TYNDP 2014
Bottom Up Scenarios for 2030

Input and Results Pan EU Market Studies

Slow Progress (Vision 1) **Green Transition (Vision 3)**

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- **Visions overview**

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- **Pan European Market Simulations for Visions 1 and 3**
  - Process
  - Key inputs: fuel/CO2 prices, demand, installed generation capacities, climate data
  - Some selected results market simulations
    - Fuel mix
    - CO2 emissions
    - Country balances

Visions overview

Bottom-up scenarios

Top-down scenarios

On track for Energy roadmap 2050

Delay of Energy roadmap 2050

Low degree of integration of the internal electricity market

High degree of integration of the internal electricity market

Vision 3 : Green transition?

- Favourable economic and financial conditions
- Reinforced national energy policies
- Parallel national R&D research schemes
- High CO2 prices and low primary energy prices (IEA – WEO 2010 450 scenario)

Vision 4 : Green revolution

- Favourable economic and financial conditions
- European energy policy
- European R&D research scheme
- High CO2 prices and low primary energy prices (IEA – WEO 2010 450 scenario)

Vision 1 : Slow progress

- Less favourable economic and financial conditions
- No reinforced national energy policies
- Parallel national R&D research schemes
- Low CO2 prices and high primary energy prices (IEA – WEO 2010 current policies scenario)

Vision 2 : Money rules

- Less favourable economic and financial conditions
- European energy policy
- European R&D research scheme
- Low CO2 prices and high primary energy prices (IEA – WEO 2010 current policies scenario)

General Characteristics of all 2030 Visions

VISION 3: "GREEN TRANSITION" | VISION 4: "GREEN REVOLUTION"
VISION 1: "SLOW PROGRESS" | VISION 2: "MONEY RULES"

	Vision 1 : Slow progress	Vision 2 : Money rules	Vision 3 : Green transition	Vision 4 : Green revolution
Economic and financial conditions	Less favourable	Less favourable	Favourable	Favourable
Focus of energy policies	National	European	National	European
Focus of R&D research schemes	National	European	National	European
CO_2 prices and primary energy prices	Low CO_2 prices and high primary energy prices	Low CO_2 prices and high primary energy prices	High CO_2 prices and low primary energy prices	High CO_2 prices and low primary energy prices
Electricity demand	Lowest level	Higher than in Vision 1	Higher than in Vision 2	Higher than in Vision 3
Demand respons potential	Used as today	Partially used	Partially used	Fully used
Electric vehicles	No commercial break through of electric plug-in vehicles	Electric plug-in vehicles (with flexible charging)	Electric plug-in vehicles (with flexible charging)	Electric plug-in vehicles (with flexible charging and generation)
Heat pumps	Implemented (although not evenly spread around Europe)	Implemented (although not evenly spread around Europe)	Implemented (although not evenly spread around Europe)	Much more heat pumps implemented (although not evenly spread around Europe)
Back-up generation	Level of back-up generation higher than in Vision 2 but lower than in Vision 4	Lowest level of back-up generation	Highest level of back-up generation	Level of back-up generation higher than in Vision 2 but lower than in Vision 3
Nuclear	National view	Public acceptance	National view	Public acceptance
CCS	Not commercially implemented	Partially implemented	Not commercially implemented	Fully implemented
Storage	As planned today	As planned today	Decentralised storage (limited amount but higher than in Vision 4)	Mainly additional centralised hydro storage + some decentralised storage
Smart grid solutions	Partially implemented	Fully implemented	Partially implemented	Fully implemented

Building of the Bottom-up Visions
“Slow Progress” & “Green Transition”

(based on stakeholders input and data collection)

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Methodology for data collection using Stakeholders input

- **In order to improve the scenarios for future grid development needs, stakeholders were consulted regarding probable tendencies towards 2030 (workshop 17/4/2012). <u>The inputs were used to establish default values and general common framework</u>**

- **National data (data for vision 1 "Slow Progress" and 3 "Green Transition") provided by Long-term Adequacy Correspondent (LAC) should be coherent with the general common framework set by ENTSO-E => <u>consistency checks</u>**

- **The top-down approach for visions 2 "Money Rules" & 4 "Green Revolution" requires that they are established at a centralized European level with visions 1 and 3 data as a starting point**

Example of defaults for Vision 1 "Slow Progress" based on stakeholders workshop 17/4/2012

Demand

- the yearly growth rate of electricity demand in vision 1 should take into account the following:
  - **The yearly change rate of electricity demand between 2010 and 2030 should be between +0.5%/year and -0.5%/year** although rates between +1%/year and -1%/year are still acceptable.
  - A minimum level of electric vehicles (between 5 and 15%). **Proposed default penetration level is 5% of passenger vehicles.**
  - A change in electricity consumption due to a minimum level of heat pumps (between 1 and 10%). **Proposed default penetration level is 1% of households.**
- No additional peak shaving**. Proposed default value is thus 0% of peak load**
- *DEVIATIONS* : LACs should explain in a comment why deviations from the given guideline are acceptable.

Similarly supply data for Vision 1 and demand/supply data for Vision 3 are bounded according to stakeholders inputs

Consistency checks to assess compliance with general common framework set using stakeholders inputs

- **2 consistency checks for EU2020 at National level**
- **21 consistency checks for national Vision 1 "Slow Progress" & 3 "Green Transition":**
  - **13 consistency checks at National level**
  - **8 consistency checks at ENTSO-E & EU level**

Examples on consistency checks at EU level:

Consistency check 1 (Vision 1): the yearly growth rate of electricity demand between 2010 and 2030 should be between +0,5%/year and -0.5%/year although growth rates between +1%/year and -1%/year are still acceptable

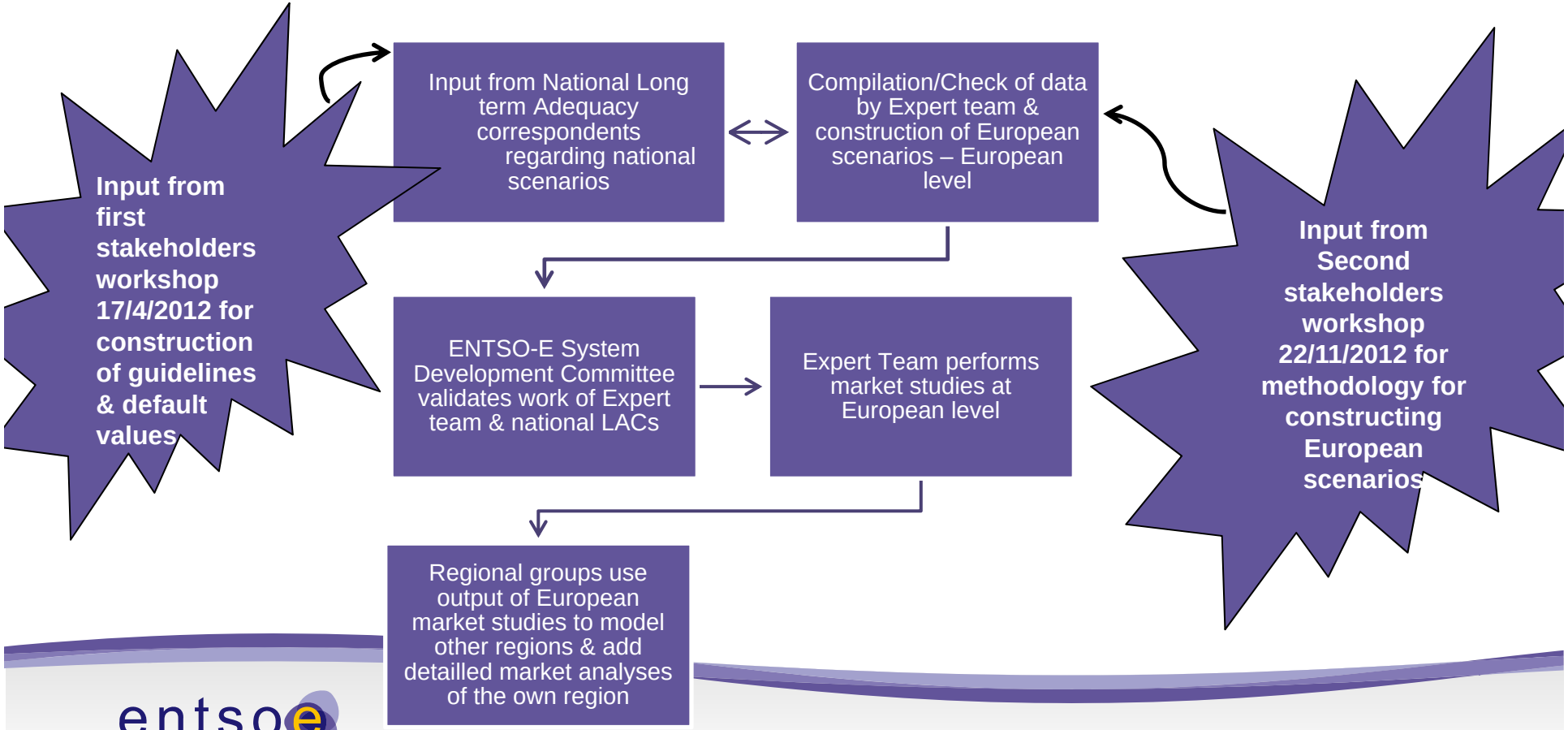
Consistency check 2 (Vision 1) & Consistency check 6 (vision 3): the minimum penetration levels of electric vehicle and heat pumps put forward by stakeholders

Consistency check 11 (Vision 1) & Consistency check 16 (vision 3): values per type of RES checked at European level

Summary of construction process for 2030 visions

Construction by a dedicated ENTSO-E TSO Expert Team

- **Consistency checks of Visions 1 “Slow Progress” and 3 “Green Transition”**
- **Quantification of the two European top down 2030 Visions 2 “Money Rules” and 4 “Green Revolution”**



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Pan European Market Simulations for Visions 1 and 3

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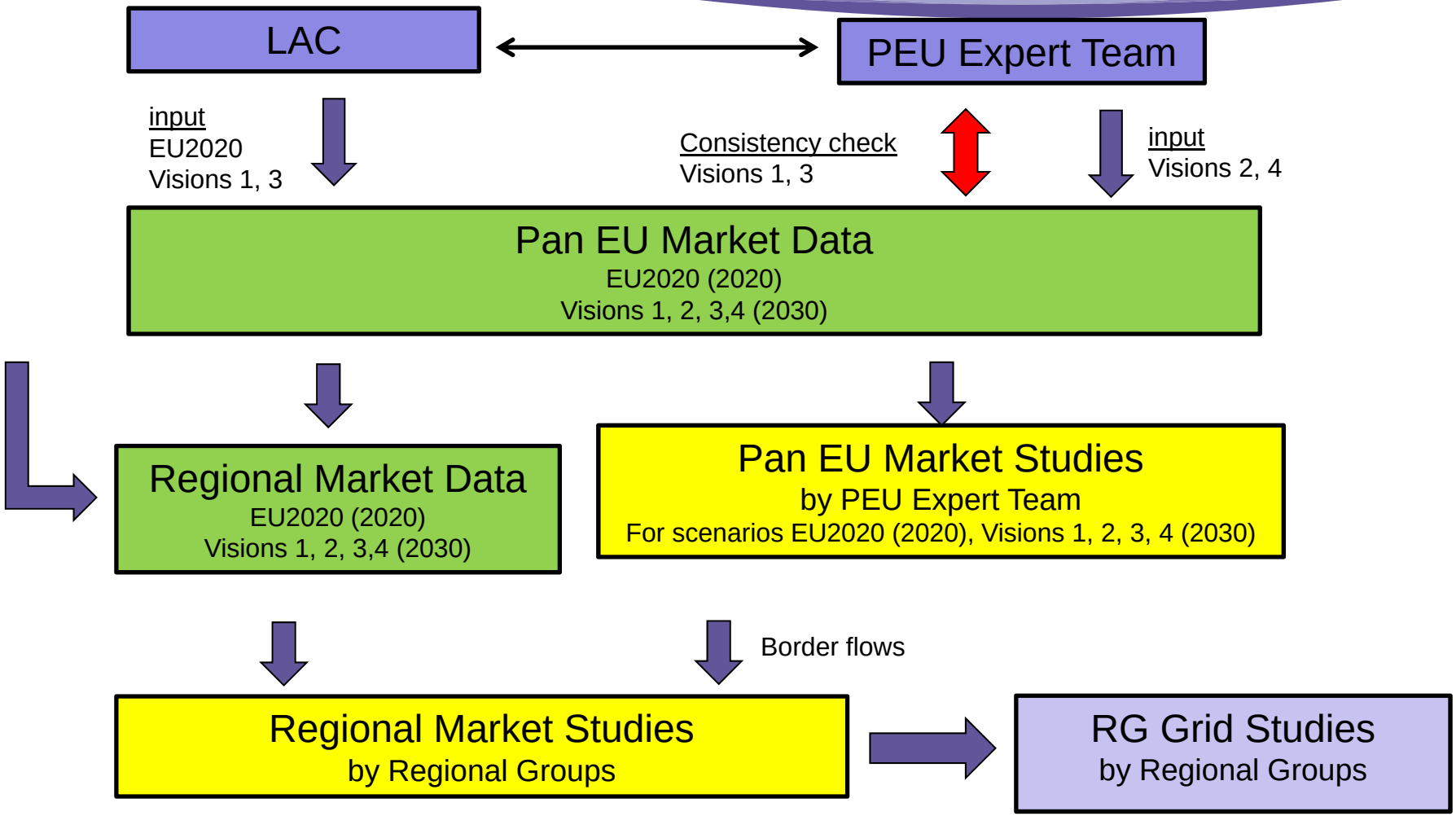
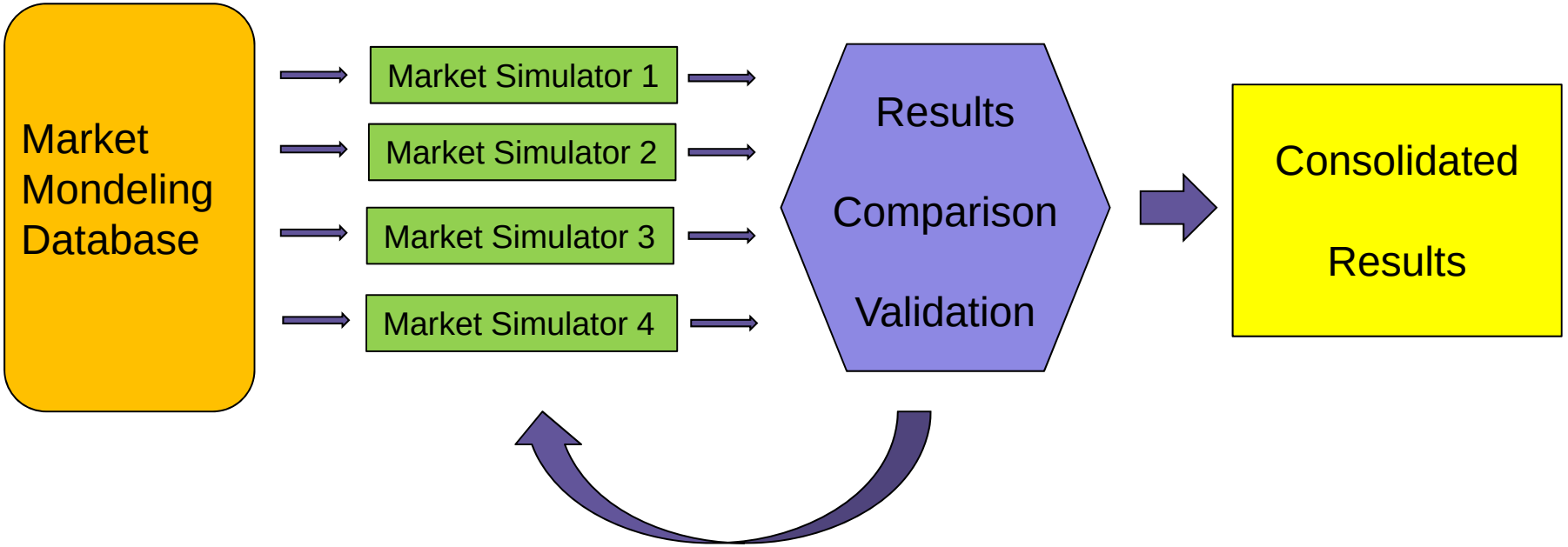
Pan European Market modeling for long-term grid development
Market data preparation and usage



Pan European Market modeling for long-term grid development
ORGANIZATION

17 TSOs cooperating together in Pan EU market studies



Pan European Market modeling for long-term grid development
Market modeling Inputs and Outputs

Inputs

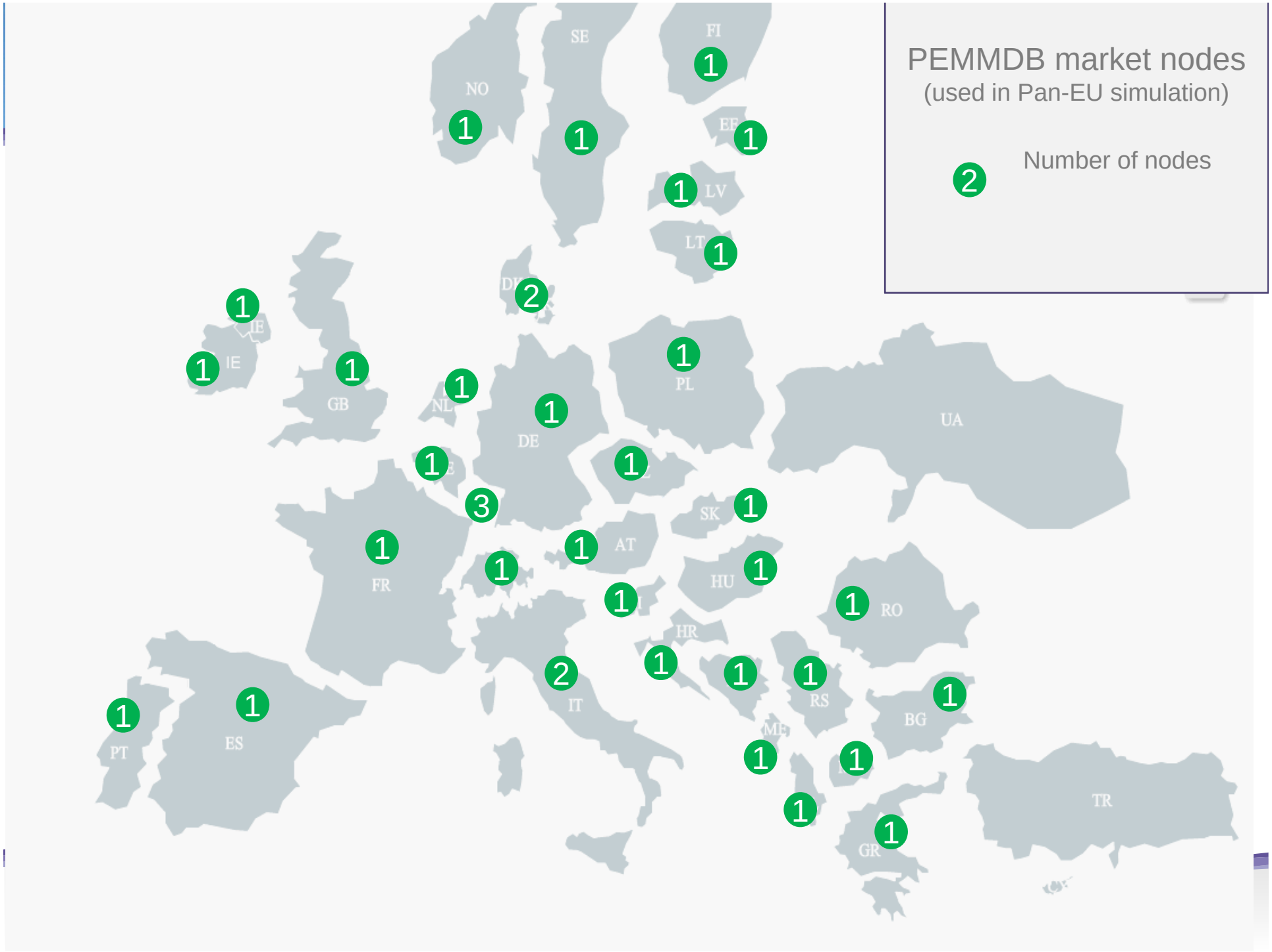
- Multiple scenarios with hypotheses regarding
  - Demand profile
  - Generator characteristics
  - Other generation profile
  - Wind and Solar Profiles
  - Transfer Capacities
  - Reserve
  - Exchanges to Rest of World profile
  - Fuel and CO_2 prices

Modelling

- Chronological Unit Commitment Economic Dispatch model
- Hourly model
- Each country is a single market node
- Minimise the system cost (fuel bill/operating costs) subject to constraints such as must-run, reserve, generator capabilities.

Outputs

- National Balances
- Market Node Marginal costs
- Hourly generation pattern for each generator
- System/Fuel cost
- Fuel consumption by fuel type
- CO_2 emissions


PEMMDB market nodes
(used in Pan-EU simulation)
Number of nodes
2
NO
SE
FI
EE
LV
LT
DK
IE
GB
NL
DE
PL
UA
BE
LU
SK
AT
FR
HU
RO
HR
IT
RS
BG
ME
PT
ES
GR
TR

Pan European Market modeling for long-term grid development

Data for each Market node

- Demand and Demand-Side Management Data Set (year around hour-by-hour time series)
- Supply data
  - Thermal Dispatchable Generation Data Set
  - Hydro Generation Data Set
  - Wind Generation Data Set
  - Solar generation
  - Other Renewables Generation Data Set
  - Other Non-Renewables Generation Data Set
- System data
  - Operational reserves Data Set
  - Exchange capacities between market nodes
  - Power Exchange Data with non ENTSO-E countries

Key input: Fuel / CO2 Prices

Fuel and CO2 prices determine the merit order of the generating resources

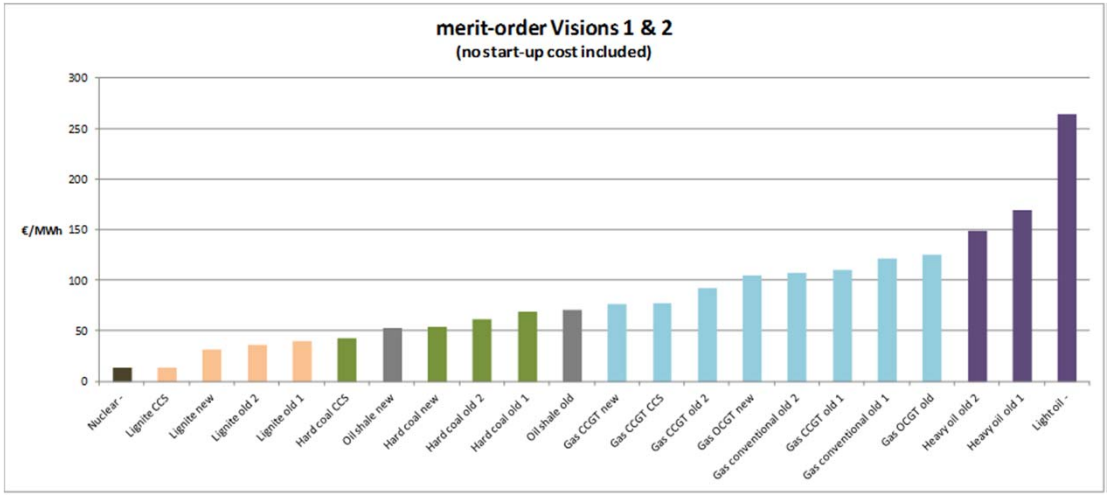
Sources for fuel and CO2 prices:

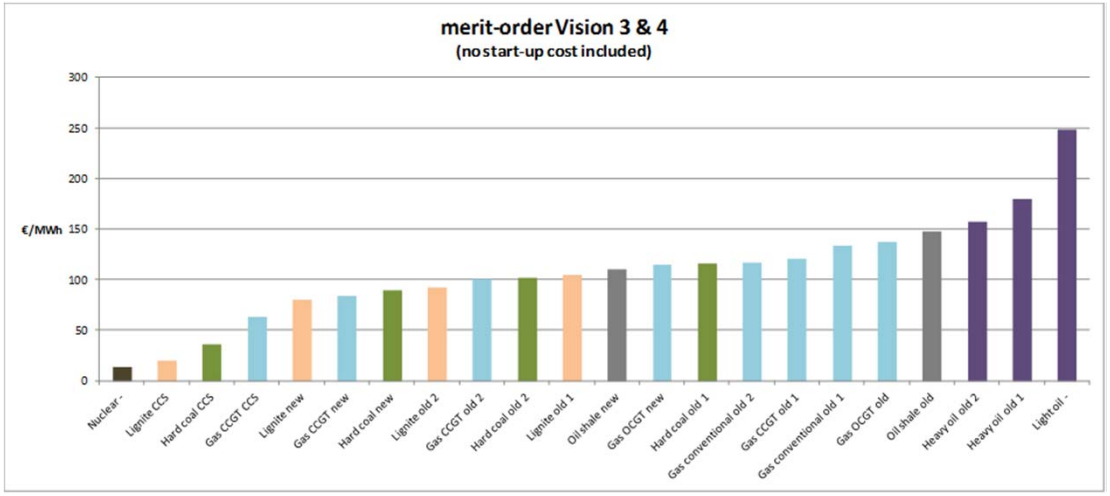
Visions 1 & 2:
Fuel & CO_2: IEA World Energy Outlook 2011, Current Policies, year 2030

Visions 3 & 4:
Fuel: IEA World Energy Outlook 2011, 450 scenario, year 2030
CO_2: IEA World Energy Outlook 2011, 450 scenario, year 2035

In order to enable the shift between gas and coal, data for Visions 3 and 4 are taken from the greenest scenario of IEA!

Focus is on the merit order shift, not on the absolute values of prices!



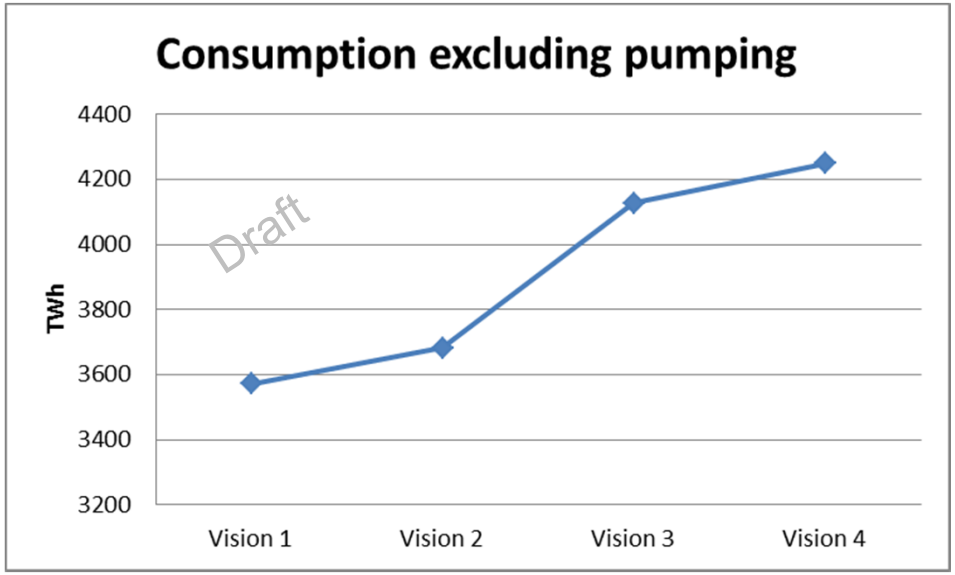


Key input: Demand (1)

Demand parameters

- Electric vehicles
- Heat pumps
- Energy efficiency
- Demand response - Peak Shaving
- Economic growth

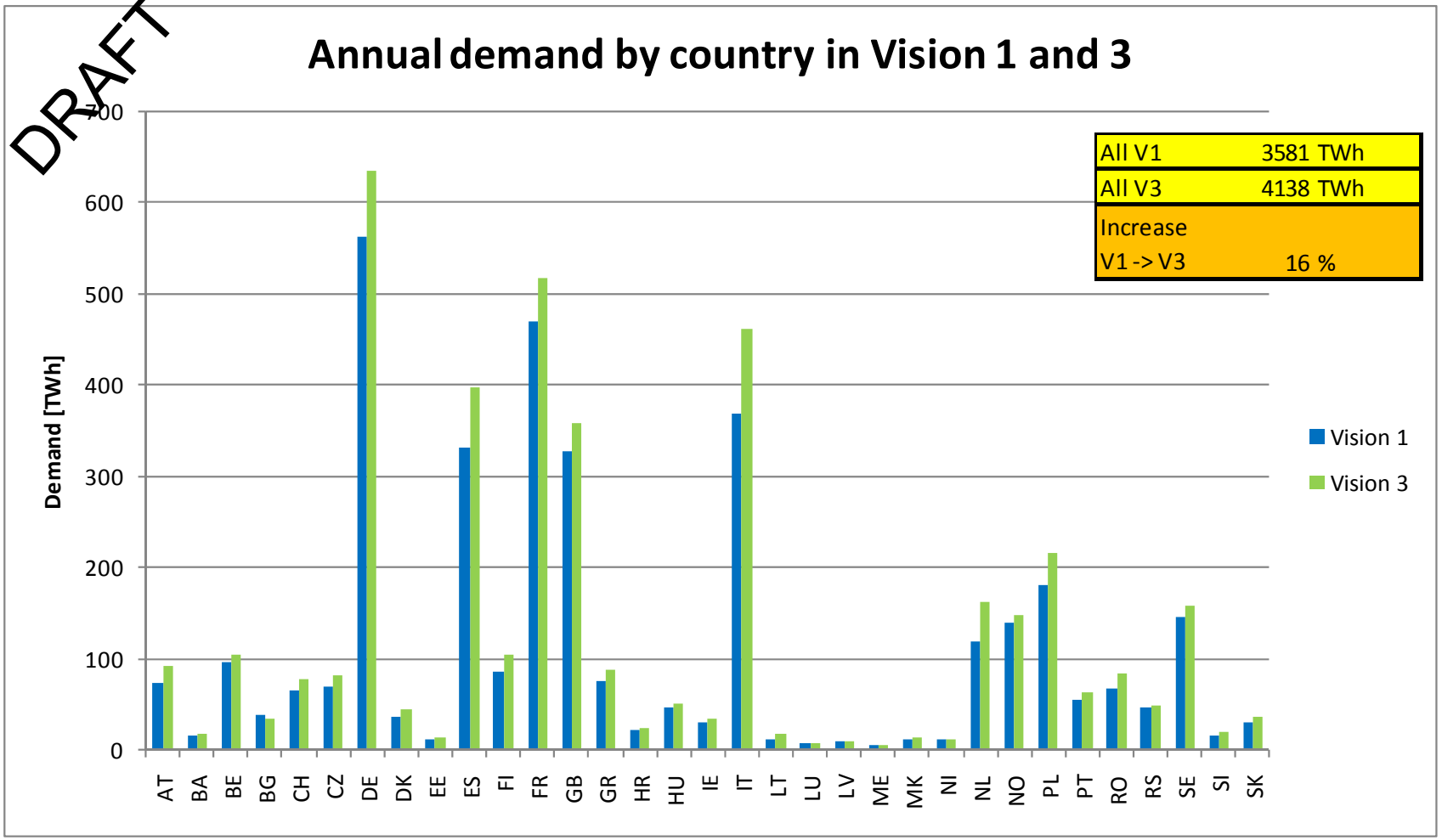
Introduction of new uses of electricty more than compensate the realized energy efficiency improvements
-> electricity demand is expected to grow!



Default values

	Vision 1	Vision 2	Vision 3	Vision 4
Electric vehicles	5%	10%	10%	15%
Heat pumps	1%	5%	5%	9%
Peak shaving	0%	2.5%	2.5%	5%

Key input: Demand (2)



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Key input: Installed Capacities (1)

Generation

Installed capacities (GW)		Vision 1	Vision 2	Vision 3	Vision4
	RES	465	465	728	727
	Hydro	182	182	192	209
	CCS+biofuel	13	13	23	23
	Nuclear	112	110	107	107
	Gas	236	222	277	270
	Lignite	47	47	49	49
	Coal	66	66	51	43
	Oil	11	11	16	16
	Other non RES	51	51	51	51
	Total	**1182**	**1167**	**1493**	**1496**

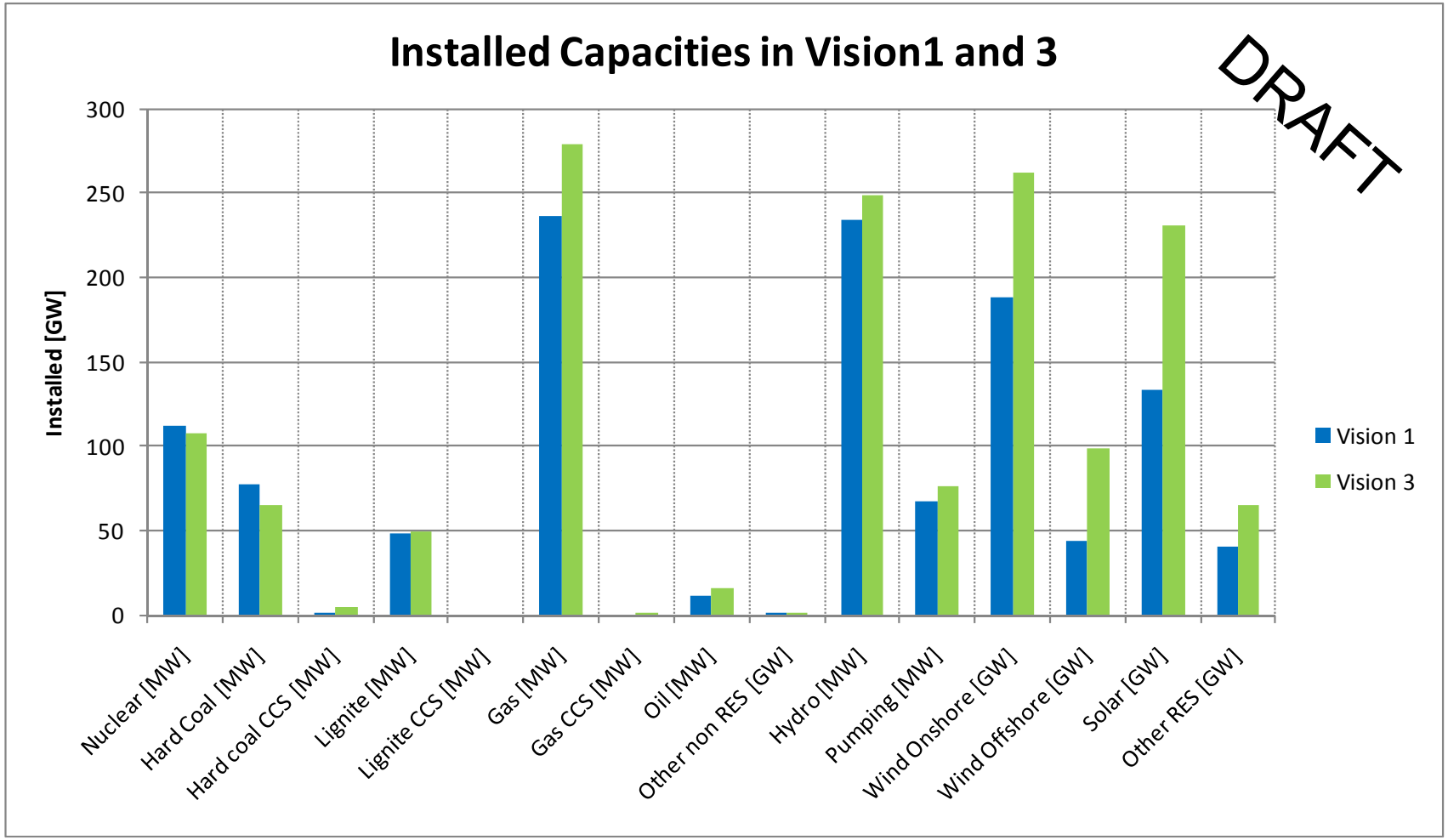
Draft

Coal scenario
RES: energy 2020 goals

Gas scenario
RES: 'on track for 2050'

Comments on Vision 4!

Key input: Installed Capacities (2)



Key input: Climate Data

PAN European climate database: wind, solar, temperature

Renewable intermitent resources will be one of the main drivers for the necessary grid investments: reliable and correlated generation profiles are needed!

Purchase of 2 datasets from independent suppliers for correlated hourly wind , solar and temperature data by ENTSO-E

« Reference provider » + « Quality check » provider

Main input data for provider

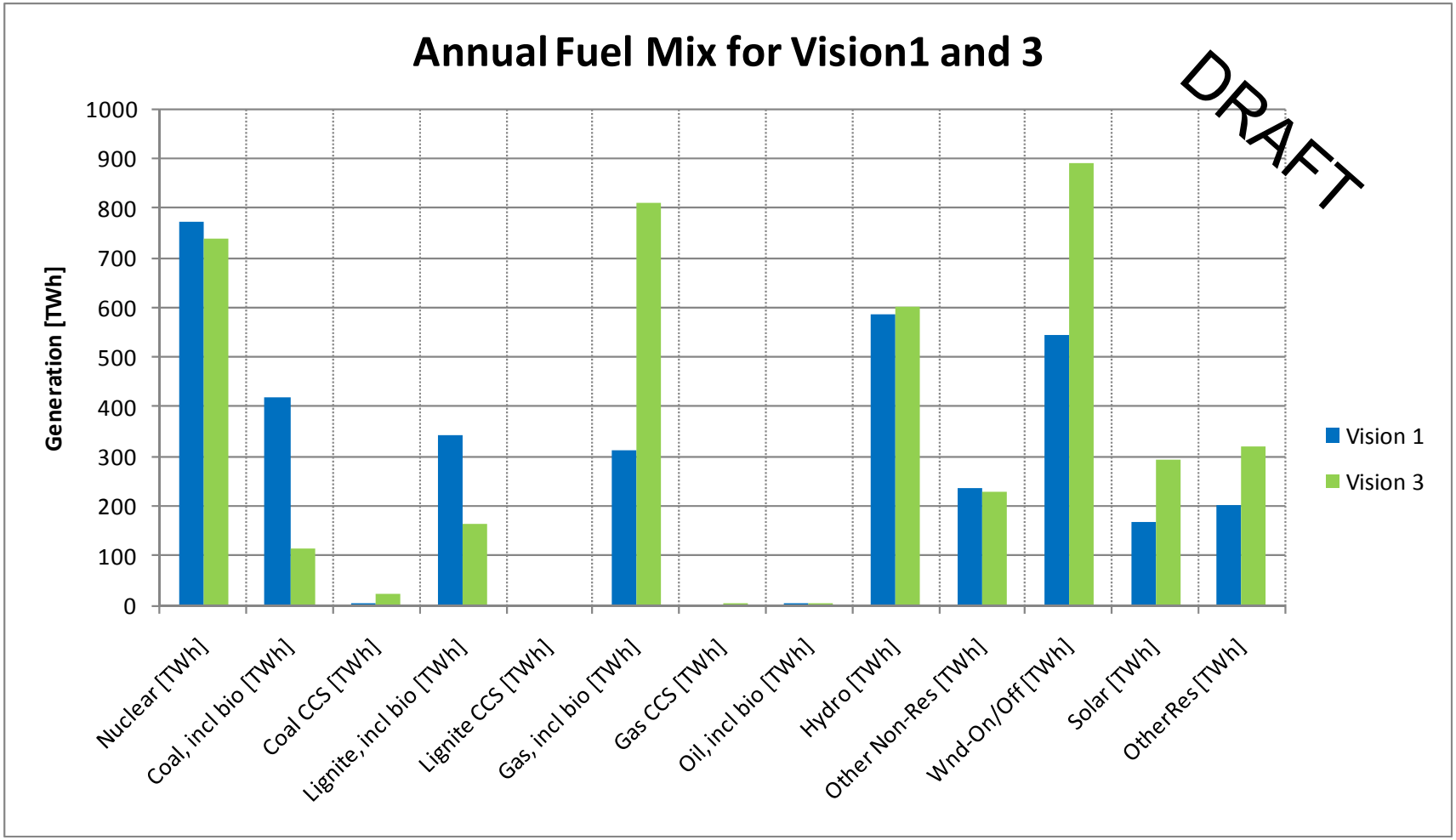
- 10 year historical weather data (wind speed and direction, radiance, temperature)
- Assumptions concerning the location of wind and solar farms in 2030
- Assumptions concerning the technology of wind and solar farms in 2030

Consistency of climate database available to TSOs

- 10 historical hourly time-series of load-factors (2002-2011), correlated between market nodes:
  - onshore wind
  - offshore wind (if relevant)
  - solar

  (applicable to a wide range of installed capacity)
- Hourly time-series of temperature also available (allow to analyse load sensitivity to temperatures for regional purposes)

Market Simulation results Vision 1 and 3



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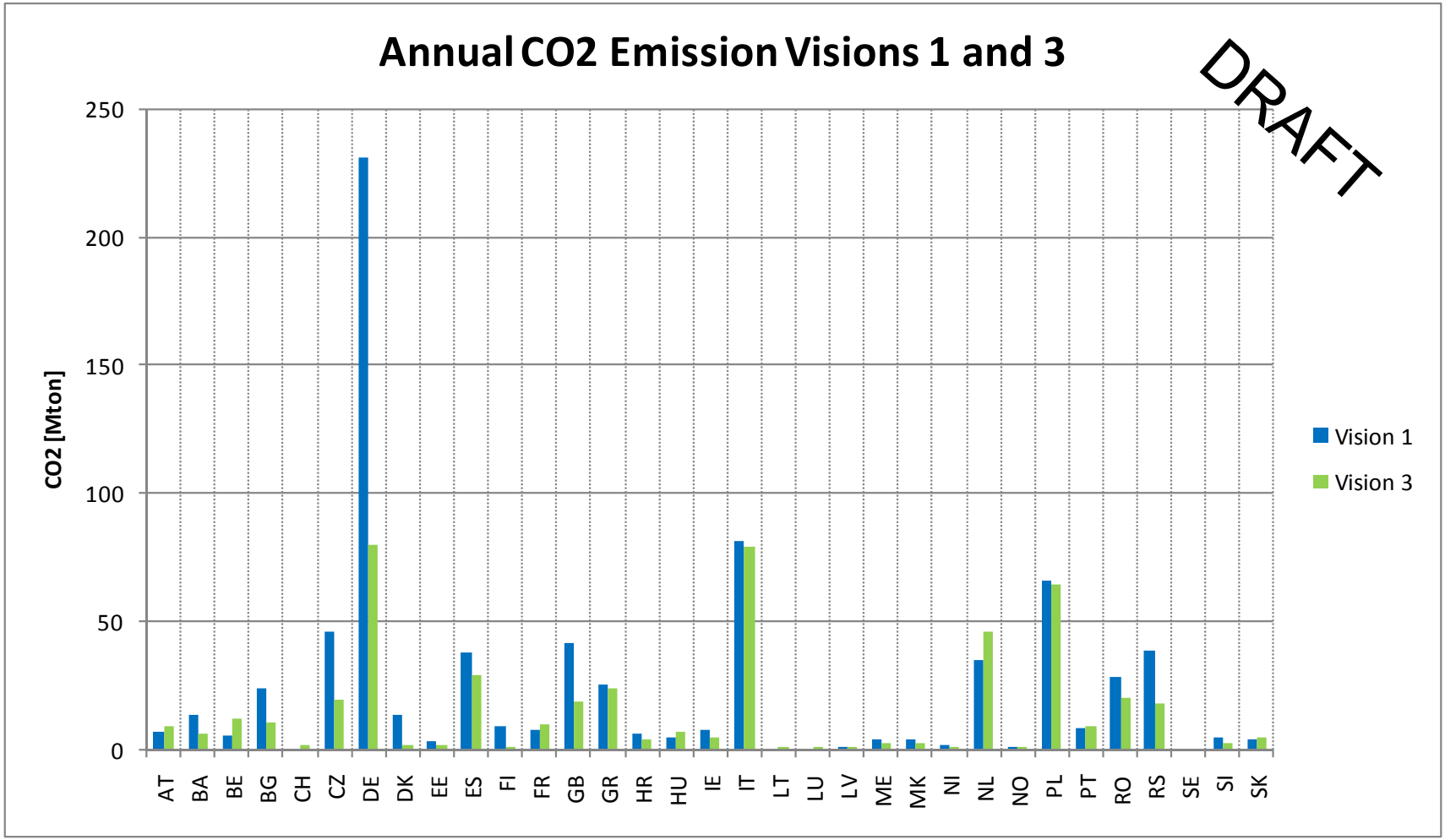
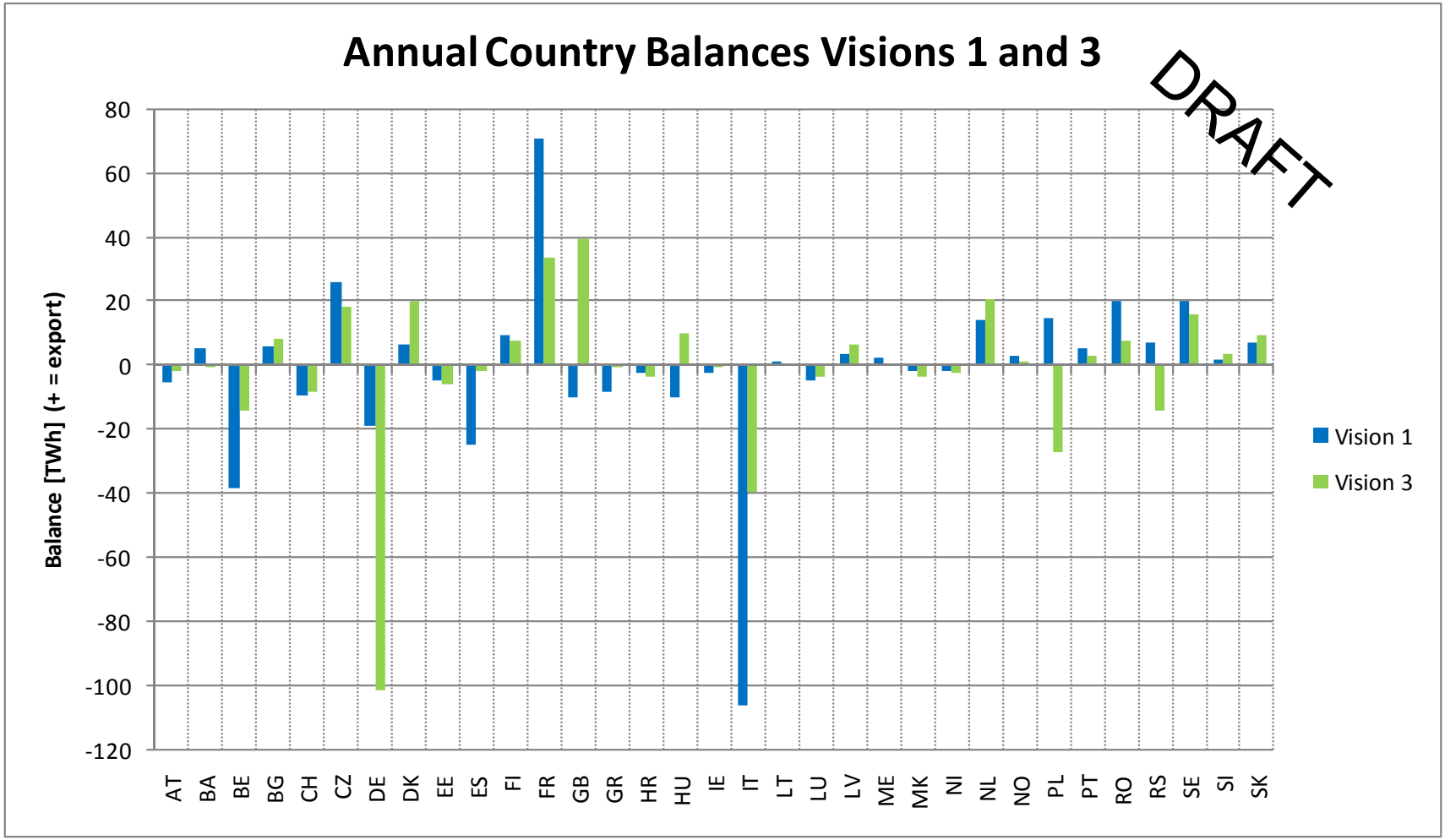
Market Simulation results Vision 1 and 3



Market Simulation results Vision 1 and 3



Usage of Results Pan EU Visions 1 and 3

- **Market input and output data of the Bottom-up Visions 1 and 3 are used for:**
  - Preparation of the top down Vision 2 and 4
  - Defining the starting points for the Regional Group Market Studies Vision 1 and 3

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BACKUP SLIDES

Stakeholders input for Vision 1 and 3

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Parameters taken into account for scenario development

- **Economy and Market**
  - economic and financial conditions
  - new market designs
  - national schemes regarding R&D expenses
  - Merit order : primary fuel pricing - carbon pricing
- **Demand**
  - energy efficiency developments
  - New usages (Heat pumps, Electric vehicles)
  - demand response potential
- **Generation**
  - RES (wind, solar, RoR, biomass)
  - Flexibility of generators
  - back up capacity (nuclear, CCS)
  - Decentralized storage
  - Centralized storage
- **Grid**
  - smart grid and the impact on load & generation patterns

Vision 1 “Slow Progress” : input based on stakeholders workshop 17/4/2012

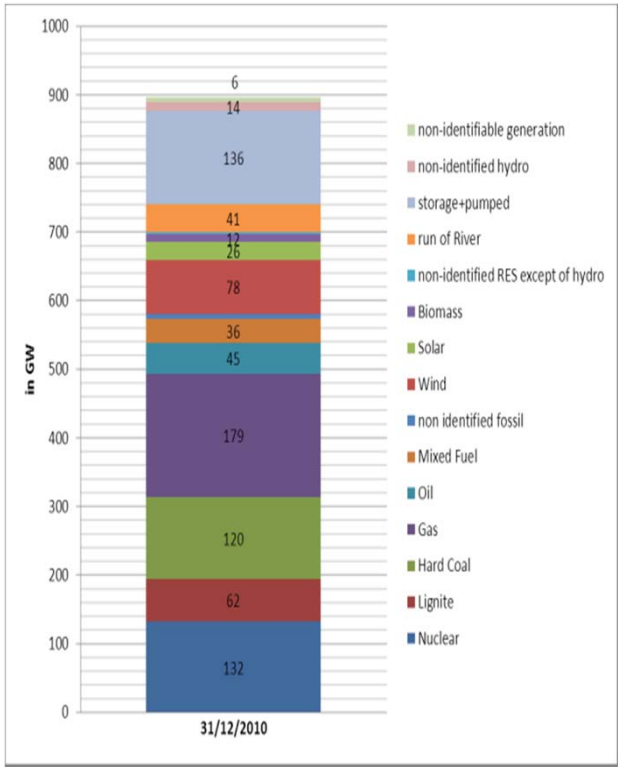
Demand

- the yearly growth rate of electricity demand in vision 1 should take into account the following:
  - **The yearly change rate of electricity demand between 2010 and 2030 should be between +0.5%/year and -0.5%/year** although rates between +1%/year and -1%/year are still acceptable.
  - A minimum level of electric vehicles (between 5 and 15%). **Proposed default penetration level is 5% of passenger vehicles.**
  - A change in electricity consumption due to a minimum level of heat pumps (between 1 and 10%). **Proposed default penetration level is 1% of households.**
- No additional peak shaving**. Proposed default value is thus 0% of peak load**
- *DEVIATIONS* : LACs should explain in a comment why deviations from the given guideline are acceptable.

Vision 1 “Slow Progress” : input based on stakeholders workshop 17/4/2012

SUPPLY

- *RES:* Based on the ENTSO-E stakeholders workshop the following minimum levels will be checked at European level in 2030:
  - **50 to 100% increase** of the installed capacity of **onshore wind** compared to 2010;
  - an installed capacity of **offshore wind of 10 to 50 GW**;
  - an installed capacity of **solar of 100 to 300 GW**;
  - **ocean energy** devices deliver **0 to 3%** of the electricity consumption;
  - **renewable hydro** power plants capacity **increases with less than 25%**;
  - **50 to 100% increase** of the installed capacity of **biomass/pellets/waste** power plants compared to 2010.
- *Non-renewable generation capacity:* Based on the ENTSO-E stakeholders workshop the following general guidelines should be taken into account:
  - **No new heavy oil** power plants (new development regarding light oil peak units & oil shale units is acceptable).
  - Increase of **nuclear capacity is not very probable** if no concrete projects already exit. Existing units can be upgraded or have life time extensions.
  - New **coal units** are primarily built **to replace existing ones**.
  - New fossil units tend to be **gas** (**50 to 100% increase** at European level).
  - New **pure pumped storage** power plants capacity is **not very probable** if no concrete projects already exist.
  - **No decentralized storage** facilities are foreseen (except if actual projects are ready to be implemented).



Vision 3 “Green Transition” : input based on stakeholders workshop 17/4/2012

Demand

- A higher economic growth rate comparable with rates seen before the financial & economic crisis. **Proposed default growth rate is the maximum of the average historic growth rates for each individual country.**
- Reduction in electricity consumption between -0.5% and -1% per year due to additional energy efficiency measures. **Proposed default reduction of -0.5% per year.**
- Increase in electricity consumption due to an intermediate level of electric vehicles. A penetration level between the minimum level (between 5 and 15%) and the maximum level (between 15 and 30%); the minimum and maximum levels were put forward by the stakeholders during the mentioned stakeholders meeting at European level. **Proposed default penetration level is 10% of passenger vehicles.**
- A change in electricity consumption due to an intermediate level of heat pumps. A penetration level between the minimum level (between 1 & 10%) and the maximum level (between 10 & 20%); the minimum and maximum levels were put forward by the stakeholders during the mentioned stakeholders meeting at European level. **Proposed default penetration level is 5% of households.**
- 50% of the peak shaving potential is introduced. **Proposed default value is a 2.5% reduction of the seasonal peak load given in vision 1.**

Vision 3 “Green Transition” : input based on stakeholders workshop 17/4/2012

SUPPLY

- *RES:* Based on the ENTSO-E stakeholders workshop the following maximum levels will be checked at European level in 2030:
  - **150 to 200% increase** of the installed capacity of **onshore wind** capacity compared to 2010.
  - An installed capacity of **offshore wind** of **90 to 170 GW**.
  - An installed capacity of **solar** of **200 to 400 GW**.
  - **Ocean energy** devices deliver **0 to 9% of the electricity consumption**.
  - **Renewable hydro** power plants capacity increases **by less than 25%**.
  - **200 to 250% increase** of the installed capacity of **biomass/pellets/waste power plants** compared to 2010.
- *Non-renewable generation capacity:* Based on the ENTSO-E stakeholders workshop the following general guidelines should be taken into account:
  - **No new heavy oil** power plants (new development regarding light oil peak units & oil shale units is acceptable).
  - New **nuclear power plants increase up to 20%** at European level is acceptable (existing units can be upgraded or have life time extensions).
  - New **coal power plants increase up to 20%** at European level is acceptable.
  - New fossil units tend to be **gas** (**50 to 150% increase** at European level).
  - New **pure pumped storage** power plants are **not very probable** if no concrete projects already exist.
  - **Decentralized storage** facilities are implemented **for 4 to 8% of the peak load**.

Consistency Checks for Vision 1 and 3 using Stakeholders Input

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Consistency checks to assess compliance with general common framework set using stakeholders inputs

- **2 consistency checks for EU2020 at National level**
- **21 consistency checks for national Vision 1 "Slow Progress" & 3 "Green Transition":**
  - **13 consistency checks at National level**
  - **8 consistency checks at ENTSO-E & EU level**

Examples on consistency checks at EU level:

Consistency check 1 (Vision 1): the yearly growth rate of electricity demand between 2010 and 2030 should be between +0,5%/year and -0.5%/year although growth rates between +1%/year and -1%/year are still acceptable

Consistency check 2 (Vision 1) & Consistency check 6 (vision 3): the minimum penetration levels of electric vehicle and heat pumps put forward by stakeholders

Consistency check 11 (Vision 1) & Consistency check 16 (vision 3): values per type of RES checked at European level

Vision 1: Demand

At European level

- **Consistency check 1:** At European level the yearly growth rate of electricity demand between 2010 and 2030 should be between +0.5%/year and -0.5%/year although growth rates between +1%/year and -1%/year are still acceptable.
- **Consistency check 2:** At European level the minimum penetration levels of electric vehicles and heat pumps put forward by stakeholders are obtained.

At national level

- **Consistency check 3:** At National level the annual electricity growth rate should be lower than the maximum of the average growth rates reported in Annex 1 for each individual country (to assess the growth rate the electric consumption of SAR 2010 will be used as starting point since 2010 was used as benchmark for the European stakeholder consultation)
- **Consistency check 4:** At National level the electricity intensity should not be higher than the maximum value observed in the past (see Annex 4).
- **Consistency check 5:** Justification is given if the level of electric vehicles and heat pumps in vision 1 deviates from the guidelines given by stakeholders at a European level .

Vision 3: Demand

At European level

- **Consistency check 6:** Penetration levels of electric vehicles and heat pumps are compatible with those put forward by stakeholders.

At national level

- **Consistency check 7: :** Justification is given if the level of electric vehicles and heat pumps in vision 1 deviates from the guidelines given by stakeholders at a European level
- **Consistency check 8:** Comparison of the electricity growth rate in vision 3 and the electricity intensity in vision 3 with the values used in vision 1.
- A higher electricity growth rate than in vision 1 combined with a higher electricity intensity level is expected for vision 3.
- **Consistency check 9:** Comparison of the ratio electricity consumption/peak load in vision 3 and the ratio electricity consumption/peak load in vision 1. This ratio should increase from vision 1 to vision 3.
- **Consistency check 10:** Comparison of ratio minimum load/peak load in vision 3 and the ratio minimum load/peak load in vision 1. The ratio should increase from vision 1 to vision 3.

Vision 1: Supply: RES

At European level:

- **Consistency check 11:** Minimum values per type of RES are obtained.

At national level:

- **Consistency check 12:** The level of energy based on RES should be not extremely different from the energy put forward in the EU2020 scenario in TYNDP 2012. Hence the given installed capacities will be multiplied by the following equivalent full power hours (EFPH) to assess whether this is a correct assumption. LACs can give specific values if they don't agree with the following default values.

☞ **All renewable hydro (except for Norway & Sweden)**	➔	**3900 h/year (but pumped storage);**
☞ **All renewable hydro for Norway & Sweden**	➔	4520 h/year (but pumped storage);
☞ **Onshore wind**	➔	1900 h/year;
☞ **Offshore wind**	➔	3500 h/year ;
☞ **Solar**	➔	1100 h/year;
☞ **Biomass/Pellets & Waste**	➔	5700 h/year;
☞ **other RES (Tidal, Waves, Geothermal)**	➔	3000 h/year;

Vision 1: Supply: NON RES

At European level:

- **Consistency check 13:** Check of the fuel mix

At national level check based on a uniform assessment:

- **Consistency check 14:** The Remaining Capacity (RC) at normal peak load (RAC – peak load) > 0
- **Consistency check 15: IF** The RC at normal peak load > 0 **THEN** the positive balance is lower than double of the spare capacity Uniform assessment for all the European countries.

Vision 3: Supply

At European level:

- **Consistency check 16:** Maximum values per type of RES are obtained.

At European level:

- **Consistency check 17:** Check of the fuel mix.
- At national level, based on a uniform assessment (see vision 1):
- **Consistency check 18:** The RC at normal peak load > 0.
- **Consistency check 19: IF** *The RC at normal peak load > 0* **THEN** *the positive balance is lower than double of the spare capacity*
- **Consistency check 20:** Level of decentralized storage - pure pump storage in vision 3 should be higher than in vision 1 since the decentralized storage is added here. The difference should be 4% of peak load in vision 1 if no specific data were delivered. If this is not the case and no specific data were entered in additional parameters data sheet the ENTSO-E Expert Team will flag this data red.

DUMP ENERGY

The ENTSO-E Expert Team will assess whether there is a problem of dump energy in visions 1 & 3. The objective of this assessment is to give a feedback to SDC on the problem of dump energy. This assessment will also be done for visions 2 & 4. (**consistency check 21**).