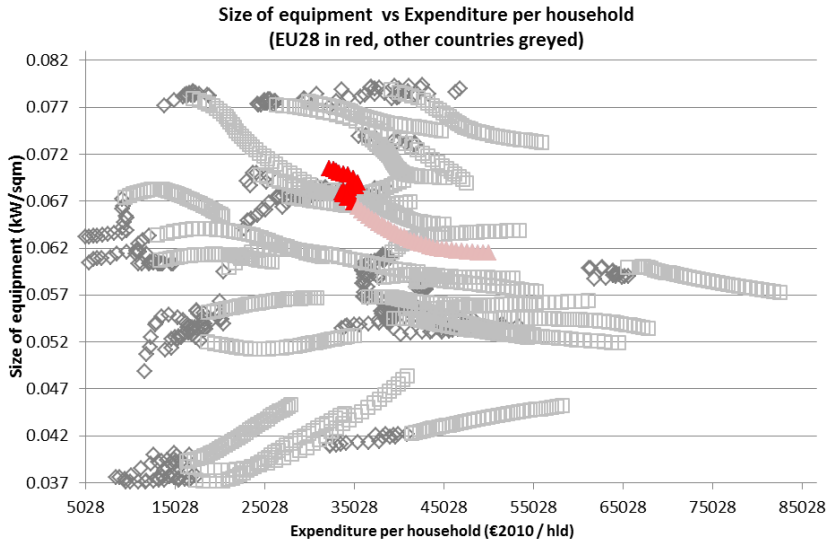
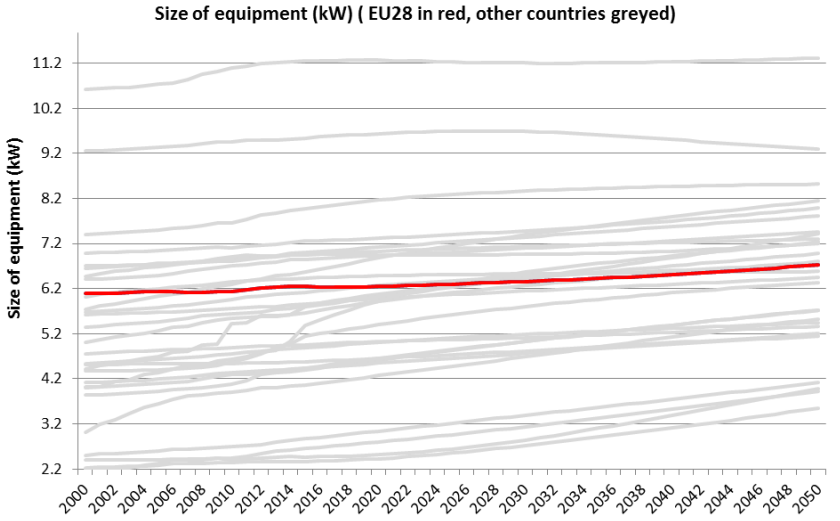
THERMAL USES – SPACE COOLING

SPACE COOLING is the only thermal use that is considered as underserviced today







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Electric Appliances

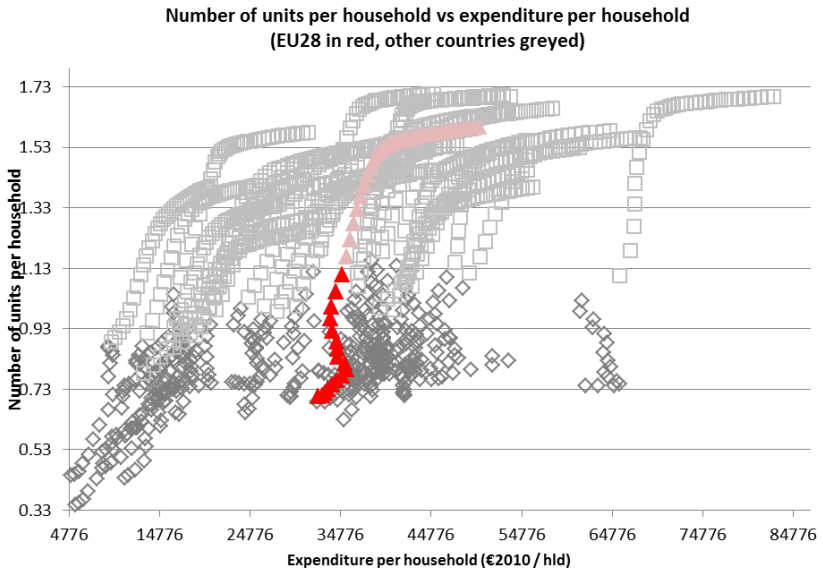
Implicit drivers embodied in the projections

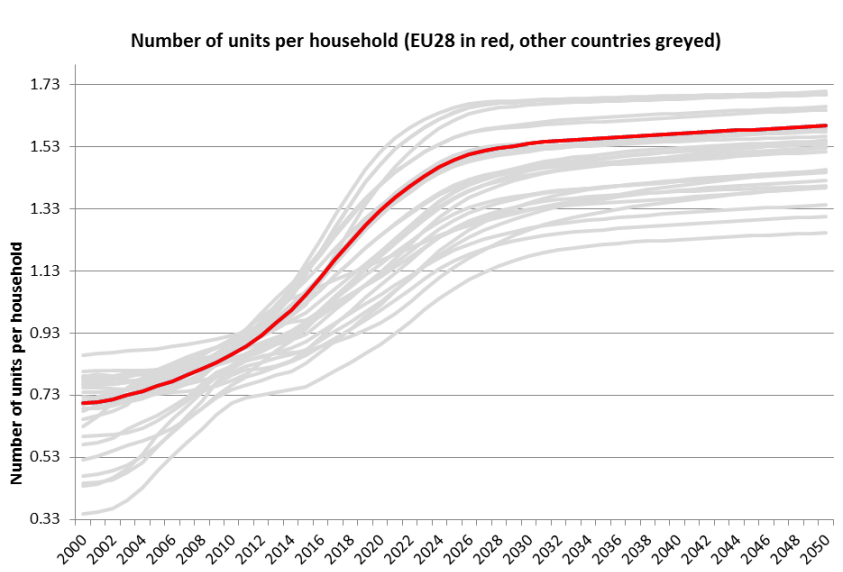
Socio –economic drivers
- Private consumption expenditure per capita
- Households occupancy - Inhabitants per household

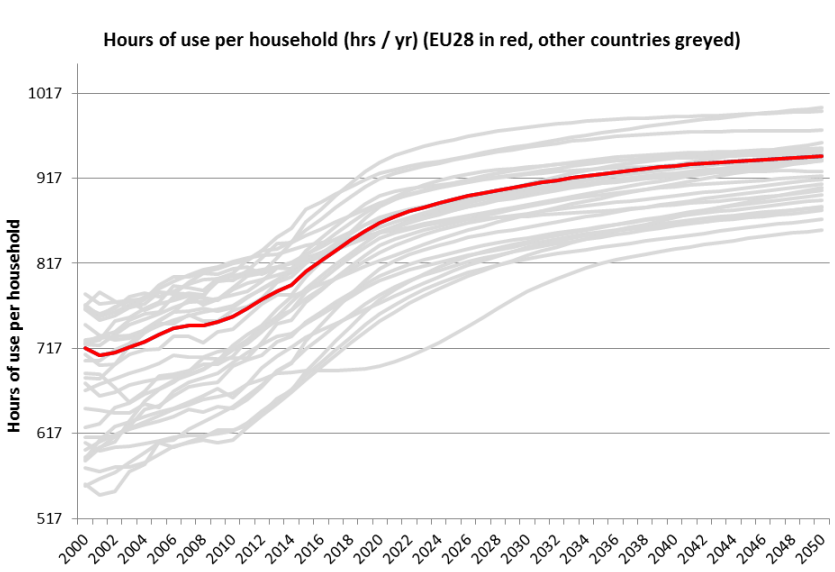
Historical trends
- Behavioural patterns identified
- Saturation effects considered

Converging behaviours assumed

Washing Machine







Size of equipment incorporated in the number of units

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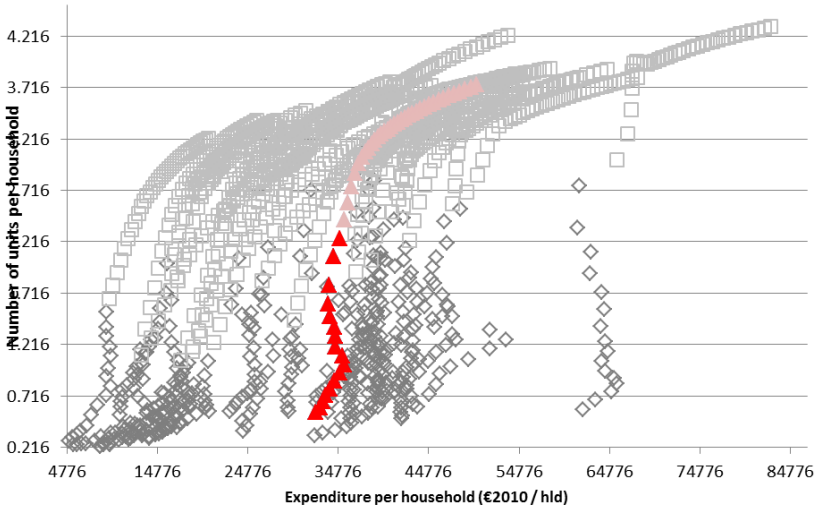
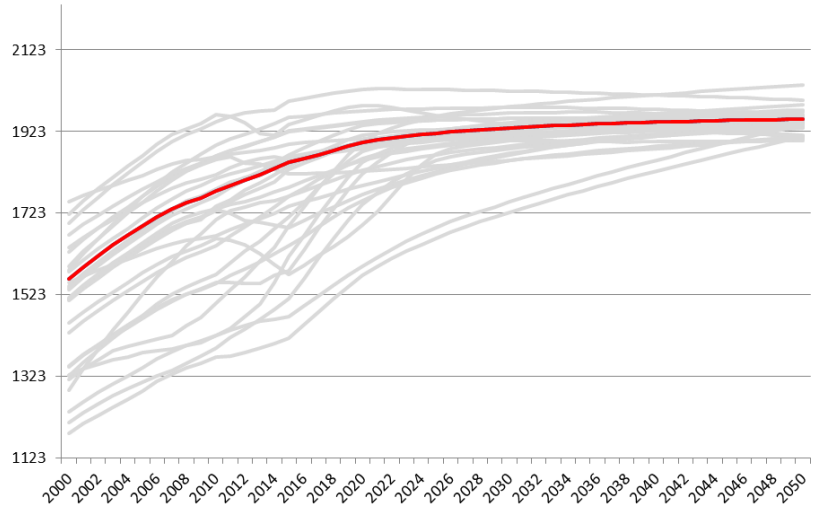
TV AND MULTIMEDIA

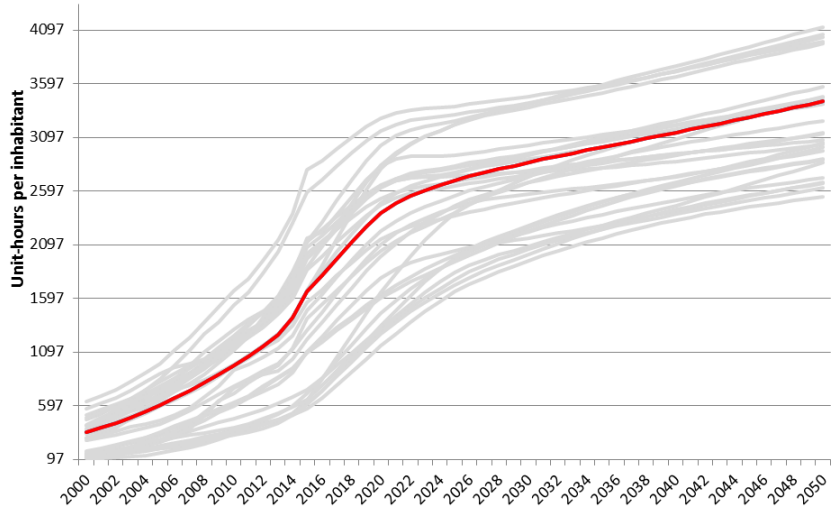
Number of units per household vs expenditure per household (EU28 in red, other countries greyed)



Hours of use per household (hrs / yr) (EU28 in red, other countries greyed)

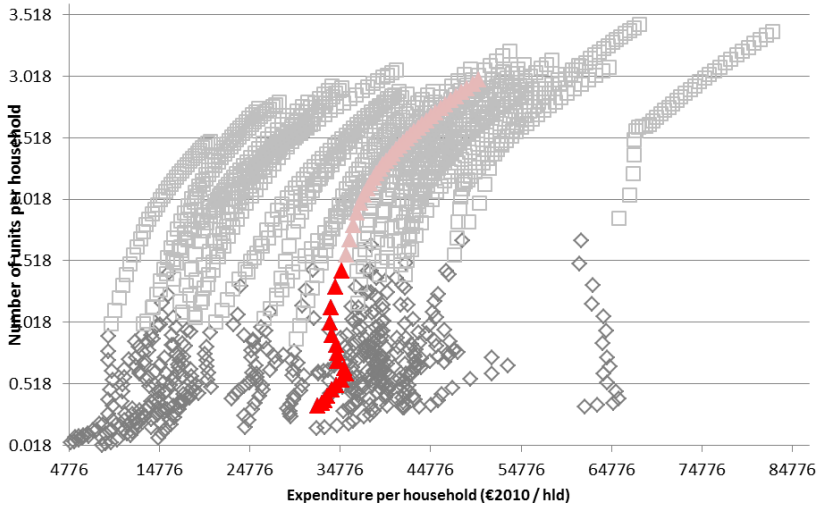


Unit.hours per inhabitant (EU28 in red, other countries greyed)



ICT EQUIPMENT

Number of units per household vs expenditure per household (EU28 in red, other countries greyed)



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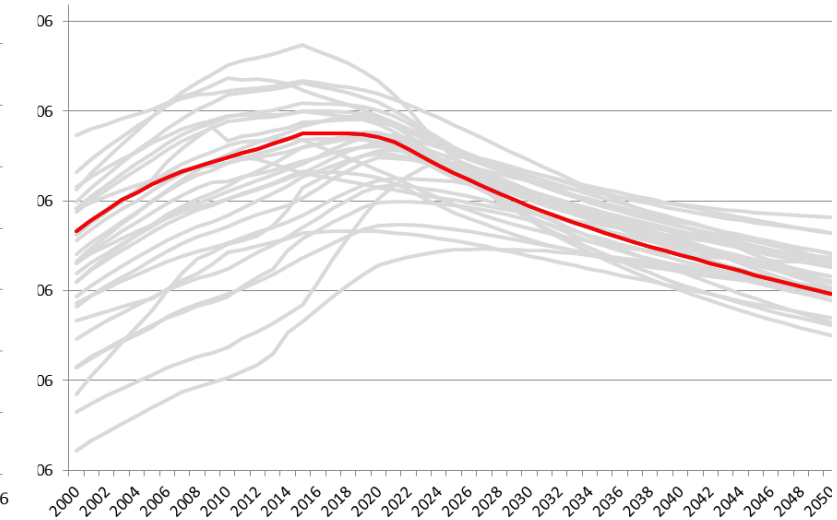

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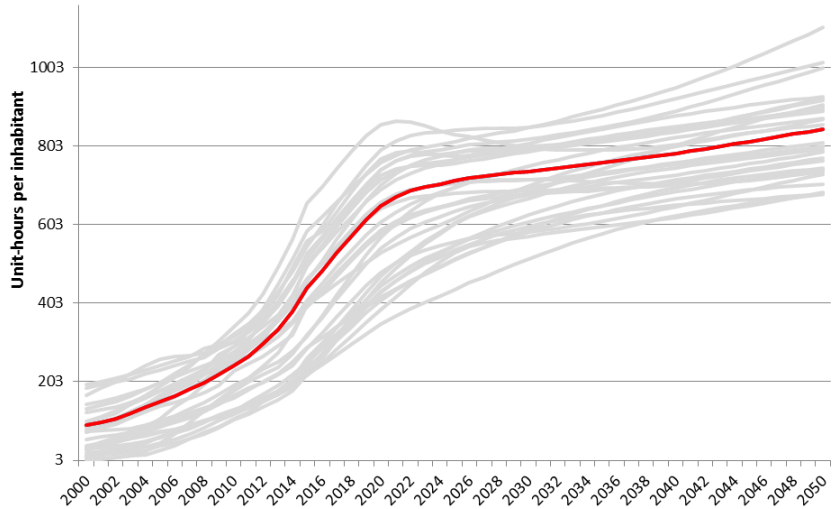

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DATA FILES OF POTENCIA ASSUMPTIONS

Macro – economic, demographic, climate drivers used in the assumptions

Thermal uses related information

- Hours of use per household
- Size of equipment
- Number of units (cooling)
- Energy indicator in various units (e.g. kWh/sqm/HDD)

Electric Appliances related information

- Hours of use
- Number of units (cooling)
- Energy indicator: Unit-hours per inhabitant

Analysis related information

- Instantaneous growth rates
- Variables of interest vs Expenditure per household Elasticities

Across **time** and by **Member State**

"Entry-point" Scenario Assumptions
TRANSPORT ACTIVITY

MEMBER STATES EXPERTS' WORKSHOP ON THE POTENCIA MODEL

Brussels, 26 February 2018

European Commission

OUTLINE

1. **Why are transport activity projections needed in an Energy System Model, and how do they enter POTEnCIA?**
    1. **The transport challenges**
    2. **POTEnCIA mechanisms for transport activity**
2. **Transport activity projections – the storylines**
    1. **Passengers**
    2. **Freight**
3. **Data files**

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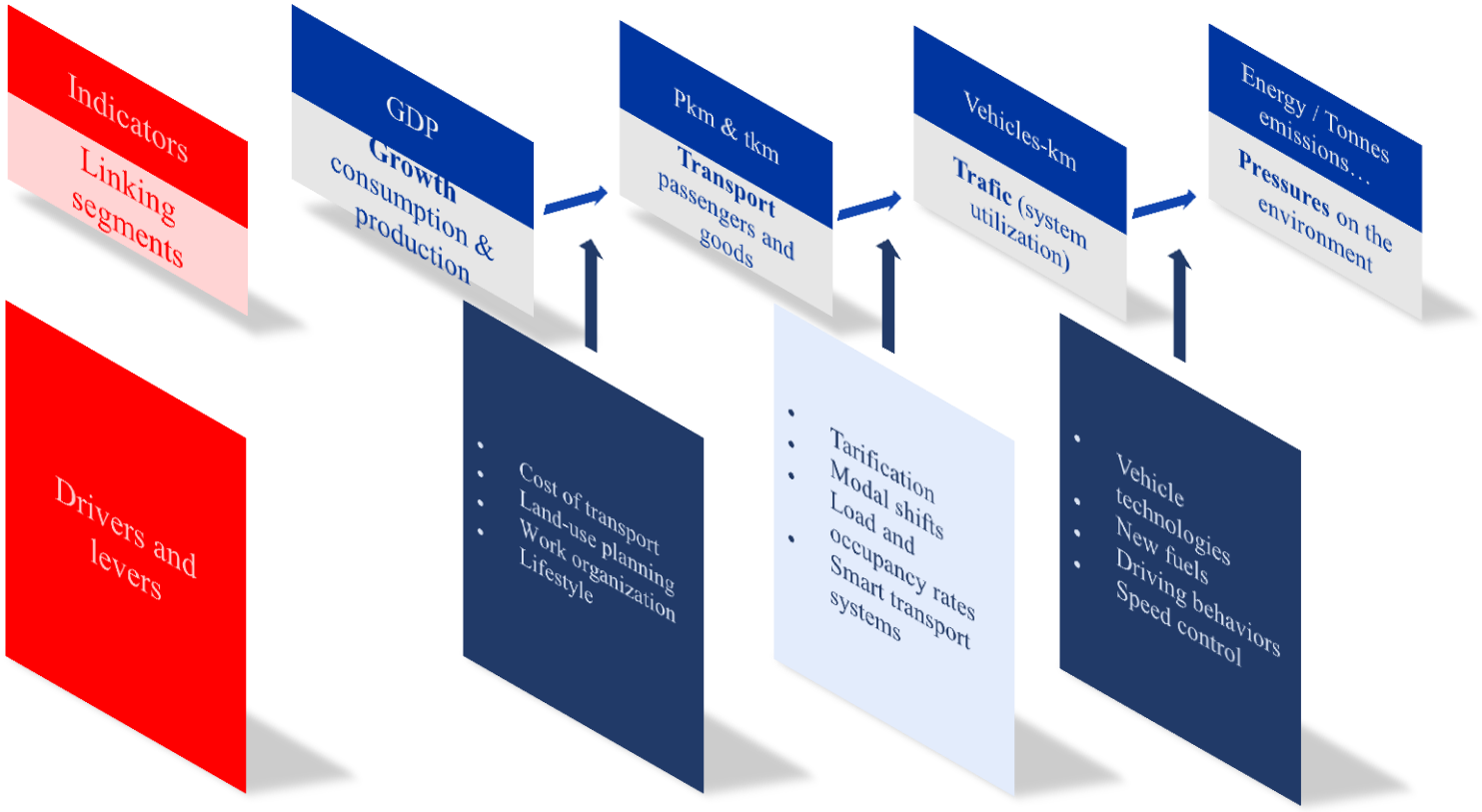
Transport and the economy



- Transport still primarily responds to economic environment (ITF, 2017; Banister and Stead, 2002)
- The intricacy of effects (Proost & Van Dender, 2012;…)
  - Energy prices
  - Technology dynamics
  - Organization, behaviours…
  - Transport and energy policies
  - ⇒ Overlaps
  - ⇒ Multiple dividends
  - ⇒ Rebounds
- Potential game changers (IEA, 2017)
  - More services-oriented economy (inc. Digitalization)
  - Behavioural response (uncertain)

European Commission

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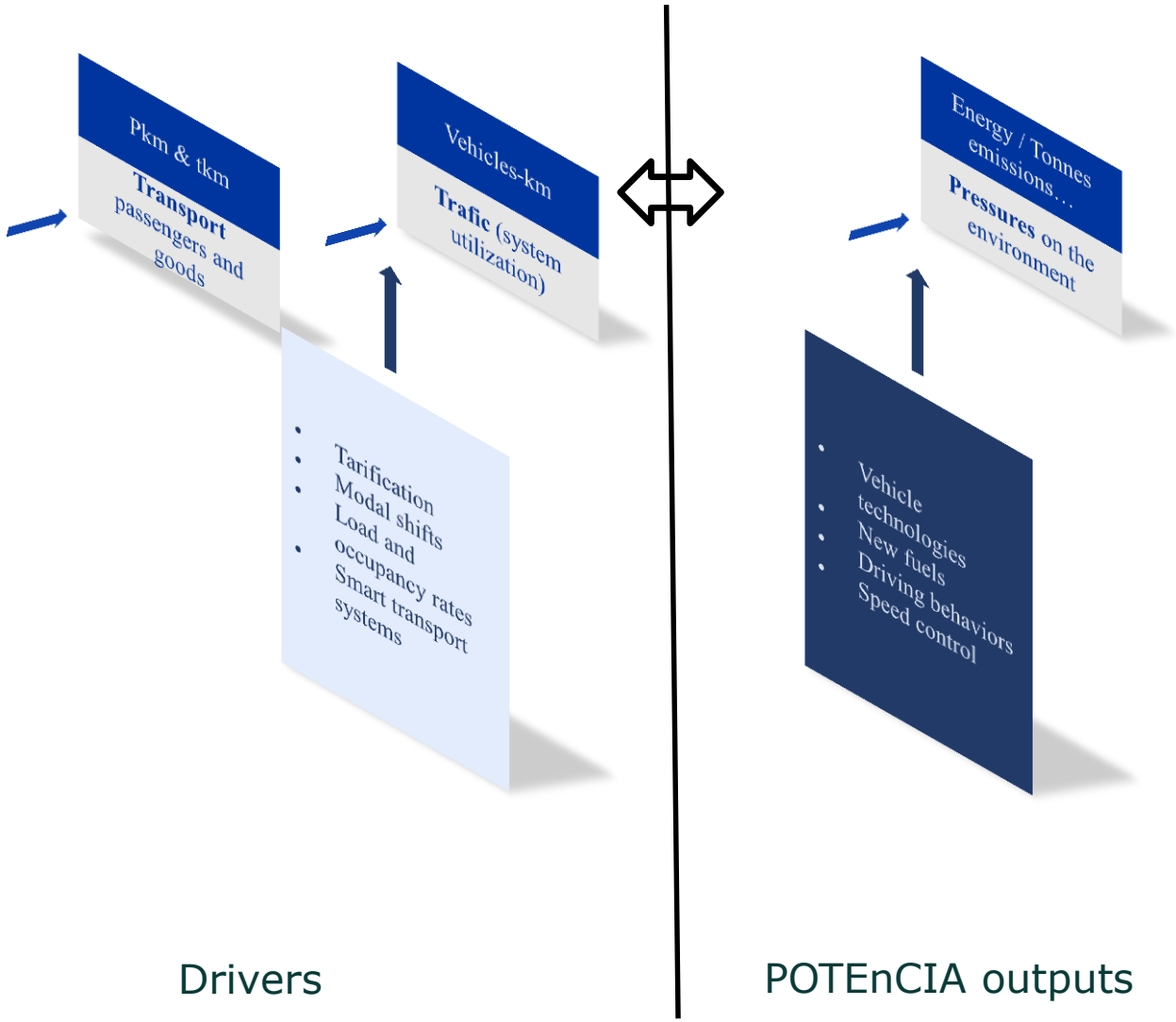

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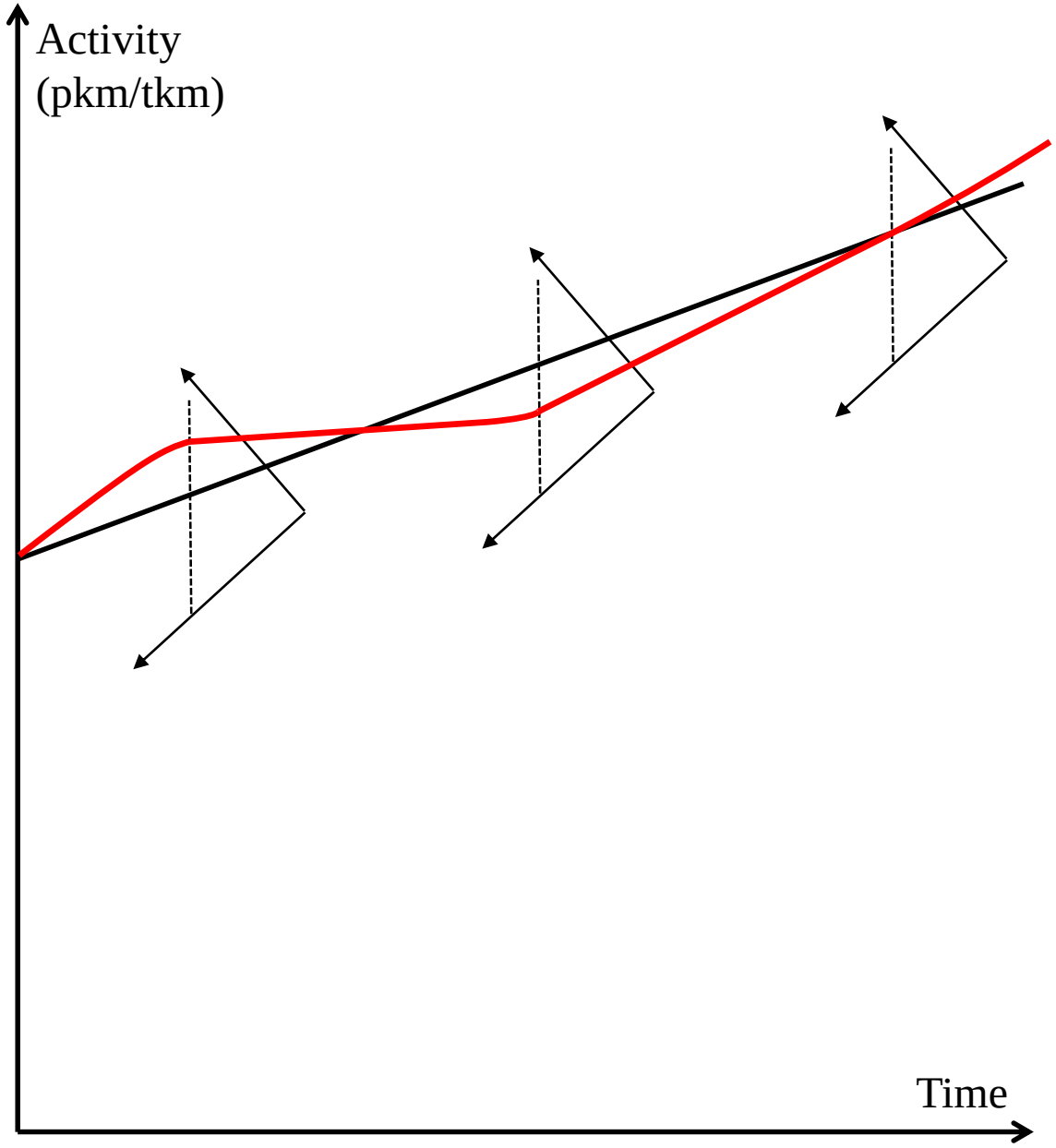
Transport activity projections within POTEnCIA

- Projections of activity (pkm / tkm) ***envisaged levels***
- ***Endogenous deviations*** based on specific model conditions
  - Relative costs of transport will induce direct price effects and substitutions
    - Technology costs
    - Fuel costs
  - Adoption, learning, behavioural effects…



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Transport segments and representation principles

- Representative configuration units…
  - Real stocks for
    - Passengers road
    - Light duty vehicles
    - Domestic trucks
  - EU-based representative configurations for freight road, aviation, rail
    - Annual mileage
    - Number of seats / cargo capacity
- … allowing
  - Comparisons for future investment decisions
  - Captures country differences in equipment use (traffic conditions, use of infrastructure…)

Passenger transport	Freight transport
Road transport	
Powered 2-wheelers	Light commercial vehicles
Private cars	Domestic freight trucks
Buses and coaches	International freight trucks
Rail, metro and tram	
Metro and tram, urban light rail	Conventional trains
Conventional passenger trains	
High speed passenger trains	
Aviation	
Domestic	Domestic and International - Intra-EU
International – Intra-EU	International – Extra-EU
International – Extra-EU	
Coastal shipping and inland waterways	
	Domestic coastal shipping
	Inland waterways
Bunkers	
	Bunkers – Intra-EU
	Bunkers – Extra-EU

Building-up transport activity projections: Process schematics

Applies to both passengers and freight

1 Derive activity projections for global activity intensity (km / cap or tkm / GDP) and activity

- Identify drivers
- Define plausible evolution rules (convergence, saturations…)
- Using population, GDP… assumptions

2 Perform modal split

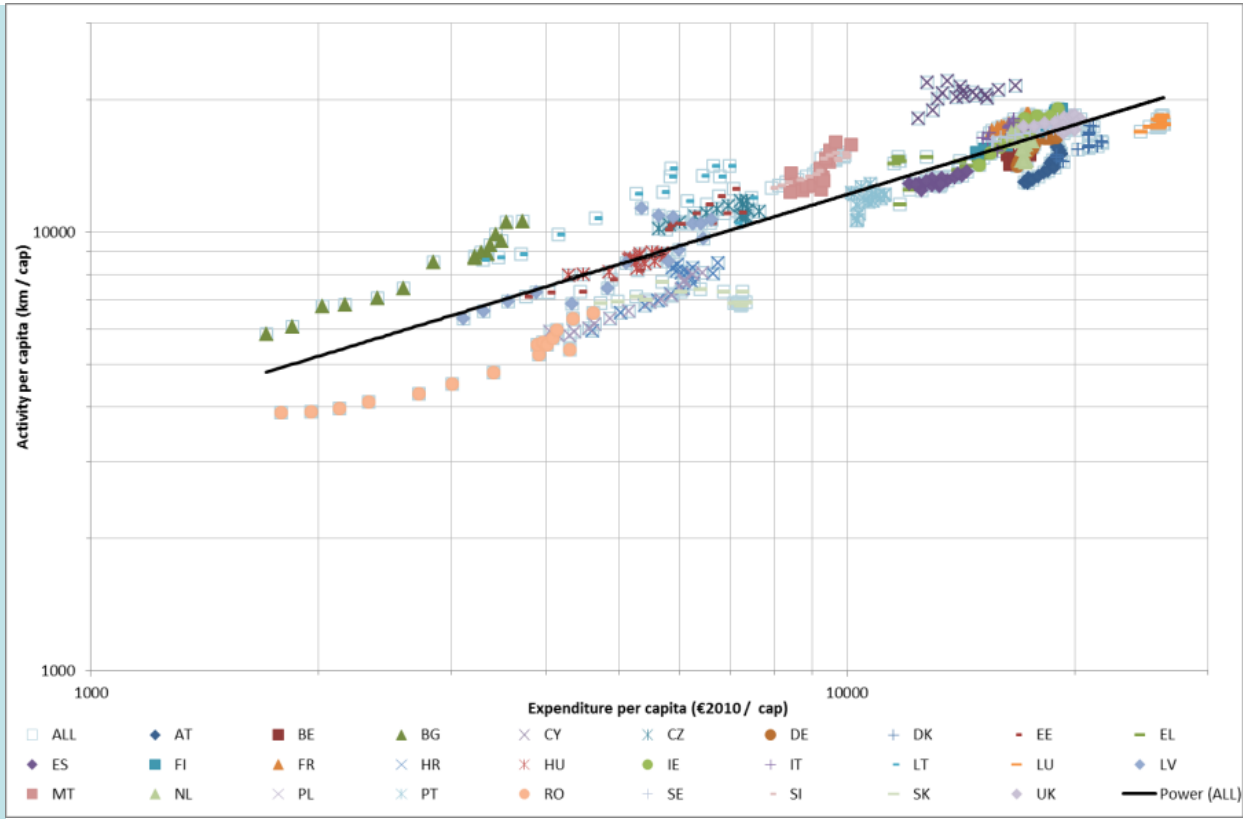
- Initial assumption
- Account for known infrastructure projects…
- Various experts studies / expertise

3 For each mode

- Derive other intensities by decomposition
  - Load factors
  - Mileage per vehicle
  - Number of flights per airplane
  - …
- Get to number of vehicles (**typical EU-configurations**)
  - See JRC-IDEES
  - Different evolutions in POTEnCIA

Passengers *Storylines* – the envelope

- Mobility per capita links to **income** (Schafer & Victor, 2000)
  - The travel need increases with income (commuting & business trips, leisure…)



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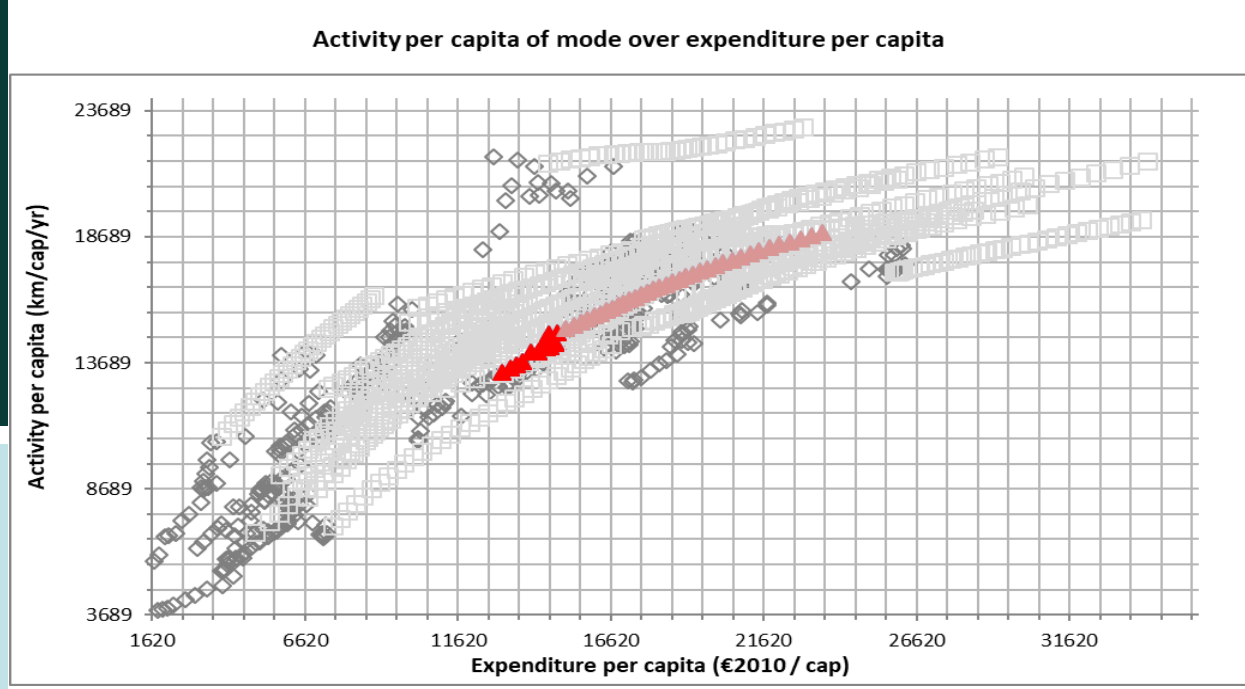

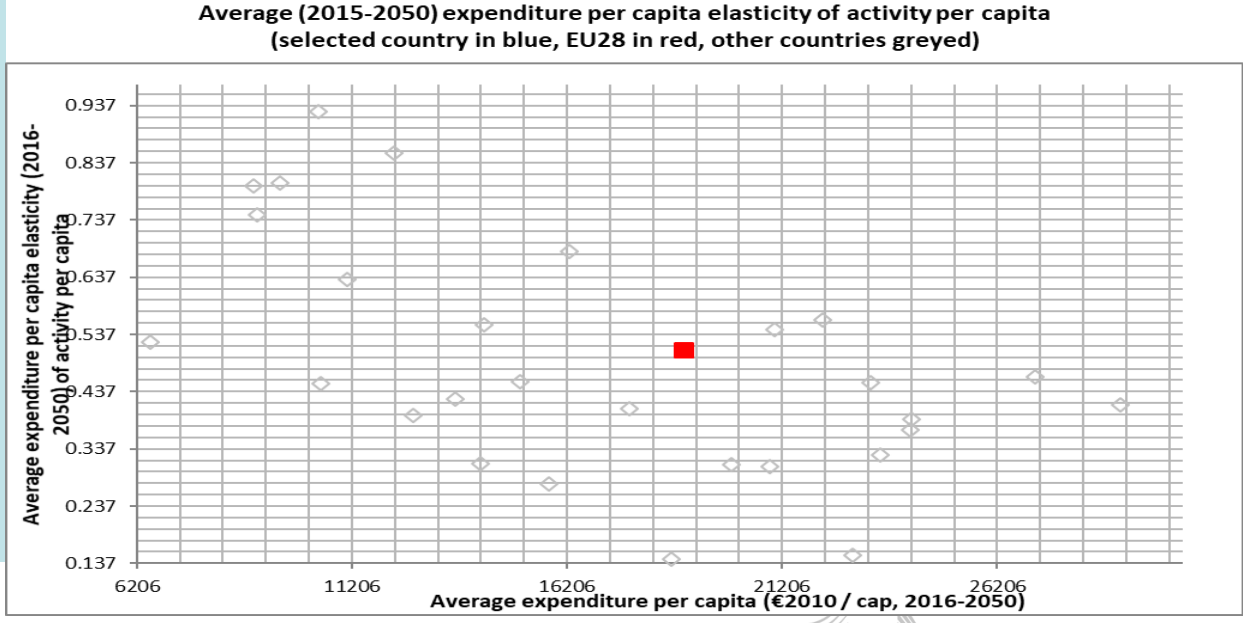

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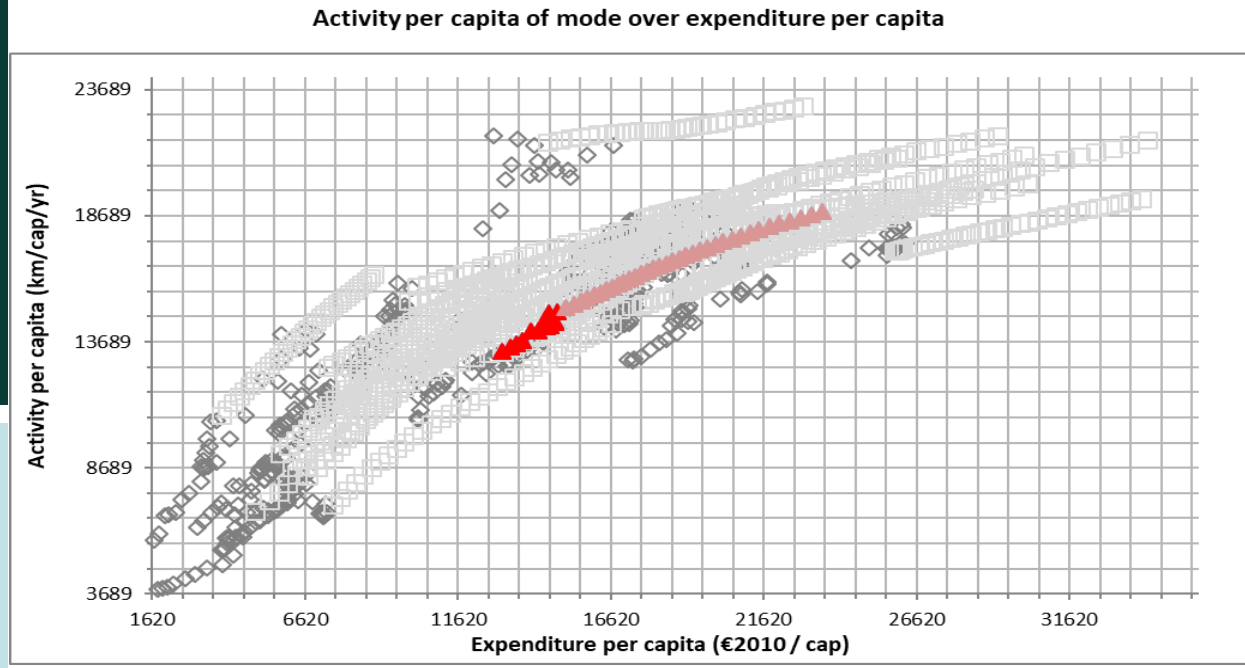
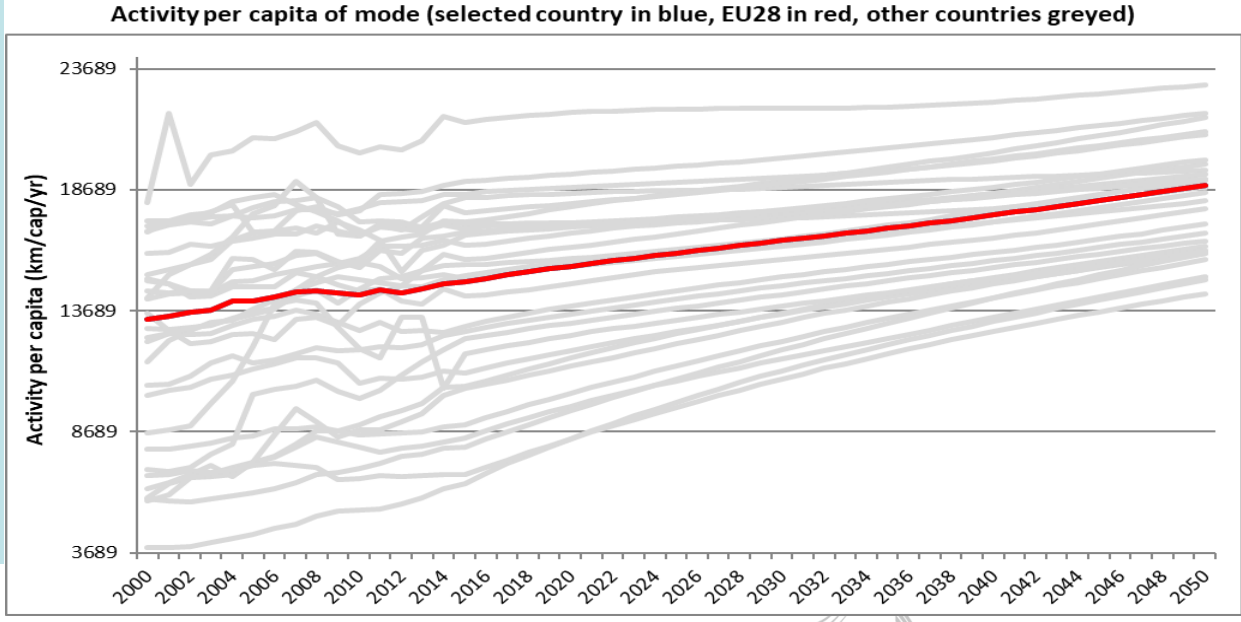
- The marginal effect of an increasing income should be overall diminishing
  - Growth of mobility saturates with growing income
- Convergence across EU MSs appears
  - Behaviours become more homogenous





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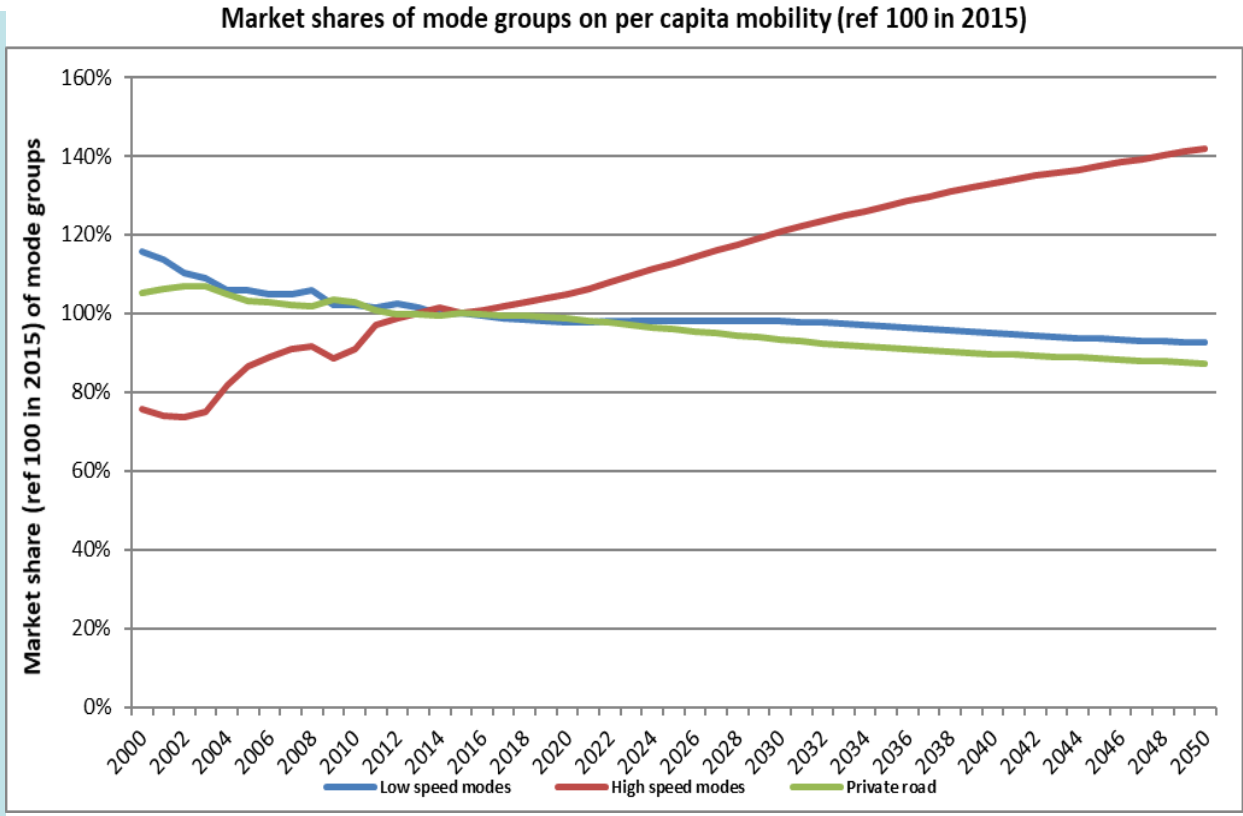
Passengers *Storylines* – the modal split

- Passengers have a finite travel time budget (Zahavi, 1974…) & revenue effect
  - Links to **income**
  - High speed modes (aviation, high speed train) should increase faster



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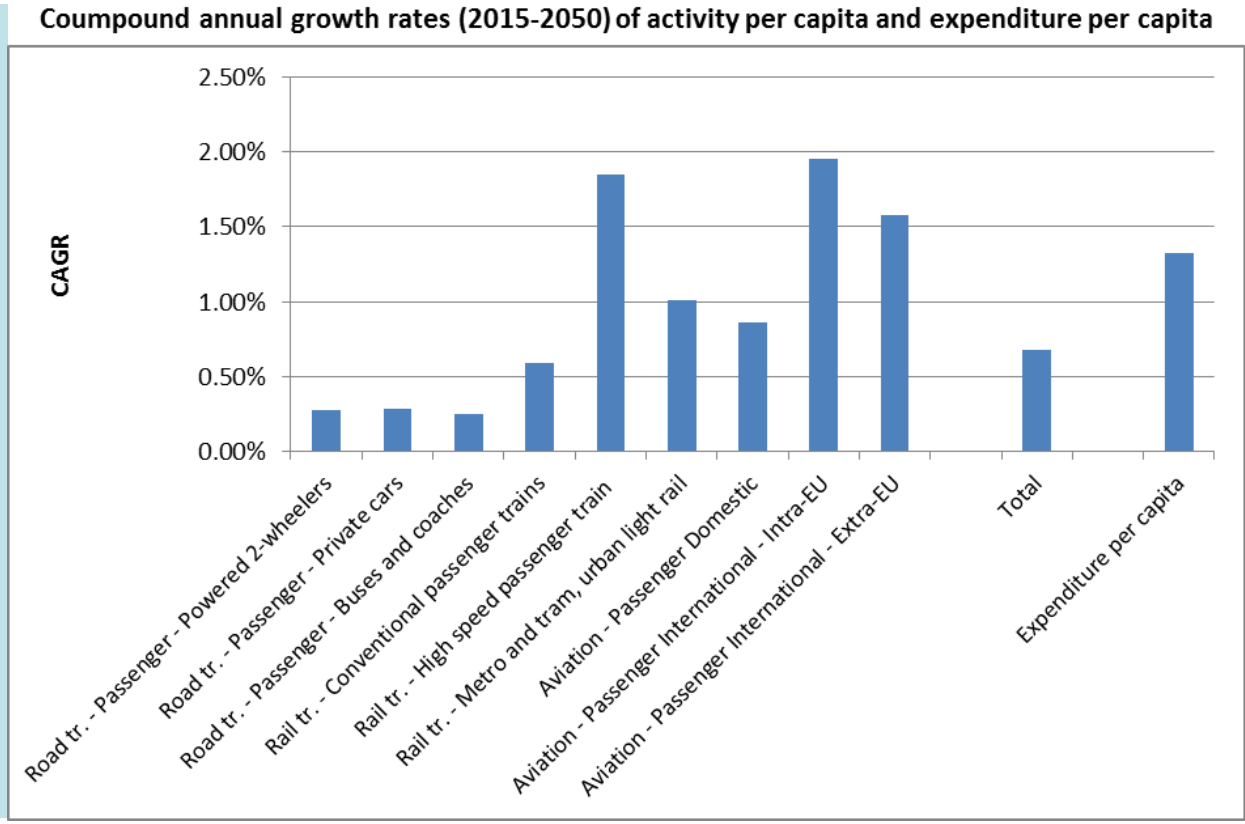
  - Links to **income**
  - High speed modes (aviation, high speed train) should increase faster
- Past trends (ITF, 2017) indicate that aviation should experience very high growth
  - High speed train competes for domestic & some intra-EU trips
  - Intra and extra-EU aviation boom



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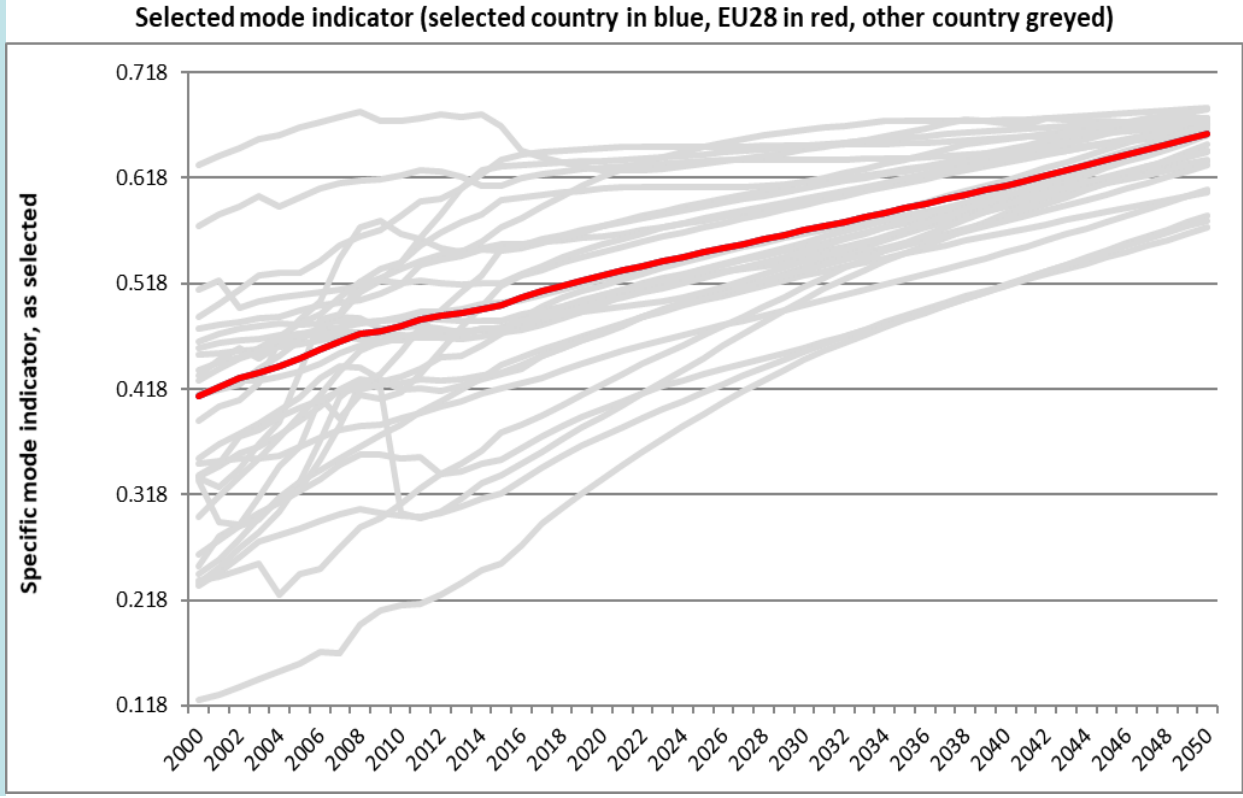
Passengers *Storylines* – modal analysis – pass. cars

- Extending the concept of vehicle ownership – the availability ratio
  - Links to **income** & **household structure** (household decision)
  - Implicitly captures the evolution of the size of representative vehicles
  - Debate: significance of car ownership + car pooling + car sharing



European Commission

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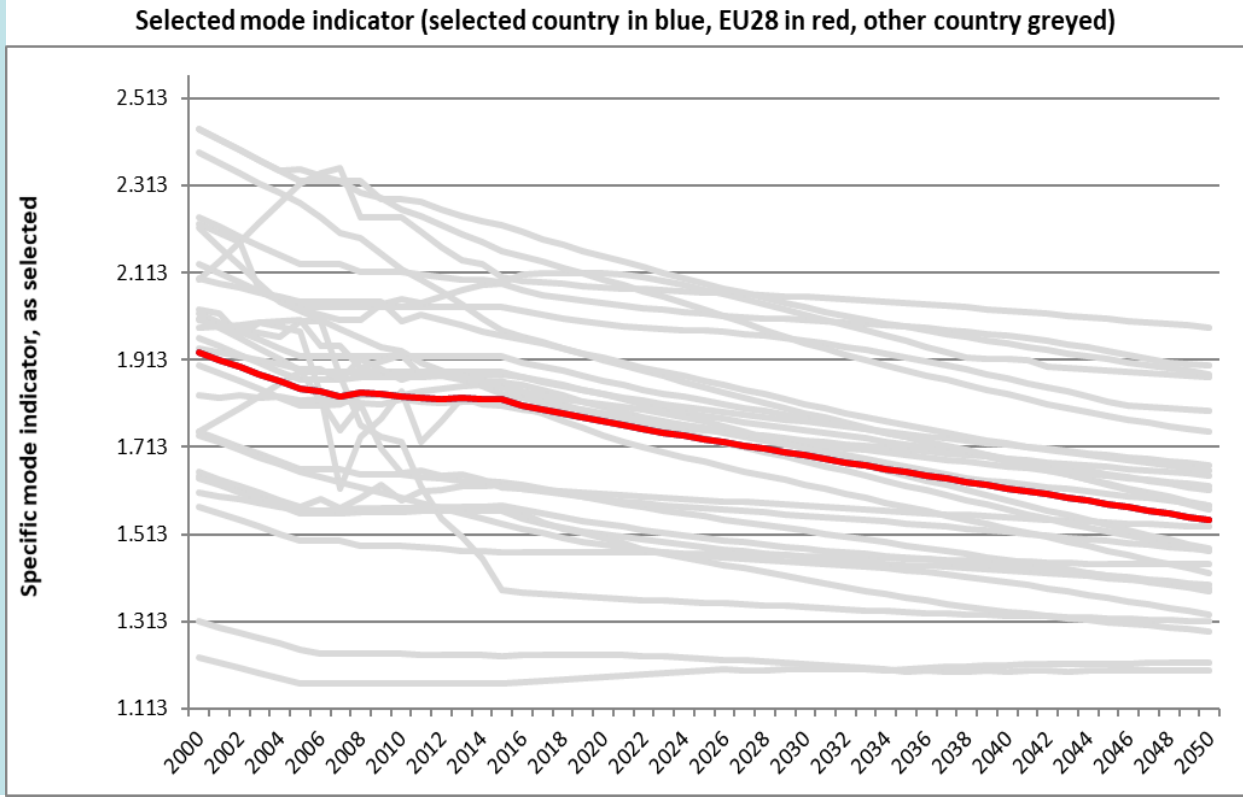
    - Increasing ownership
    - Drop in Inh / hld



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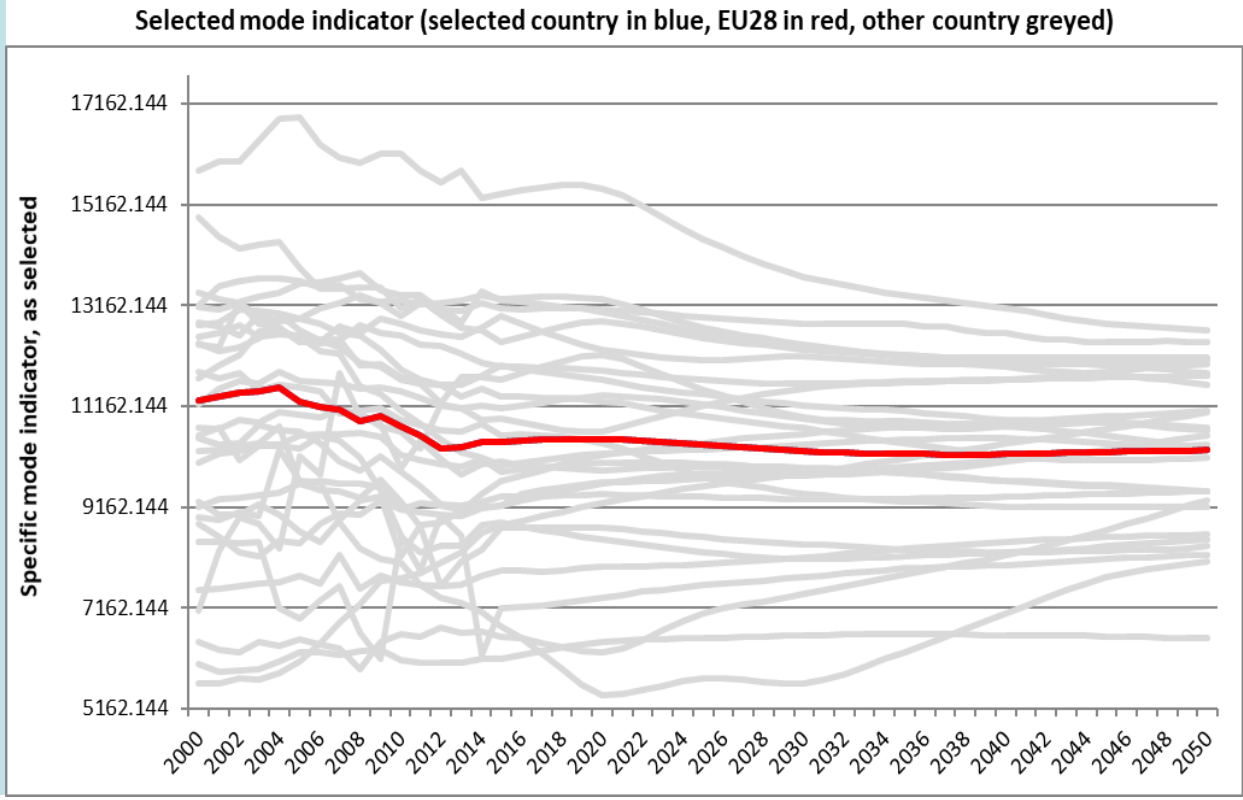
- Mileage per vehicle
  - Stabilization at EU level with heterogeneous country profiles
    - Saturation of use and modal shifts
    - Catch-up of lagging countries



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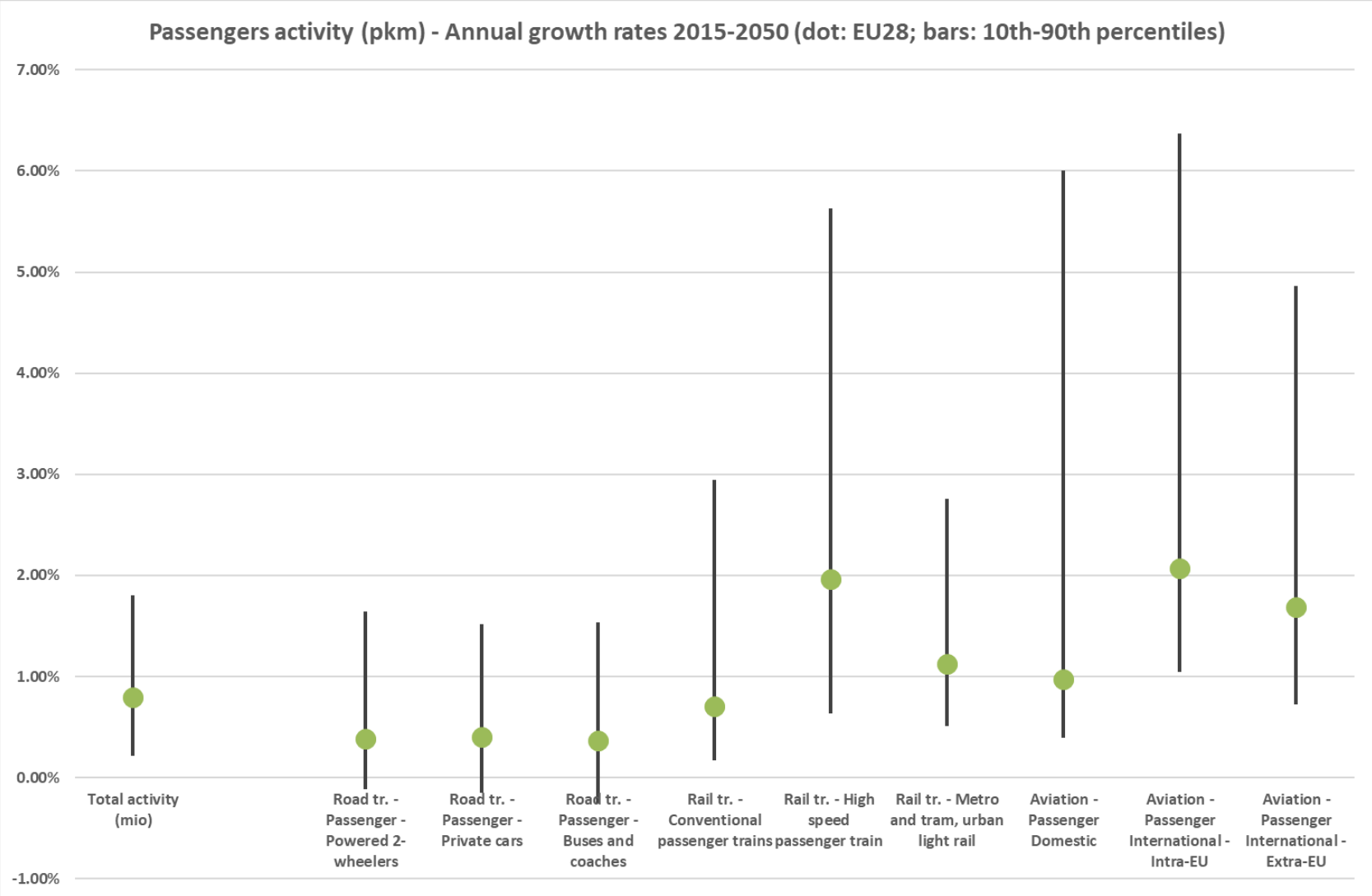
Passengers *Storylines* – wraping up



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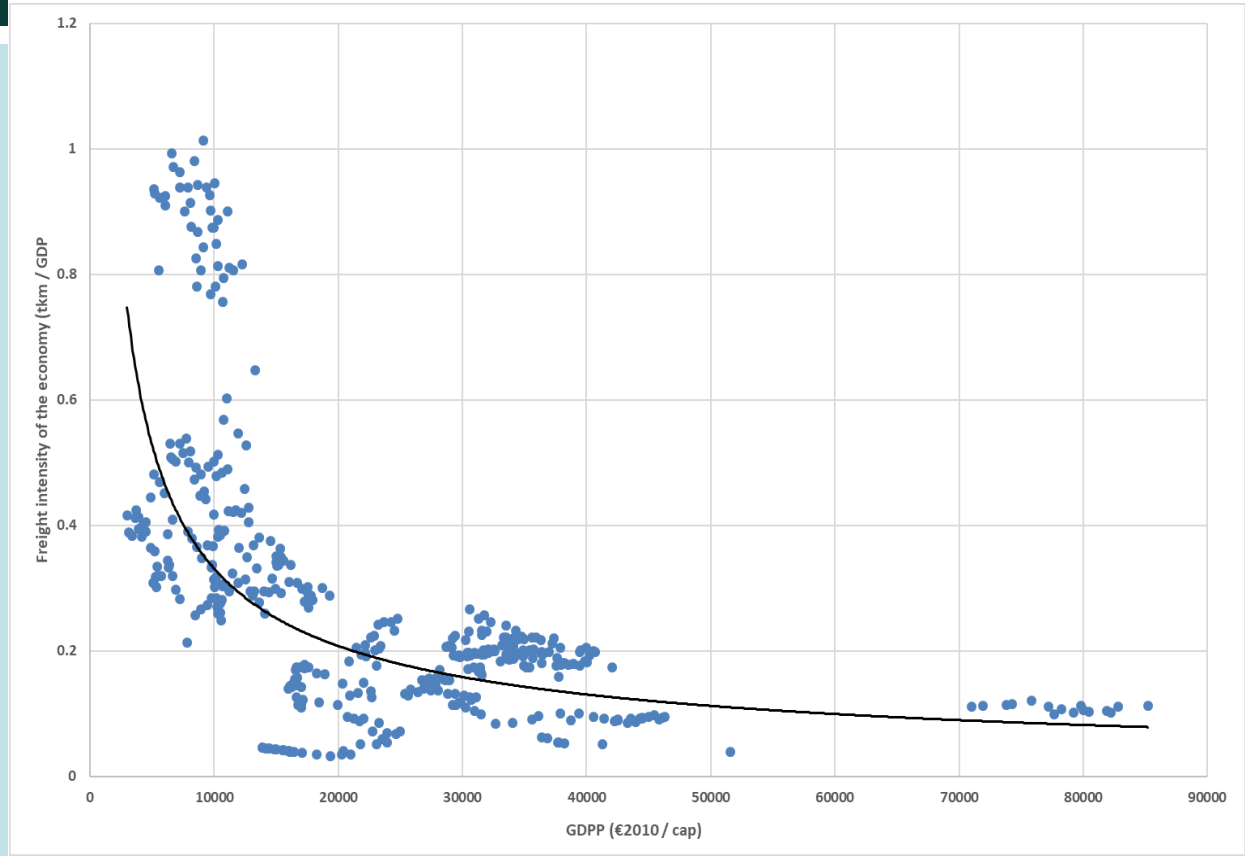
Freight *Storylines* – the envelope

- Freight activity intensity of the economy links to **GDP per capita** (ITF, 2017; Alises & Vassalo, 2015) and **economic structure** (% serv. In GVA)



European Commission

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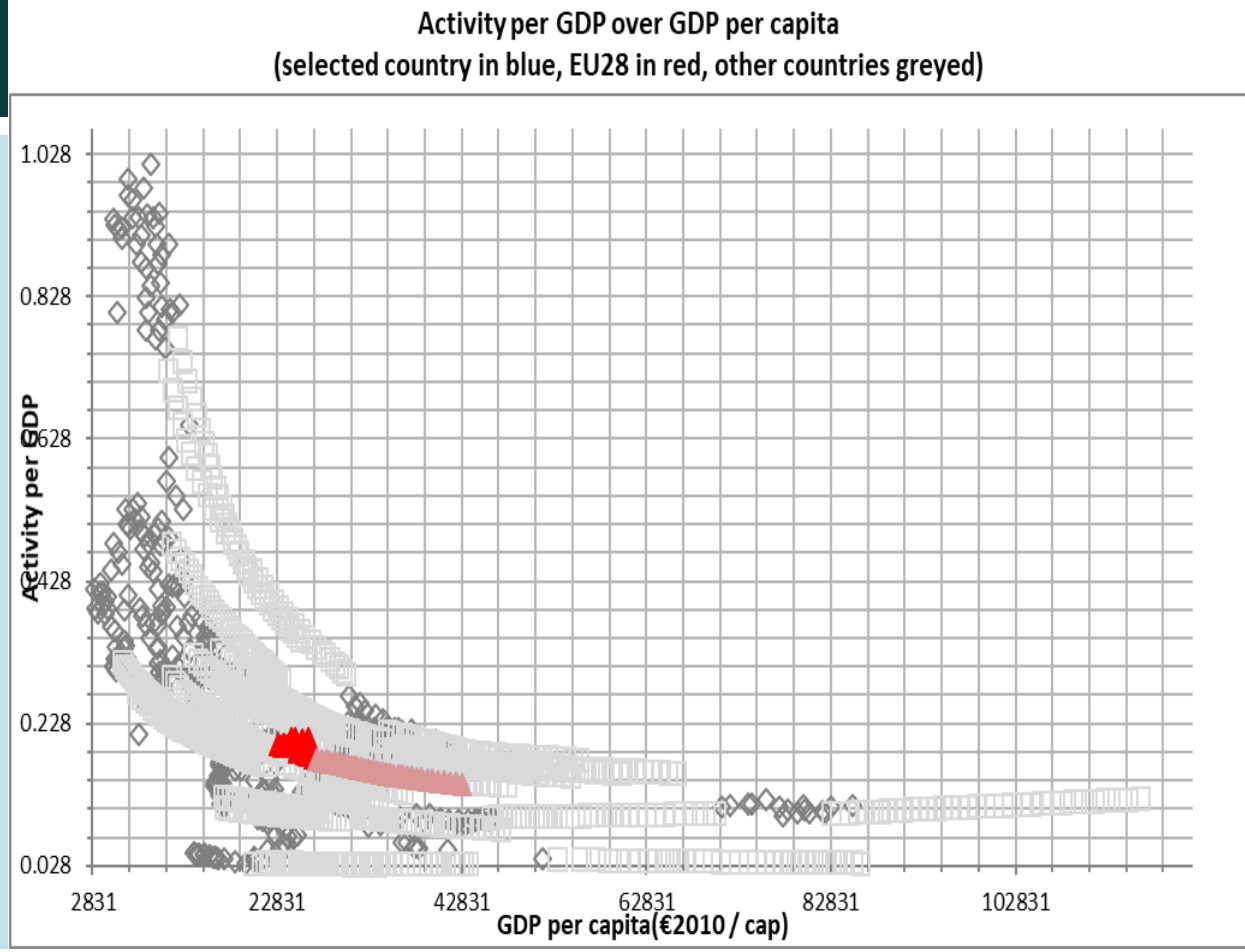

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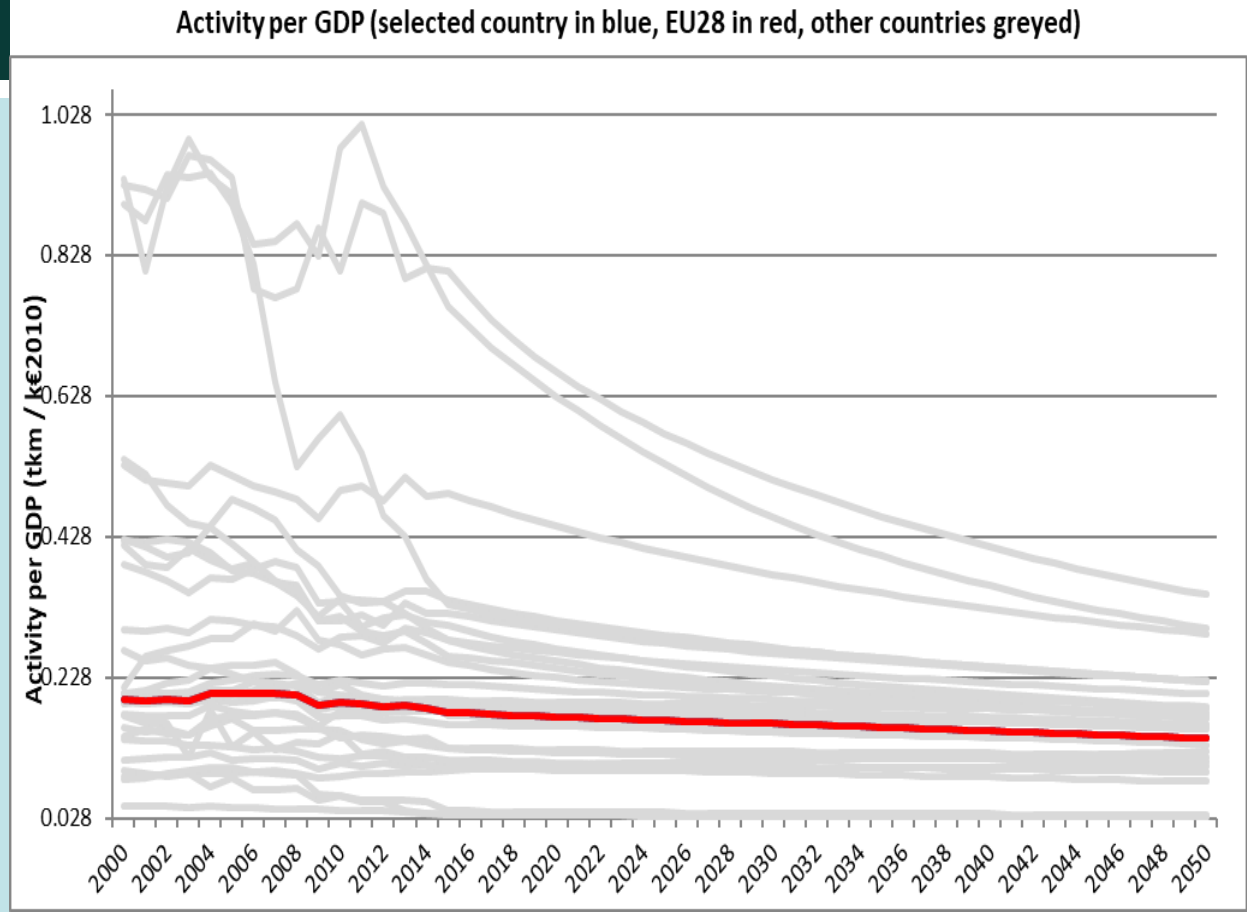
Freight *Storylines* – the envelope

- Freight activity intensity of the economy links to **GDP per capita** (ITF, 2017; Alises & Vassalo, 2015) and **economic structure** (% serv. In GVA)
- Saturation effect
- Slight convergence across EU MSs should appear



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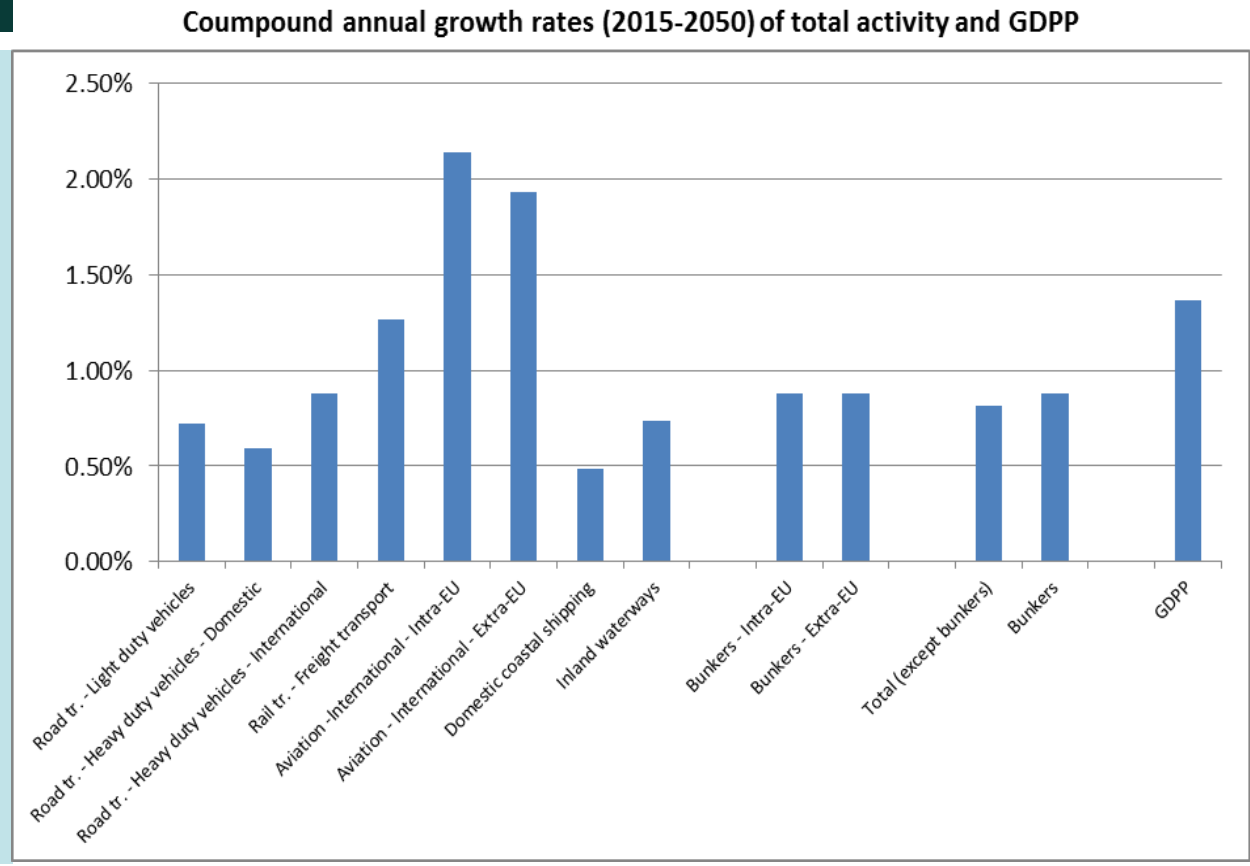
Freight *Storylines* – the modal split

- Alternatives to road develop fast
  - Aviation along with passengers
  - Rail
- Explicit accounting for **domestic versus international haulage**



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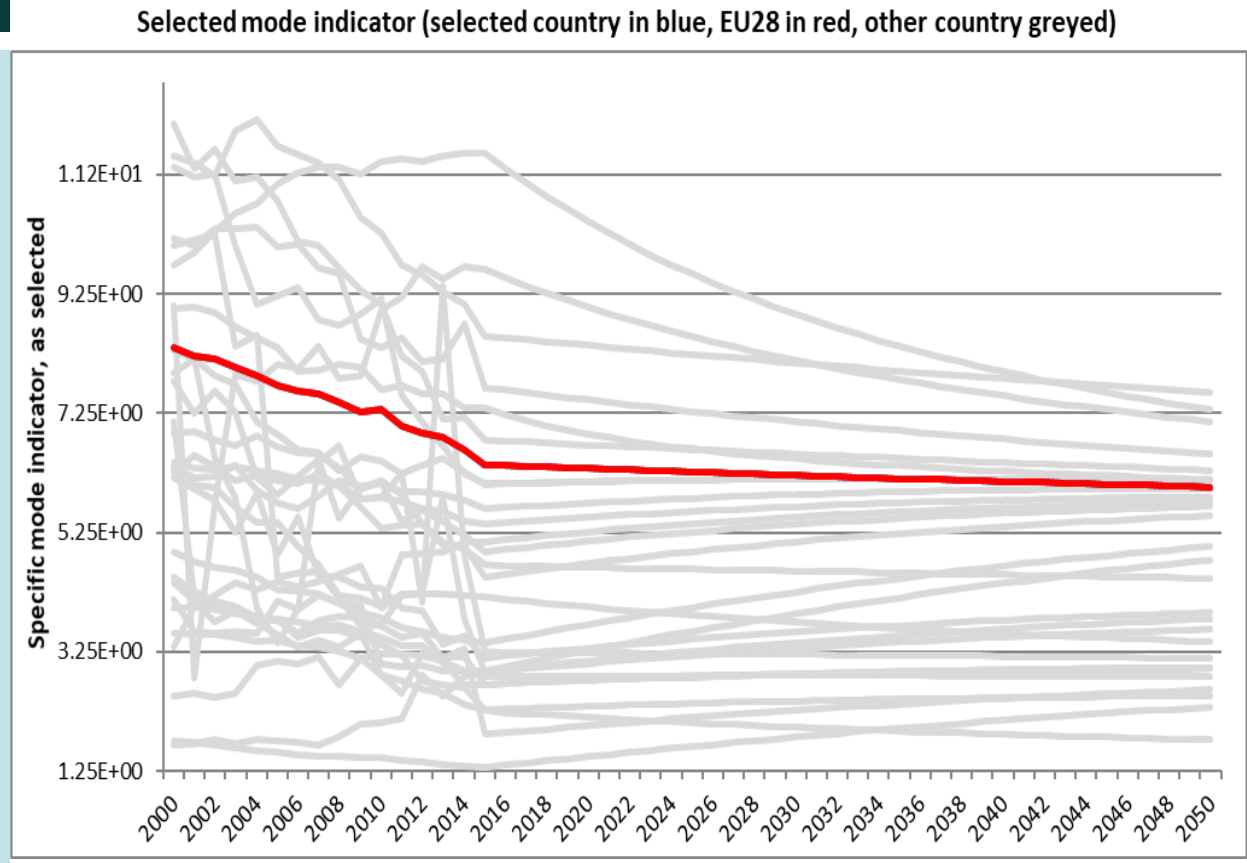
Freight *Storylines* – modal analysis – Dom. & Int. haulage

- Load factor
  - Improved logistic
  - Volume versus tonnage effects



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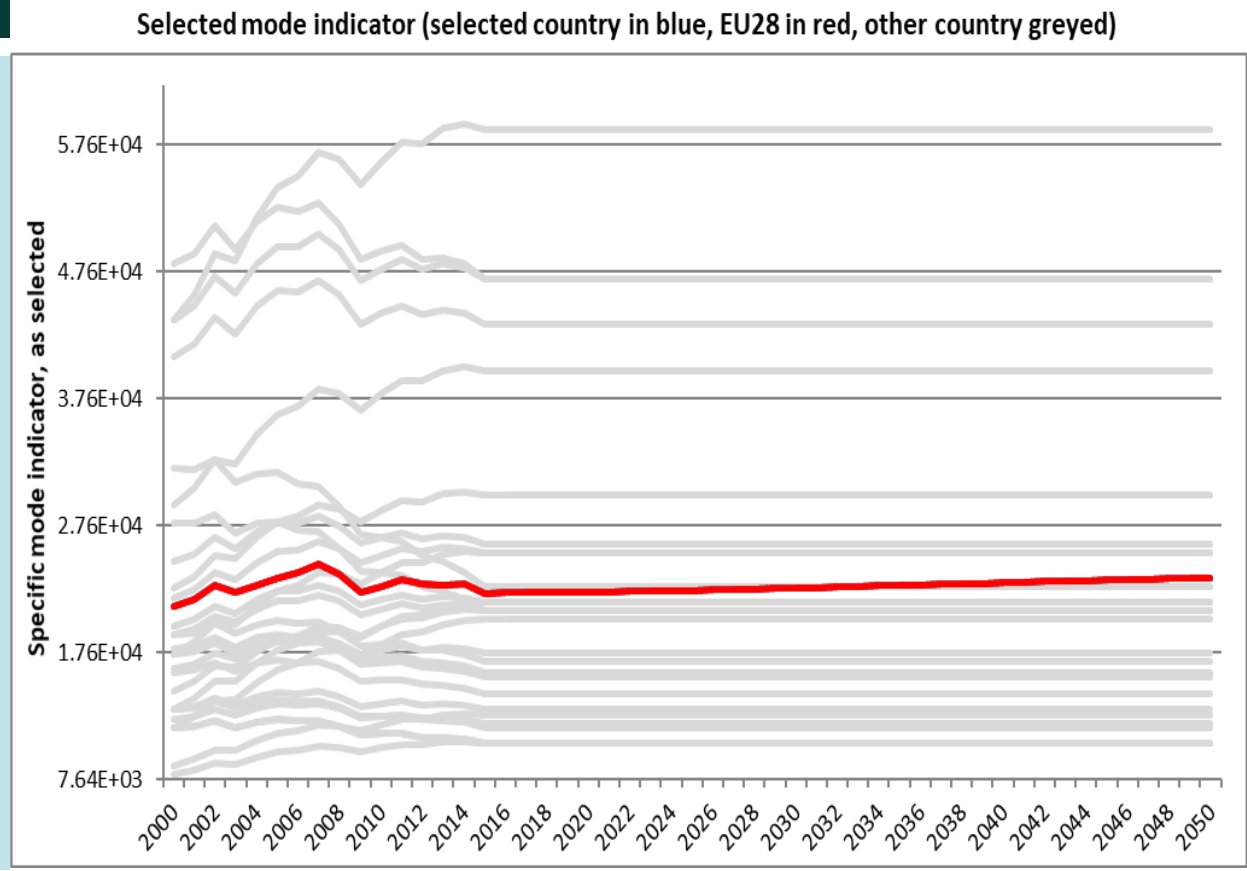
Freight *Storylines* – modal analysis – Dom. & Int. haulage

- Load factor
  - Improved logistic
  - Volume versus tonnage effects
- Mileage per vehicle
  - Identifying and projecting goods mobility patterns is difficult



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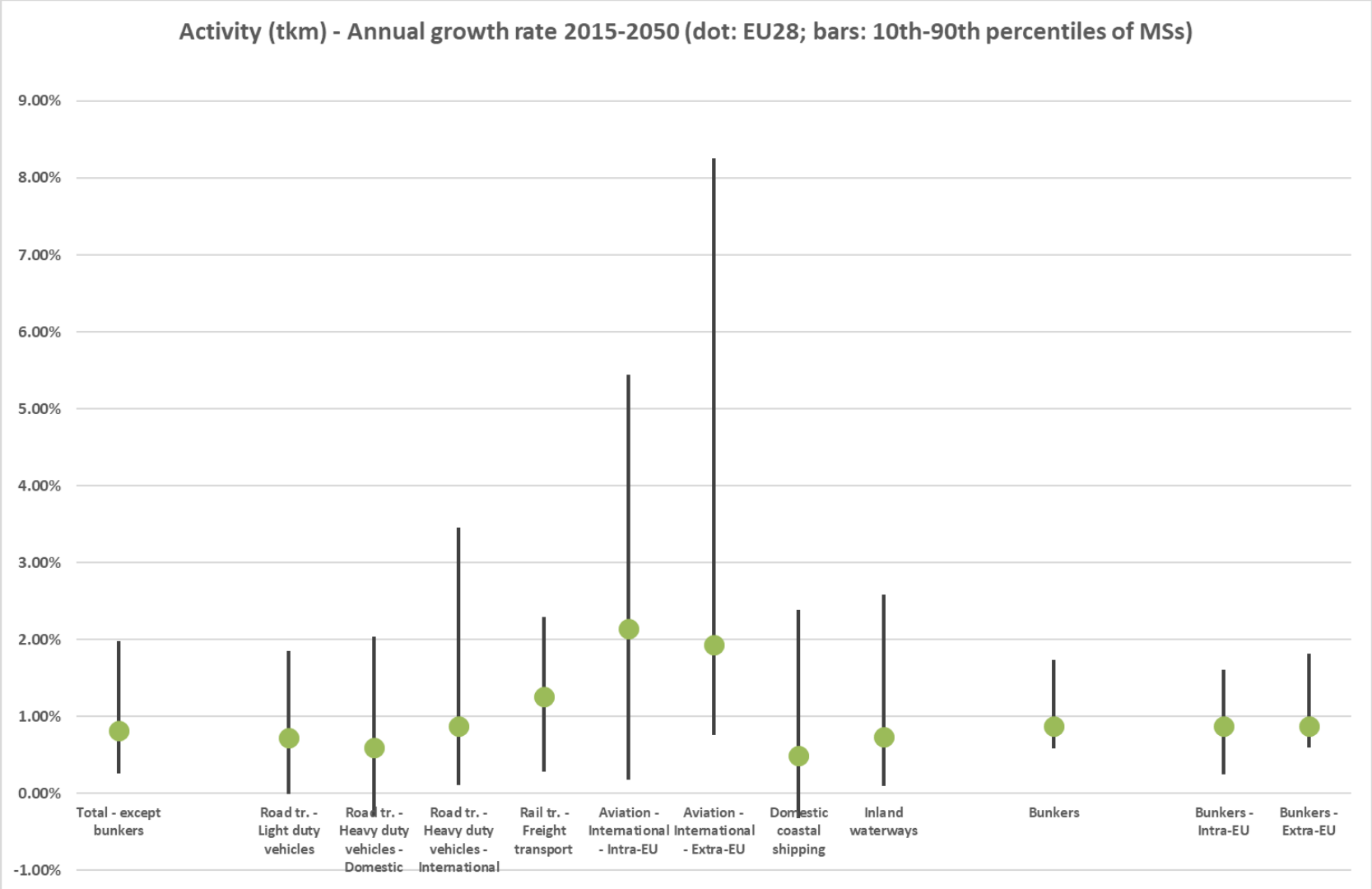
Freight *Storylines* – wrapping up



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Data Files of POTEnCIA assumptions

Macro – economic, demographic drivers used in the assumptions

Passenger transport - total and by mode

- Activity (Passenger-km)
- Activity per capita (km/capita)
- Mileage driven (Vehicle-km)
- Load factor (passenger per movement)
- Vehicle availability ratio (%)

Freight transport - total and by mode

- Activity (ton-km)
- Mileage driven (km)
- Intensity (ton-km/GDP)
- Load factor (tons per movement)
- Vehicle ownership ratio (%)

Distinction between domestic and international road (transit)

Analysis related information

- Instantaneous growth rates
- Variables of interest vs Expenditure or GDP per capita (for passengers or freight respectively)
- Elasticities

Across **time** and by **Member State**

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Dissemination

MEMBER STATES EXPERTS' WORKSHOP ON THE POTENCIA MODEL

Brussels, 27 February 2018

European Commission

Outline

File sharing – Research Collaboration Portal

Scenario result files

- Summary
- Industry
- Residential
- Services, Agriculture
- Transport
- Power Generation
- Energy balances

Research Collaboration Portal (RCP)

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RCP - ACCESSING THE POTENCIA PROJECT

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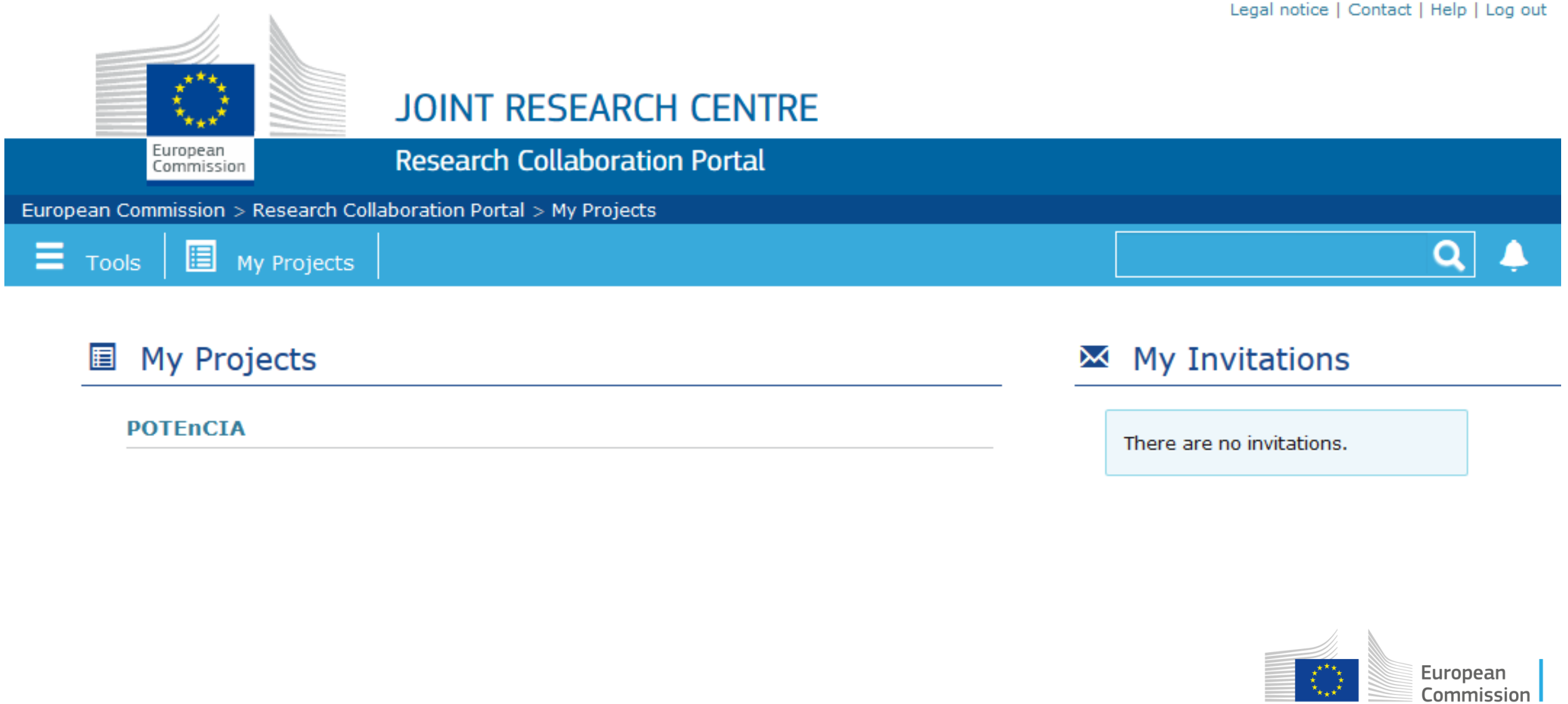
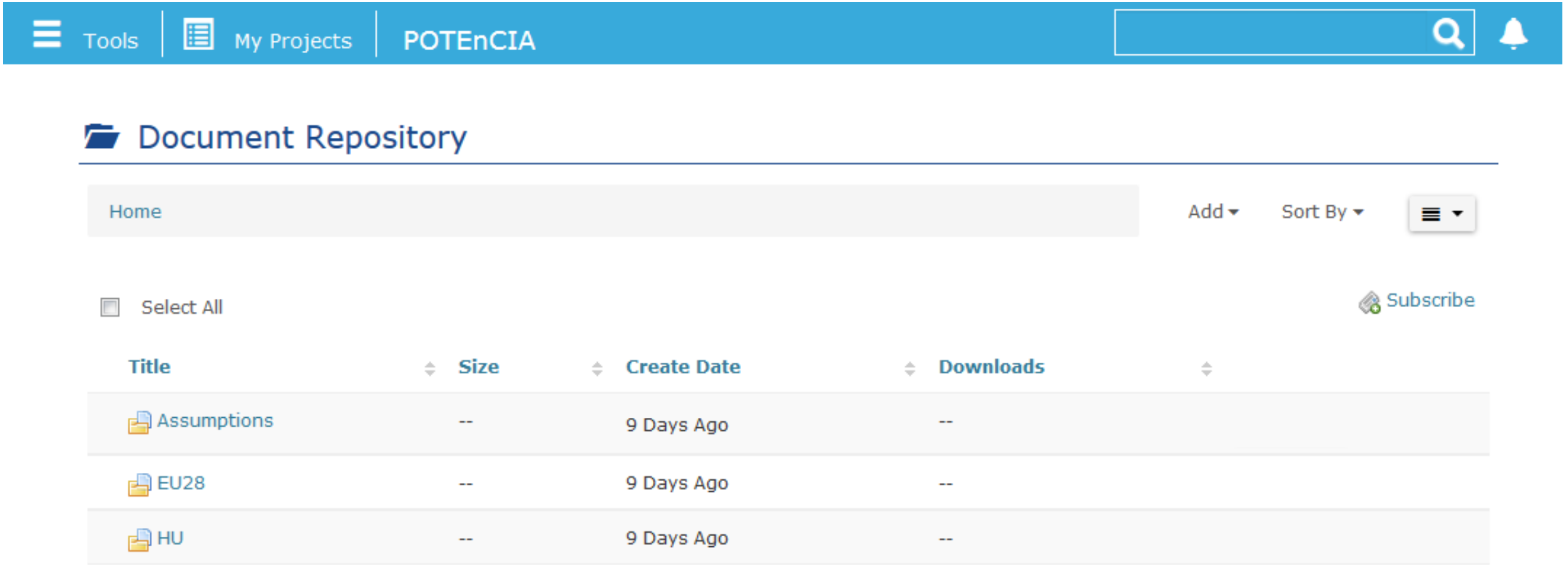
RCP – Opening Screen



RCP – Document Repository



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Scenario result files

- Summary file
- Energy balance
- Sectoral aggregates
  - Industrial sectors
  - Residential sectors
  - Tertiary sectors (Services, Agriculture)
  - Transport
  - Power and steam generation
- Sectoral detailed files
  - Transport sectors
- Reports with 5 year steps
- Reports with annual steps
- Yearly files (power generation)

Summary result file

e.g. *dm_EntryPoint_EU28_summary_yearly.xlsx*

Summarizes the results in an aggregated level: Energy consumption, Emissions, Costs, Indicators

- *Overview* - Overview of the country's energy system
- *Industry* - Industrial sectors overview
- *Residential* - Residential sector main aggregates
- *Tertiary* - Services and agriculture sector
- *Transport* - Transport sectors overview
- *PowerGen* - Power generation
- *EnergyBalances* - Energy balances / all products aggregate
- *Emissions* - CO2 Emission balances
- *ETS* - (current) ETS sector balances
- *RESshare* - Share of energy from renewable sources

Energy balance result file

e.g. *dm_EntryPoint_EU28_bal_yearly.xlsx*

Provides a complete energy balance at Eurostat fuel level and POTEnCIA sectoral detail.

- Timelined – one sheet contains data for a sector for 2000-2050

Final energy consumption	[ktoe]	2044	2045	2046	2047	2048	2049	2050
All Products	0000	1 137 244.57	1 139 525.33	1 142 721.95	1 145 203.79	1 147 895.79	1 150 362.48	1 153 033.78
Solid Fuels	2000	54 796.68	54 857.08	54 900.57	54 990.26	54 997.03	54 904.66	54 911.52
Hard coal and derivatives	2100	49 867.00	49 913.21	49 943.21	50 023.15	50 022.57	49 924.23	49 920.34
Hard Coal	2111	37 168.45	37 204.47	37 228.49	37 286.09	37 282.37	37 208.46	37 241.94
Anthracite	2115	2 374.11	2 377.80	2 381.37	2 393.39	2 391.24	2 381.54	2 391.24
Coking Coal	2116	2 437.89	2 434.69	2 431.95	2 415.16	2 419.60	2 403.05	2 409.22
Other Bituminous Coal	2117	31 861.29	31 895.68	31 917.55	31 978.90	31 972.32	31 924.14	31 941.26
Sub-bituminous Coal	2118	495.17	496.29	497.61	498.64	499.22	499.72	500.21
Patent Fuels	2112	343.37	343.80	344.31	344.76	345.14	345.52	345.76
Coke	2120	12 241.05	12 250.20	12 255.03	12 276.36	12 278.62	12 253.18	12 214.69
Coke Oven Coke	2121	12 241.05	12 250.20	12 255.03	12 276.36	12 278.62	12 253.18	12 214.69
Gas Coke	2122	-	-	-	-	-	-	-
Coal Tar	2130	114.14	114.75	115.38	115.94	116.45	117.09	117.95
Lignite and Derivatives	2200	4 897.38	4 911.10	4 924.31	4 933.80	4 941.10	4 946.82	4 957.33
Lignite/Brown Coal	2210	1 772.08	1 774.43	1 774.95	1 776.14	1 775.63	1 775.05	1 774.54
Peat	2310	469.44	471.64	473.67	474.77	476.44	476.73	477.89
BKB (brown coal briquettes)	2230	2 553.33	2 562.63	2 573.37	2 580.68	2 586.93	2 593.05	2 602.96
Peat Products	2330	102.53	102.41	102.33	102.22	102.09	101.99	101.95
Oil Shale and Oil Sands	2410	32.29	32.76	33.04	33.31	33.36	33.61	33.85
Total petroleum products (without biofuels)	3000	410 691.95	411 320.48	412 477.97	413 670.06	414 655.36	415 729.82	416 818.92
Crude oil, feedstocks and other hydrocarbons	3100	8.15	8.16	8.17	8.17	8.17	8.18	8.18
Crude oil and NGL	3110	8.15	8.16	8.17	8.17	8.17	8.18	8.18
Crude Oil without NGL	3105	-	-	-	-	-	-	-
Natural Gas Liquids (NGL)	3106	8.15	8.16	8.17	8.17	8.17	8.18	8.18
Feedstocks and other hydrocarbons	3190	-	-	-	-	-	-	-
Refinery Feedstocks	3191	-	-	-	-	-	-	-
Additives / Oxygenates	3192	-	-	-	-	-	-	-
Other Hydrocarbons (without biofuels)	3193	-	-	-	-	-	-	-

INDUSTRIAL SECTORS RESULT FILE

e.g. *dm_EntryPoint_EU28_ind_yearly.xlsx*

Provides the results at a detailed process / technology level:

Value added; production; capacities; energy consumption; emissions; costs; indicators, ...

- *Summary* - Overview of sectors
- *first sector-sheet* - Value added; physical output; energy consumption; CO2 emissions; intensities; costs
- *second sector-sheet* - Production capacities (incl. investment; idle capacities; normal and pre-mature replacement); energy and emission reductions through non-energy measures

RESIDENTIAL SECTOR RESULT FILE

e.g. *dm_EntryPoint_EU28_res_yearly.xlsx*

Provides the results at a household / end-use level:

- *RES_summary* - Macro-economic drivers; household indicators; end-use level indicators for energy consumption, thermal energy service, emissions, efficiencies (e.g. energy consumption per household for space heating); costs
- *RES_sectors* - Thermal uses: energy consumption; energy service at fuel level, emissions
- *RES_appliances* - Appliances: energy consumptions; operating hours; wattage; penetration
- *RES_hh-type* - Thermal uses at household type / end-use level: energy consumption
- *RESU_hh-type* - Thermal uses at household type / end-use level: energy service

TERTIARY SECTORS RESULT FILE

e.g. *dm_EntryPoint_EU28_ter_yearly.xlsx*

Provides the results for services and agriculture:

- *SER_sum_sqm* - Macro-economic drivers; indicators at useful surface area level; end-use level indicators for energy consumption, thermal energy service, emissions, efficiencies; costs (Same information is available per employee, per building, per capita and per value added – *SER_sum_<...>* sheets)
- *SER_sector* - Thermal uses: energy consumption; energy service at fuel level, emissions
- *SER_appliances* - Appliances: energy consumptions; operating hours; wattage; penetration
- *AGR* - Agriculture: energy consumption, emissions, intensities, costs

TRANSPORT SECTORS RESULT FILE

e.g. *dm_EntryPoint_EU28_tra_yearly.xlsx* - Provides the results at mode / technology level

- *TRA_Totals* - Aggregated results at transport mean level (activity, stock, energy consumption, emissions)
- *TRA_Passenger* - Overview of the passenger transport (additional indicators, costs)
- *TRA_Freight* - Overview of the freight transport (additional indicators, costs)

Each transport mode has the following sheets:

- *..._Act* - Activity, vehicle-km, stock, indicators, costs at mean / technology level
- *..._EnEm* - Energy consumption, emissions, efficiencies at mean / technology level

Second file: detailed results at technology / fuel level (e.g. *dm_EntryPoint_EU28_tra_det_yearly.xlsx*)

different structure: one sheets combines all means for one indicator

POWER GENERATION RESULT FILE

e.g. *dm_EntryPoint_EU28_pg_yearly.xlsx*

- Specific energy balances: *Electricity Balance, Steam Balance*
- Results at power plant type / co-generation level:

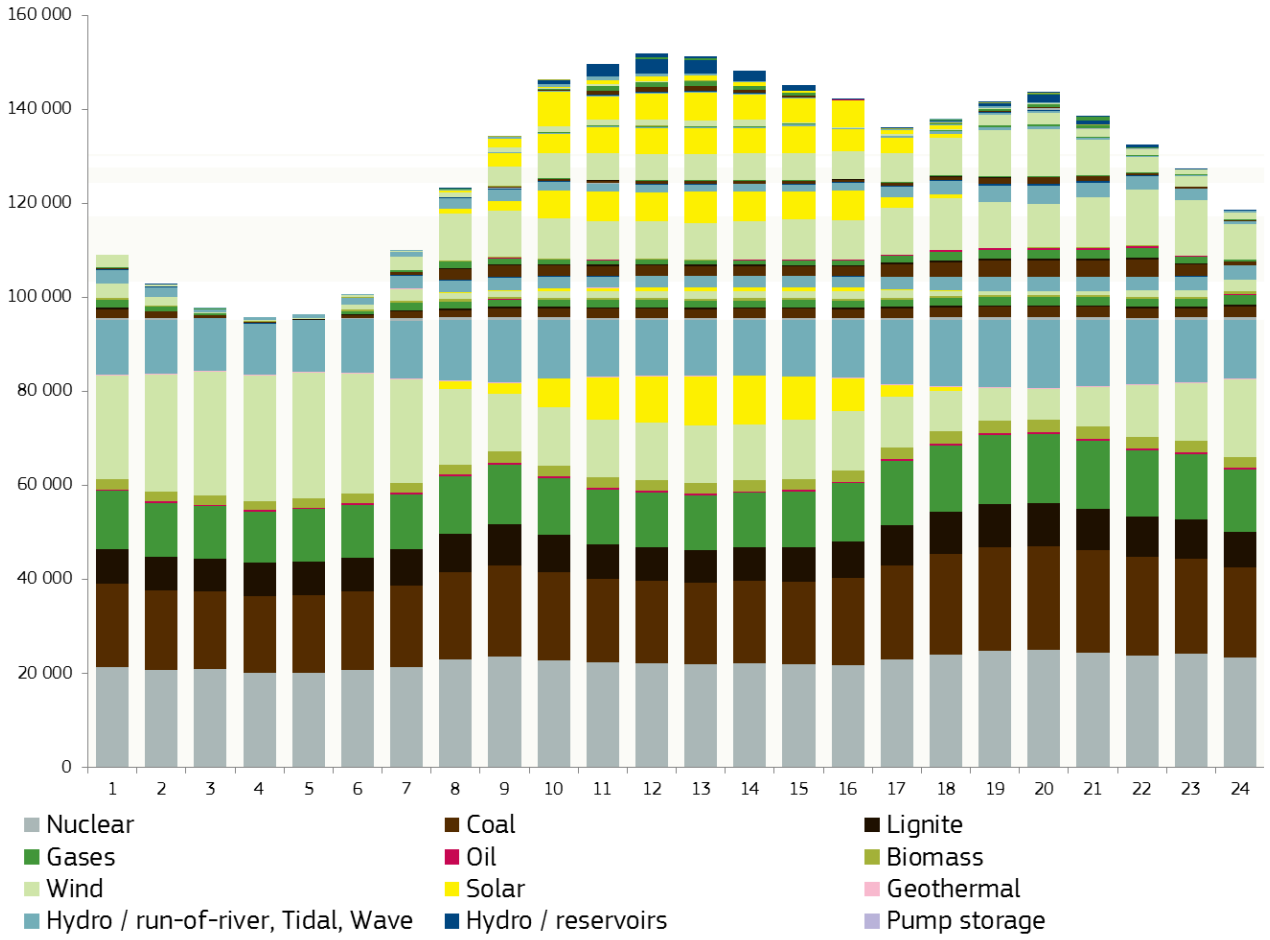
Gross Electricity Generation	*Net Electricity Generation*	*Steam Generation*
Transformation input Total	*Transformation input Nominal*	*Transformation input Oper*
CO2 emissions	*CO2 emissions captured*	
Gross Generation Efficiency	*Net Generation Efficiency*	*Steam to Electricity ratio*
Net Capacities in Operation	*Number of Units in Operation*	
Operating Hours	*Spinning Hours*	
Gross Capacities	*Net Capacities*	*Number of Units*
Gross Capacities Investment	*Net Capacities Investment*	*Number of Units Investment*
System Costs	*Unit Costs*	

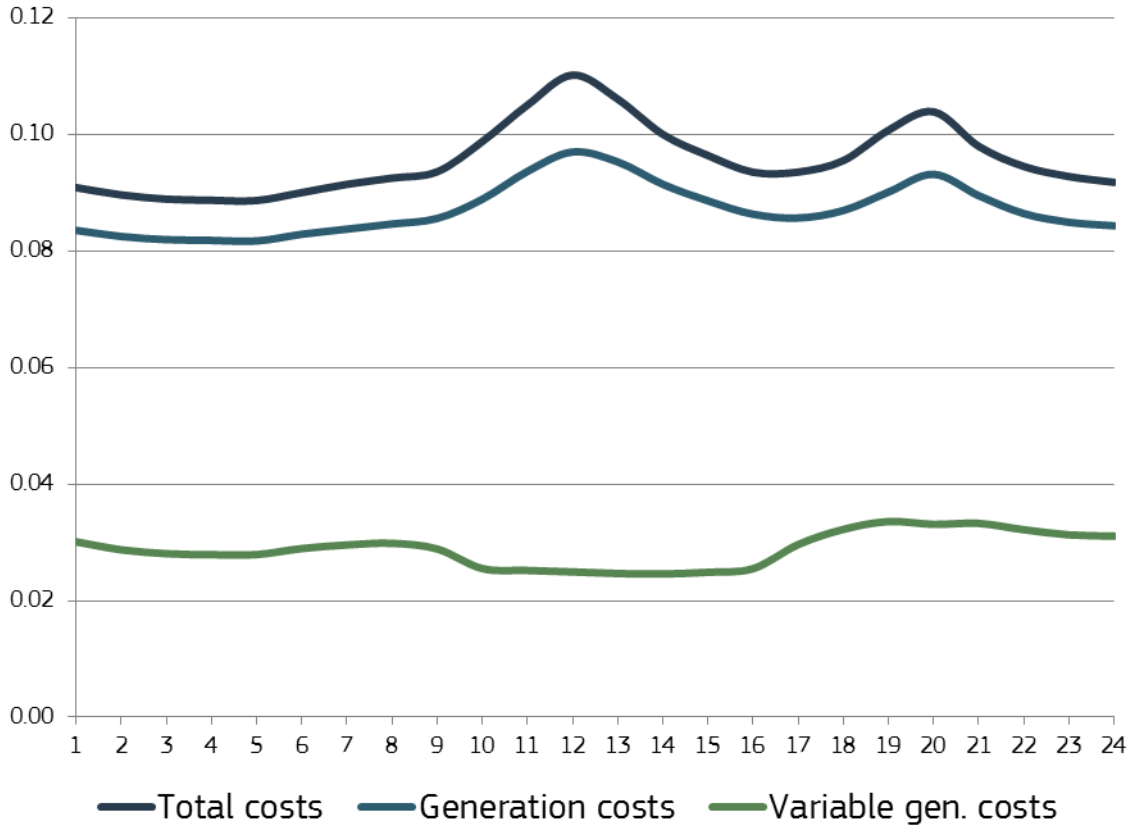
- Load for the representative day: *Net Generation load*

Power generation yearly special reports

e.g. *dm_EntryPoint_EU28_ctsl_2034*

Provides information on the unit commitment and costs at hourly resolution for the representative day





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File structure

5_year_reports
- dm_EntryPoint_EU28_summary_5years.xlsx
- dm_EntryPoint_EU28_bal_5years.xlsx
- dm_EntryPoint_EU28_ind_5years.xlsx
- dm_EntryPoint_EU28_res_5years.xlsx
- dm_EntryPoint_EU28_ter_5years.xlsx
- dm_EntryPoint_EU28_tra_5years.xlsx
- dm_EntryPoint_EU28_pg_5years.xlsx

Det_5_year_reports
- dm_EntryPoint_EU28_tra_det_5years.xlsx

Annual_reports
- dm_EntryPoint_EU28_summary_yearly.xlsx
- dm_EntryPoint_EU28_bal_yearly.xlsx
- dm_EntryPoint_EU28_ind_yearly.xlsx
- dm_EntryPoint_EU28_res_yearly.xlsx
- dm_EntryPoint_EU28_ter_yearly.xlsx
- dm_EntryPoint_EU28_tra_yearly.xlsx
- dm_EntryPoint_EU28_pg_yearly.xlsx

Det_annual_reports
- dm_EntryPoint_EU28_tra_det_yearly.xlsx

Year_spec_reports
- dm_EntryPoint_EU28_ctsl_2015.xlsx
- dm_EntryPoint_EU28_ctsl_2016.xlsx
- dm_EntryPoint_EU28_ctsl_2017.xlsx
- dm_EntryPoint_EU28_ctsl_2018.xlsx
- . . .
- dm_EntryPoint_EU28_ctsl_2047.xlsx
- dm_EntryPoint_EU28_ctsl_2048.xlsx
- dm_EntryPoint_EU28_ctsl_2049.xlsx
- dm_EntryPoint_EU28_ctsl_2050.xlsx

European Commission

Constructing the POTEnCIA 'Central' Scenario

Questionnaire to Member States

MEMBER STATES EXPERTS' WORKSHOP ON THE POTENCIA MODEL
Brussels, 27 Feb 2018

European Commission

POLICY ANALYSIS WITH A MODELLING TOOL

… requires continuous interactions

between European Commission and Member States' experts

- Understanding and correctly reflecting the past

  JRC-IDEES database

  → Exchanges with national experts on-going

- Agreeing in key future assumptions

- Understanding the model features and scope

  → illustrative **"Entry-point"** stylised scenario

- Addressing **country specificities**

  → incorporation of country specific policies in place

  → inclusion of on-going investments plans

  → Understand the evolution of national energy systems in a European wide context

Overview and Guidelines

- The scope covers **energy policies & other policies impacting energy-related CO2 emissions:**

  → To identify the expected impact of existing policies **(i.e. adopted and implemented by 1 January 2018)**

  → To reflect ongoing investment plans

  … and understand Member States long-term visions on their energy system in an EU-wide context

- Questions are designed to:

  → Gather quantitative information, as far as possible

  → Can be complemented via attachment of relevant reports, studies, impact assessments

- Submission of replies to the questionnaire is of voluntary and non-binding nature
- Replies to the questionnaire do not replace/ substitute for MS reporting obligations under relevant energy and climate Directives & Regulations

QUESTIONNAIRE STRUCTURE

Part A

POLICIES AND MEASURES IN PLACE AND INVESTMENTS

- What are existing policies and measures adopted and implemented by 1 January 2018 expected to deliver in terms of:
- What are the existing investment plans:

INFRASTRUCTURE

Energy and transport networks

POWER GENERATION

Conventional and renewable electricity

DEMAND SIDE

Industry, buildings, transport

Part B

MEMBER STATES' ENERGY SYSTEM VISION

- What do long-term strategies and objectives envisage in terms of:

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Part A: Policies and Measures in Place and investments (1)

INFRASTRUCTURE

Energy networks

- → Electricity (transmission and distribution, interconnection)
- → Natural Gas network (transmission, storage and LNG)
- → Distributed heat
- → Hydrogen and other fuel networks

Transport networks

- → Electric vehicle fast charging
- → Alternative fuels infrastructure (hydrogen & others)
- → High-speed, conventional & metro/tram/light rail
- → Inland waterways
- → Aviation

Indigenous energy production

- → Fossil-fuel resources
- → Biomass production

Key questions

Any policies and measures in place to expand coverage?

Projects currently under construction?

Any legislation in place which might hinder/limit development ?

Part A: Policies and Measures in Place and investments (2)

POWER GENERATION

- **New capacities** under construction

  → Fuel, technology, capacity and unit breakdown, CHP, CCS, costs, and indicative commissioning year

- **Decommissioning** schedule

  → Any discrepancies between JRC-IDEES and latest national information

- Place of **nuclear** and place of **coal/lignite** in the mix

  → Expected contribution in the future under policies in place (e.g. stable, decrease, phase-out)

  → Explicit policies in place to deliver

- **Renewables** (intermittent or non-intermittent)

  → Expected contribution in the future under policies in place

  → Explicit policies in place to deliver (policy type, description, expected impact, projected costs)

- **Carbon Capture and Storage** or use

  → Policies or measures in place which hinders, limits or supports the development CCS/CCU

  → Any project under construction

Part A: Policies and Measures in Place and investments (3)

DEMAND SIDE

- **Industry**
  - → Any major capacity expansion/decommissioning
  - → Policies and measures to reduce energy consumption or CO2 emission – policy type, cost and impact
- **Buildings**
  - → Policies and measures in place on renovation, heating and cooling equipment use, appliances, renewable uptake) – policy type, cost and impact
  - → VAT on energy related equipment and other relevant taxes
- **Transport**
  - → Policies and measures in place on the uptake of alternative fuel vehicles, increased use of renewables, on activity shifts (in mobility patterns, in modes, in vehicle stock) - policy type, cost and impact
  - → Taxes and levies on vehicles, VAT, road charges (passenger cars and heavy duty) and any other relevant taxes
- **Article 7 Implementation (EED)**
  - → Any cross-sectoral newly implemented legislation or other policy measures
- **Energy Taxation**
  - → Sectoral breakdown of tax revenues from energy consumption by fuel

Part B: Member States Energy System Vision (1)

INFRASTRUCTURE

- Foreseen evolution of coverage/activity of:
  - → energy networks (gas, hydrogen, others)
  - → Vehicle fuelling networks (electric, hydrogen, others)
  - → Transport networks (rail, waterways)

POWER GENERATION

- Foreseen evolution of:
  - → renewable resources in the mix
  - → CCS/CCU

DEMAND

- Any foreseen industrial restructuring
- Any relevant strategy for energy consumption in buildings (e.g. 2050 renovation strategy, renewable penetration)
- Foreseen penetration of alternative fuel in transports (by fuel –if available)

Sample Question – Good example

- Are there policies and measures in place to develop or expand coverage of **distributed heat** infrastructure? *(please define the indicator used, e.g. % of buildings, population)*

Estimated current coverage	25% of **total building stock**
Policies or measures in place	**National Infrastructure Investment Plan:** - € XX million investments in heat networks between 2012 and 2020 *Reference: Adopted Act Y – date* **Regional and local investment plans:** - € XX million investment in city X, Y and Z *References*
Estimated impact (with year, e.g. by 2030, 2050)	Estimated increased coverage to 45-49% of building stock by 2022. *See published impact assessment in Annex A.*

Sample Question – Bad example

- Are there policies and measures in place to develop or expand coverage of **distributed heat** infrastructure? *(please define the indicator used, e.g. % of buildings, population)*

Estimated current coverage	14% of dwellings in urban areas
Policies or measures in place	New District heat partnerships between **City Y & City Z**
Estimated impact (with year, e.g. by 2030, 2050)	6 separate networks to be connected by 2025.

Please consider as far as possible:

- *If the information provided falls within the scope of an energy system model like POTEnCIA*
- *That any complementary information required to make use of estimates is available to the modelling team*

Next steps
Construction of the POTEnCIA "Central scenario"

MEMBER STATES EXPERTS' WORKSHOP ON THE POTENCIA MODEL

Brussels, 27 February 2018

European Commission

Next Steps

Development of the "**Central**" scenario in collaboration with the Member States

- Describes the evolution of the energy system with the current *policies in place*
- Corresponds to the "projections with existing policies and measures" as requested in Governance Proposal.
- Builds on the "Entry-point" scenario and the feedback received from Member States

Feedback received from Member States (return of questionnaires by end of March 2018)

Draft "Central" scenario results to be circulated (by the end of April 2018)

JRC-IDEES workshop with Member States (late April 2018)

Bilateral discussions on the scenario results (May 2018)

Consistency check of the **macroeconomic assumptions** with the **JRC GEM-E3 model**

2nd POTEnCIA Workshop to discuss the advanced "Central" scenario (June 2018)

Consolidated "Central" scenario results planned for July 2018

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Next Steps

Development of the "**NECPs**" scenario in collaboration with the Member States

- Describes the evolution of the energy system with the **planned** *policies and measures*
- Reflects the impact of **National Energy and Climate Plans** to the Member States energy systems

Policy assumptions to be introduced are going to be based on the communicated plans of the Member States

Bilateral discussions may also be envisaged

Consolidated "NECPs" scenario results planned for December 2018

Both scenarios can act as an input for the Commission's assessment of the combined impact of Member States' National Energy and Climate Plans

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Next Steps

In order to deliver on the work outlined two special groups as to formally involve national experts have been created:

- The JRC-IDEES Special Group

  The members of the working group will provide comments on /review/validate their country-specific files of the JRC-IDEES database. JRC-IDEES will be updated on an annual basis. It forms both a key input for the POTEnCIA model and a comprehensive stand-alone data-box for policy analysis.

- The POTEnCIA Special Group

  The purpose of this group is to further improve the input and output of the POTEnCIA model, in particular as to better reflect the properties of the national energy systems.

Thank you for your attention

JRC Science Hub –POTEnCIA:
ec.europa.eu/jrc/POTEnCIA

Contact:
JRC-C6-POTENCIA@ec.europa.eu

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