European Network of
Transmission System Operators
for Electricity

TYNDP 2016
Scenario Development Report

- Final after public consultation -

3 November 2015

1 Contents

2 Executive Summary

This Scenario Development Report explores possible future situations of load and generation, interacting with the pan-European electricity system. These scenarios will be the baseline on which TYNDP2016 projects are to be assessed in the coming year.

As in the most recent TYNDP2014, also the next TYNDP will focus on the year 2030. European ambitious targets as set by the Council in October 2014 on renewables, energy efficiency, decarbonisation and interconnection targets, give a stronger direction to the studies and resulting recommendations for grid development up to 2030. It is the ambition of ENTSO-E's TYNDP to demonstrate the need and the value of grid infrastructure in this context, to inform decision makers and the general public, and to enable these targets to be met. For the long-term horizon 2030, four contrasting 'Visions' are presented which differ in terms of energy governance and RES ambitions. In addition a mid-term 2020 'best estimate scenario' is covered to allow grid infrastructure candidates to be valued at a mid-term horizon as well.

The new TYNDP2016 scenarios show a natural evolution compared to the earlier TYNDP2014 Visions, taking stock of updates in national scenarios and taking a leap forward in the construction of pan-European top-down scenarios.

The aim of this report is to provide insight in how ENTSO-E's scenarios for TYNDP are developed, highlight how infrastructure needs 'are linked to choices' in future energy policies, and to engage on these topics in a transparent manner.

A draft version of the report was published for consultation in May and June 2015. Other stakeholder activities guiding the finalization of this report, as well as a summary of the public consultation are summarized in Annex of this report.

ENTSO-E finalized the TYNDP 2016 Scenario Development report with a re-run of the market models during the summer.

ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

3 Objective of TYNDP scenarios and visions

How does it fit in the overall TYNDP work?

The ENTSO-E TYNDP report provides a comprehensive and transparent overview of projects of pan-European significance, which are all assessed against several scenarios, based on a common data set, and with a robust CBA methodology.

During 2014 and early 2015, the work was mainly focused on identifying investment needs (presented in the Regional Investment Plans 2015), and analysing at the same time new scenarios for project assessments (given in this report). Based on a consulted final list of projects and scenarios, the actual assessment work starts after summer 2015 and will be reported in a draft TYNDP report mid-2016.

The development of scenarios and the joint planning exercise performed by ENTSO-E's members run in parallel. Both continue from earlier TYNDP2014 work, and both are strongly interlinked; investment needs are driven by evolutions in generation and load patterns, while a pan-European approach on generation incentives has to take into account physical grid constraints.

The TYNDP provides four long-term scenarios ('Visions') for 2030, and one mid-term scenario for 2020.

The TYNDP 2030 Visions present contrasting scenarios that reflect similar boundary conditions and storylines for every country, and which differ enough from each other to capture a realistic range of possible future pathways. All result in different future challenges for the grids which a TYNDP grid endeavours to accommodate. The mid-term TYNDP 2020 scenario gives a best estimate for this time frame. The goal of the scenarios is to eventually allow TYNDP projects to be assessed across the same range of possible futures.

The assessment of all TYNDP projects is done based on a Cost-Benefit Analysis methodology, developed in line with Regulation (EU) 347/2013, and approved by the European Commission. The CBA approach will be used for all projects on a mid- and long-term horizon, which are presented in this report. The CBA methodology applicable for TYNDP2016 is the present approved version. Meanwhile work continues to improve the methodology for future TYNDPs.

The overall two-year process of all TYNDP activities is summarized in the following graph.

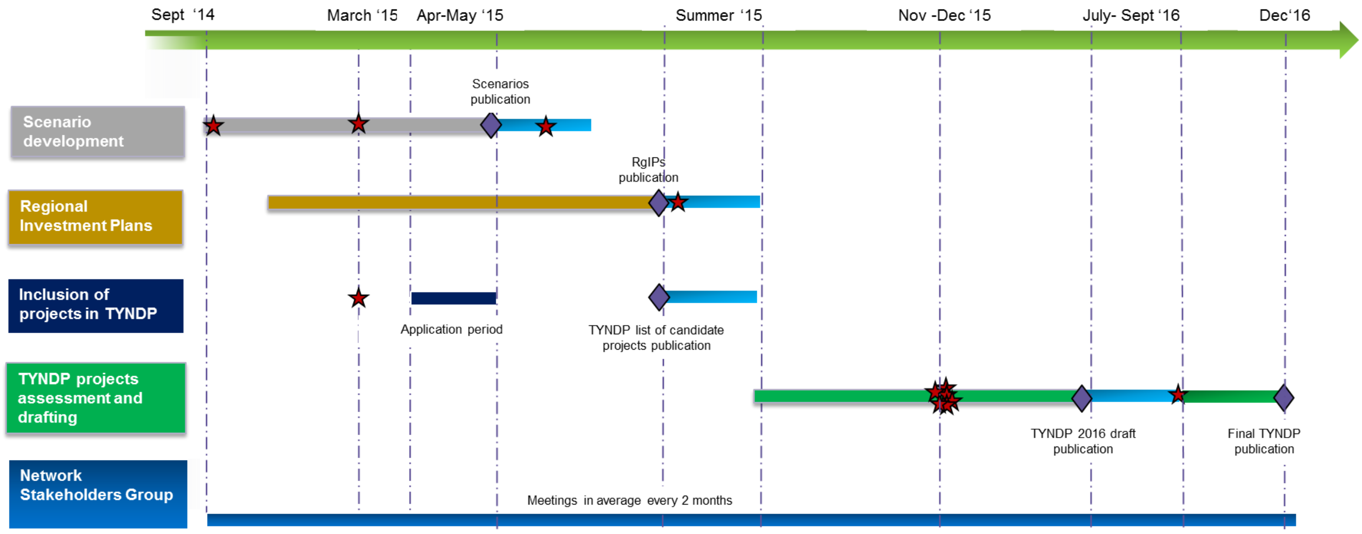


FIGURE 3-1 OVERVIEW OF THE TYNDP 2016 ROADMAP, INDICATING MAIN WORK STREAMS, CONSULTATIONS (BLUE BARS) AND PUBLIC WORKSHOPS/WEBINARS (RED STARS).

How are these scenarios developed?

In general terms scenarios are based on a storyline, assumptions, data collections, quality checks, pan-European methodologies, and final market simulations to quantify energy outputs.

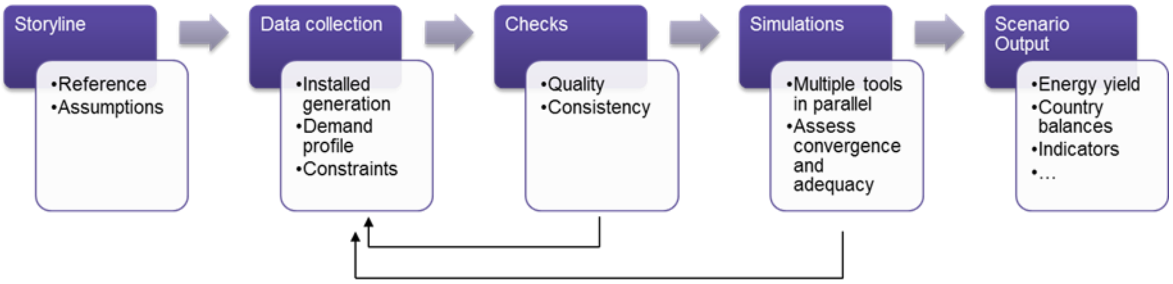


FIGURE 3-2 SCENARIO DEVELOPMENT PROCESS

A key strength of the ENTSO-E scenarios is that it combines the views of national plans provided via TSO correspondents, the expertise and large variety of tools of dozens of market modelling experts, and the pan-European perspective via elaborate scenario development methodologies. Considering a quite close time horizon (max. 15 years) ENTSO-E scenarios are not developed as starting-from-scratch based on ideal optimizations, but are strongly linked with both national development plans and pan-European coordination.

Section 4 explains the storyline on which each scenario is developed. These storylines take into account binding targets, long-term ambitions, and available technology roadmaps. Still it is important to note that the scenarios do not aspire to give a forecast of the future, nor is there any probability attached to any of the 2030 Visions. The Visions do not have the pretext to show what some would hope the future to be like, but rather give the full spectrum of what is considered realistic.

To build up relevant storylines and assumptions, and to finally test the acceptance of the set of scenarios, continuous engagement with various stakeholders, regulators, policy makers, and all TSOs is essential.

Event	Focus	Date	Material
Public workshop on Scenario Methodology for TYNDP 2016	Definition of the overall scenario framework by the mean of brainstorming in small groups	16/09/14	Presentations Inputs from Stakeholders during the workshop
Network Development Stakeholder Group meeting	Discussion of the principles to find a mid-term best estimate scenario	10/03/15	Presentation and outcomes
2nd public workshop on TYNDP 2016 Scenario Development	Draft methodology to build the top-down scenarios Draft results of scenario quantification (Visions 1 and 3, and intermediate steps of Vision 4)	11/03/15	Agenda and presentations
3rd public workshop/webinar on TYNDP 2016 Scenario Development	Draft results of scenario quantification (all scenarios)	11/06/15	Agenda and presentations

ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

Public consultation on the draft TYNDP 2016 Scenario Development Report	Description of the storyline and methodologies used to build the scenarios Draft scenario quantifications	21/05/15-22/06/15	The main outcomes are summarized in Annex.

FIGURE 3-3 SUMMARY OF THE PUBLIC EVENTS ORGANIZED FOR THE TYNDP 2016 SCENARIO BUILDING

How is it linked to the work on adequacy forecasts?

Deployment of grid infrastructure requires a long planning and decision horizon (typically 10 to 15 years). Such infrastructure is central to the completion of the European Internal Electricity Market, to facilitate increased renewable energy penetration and, at the same time, ensure pan-European adequacy. The 2030 Visions of TYNDP are used as representative and exploratory scenarios regarding generation, demand and Pan-EU adequacy of possible futures within certain storylines. These storylines express the fundamental uncertainty on the evolution of the energy mix and their adequacy assumptions at a long term horizon.

For adequacy studies the uncertainties are mainly related to extreme situations such as high load related to temperature conditions, either in a present or a future power system. .The most suitable time frame to assess generation adequacy at national and regional resolution, anticipating possible adequacy issues, is typically 5 years - 10 years (maximum) horizon, as recommended by the Electricity Coordination Group (ECG) – subgroup on adequacy[1]. Within this time frame, trustable diagnoses of generation adequacy risks are possible, by use of a sound, widely accepted and transparent methodology. Scenarios for adequacy are 'predictive' and designed to inform about and assess the possible risks the Pan-European system faces regarding generation adequacy. In that sense, they are fundamentally different than the TYNDP 2030 Visions, which should be understood more as 'exploratory' scenarios without focus on extreme events as cold spells, dry years, bad wind/solar years which are extremely important in the context of adequacy assessments.

ENTSO-E is mandated to deliver a community wide grid investment plan, including a generation adequacy assessment. To clarify the different levels of uncertainty at different time horizons, ENTSO-E has restructured the former TYNDP and SO&AF reports. The next TYNDP2016 report will address the scenarios used in the TYNDP project assessments (and covered in this report), while the SO&AF report as of 2015 addresses the scenarios used for generation adequacy. A remaining key link will be the 2020 best estimate scenario, which is introduced as the mid-term horizon for TYNDP project assessments, and which is closely related to the bottom-up scenario B in SO&AF (see also the conclusions of the Network Development Stakeholder Group). In addition, also the methodological elements of the next SO&AF reports are scheduled to improve, while ENTSO-E still has the ambition to publish the report on annual basis.

How are these scenarios linked with other available scenarios?

An issue in the use of scenarios for grid development, is the ever possible confusion when comparing different development plans (in particular national versus pan-European). ACER's opinion on consistency of ten-year network development plans[2] highlights the different approaches in national plans (e.g. frequency of updates, time horizon) in which main directions are most often set in perspective of national policies. As

[1] *"The further ahead one assesses adequacy the greater the uncertainty. There becomes a point where the uncertainty outweighs any information that might be learnt from the assessment in the first place. It appears from the forecast periods utilised that this is likely to be in the range of 5 – 10 years"*
[2] http://www.acer.europa.eu/Official_documents/Acts_of_the_Agency/Opinions/Opinions/ACER%20Opinion%2008-2014.pdf

plans and scenarios continuously evolve there is a challenge to any reader when comparing a pan-European plan for 2030 published in 2016 with for example a national plan published in 2015 looking at 2025.

The results in section 5 put the draft scenarios in context of the EC trends and IEA world energy outlook. A comparison of installed generation and electrical demand may be valuable. It is worth noting the different strengths of each scenario report. On one hand pure energy-models (such as the PRIMES model used in the EC trends) allow to look forward based on an optimization of all energy components, not purely electricity but also gas and oil which all interact. On the other hand power-based models (such as the ones used by ENTSO-E in this report) are based on electricity market simulations which take into account full-year hourly based profiles of load and climate data, as well as grid constraints. Such power-based model allows to assess price zone differentials, RES spillage, country balances, etc… and are key in the methodologies which make the bridge from bottom-up scenarios to top-down scenarios. The scenarios of the gas and electricity TYNDPs (both published every two years, but in alternating years) of respectively ENTSO-G and ENTSO-E interact; gas-based generation is an essential input for gas scenarios, while risks of gas shortages are a continuous topic in electricity adequacy assessments (seasonal outlook reports and System Outlook & Adequacy Forecast). Both ENTSOs continuously explore further synergies between the two TYNDPs and their scenarios (storyline and data).

Making an explicit comparison between the 2020 and 2030 scenarios in this report and 2050 outlooks (EC trends, IEA, electricity-Highways 2050 project) can be done on a qualitative level as it based on roadmap and progress assumptions. The four 2030 Visions are on track with the recent set targets for 2030, and are such assumed to also all be on track to meet the ambitious 2050 goal of de-carbonization of the generation fleet, though at a different pace.

ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

4 Main storyline for the TYNDP2016 scenarios

The ENTSO-E Visions encompass a broad range of possible futures that flex European integration and the achievement of the sustainability goals within the EU 2050 Roadmap. The year 2030 is used as a bridge between the European energy targets for 2020 and 2050. As it can take more than 10 years to build new grid connections, the Visions for the TYNDP 2016 look beyond 2020. However, when looking so far ahead it becomes more difficult to predict the future. Therefore, the objective of the Visions for 2030 is to construct contrasting Visions that reflect the same boundary conditions for all countries but that differ enough from each other to capture a realistic range of possible future pathways as well resulting in different future challenges for the grid. In order to keep the number of long term Visions limited, the choice was made to work around two main axes that are described later in this text and as a consequence limit the number of Visions to four. Stakeholders have engaged with the Visions more than ever and we have received strong positive feedback.

A number of stakeholders have expressed the requirement to understand more and shorter timeframes than the single 2030 view in the TYNDP 2014. To meet this requirement, for the TYNDP 2016 we are developing a new scenario to cover the time period of 2016 to 2020. This new scenario is called “Expected Progress” and covers the period to 2020. This scenario is not directly linked to the 4 2030 Visions but represents an intermediate stage. It is defined as the last point in time before uncertainties increase to a level where a broader envelope of potential futures is required.

By the time the TYNDP 2016 is published, the vast majority of investments realized in 2020 will be determined to a large extent. The potential changes in the power system with regard to transmission and transmission connected thermal generation between 2016 and 2020 are much less than for a 2030 forecast due to the relatively short time period between the two points in time compared to development times of power system infrastructure (“industry inertia”). Construction of transmission connected thermal power stations and construction of transmission lines usually takes longer than 4 years between planning and beginning of operation. Beyond 2020, the 4 Visions provide the envelope within which the future is likely to occur but strictly do not have probability of occurrence attached to them. This does not mean that there are no uncertainties attached to “Expected Progress”, however it can be considered as a forecast for the year 2020 as the deviation between this scenario and the real system in 2020 should be much less than for a 2030 forecast. “Expected Progress” can serve as a starting point for the scenario envelope, which is expanded by the 4 Visions as shown below in Figure 4-1.

ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

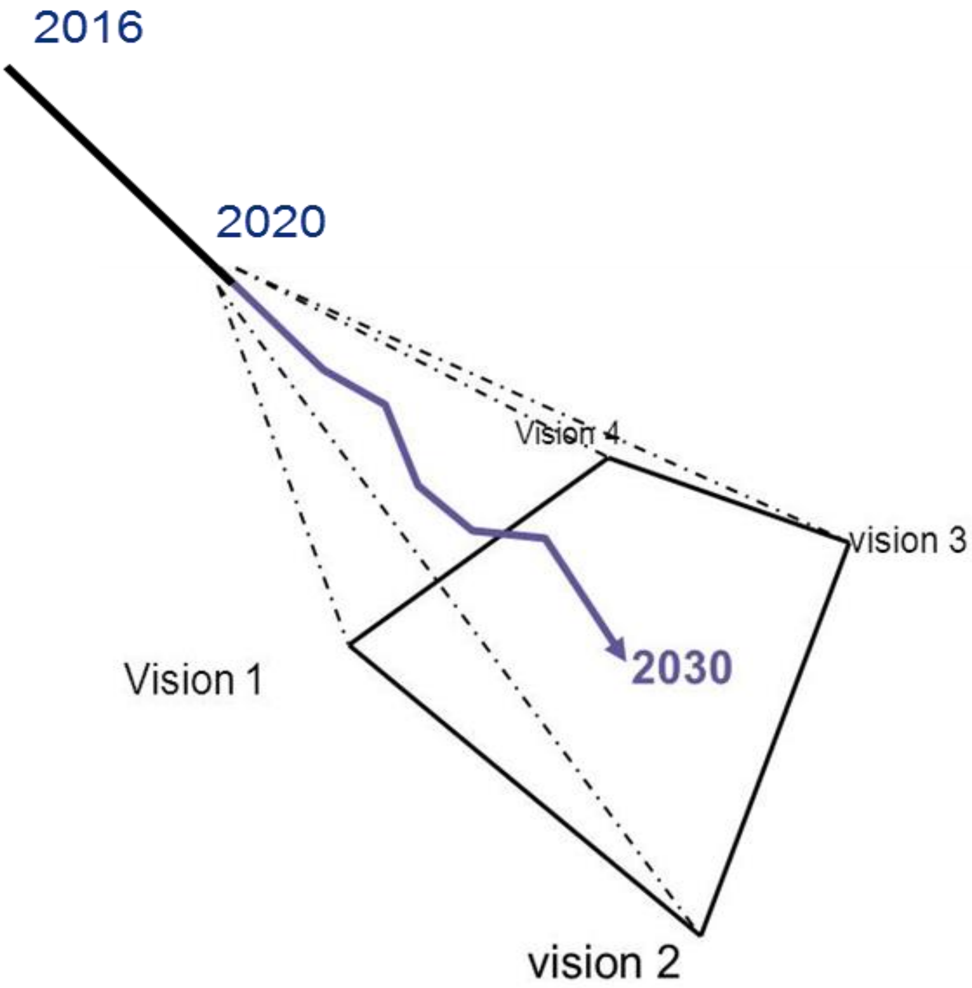


FIGURE 4-1 EXPANDED SCENARIO SPACE

To analyse the 2030 time-horizon, four visions are elaborated based on two axes. A similar approach was already applied in the visions development of TYNDP2014.

One axis is related to European ambitions and targets to reduce greenhouse gas emissions to 80-95% below 1990 levels by 2050. The axes provides a spectrum of progress, with the goal to assess the impact of progress/delay in decarbonisation of energy on grid development needs by 2030. The two selected outcomes are viewed to be extreme enough to result in very different flow patterns on the grid. The first selected outcome is a state where Europe is very well on track to realize the set objective of energy decarbonisation by 2050. The second selected outcome is a state where Europe progresses beyond 2020 targets to align with the recent 2030 targets set for renewables. It is assumed that the 27% target for renewables translates to about 40% of renewable share in electrical energy consumption[3].

The second axis relates to perspective of measures for decarbonisation of the energy system. This can be done firstly in a strong European framework in which national policies will be more effective, but not preventing

[3] EC, A policy framework for climate and energy in the period from 2020 to 2030 [COM(2014) 15], http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52014DC0015&from=EN

Member States developing the options which are most appropriate to their circumstances, or secondly in a looser European framework effectively resulting in parallel national schemes.

The Figure 4-2 shows how the four Visions relate to the two axes.

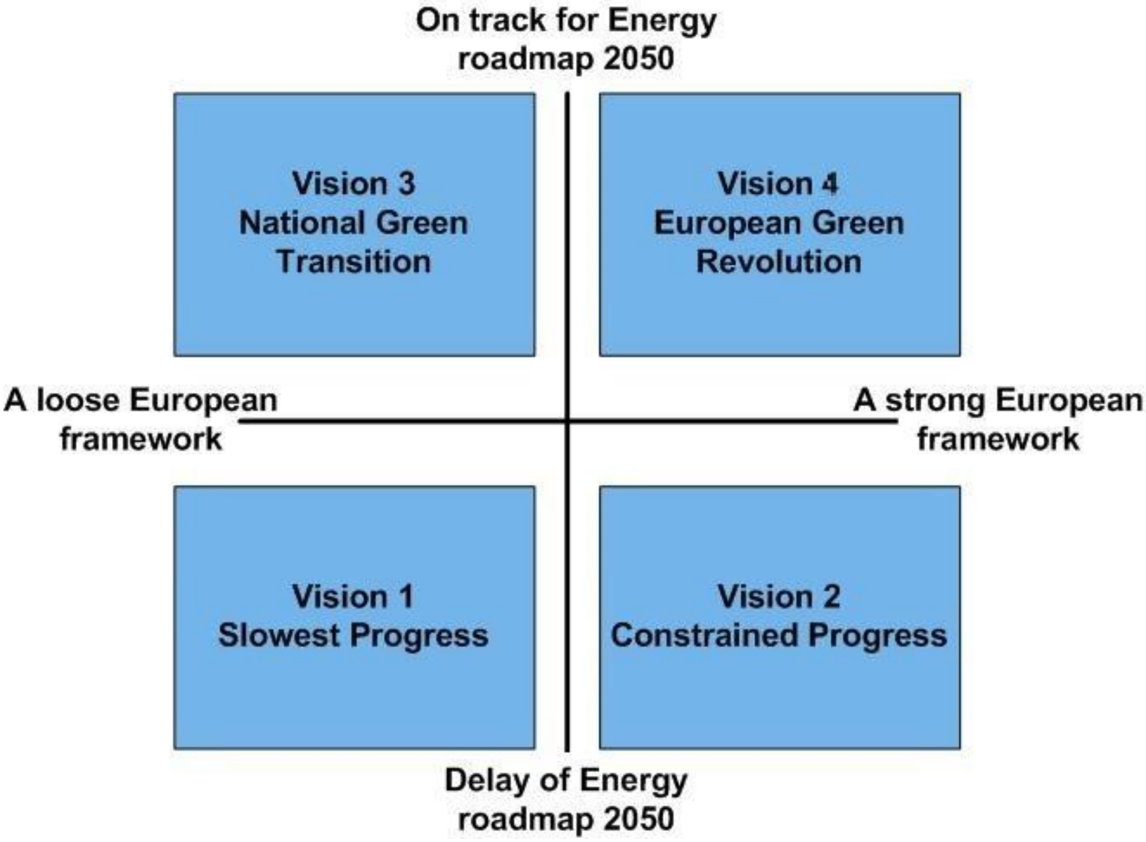


FIGURE 4-2 TWO-AXIS OVERVIEW OF THE 4 VISIONS (GENERAL)

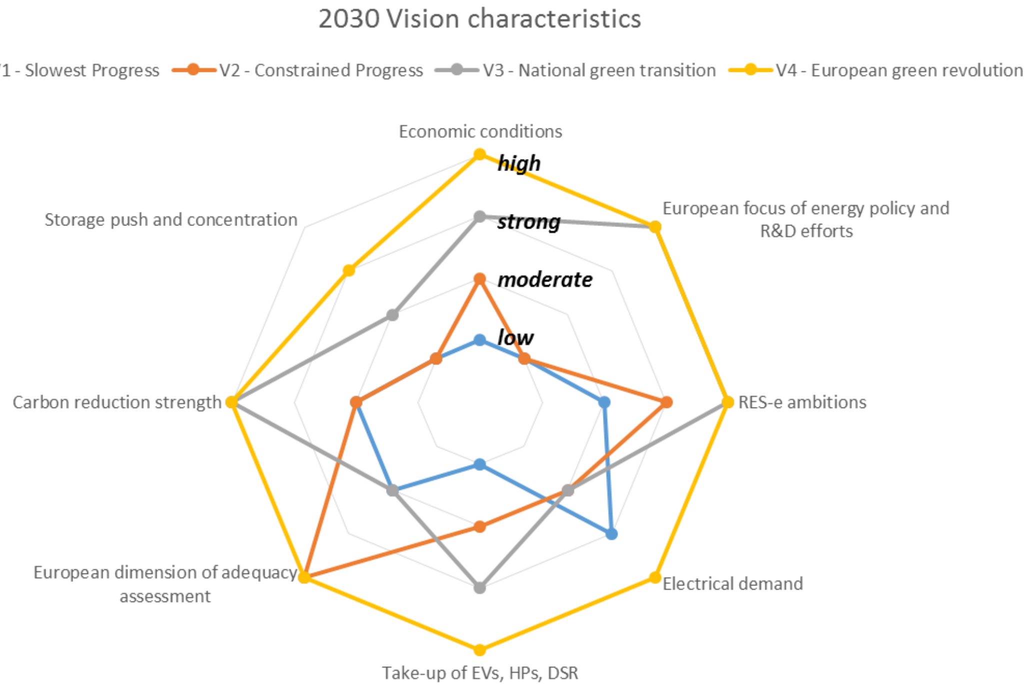


FIGURE 5-3 CHARACTERISTICS OVERVIEW OF THE 4 VISIONS (MORE DETAILED)

2020 Best Estimate Scenario of "Expected Progress"

Overall perspective	"Expected Progress" can be described as the best estimate of development until 2020, within the following boundaries.
Demand	Development of electricity demand is determined by diverging driving forces. On the one hand innovations lead to higher efficiencies of consumers and thus to a reduction of demand. On the other hand, innovation leads to a fuel switch of applications like electric vehicles, for example. A fuel switch towards electrification increases electric demand. Demand forecast in the "Expected Progress" scenario is the best national estimate available, under normal climatic conditions out to 2020. It is estimated according to technical and economic assumptions, especially on demography and economic growth.
Renewable Energy Sources	Binding EU driven national targets exist for the share of renewable energy sources in the energy mix by 2020. Renewable energy sources covered in this scenario report include electricity generation from solar, wind power, run-of-river, biomass and other supply depended renewable sources. The forecast of renewable energy sources in "Expected Progress" takes into account the current supporting mechanisms for renewable energy sources in each country and the expected development of support mechanisms, if changes are under discussion. Including the cost decrease, a realistic forecast for the year 2020 is derived, even if this means that the targets set by the National Renewable Energy Action Plans (NREAPs) will not be met.
Hydro Reservoir and Pumped Storage	In contrast to run-of-river power plants, hydro reservoir stations can regulate their electricity generation as long as their reservoir holds water. The creation of a new water reservoir is an expensive project which may cause high local environmental impact. Additional hydro generation capacity is only included in this scenario if the projects are confirmed and under construction[4]. Pumped storage hydro stations are easier to build, if the required reservoir already exists and only the pumping machines have to be added. However, economic conditions for pumped energy storages are unfavourable, because of the absence of peak prices due to the high infeed of renewable energy sources. As such, also only confirmed pumped hydro projects are included.
Conventional Thermal Generation	The development of conventional thermal generation follows market mechanisms. As explained before this scenarios assumes the prices for emission certificates remain low. Due to coal-gas price spread the general economic conditions are more favourable for existing coal power stations. The estimated decommissioning of power stations is based on best available information and trends to TSOs. Regarding new units, only confirmed thermal power stations are taken into account. Carbon Capture and Storage (CCS) is assumed not to be an option yet for lignite and coal power stations by 2020. Generally, it is assumed that new nuclear power stations that are operational by 2020 need at least a final investment decision today, so that their construction will be finished by 2020. As a consequence, only confirmed new nuclear power projects are taken into account in this scenario.

[4] This is without prejudice to hydro and pumped storage projects which could be promoted for TYNDP inclusion during April 2015. Additional hydro storage projects can be included in the scenario used for project assessments.

ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

	Power plants of the strategic reserve (as defined in some countries) are kept ready to start-up for emergency periods when secure operation of the system is at risk. They are not participating in the market. The capacity of power plants belonging to present strategic reserves have been included, but are in the market simulations distinguished from generation capacity that participates in the electricity markets. This scenario gives no specific assumptions about evolutions of strategic reserves or capacity mechanisms in the coming years.
Adequacy	"Expected Progress" should consider adequacy from a Pan-European perspective without explicitly addressing potential generation adequacy issues in some countries at present. This scenario does not assume autonomous adequacy of single countries. Still it is assumed that conventional thermal power stations do not face shortage in fuel supply, which might be different in a true generation adequacy analysis (see SO&AF report, as well as the Seasonal Outlooks).
Emission and Fuel prices	Prices for CO2 emissions are currently low, which has an impact on the type of generation plant utilised in the electricity market. Under low CO2 prices, coal fired generation tends to be favoured over gas in the merit order. There is no indication of change in the short term of prices of emission certificates. Also natural gas prices in Europe have been relatively stable in recent years. In contrast, prices for import coal have decreased in previous years. As a consequence, based on primary fuel prices coal generation is favoured over gas generation. For the 2020 "Expected Progress" scenarios it is assumed that no major change happens in the boundary conditions for primary fuels and emission certificates.

ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

2030 Vision 1 of "Slowest Progress"

Economy and Market	The perspective of Vision 1 is a scenario where no common European decision regarding how to reach the CO_2-emission reductions has been reached. Each country has its own policy and methodology for CO_2, RES and system adequacy. Economic conditions are unfavourable, but there is still modest economic growth. This results in a limitation on willingness to invest in either high carbon or low carbon emitting sources due to investment risks, low CO_2-prices and lack of aligned support measures. Consequently older power plants are kept online rather than being replaced if they are needed in order to maintain adequacy. The situation varies across countries. The absence of a strong European framework is a barrier to the introduction of fundamental new market designs that benefit from R&D developments resulting in parallel, loosely coordinated national R&D expenditure and cost inefficiencies. Carbon pricing remains at such a level that base-load electricity production based on hard coal is preferred to gas in the market.
Demand	In this Vision there are no major breakthroughs in energy efficiency developments such as large scale deployment of micro-cogeneration or heat pumps nor minimum requirements for new appliances and new buildings due to a lack of strong political and regulatory policy. There are also no major developments of the usage of electricity for transport such as large scale introduction of electric plug-in vehicles nor heating/cooling. A modest economic growth brings a modest electricity demand increase. Also demand response potential that would allow partial shifting of the daily load in response to the available supply remains largely untapped.
Generation	The future generation mix is determined by national policy schemes that are established without coordination at a European level. Due to a lack of joint framework and joint decision to reduce emissions, the generation mix in 2030, on a European level, fail to be on track for the realization of the energy roadmap 2050 and no additional policies are implemented after 2020 to stimulate the commissioning of additional RES except locally due to local subsidy schemes. Adequacy is handled on a National basis. Some countries may require complete adequacy while others may depend on neighbouring countries. Very little new thermal capacity will come online except in the case for subsidized production or adequacy required peak capacity. New CO2-emitters risk to be closed down after 2030 in order to reach the 2050 target; hence the financial risk is substantial and old units are kept online instead of replacing them. Nuclear power is a national issue. In some countries nuclear power is regarded as a clean and affordable source of electricity and new units are brought online before 2030.

ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

2030 Vision 2 of "Constrained Progress"

Economy and Market	The perspective of Vision 2 is that the economic and financial conditions are more favourable compared to Vision 1 providing more room to reinforce/enhance existing energy policies. There is a strong European framework. The economic outlook facilitates new market implementations, and R&D expense focuses on cost cutting, increased energy efficiency and energy savings. On the other hand, there is a limitation on willingness to invest in either high carbon or low carbon emitting sources due to investment risks, low CO_2-prices and lack of aligned support measures. Carbon pricing remains at such a level that base-load electricity production based on hard coal is preferred to gas in the market.
Demand	The breakthrough in energy efficiency developments (e.g. large scale deployment of micro-cogeneration or heat pumps as well as minimum requirements for new appliances and new buildings) and the development of the usage of electricity for transport (e.g. large scale introduction of electric plug-in vehicles) and heating/cooling is driven by innovation caused by R&D expenses focused on cost cutting and energy saving. As a consequence the electricity demand is lower compared to Vision 1. Furthermore, demand response potential is partially used to shift the daily load in response to the available supply, as it allows savings in back-up capacity.
Generation	The future generation mix is driven by a strong European Vision which faces still financial challenges and construction delays due to permitting issues, combined with a halt in the implementation of additional policies needed for the realization of the energy roadmap 2050. As a consequence, lifetime extension of existing conventional thermal power plant is likely. Some additional policies are implemented after 2020 to stimulate the commissioning of additional RES, causing RES capacity to be higher than in Vision 1. Decarbonisation is only driven by carbon pricing (no additional policies are assumed if carbon prices are too low to ensure a lower usage of coal fired units). Adequacy is ensured on a European level in order to have the optimized cost for society. This results in less back-up capacity than for Vision 1.

2030 Vision 3 of "National Green Transition"

Economy and Market	Vision 3 shows economic conditions being more favourable than in Vision 1 and 2. It results in member states having more financial means to reinforce existing energy policies. Still a loose European energy governance is a barrier to the introduction of fundamental new market designs that fully benefit from R&D developments. Furthermore, opting for parallel national schemes regarding R&D expenses also results in a situation where major technological breakthroughs suffer from suboptimal R&D spending. Energy policies drive carbon pricing (e.g. the EU Emissions Trading System, carbon taxes or carbon price floors) to levels such that baseload electricity production based on gas is preferred to hard coal. On the balance gas is likely to push out hard coal for baseload electricity generation.
Demand	Developments in energy efficiency, as well as electrification of transport and heating/cooling minimize the ecological footprint. On the balance electricity demand is lower than in Vision 1 on European level. Demand response potential is partially used to shift the daily load in response to the available supply.
Generation	The future generation mix is determined by parallel national policy schemes that are aiming for the decarbonisation objectives for 2050. Large scale RES expansion drives the price of RES electricity production to a competitive level. The cost of the electricity system will be higher than it would be for the case with a strong European framework, since RES and adequacy is handled on a national basis without cooperation between the countries. Demand response potential is used, however, the majority of the additional back-up capacity in 2030 would come from gas units since additional central hydro storage is not developed due to the lack of a strong European framework. Only some extra national storage is developed (e,g, pump storage, decentralized batteries,,,) Favourable economic conditions in combination with capacity mechanism (if needed) on a national basis result in conventional power plant investments and additional backup-capacity. Adequacy is handled on a national basis without cooperation between the countries. Old units are more likely to be decommissioned. New nuclear power plant projects become economically unattractive; only projects with a national acceptance for existing (or with final investment decision already made) are included in this vision. Carbon capture and storage are not (yet) economically attractive but are developed for pilot plants and for full-size demonstration plants.

ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

2030 Vision 4 of "European Green Revolution"

Economy and Market	Vision 4 sees financial conditions that are more favourable than in any of the other Visions, allowing member states to reinforce existing energy policies. Significant investments in sustainable energy generation are undertaken. Furthermore, a strong European framework makes the introduction of fundamental new market designs that fully benefit from R&D developments more likely. This also allows R&D expenses to be optimized so that major technological breakthroughs are more likely. Energy policies drive carbon pricing (e.g. the EU Emissions Trading System, carbon taxes or carbon price floors) to reach levels such that baseload electricity production based on gas is preferred to hard coal. Gas is likely to push out hard coal for baseload electricity generation.
Demand	Efforts in energy efficiency developments (e.g. large scale deployment of micro-cogeneration or heat pumps as well as minimum requirements for new appliances and new buildings) and further electrification of transport and heating/cooling are intensified. Furthermore market designs are adapted in such a way that the highest energy savings coincide with the highest energy substitution to electrical. Electrical usage still outweighs efficiency savings, giving a net energy increase. These new usages are intensified through additional national and/or European subsidies. Furthermore the demand response potential is fully used to shift the daily load in response to the available supply, because it allows a saving on back-up capacity.
Generation	The future generation mix is determined by a strong European Vision that is on clearly track to realize the decarbonisation objectives for 2050 at least cost. Thanks to a strong governance approach towards RES, RES is located in Europe in an optimal way lowering the cost for society. Likewise backup capacity to secure adequacy is handled on a European level. Large scale RES expansion drives the price of RES electricity production to a competitive level. Smart metering and smart grids are fully developed and thus demand response has a strong take-up. Additional hydro storage is built in centralized manner (focusing predominantly on Scandinavia, the Alps and the Pyrenees), with the remaining additional back-up capacity in 2030 coming predominantly from gas units. In this Vision no generating technology receives specific support and technologies compete with each other purely on a market basis. Furthermore decarbonisation is driven by carbon pricing. New nuclear power plant projects are not economically viable due competitiveness of RES production and no public acceptance for new projects. Older nuclear power plants are not considered flexible enough to balance the demand and RES and are consequently phasing out in areas with high RES production.

In order to build the four 2030 Visions matching the storylines mentioned in this section, a set of parameters was set up to describe with more details these scenarios. Based on these parameters, data were collected from TSOs for the two bottom-up 2030 Visions (Vision 1 and Vision 3).

TABLE 1 – SUMMARY OF CHARACTERISTIC ELEMENTS OF 4 VISIONS

	Slowest progress	Constrained progress	National green transition	European green revolution
	V1	V2	V3	V4
Economic and financial conditions	Least favourable	Less favourable	More favourable	Most favourable
Focus of energy policies	National	European	National	European
Focus of R&D	National	European	National	European
CO_2 and primary fuel prices	low CO_2 price, high fuel price	low CO_2 price, high fuel price	high CO_2 price, low fuel price	high CO2 price, low fuel price
RES	Low national RES (>= 2020 target)	Between V1 and V3	High national RES	On track to 2050
Electricity demand	Increase (stagnation to small growth)	Decrease compared to 2020 (small growth but higher energy efficiency)	stagnation compared to 2020(	Increase (growth demand)
Demand response (and smart grids)	As today	Partially used	Partially used	Fully used
	0%	5%	5%	20%
Electric vehicles	No commercial break through of electric plug-in vehicles	Electric plug-in vehicles (flexible charging)	Electric plug-in vehicles (flexible charging)	Electric plug-in vehicles (flexible charging and generating)
	0%	5%	5%	10%
Heat pumps	Minimum level	Intermediate level	Intermediate level	Maximum level
	1%	5%	5%	9%
Adequacy	National - not autonomous limited back-up capacity	European - less back-up capacity than V1	National - autonomous high back-up capacity	European - less back-up capacity than V3
Merit order	Coal before gas	Coal before gas	Gas before coal	Gas before coal
Storage	As planned today	As planned today	Decentralized	Centralized

ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

INSERT 1 – A CONTINUOUS IMPROVEMENT – BRIEF COMPARISON TO TYNDP 2014 SCENARIOS[5]

The scenarios of the TYNDP are evolving and improving in each release. The main axis of the four Vision have been kept as in the TYNDP 2014. However, based on the feedback received from the Stakeholders on the past scenarios – especially from the September 2014 stakeholder workshop[6] – the parameters used to build the four 2030 Visions were updated.

Demand: One of the main change is related to the overall demand assumed in the four Visions, as well as how the demand evolve from one Vision to another. In the TYNDP 2014, the demand was increasing from Vision 1 to Vision 4. In the new scenarios, the demand is the lowest in Vision 2 where the overall demand is expected to decrease compared to 2020 (small basic growth assumed but out-weighed higher energy efficiency). On the other side, the highest demand is assumed in Vision 4 were the economic and financial condition as well as the stronger European framework lead more energy substitution to electricity (e.g. in transportation and heating).

RES optimization: In the TYNDP2014 a RES optimization was only performed for Vision 4 in order to reach EU target for 2030. A new methodology for RES optimization has been developed and applied to Vision 2 and 4. The optimization handles extra RES capacity in the ENTSO-E perimeter, but also re-allocates the RES over the different countries.

Thermal optimization: In the TYNDP2014 a thermal reduction is performed based on a simple CBA exercise, resulting in limited reductions. A new methodology for thermal optimization is developed and applied to Vision 2 and Vision 4. The optimization is based on economic criterion (trade-off between fixed costs and variable generation costs).

Adequacy level: The adequacy level is explicitly described in the storyline of each Vision. In the Vision 1 it is now possible to count up to 20% of the peak load on neighbouring countries (no longer autonomous).

[5] A comparison of the main figures of TYNDP 2014 and 2016 scenarios was presented during the 3rd Stakeholder workshop. The material presented can be accessed here.
[6] The outcomes of the workshop are summarized in the material of the second workshop here.

ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

5 Scenario quantification results

Based on the storyline of the scenarios described in the section 4, and the methodologies summarized in section 6, market modelling experts within ENTSO-E delivered a draft quantification of the five TYNDP2016 scenarios in a draft Scenario Development Report published in May 2015. Taking into account the draft list of TYNDP 2016 candidate projects published in June 2016 and the consultation feedback on the draft report, these simulations were re-run. .

Quantifications of the final TYNDP2016 scenarios are presented in this section, including annual demand, installed capacities and annual generation, to illustrate study results stemming from the storyline assumptions and the described methodologies.

Another update compared to the earlier draft report is that two additional countries (Albania and Cyprus) were modelled and are now added in the following charts.

The underlying data behind the graphs are also available in the Annex B. The fuel and CO2 prices assumptions are depicted in the section 7.

2020 Best Estimate Scenario of “Expected Progress”

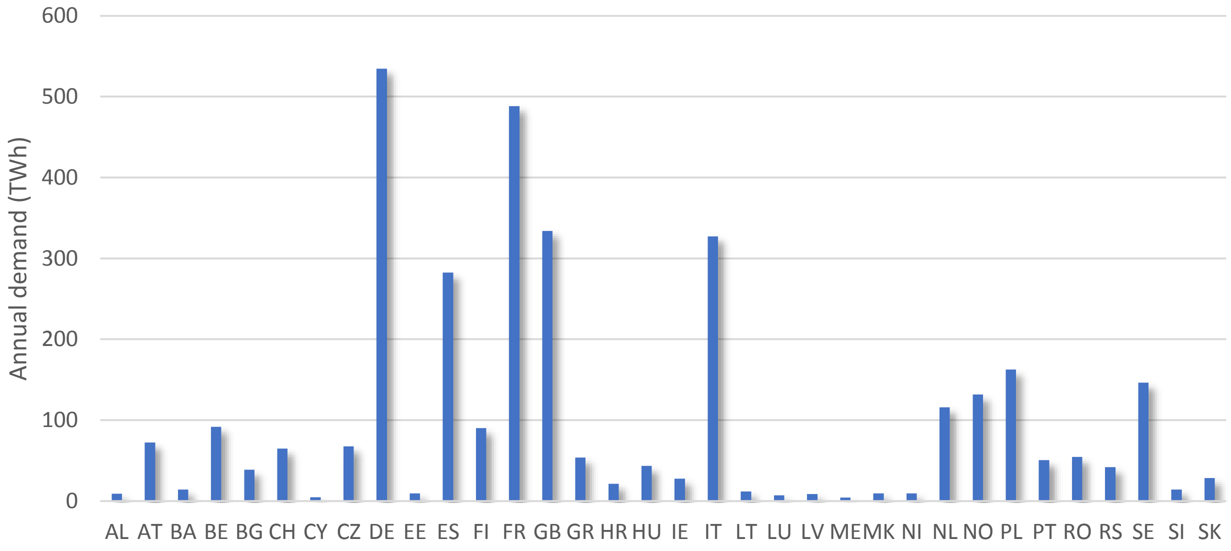


Figure 5-1 2020 Expected progress - Annual demand

ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

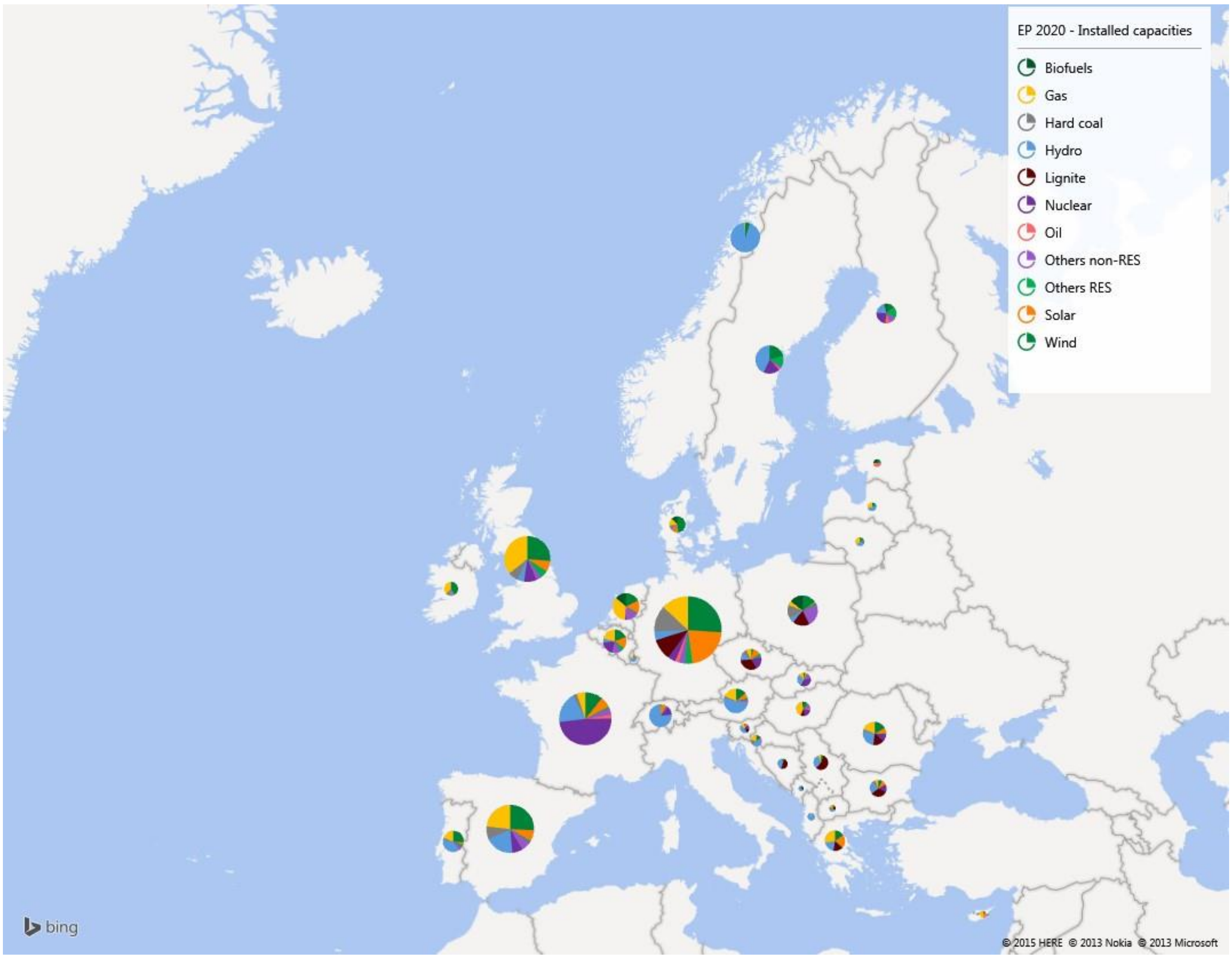


FIGURE 5-2 2020 EXPECTED PROGRESS - INSTALLED CAPACITIES

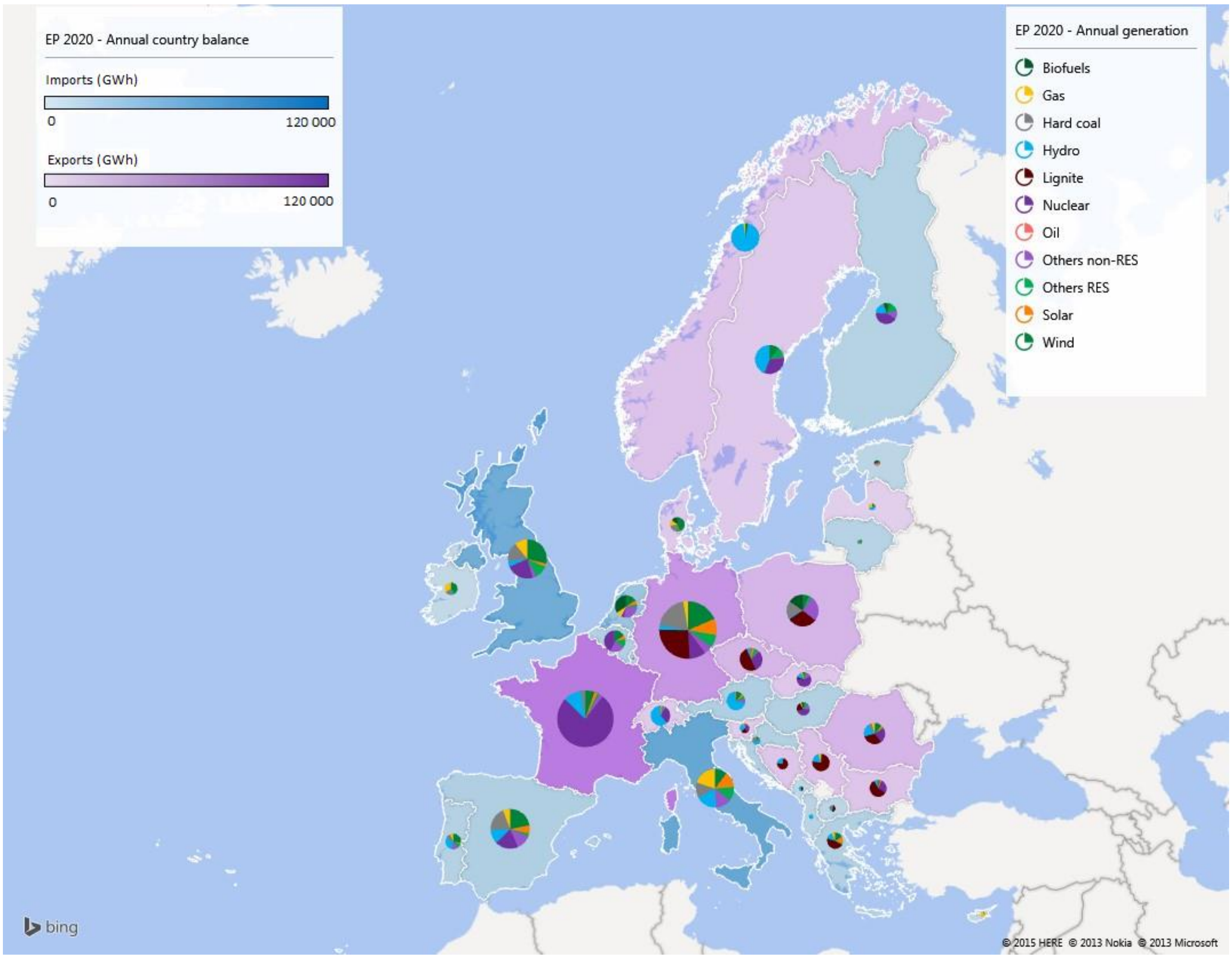


FIGURE 5-3 2020 EXPECTED PROGRESS - ANNUAL GENERATION AND COUNTRY BALANCES

2030 Vision 1 of "Slowest Progress"

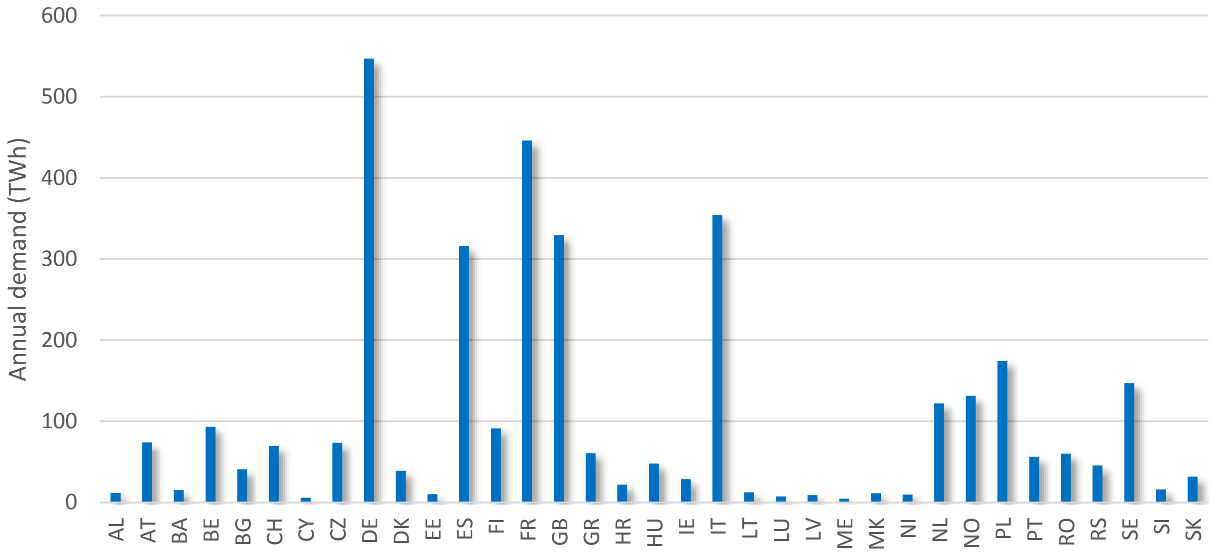


FIGURE 5-4 2030 VISION 1 - ANNUAL DEMAND

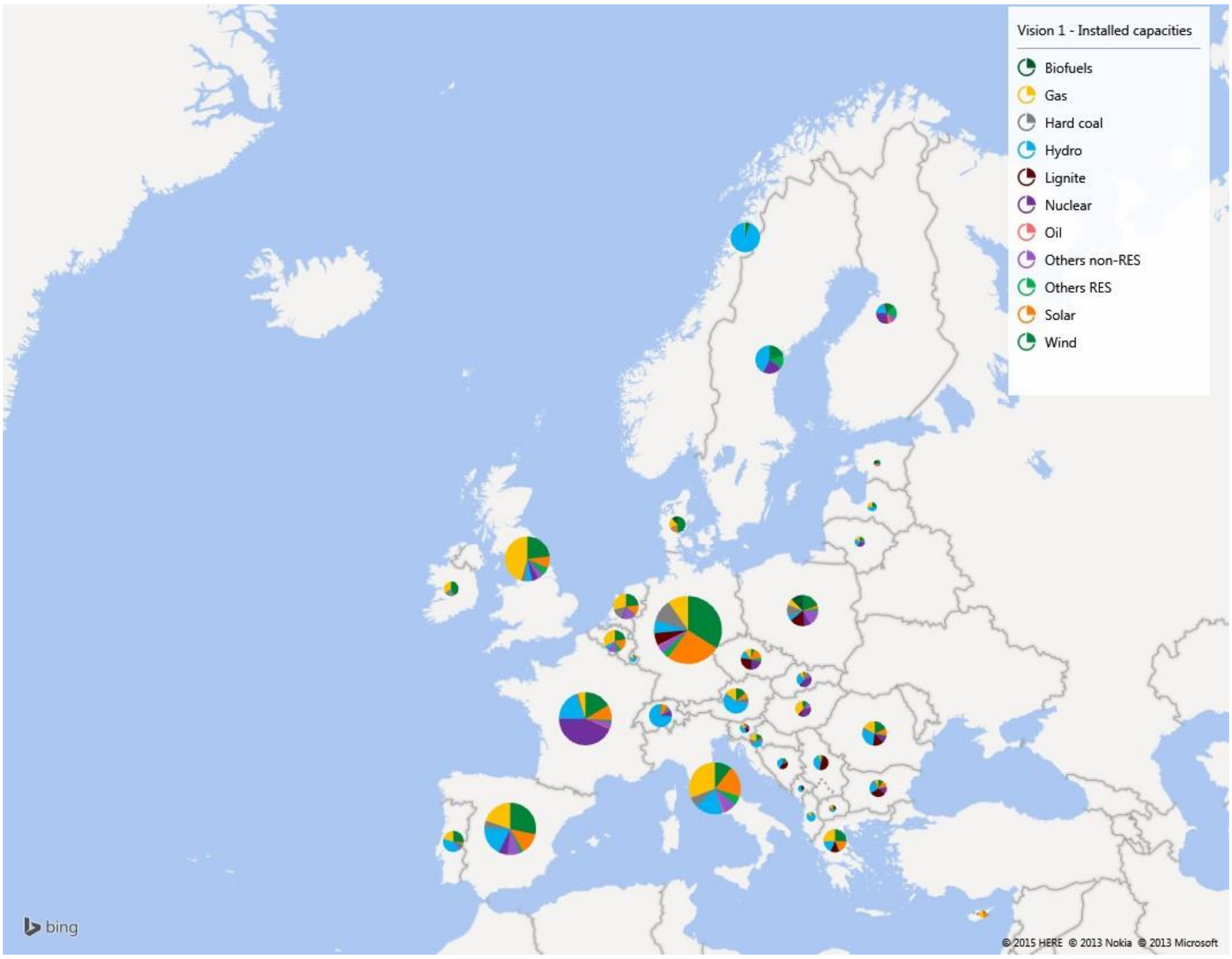


FIGURE 5-5 2030 VISION 1 - INSTALLED CAPACITIES

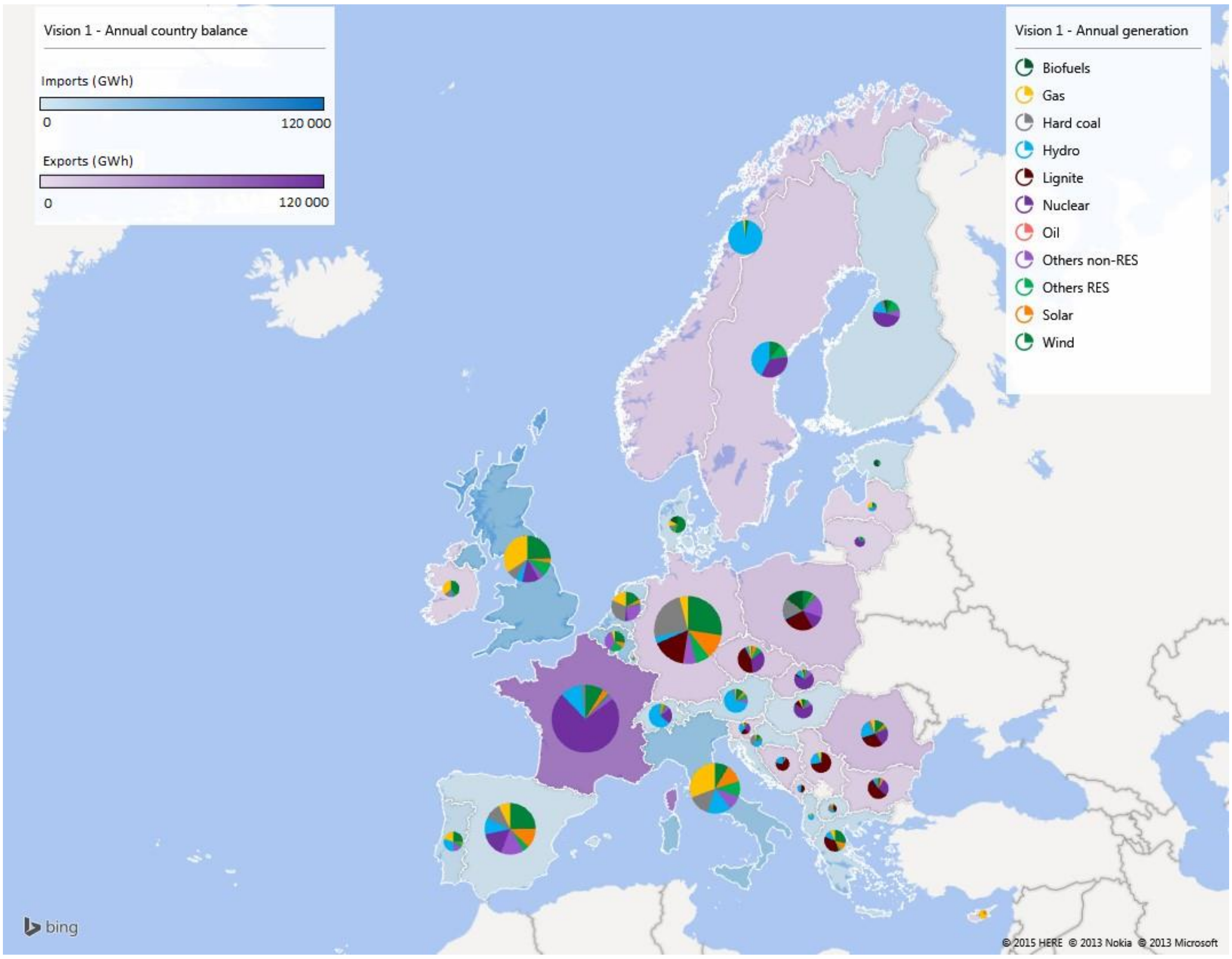


FIGURE 5-6 2030 VISION 1 - ANNUAL GENERATION AND COUNTRY BALANCES

2030 Vision 2 of "Constrained Progress"

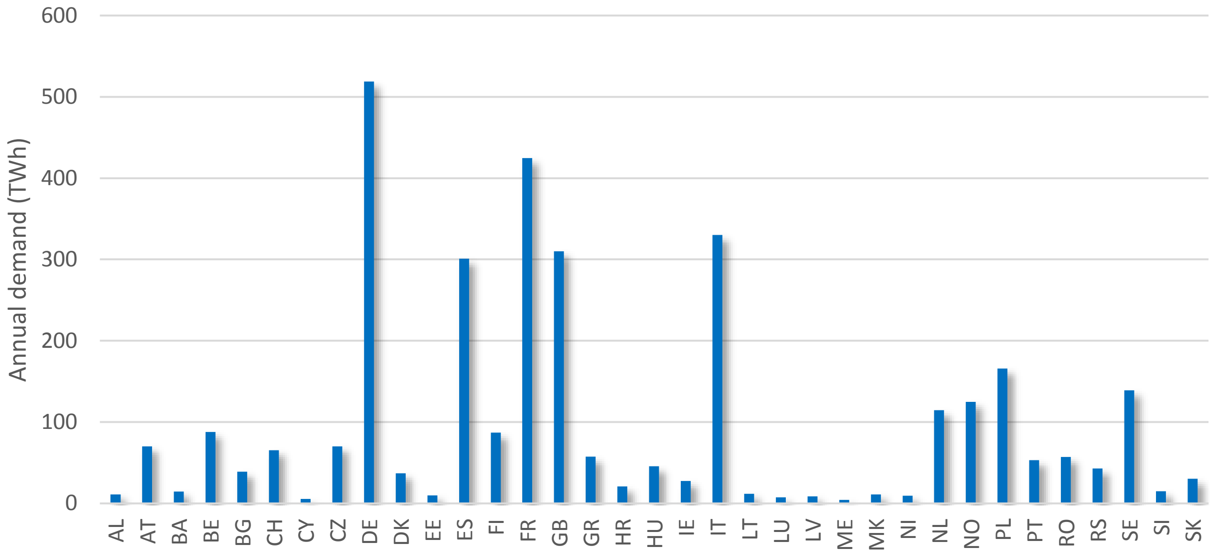


FIGURE 5-7 2030 VISION 2 - ANNUAL DEMAND

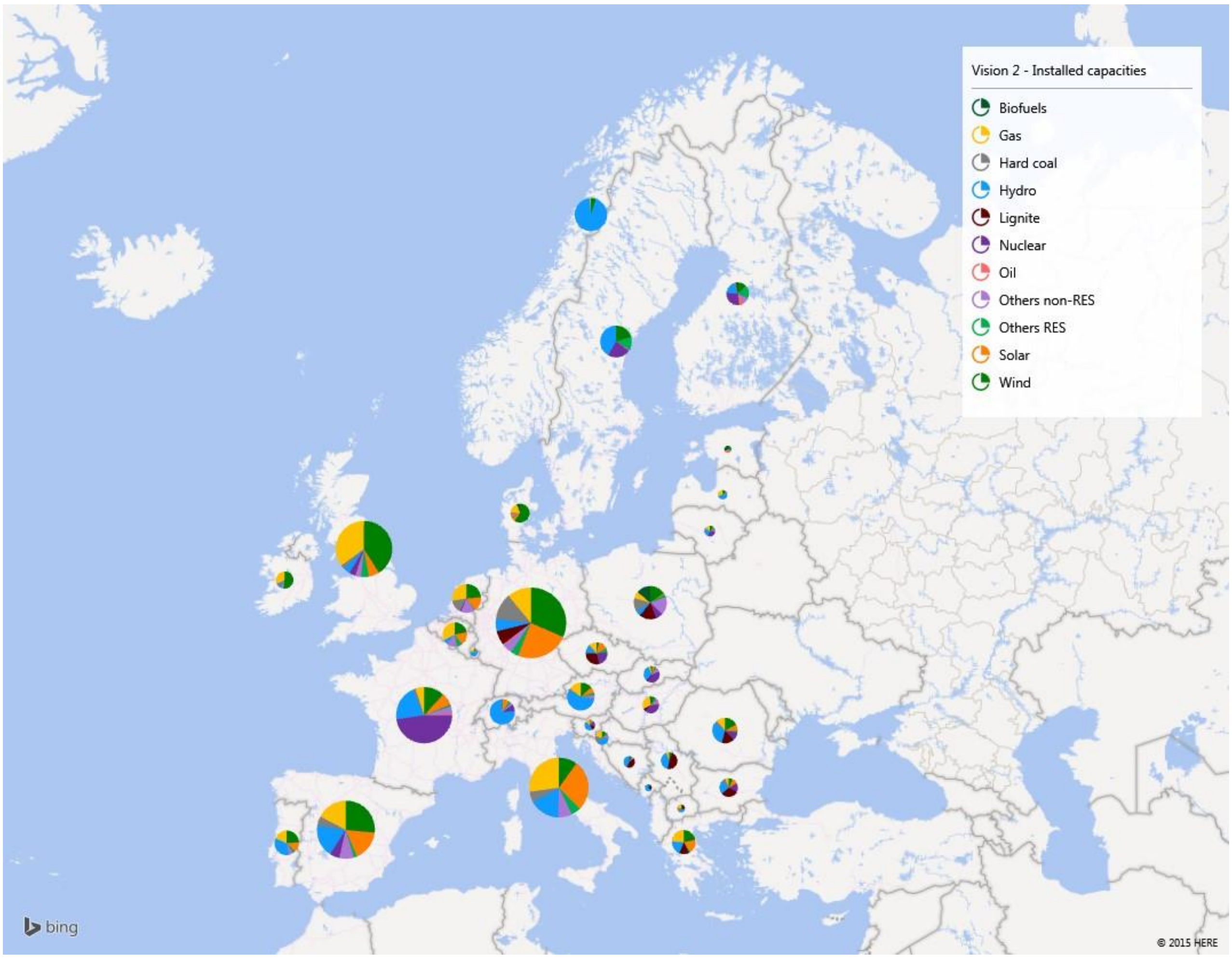


FIGURE 5-8 2030 VISION 2 - INSTALLED CAPACITIES

ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

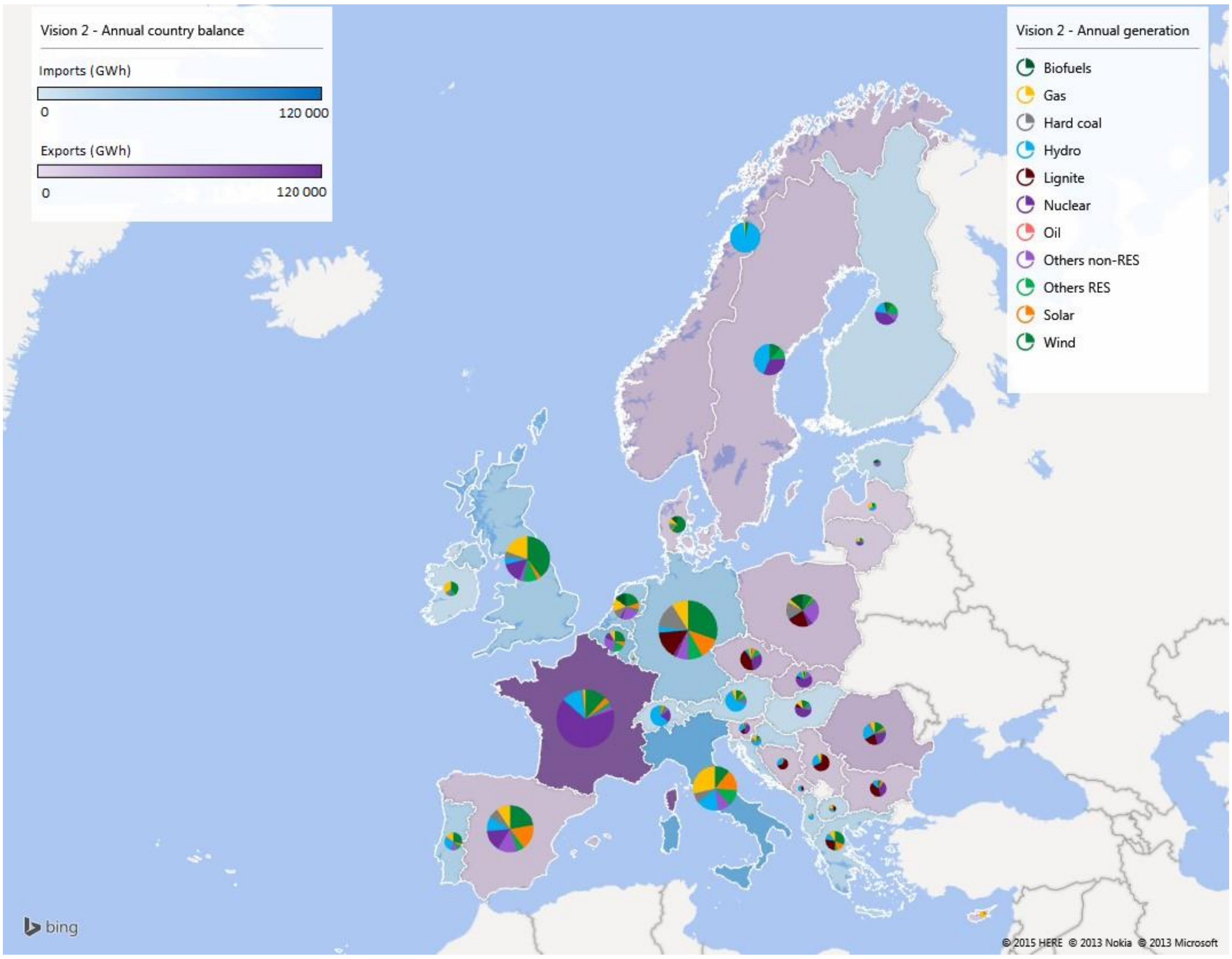


FIGURE 5-9 2030 VISION 2 - YEARLY GENERATION AND ANNUAL COUNTRY BALANCES

2030 Vision 3 of "National Green Transition"

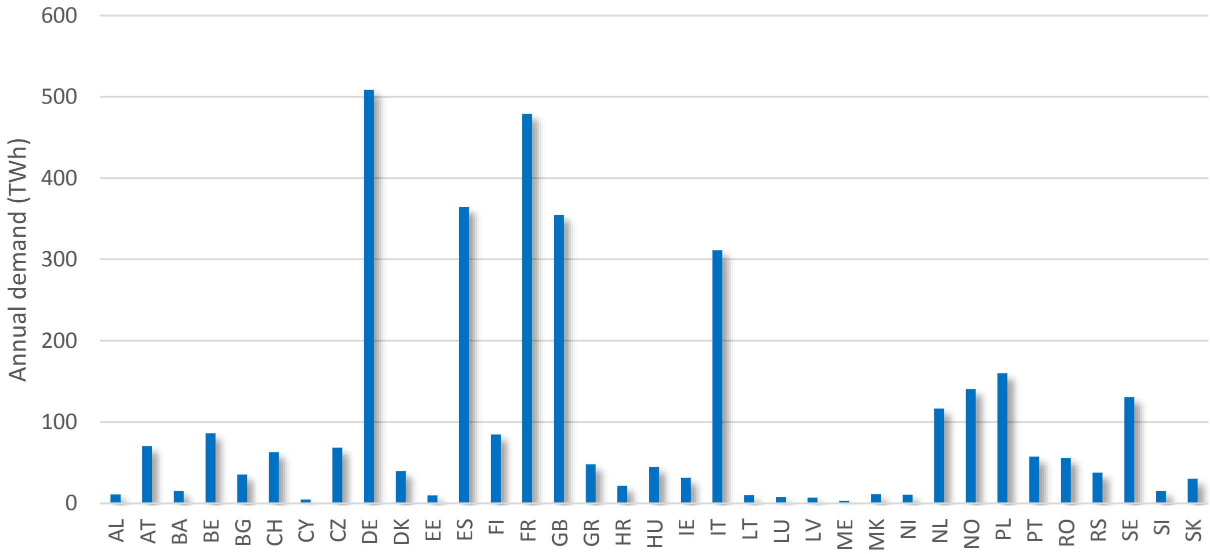


FIGURE 5-10 2030 VISION 3 - ANNUAL DEMAND

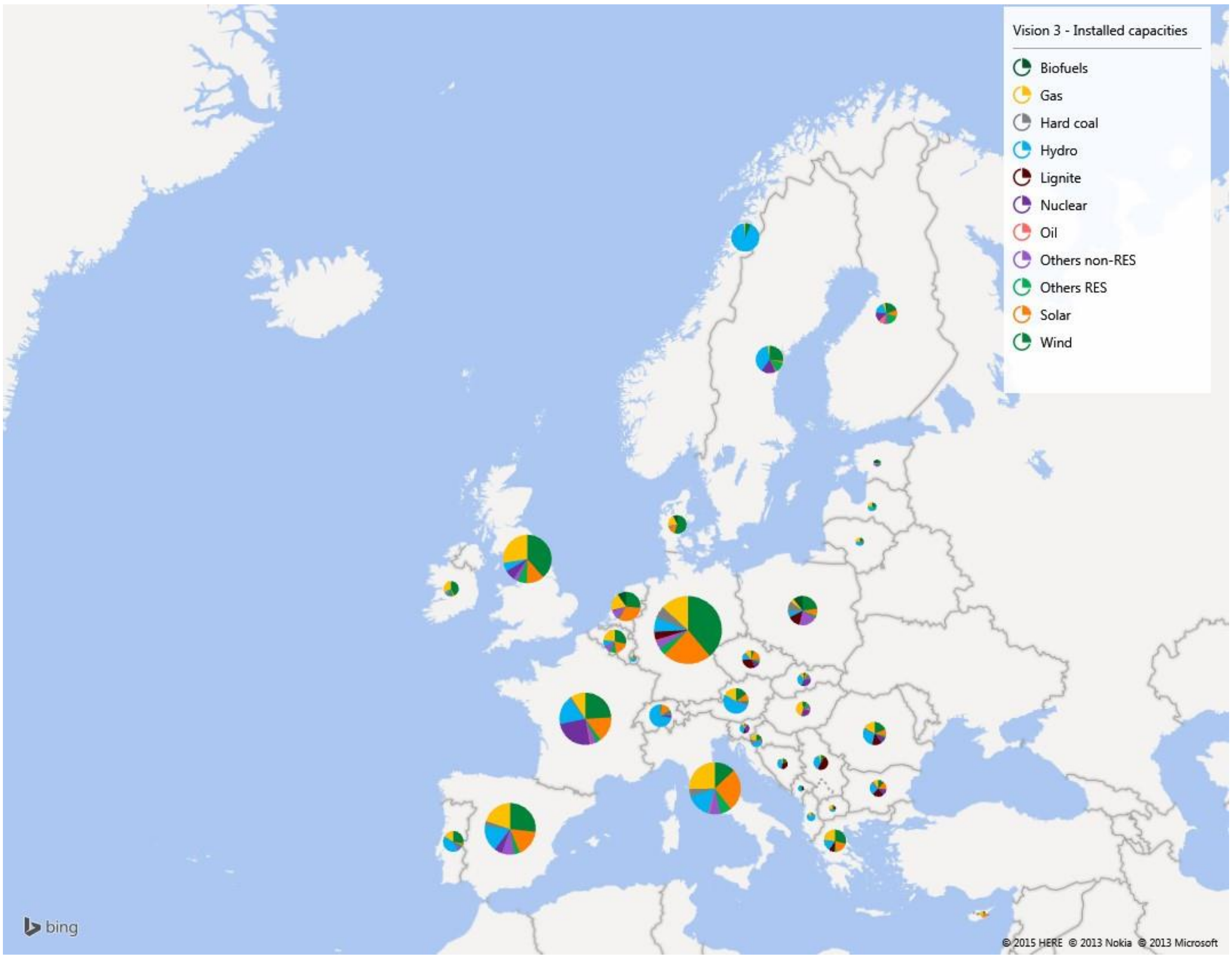


FIGURE 5-11 2030 VISION 3 - INSTALLED CAPACITIES

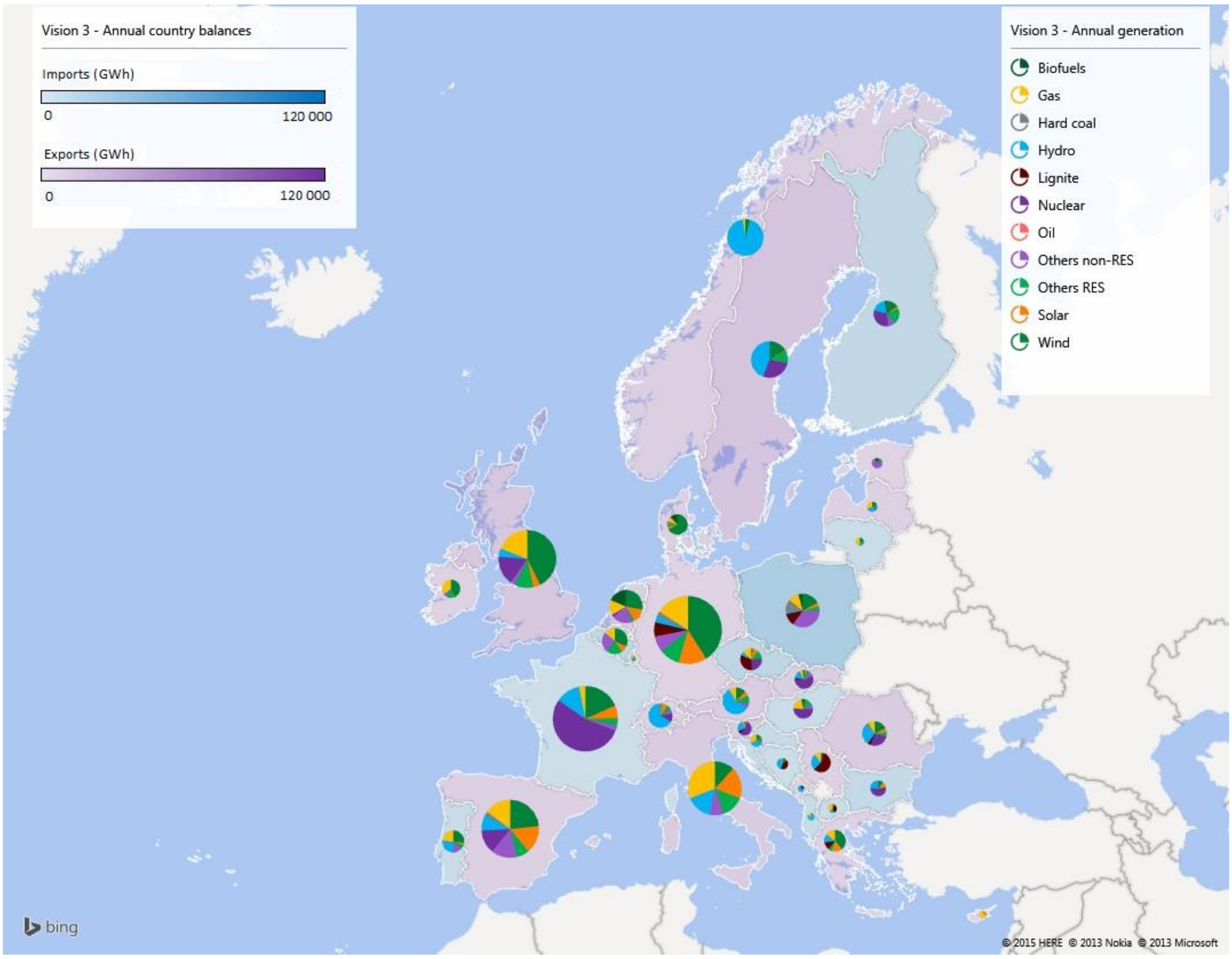


FIGURE 5-12 2030 VISION 3 - YEARLY GENERATION AND ANNUAL COUNTRY BALANCES

2030 Vision 4 of "European Green Revolution"

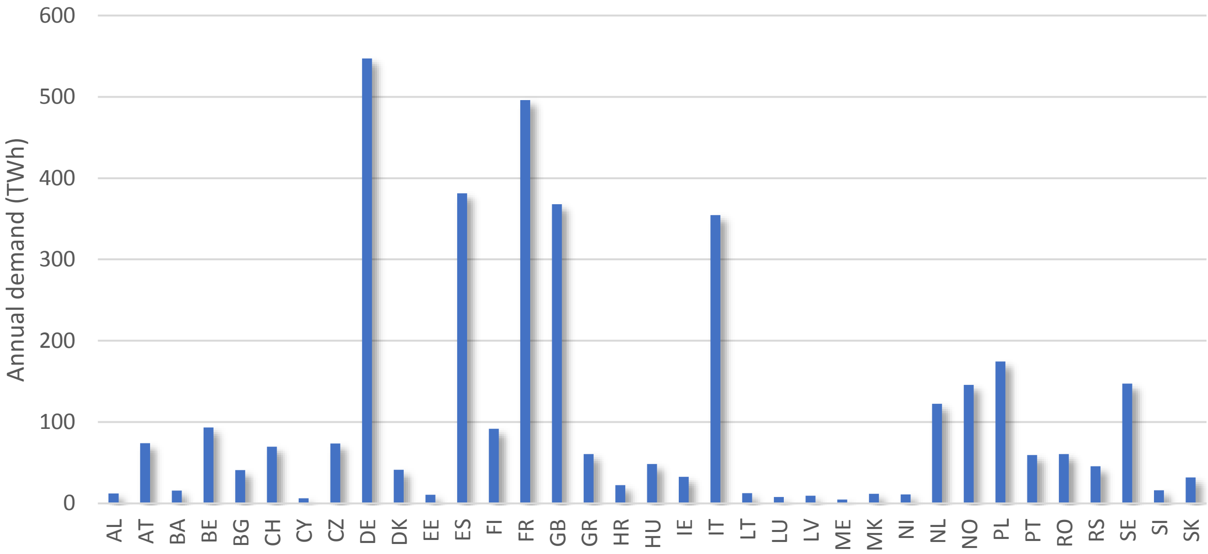


FIGURE 5-13 2030 VISION 4 - ANNUAL DEMAND

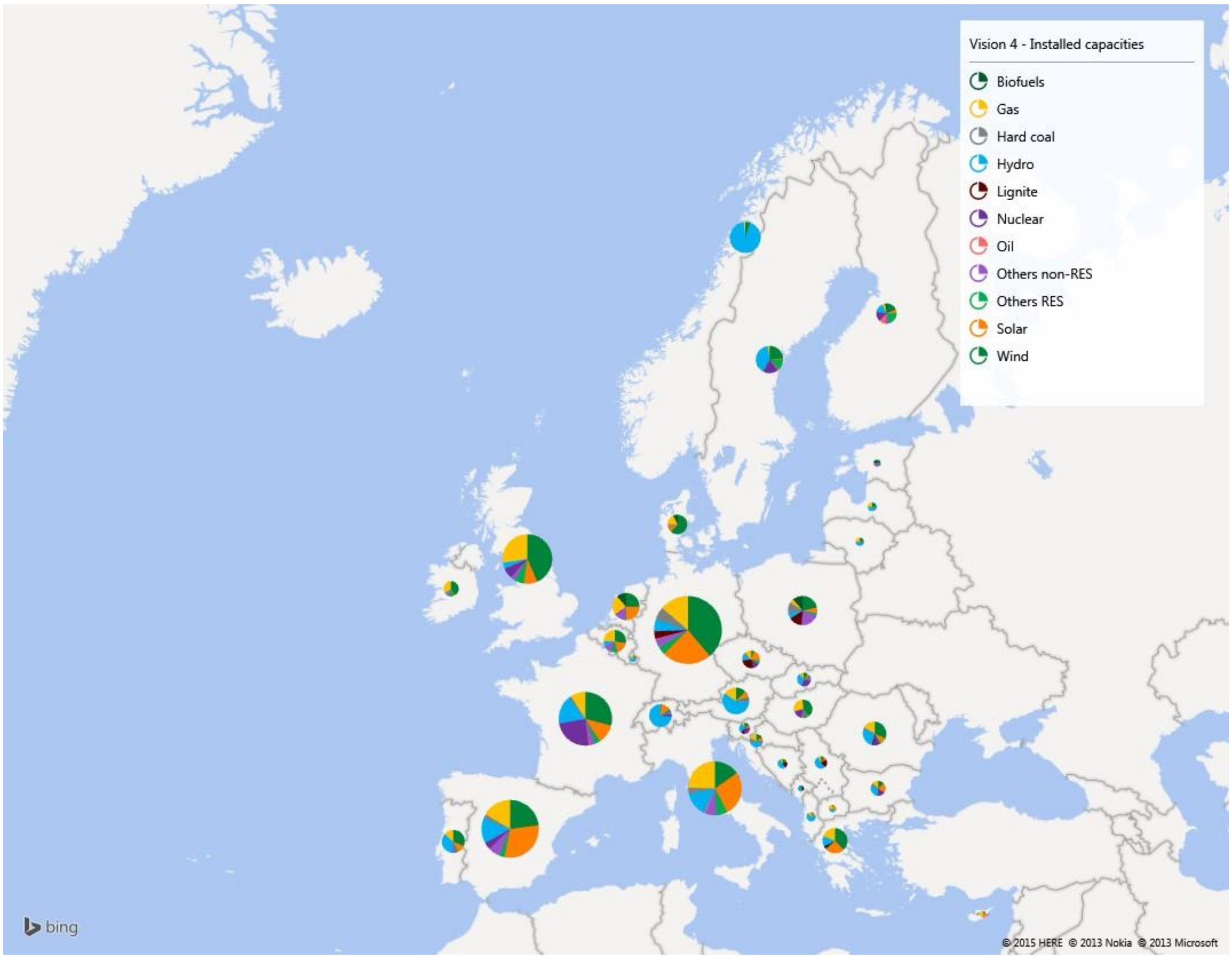


FIGURE 5-14 2030 VISION 4 - INSTALLED CAPACITIES

ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

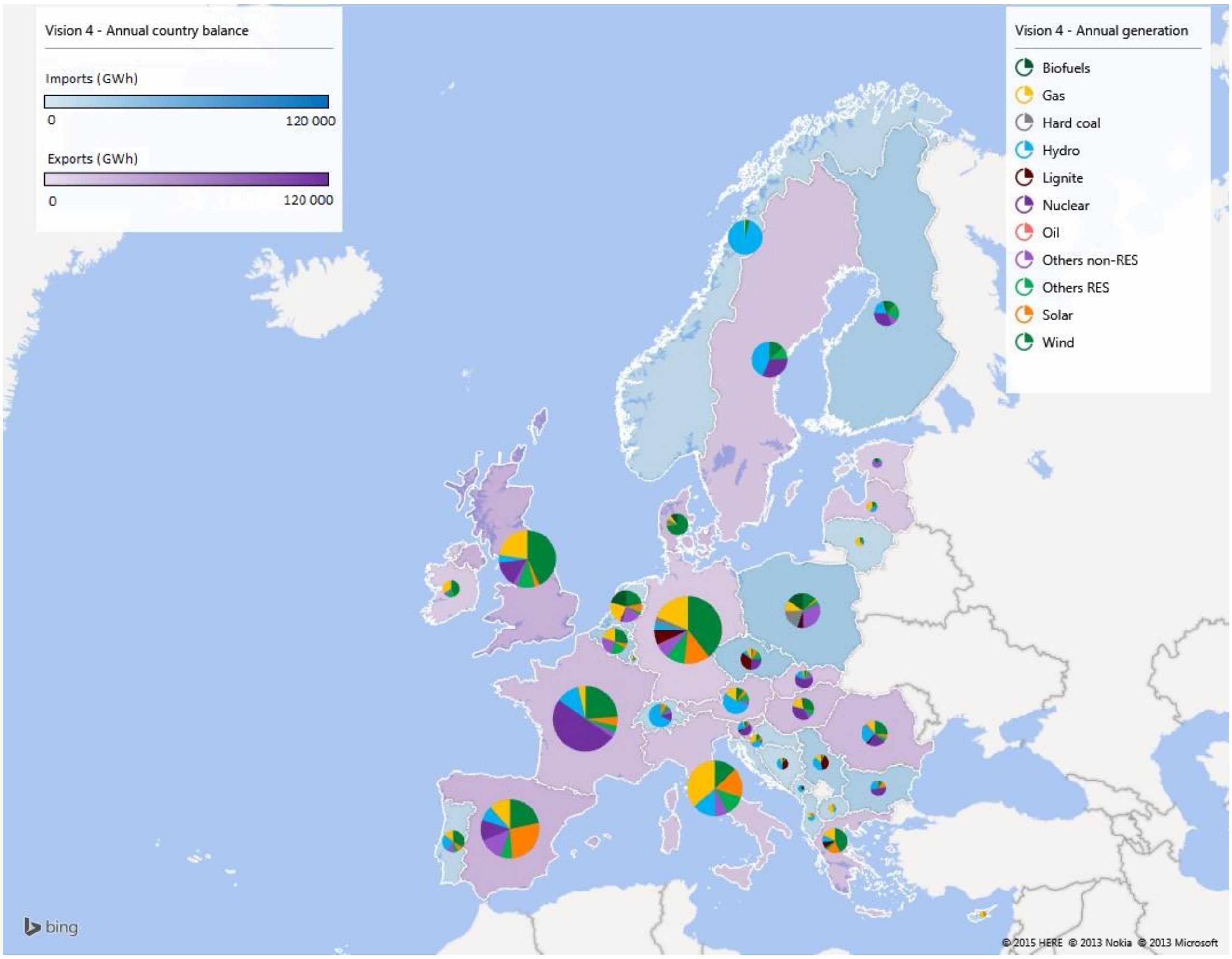


FIGURE 5-15 2030 VISION 4 - ANNUAL GENERATION AND COUNTRY BALANCES

General overview

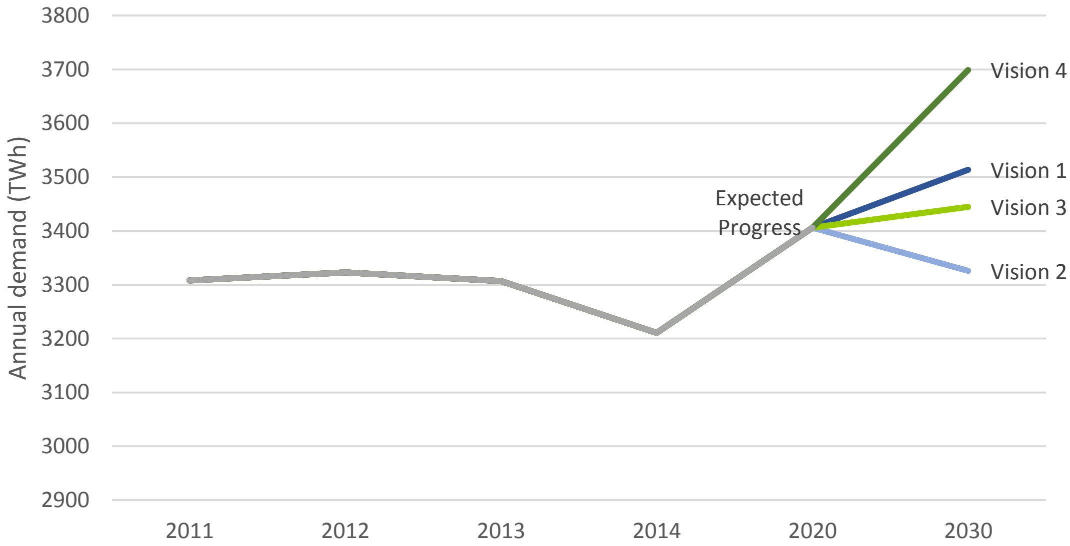


FIGURE 5-16 - COMPARISON OF THE ANNUAL DEMAND AMONG THE FIVE SCENARIOS

The four 2030 Visions show a range of electrical demand from 3318 TWh (Vision 2) to 3680 TWh (Vision 4), in line with the scenario storyline. The 2020 Expected Progress shows a yearly change rate of electricity demand between 2014 and 2020 of around 1%/year at the level of the ENTSO-E perimeter. Note that the scenario building uses data collections of 2014; Figure 5-16 shows historical data up to 2014, and scenario interpolations beyond that year.

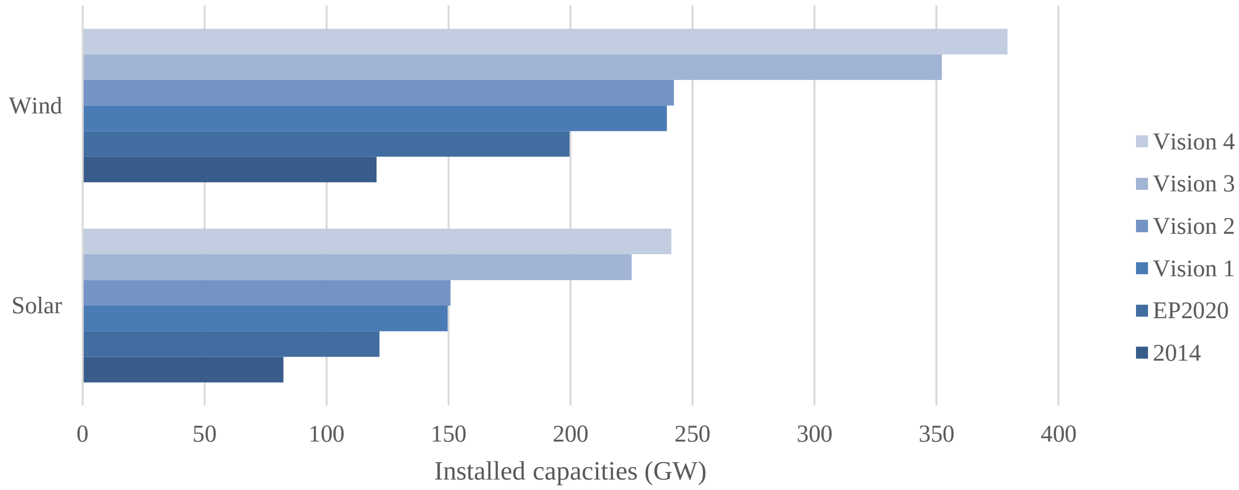


FIGURE 5-17 COMPARISON OF INSTALLED CAPACITIES

The installed capacity of wind and solar increases from Vision 3 to Vision 4 in order to cover the increase of demand from Vision 3 to Vision 4. Thus, Visions 3 and 4 show the same share of the electricity demand being supplied by wind and solar sources.

ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

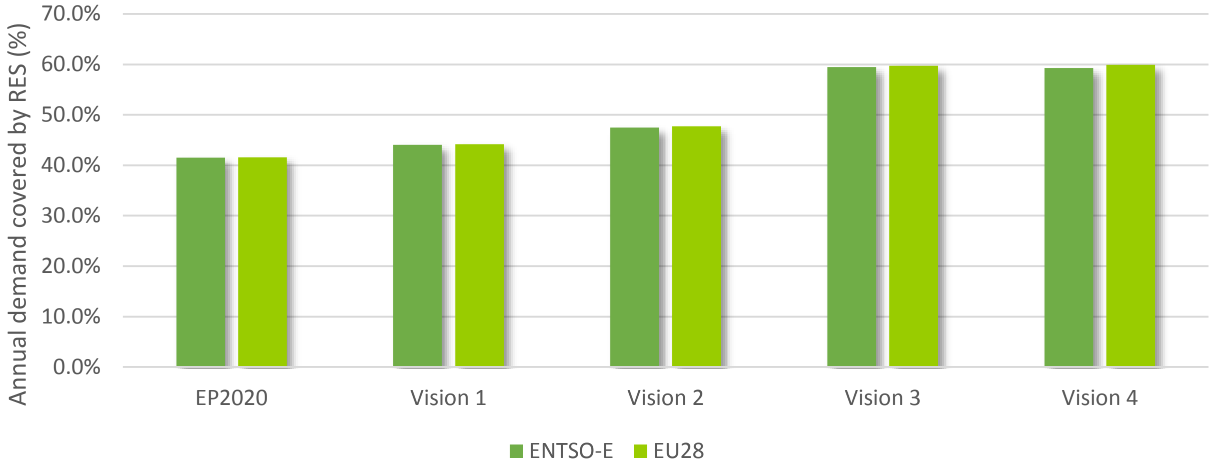


FIGURE 5-18 COMPARISON OF %RES

The percentage of the demand covered by RES spreads from 44 % in Vision 1 to close to 60 % for Visions 3 and 4. The total RES installed capacity in Vision 4 was increased compared to Vision 3 in order to keep the same percentage of electrical demand being covered by RES generation in both scenarios. All the 2030 Visions are expected to be in line with the recent 2030 targets set for renewables. Note that the Vision 3 and 4 (i.e. high RES) storylines are characterized by a demand which is lower as compared to TYNDP2014. Therefore even with lower installed RES capacities as in the TYNDP2014 scenarios the %RES figure still approaches 60%; in case less energy efficiency savings are assumed (thus higher electrical demand), the %RES figure would drop.

To place it in perspective of the present situation, EUROSTAT's latest report (based on 2012 data) gives a 23.5 %RES level in the EU-28 region[7].

INSERT 2 – WHAT DOES A %RES FIGURE MEAN?

In this Scenario Development Report, the %RES value for a given scenario is calculated as the ratio of annual electrical energy generated by renewable sources (e.g. PV, wind, biomass, hydro inflow, geothermal, tidal, wave, and others), over electrical energy consumed, within the modelled countries.

The classification of renewable sources follows as much as possible the interpretation of the Renewable Energy Directive (2009/28/EC), stating that energy from renewable sources means energy from renewable non-fossil sources, namely wind, solar, aerothermal, geothermal, hydrothermal and ocean energy, hydropower, biomass, landfill gas, sewage treatment plant gas and biogases.

It is important to note that for the purpose of the analysis in this report, only electricity is considered. While the recent Council conclusions of October 2014 set clear targets for a European renewable level of 27% by 2030, the impact on the electricity sector and the balance of efforts across industries is still assessed. Provisional prognoses (such as the 2013 "EU energy, transport, and greenhouse gas emissions trends to 2050") indicate a level of 40 to 45% of gross electricity consumption based on renewable power generation by 2030[8].

It is also important to note that classifications of electrical generation (in particular on biofuels and hydro) do differ across various public reports.

[7] http://ec.europa.eu/eurostat/statistics-explained/index.php/Renewable_energy_statistics
[8] See the Impact Assessment accompanying the Communication from the Commission "A policy framework for climate and energy in the period from 2020 up to 2030"

In addition the %RES figure is highly impacted by the denominator element in the ratio, referring to electrical demand, which demonstrates the strong link between both energy efficiency and renewable targets.

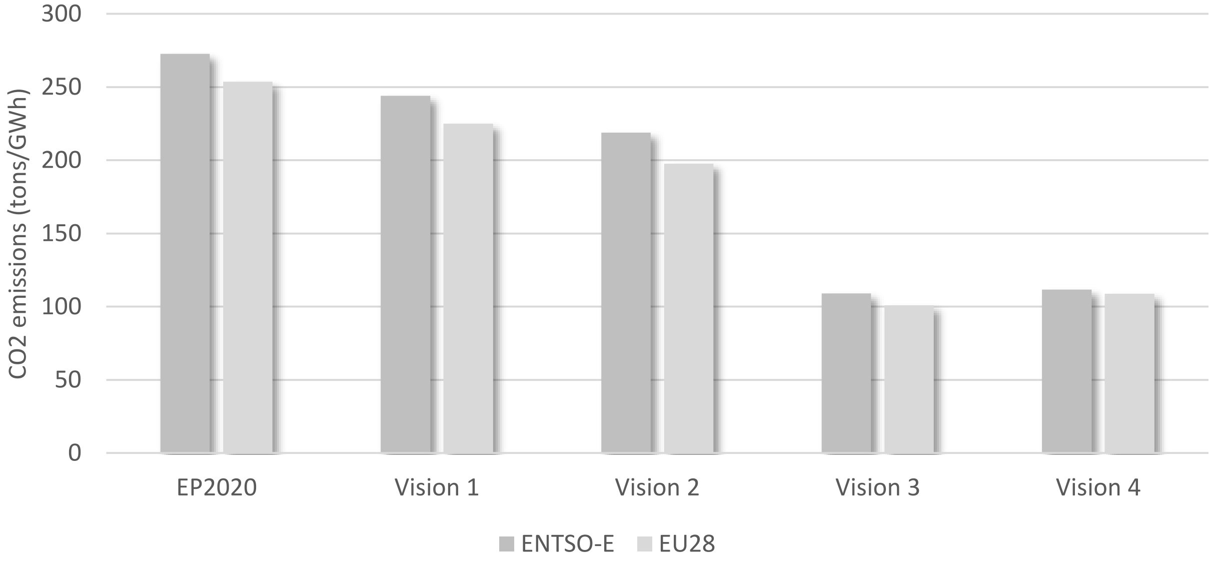


FIGURE 5-19 COMPARISON OF THE CO_2 EMISSION INTENSITY IN THE 5 SCENARIOS

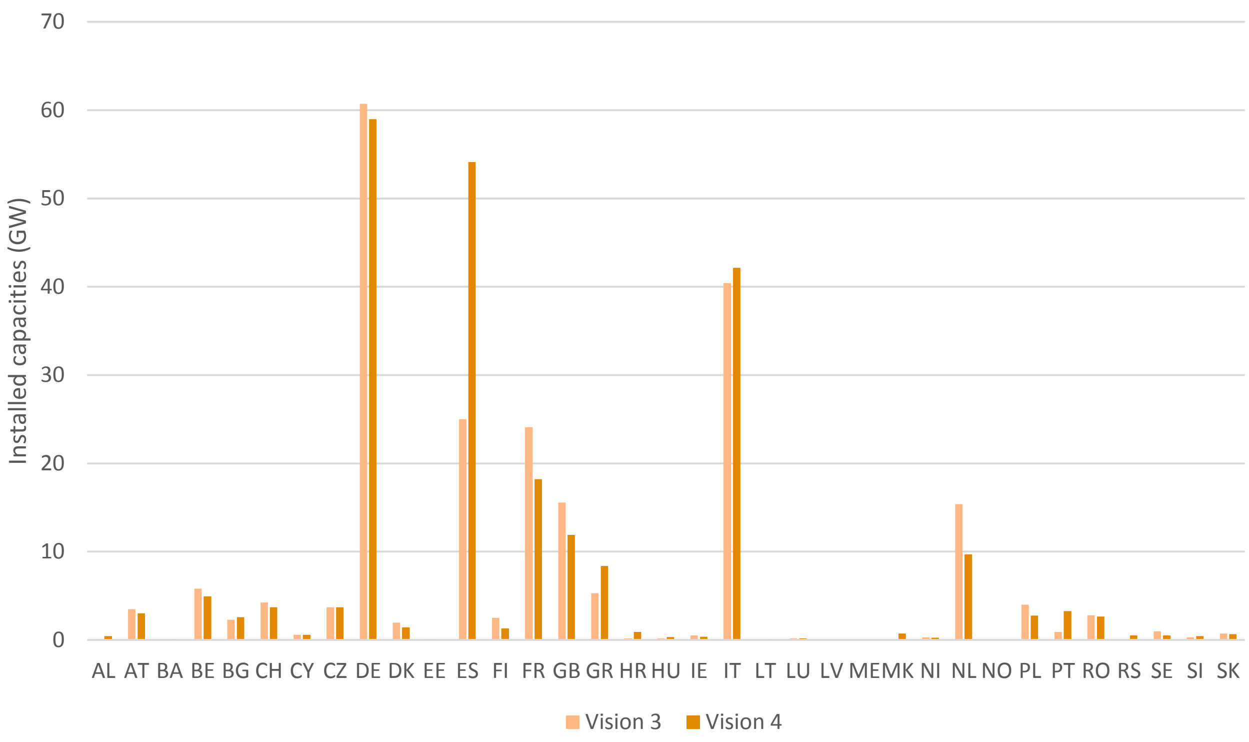


FIGURE 5-20 PV REALLOCATION FROM VISION 3 TO VISION 4

The above picture shows the effects of the RES re-allocation on the PV installed capacities, with the re-allocation PV among countries between the Vision 3 (bottom-up scenario) and the Vision 4 (top-down scenario). The similar process was run for the Vision 2 building. More examples of the re-allocation (V4 wind, and V2) can be found in appendix.

INSERT 2 COMPARISON WITH OTHER SCENARIOS (EU 28 PERIMETER)

The following comparison has been performed scaling the ENTSO-E scenarios to the EU 28 perimeter to match with the EU trends to 2050 and the IEA WEO 2014 EU 28 perimeters. For the EU trends to 2050 and the WEO2014, the snapshot for the year 2030 was used as comparison basis.

In the EU 28 perimeter, the ENTSO-E 2030 Visions annual demand ranges from 3062 (Vision 2) to 3397 TWh (Vision 4). The IEA scenarios from the WEO 2014 ranges from 3362 TWh (“450 Scenario”) to 3798 TWh (“Current policies”).

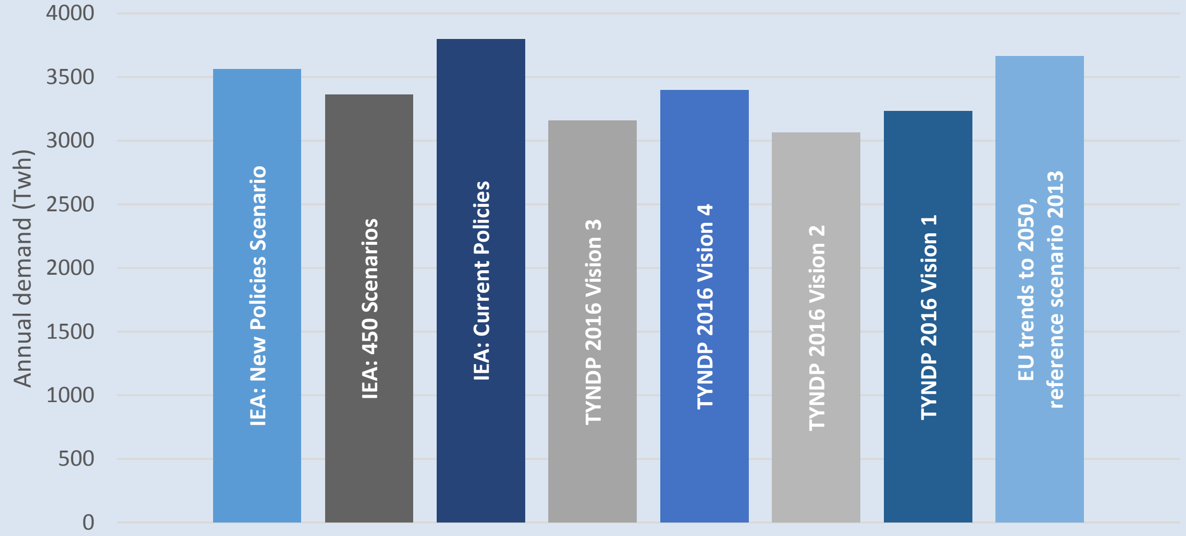
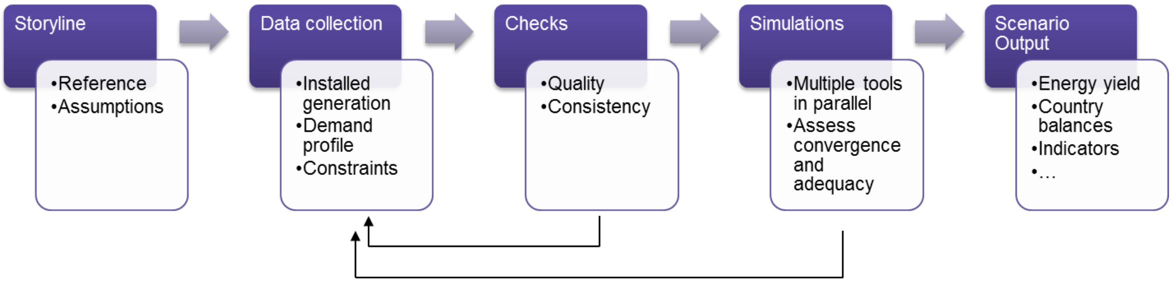


Figure 5-21 Comparison of the annual demand for the year 2030 (EU 28 perimeter)

6 Methodologies to derive pan-European scenarios

As highlighted in Section 5, the set of scenarios gives a balance between so-called bottom-up and top-down scenarios.

Bottom-up scenarios (2020 Expected Progress, and 2030 Visions 1 and 3) are driven by a straightforward process as depicted in the following graph



Note that "bottom-up" refers to approach to collect national figures to assemble a pan-European scenario. Still, the data collection is based on a single pan-European storyline (as described in Section 4) with quantitative and qualitative guidance on specific data sets for national correspondents. Data collected is next checked for quality and consistency with the storyline, which can result in an update of the bottom-up data. Also simulation results can still trigger a need for update of data to ensure a credible pan-European scenario.

Top-down scenarios (2030 Visions 2 and 4) take a bottom-up scenario as starting point (resp. 2030 Vision 1 and 3), and adapt it step by step to simulate and analyse European governance and Member State coordination.

The following steps are taken in the top-down scenario building methodology, starting from capacities and load profiles of a bottom-up scenario, and available 2030 grid models. For further insight in the methodology, please refer to Annex 1.

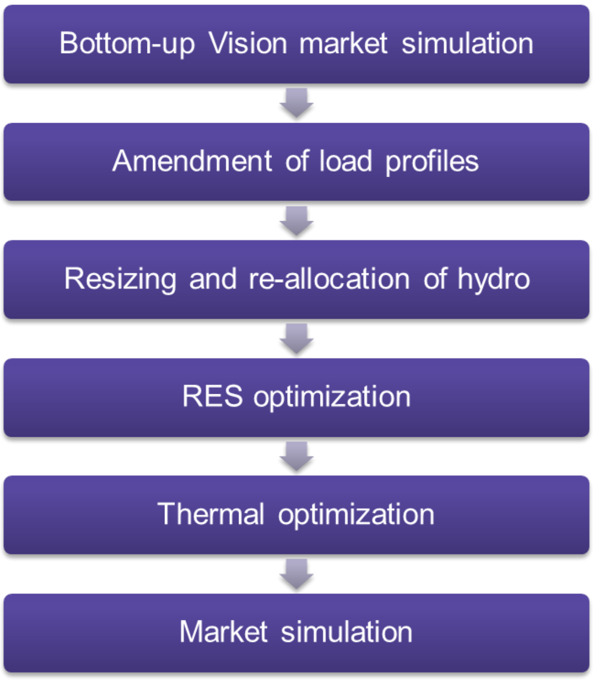


FIGURE 6-1 CONSTRUCTION OF THE TOP-DOWN SCENARIOS FROM THE BOTTOM-SCENARIOS

1. Amendment of load profiles

The load in the top-down scenarios is constructed using a re-scaling of the bottom-up load curves driven by energy efficiency savings, introduction of electric vehicles, introduction of heat pumps, and additional peak-shaving. Specific European targets for these demand indicators are assumed (targets are fixed based on input from stakeholders). The extent to which national load profiles are re-scaled depends on e.g. the amount of electric vehicles, heat pumps and energy efficiency measures assumed in the relevant top-down scenario.

2. Re-sizing and re-allocation of hydro

This step is only implemented in the construction of Vision 4, not for Vision 2. The methodology introduces in Vision 3 an additional amount of hydro generation in each country based on 4% of peak demand from Vision 3. Next, a distinction is made between hydro and non-hydro countries, based on a threshold of 15% of national generation capacity. The top-down Vision 4 (with strong European energy governance) assumes hydro is pooled in hydro countries (e.g. Alpine, Pyrenees and Nordic countries). For hydro-countries, the amount of hydro is increased until an estimated maximum potential. This total increase is used to re-scale (i.e. down-scale) the installed capacity in non-hydro countries.

3. RES re-allocation

A key feedback from many stakeholders in the past TYNDP2014 was the request to see a top-down scenario which optimizes installed RES capacities across Europe, with the aim to concentrate efforts for RES integration in places which optimizes the benefit for all end-consumers. Rather than performing such re-allocation based on rule-of-thumbs ENTSO-E developed an optimization strategy to perform such re-allocation optimization.

ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

The objective is to minimize the total system operation cost by re-allocating the RES available (based on European targets) among all ENTSO-E countries in the most economic and efficient way, taking into account market potential and limitations of a 2030 grid. The main constraint is to keep the total installed capacity per RES technology constant in the ENTSO-E perimeter.

The principal variables in the optimization are the revenues per installed MW per technology and per country (Rx,c). In the theoretical optimal solution, the revenues per installed MW of a particular RES technology need to be the same in all countries except in case additional constraints are reached (e.g. grid infrastructure constraints, reserve limits, etc…). The RES technologies optimised are wind onshore, wind offshore and PV.

The revenue indicators are calculated as follows:

$$R_{x,c} = \frac{\sum_{h=1}^{8760} (LMP_{h,c} * Generation_{h,x,c})}{Inst.Capacity_{x,c}} \quad (€/MW)$$

x = Onshore, Offshore and PV
c = Country
h = Hour

The main purpose is reaching for each country a Rx,c very close or equal to the weighted average revenue across all countries (see Figure 7-2).

The term LMP (Locational Marginal cost of Production) refers to the marginal costs computed by mean of market simulations. The simulations provide hourly values for each modelled node/country.

The revenue indicators are translated into a re-allocation of installed RES of a particular technology across countries. The two steps of revenue indictor calculations and RES re-allocations are repeated until Rx,c converges, as does the total system operation cost (see Figure 7-3).

This step-by-step optimization is illustrated in the following example:

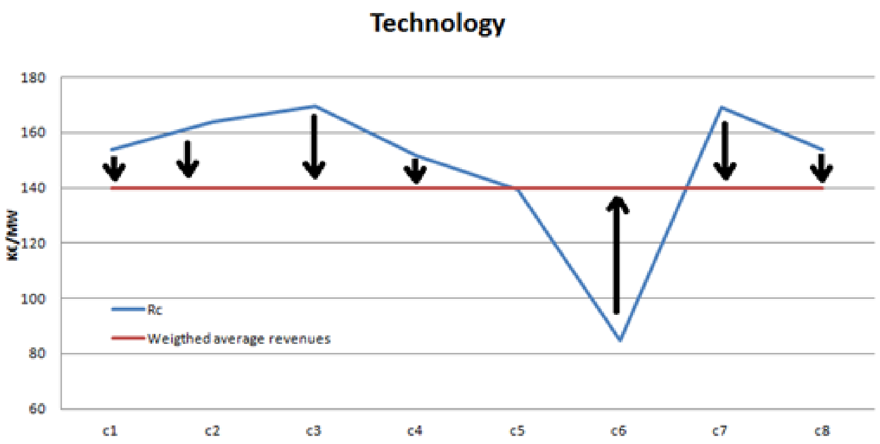


FIGURE 6-2 - EXAMPLE OF RES RE-ALLOCATION FOR A SPECIFIC TECHNOLOGY WITH IMPACT ON REVENUE INDICATORS ACROSS EIGHT COUNTRIES (LEFT)

ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

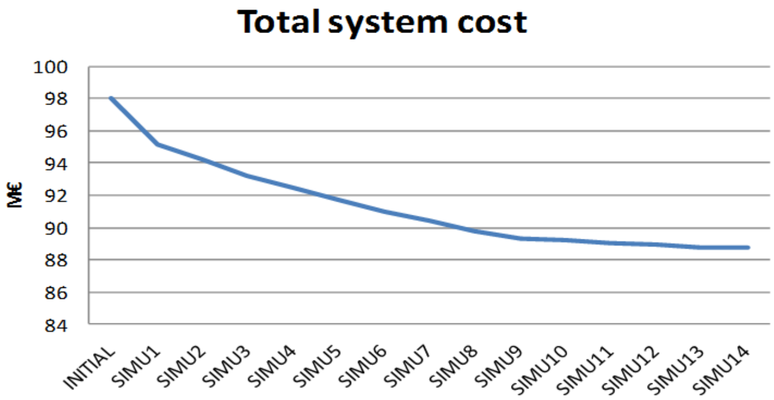


FIGURE 6-3 - EXAMPLE OF RES RE-ALLOCATION FOR A SPECIFIC TECHNOLOGY WITH IMPACT ON TOTAL OPERATIONAL COST WITH FOURTEEN ITERATIONS (RIGHT)

This methodology gives crucial insight in the benefit increase of step-by-step optimal re-allocations, which could be a role-model for policy initiatives on pan-European energy governance. The optimization steers new RES investments across Europe based on efficiency (climate data) and substitution of energy production with high marginal costs. It is acknowledged that the present methodology has some specific limitations: no overall shift between technologies is considered (e.g. the total installed capacity of PV remains the same, and is not 'traded' for wind), the same installation cost per technology/MW/country is assumed and only one profile per technology per country is used. The methodology could well be adapted by for example explore technology shifts, but this would require strong assumptions on subsidies, R&D concentration, and political drive. As the method allows for RES to be 'drawn out' of a country, minimum constraints for RES capacities per technology are applied in each country; for Vision 2 the 2020 level is taken as minimum, while for Vision 4 the average of Vision 1 and 3 is taken. No explicit maximum penetration of RES technology per country is taken as constraint; as the provisional results did not show a total installed capacity per country going beyond maximum penetration levels identified in RES potential studies.

The methodology could be used to explore the impact of other pan-European RES targets in case of optimal European integration of RES capacities.

4. Thermal optimization

The bottom-up scenarios based on national generation adequacy or with limited headroom of pan-European adequacy margins, potentially underestimate the value of country cooperation and thus over-estimate a generation portfolio. Also the slight increase of installed RES from V3 to V4 (in the storyline based on demand increase), could result in need for less thermal generation if pan-European collaboration is assumed.

To optimize the thermal generation fleet, a principle trade-off between variable generation costs and investment costs is taken as basis. First, non-dispatchable generation (mostly RES generation with negligible marginal costs), and hydro storage-based generation (mostly driven by peak price moments) are subtracted from the demand profile to obtain a 'residual load'. It is this residual load which is considered to be a relevant time series for conventional thermal generation.

Figure 7-4 illustrates how a combination of fixed and variable costs per technology indicates how for a given number of full-load hours one technology becomes preferable over the other. Together with the residual load profile, this is translated to an optimization problem which seeks the thermal fleet with least total costs. Taking into account potential and limitations of a 2030 grid. Specific reserve margins can be taken into account. No explicit distinction is made between existing and planned generation for this optimization exercise. Differentiated cost assumptions could allow to take into account modernization, mothballing and de-commissioning, as well as presumed new capacity from the bottom-up scenario.

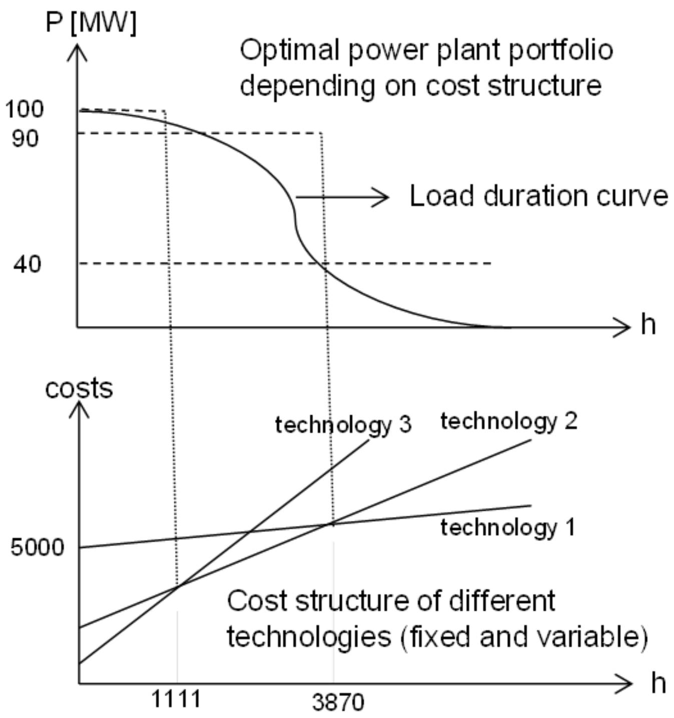


FIGURE 6-4 LINK BETWEEN RESIDUAL COST CURVE AND COST ELEMENTS OF THERMAL GENERATION TYPES, BOTH DRIVING THE THERMAL GENERATION FLEET OPTIMIZATION

7 Data references

ENTSO-E publish together with the final version of this report, a market modelling datasets which includes the most relevant assumptions and data sources ENTSO-E used to build the 5 TYNDP 2016 scenarios[9]. Some of the data sources are also described below.

Fuel and CO_2 prices

In order to trigger the merit order that was assumed in the different storylines of the scenarios, different sources are used. The table gives an overview of the primary fuel prices and CO_2 prices used in the simulations. IEA is used as the main reference, taking into account recent conversion rates. The use of the IEA WEO as data source was chosen based on the recommendation of the first stakeholder workshop (September 2014).

	Expected Progress 2020 Fuel prices (€/ net GJ)	Vision 1 2030 Fuel prices (€/ net GJ)	Vision 2 2030 Fuel prices (€/ net GJ)	Vision 3 2030 Fuel prices (€/ net GJ)	Vision 4 2030 Fuel prices (€/ net GJ)
Nuclear	0.46	0.46	0.46	0.46	0.46
lignite	1.1	1.1	1.1	1.1	1.1
Hard coal	2.86	3.01	3.01	2.8	2.19
Gas	8.9	9.49	9.49	7.23	7.23
light oil	15.6	17.34	17.34	13.26	13.26
Heavy oil	12.32	13.7	13.7	9.88	9.88
Oil shale	2.3	2.3	2.3	2.3	2.3
CO_2 prices (€/ton)	11	17	17	71	76
Source[10]	IEA "Current Policies"	IEA "Current Policies"	IEA "Current Policies"	IEA "450" except coal price IEA "New Policies"	IEA "450" except CO2 price (UK FES High)

RES capacity factors

With regards to the assumptions of wind and solar hourly generation, ENTSO-E is using a pan-European Climatic Database (PECD) since TYNDP 2014 which includes correlated hourly capacity factors for PV, onshore wind and offshore wind for each market node across the ENTSO-E perimeter. It takes into account technological development of RES technologies, as well as capacity factors based on available (optimal / sub-optimal) land sites. The data is not made publically available due to contract and confidentiality restrictions.

Reference interconnection capacities

The reference interconnection capacities assumed for the draft quantification of the scenario consulted before the summer were derived from the TYNDP 2014. The ones used for the final quantification of the scenarios, presented in this report, are based on the TYNDP 2016 list of projects. These reference capacities were consulted during the summer and are included in the TYNDP 2016 Market Modelling dataset published together with this report[9].

[9] See TYNDP 2016 Market Modelling dataset available on ENTSO-E website
[10] World Energy Outlook 2013

8 Next steps in the TYNDP process

ENTSO-E is starting the assessment of all TYNDP 2016 candidate projects based on the Cost Benefit Analysis methodology. The assessment results and other main findings will feed into a draft TYNDP2016 report published for consultation in summer 2016.

ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

A. Annex of top-down scenario building methodologies

Load profile update

The following figure shows the impact of the load adaption from Vision 1 to Vision 2.

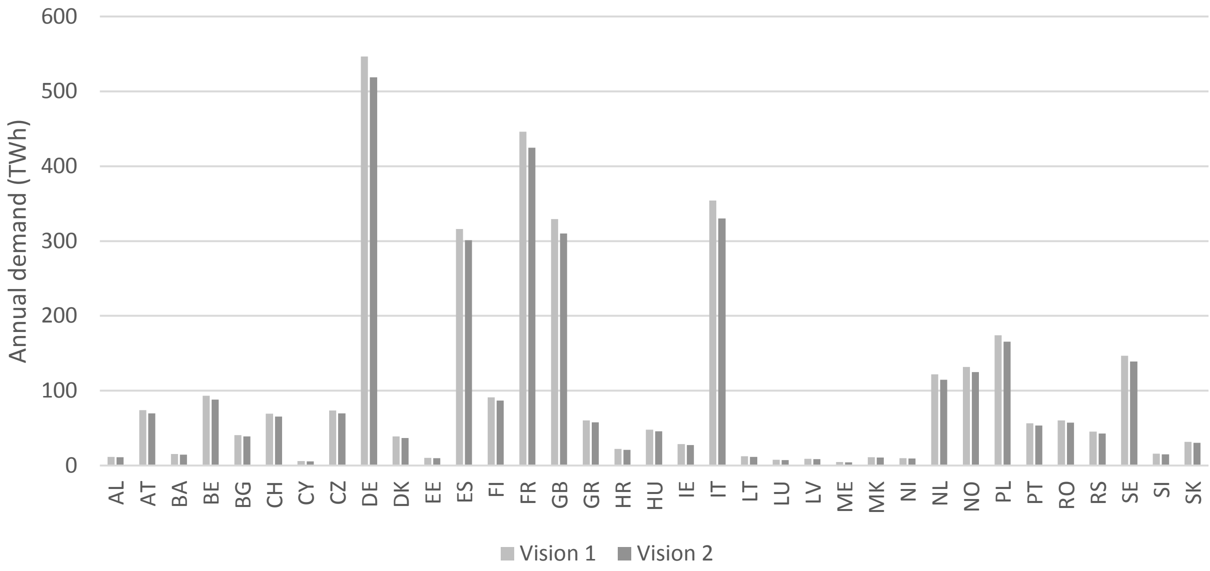


Figure 8-1 Load profile update from Vision 1 to Vision 2

RES re-allocation

The following figure shows the impact of the wind production re-allocation in Vision 4.

ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

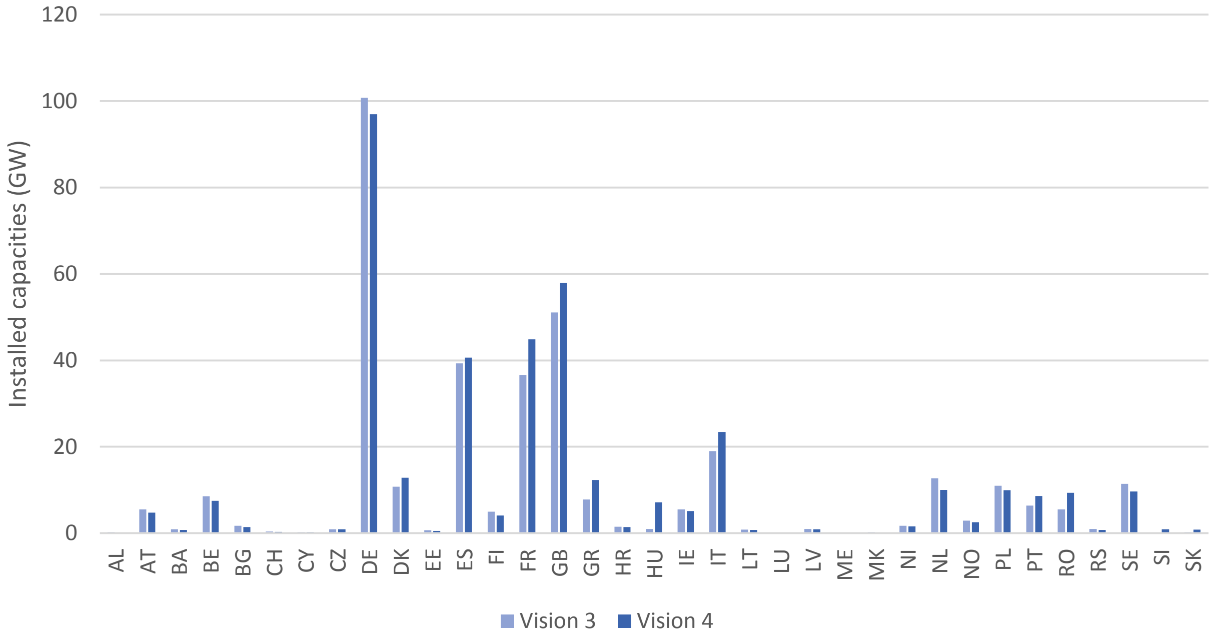


FIGURE 8-2 WIND REALLOCATION FROM VISION 3 TO VISION 4

The following figure shows the impact of the PV re-allocation in Vision 2.

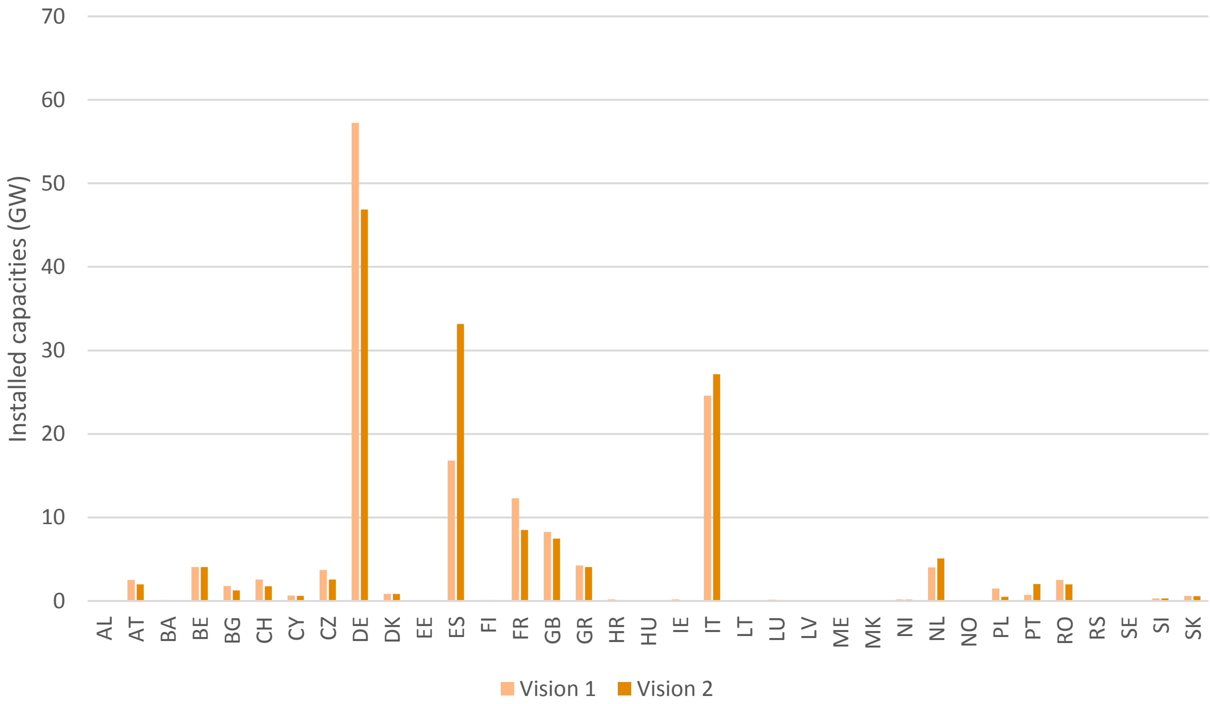


FIGURE 8-3 PV REALLOCATION FROM VISION 1 TO VISION 2

The following figure shows the impact of the wind re-allocation in Vision 2.

ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

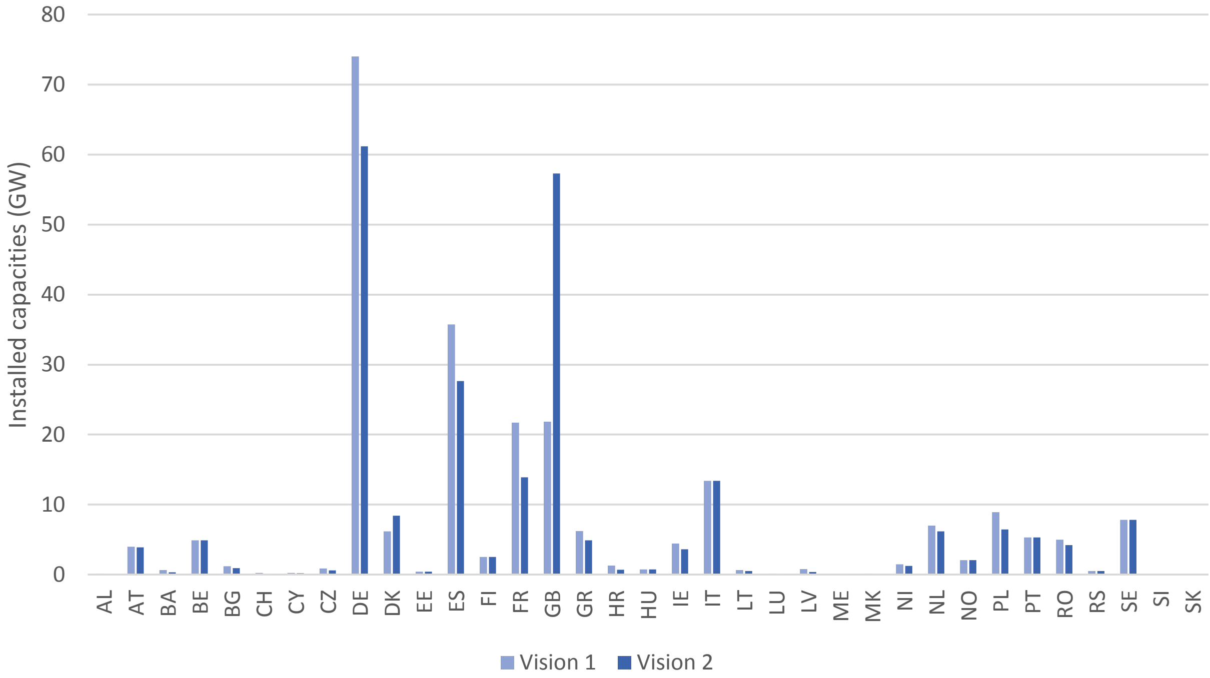


FIGURE 8-4 WIND REALLOCATION FROM VISION 1 TO VISION 2

Thermal optimization

The following table shows in which countries the thermal optimization exercise resulted in reduction of installed capacity going from Vision 3 to Vision 4. For other countries the methodology showed no change based on the described methodology and Vision 3 starting point.

Country	Capacity reduction (MW)
BA	1215
BG	3300
CZ	906
DE	1183
GR	1142
IT	1389
MK	410
RO	3549
RS	4050
SK	223

FIGURE 8-5 EXAMPLE OF THERMAL REDUCTION - FROM VISION 3 TO VISION 4

B. Annex - Overview of stakeholder engagement

This Scenario Development Report took benefit of on an extensive stakeholder engagement starting September 2014 with several calls for input. This annex summarizes the main steps and recommendations given by stakeholders; and how they have been incorporated in the scenario development process. The process is summarized in the graph below.

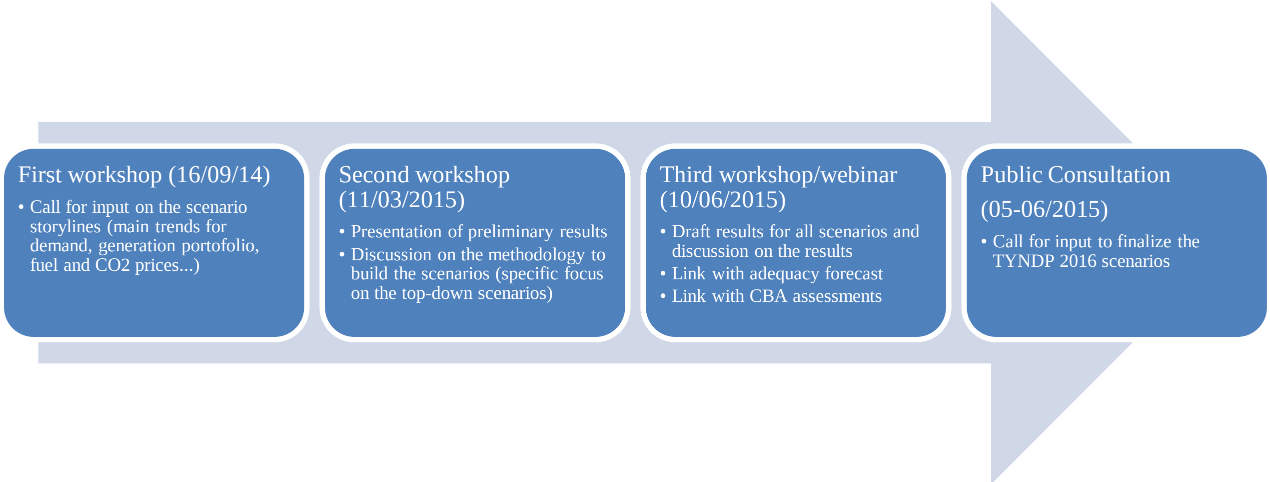


FIGURE 8-6 CALL FOR INPUT TO BUILD THE TYNDP 2016 SCENARIOS

Defining the scenario framework (workshop 16/09/14)

The workshop focused on the development of scenario methodology, the identification of scenarios and the methodology designed to build them being one of the key steps in developing the 2016 version of the TYNDP. The event was structured as an interactive event where ~50 participants participated in brainstorming sessions. The participants went through all the scenario related parameters and expressed their suggestions. All recommendations can be accessed on the ENTSO-E website.

Methodologies and draft results (workshop 11/03/15)

This 2nd workshop concentrated on the visions, assumptions and methodology including consideration of input from stakeholders, the presentation of draft simulation results and the next scenario steps. The workshop was a mixture of information sharing and open discussion. The results from the first workshop were presented, including how ENTSO-E took into account these results in the scenario storyline and quantification methodologies presented (e.g. in the choice of the sources for the CO2 price, or the choice of merit order with gas between cheaper or more expensive than coal). The aim of the workshop was to gain common understanding of the scenarios and the methodology; as well as to collect improvement suggestions for this and future TYNDPs.

Set of draft results (webinar 10/06/2015)

This webinar was for all interested parties to better understand, discuss and express views on a complete set of draft scenarios publishes for consultation. The distinction between the scenarios that are used in the TYNDP and the scenarios used in ENTSO-E's adequacy forecast was also explained. Each of the five TYNDP 2016 scenario was presented in details, followed by a Q&A session.

Public consultation on a draft Scenario Development Report (10/05/15 - 22/06/15)

Included in the draft Scenario Development Report in public consultation, a set of seven questions were presented. The main inputs received for the seven questions are summarized below together with ENTSO-E's view how these suggestions are integrated in this work. Most of the comments given their focus on the methodologies and scenario storyline provide valuable suggestions for next TYNDPs and deserve broader discussion across stakeholders, but cannot yet be taken into account for the TYNDP 2016 scenarios.

Type	Main comments from the public consultation
Suggestions that improved this final TYNDP 2016 Scenario Development Report	• Clarification of what technologies are included in the storage category. • Further explanations on the stakeholder engagement set up for the TYNDP 2016 scenario building. • Clarification on how the sources for CO2 prices where chosen. • Addition of information on historical demand. • Explicit modelling of Cyprus (not a direct outcome of the consultation, but requested at other stakeholder events). • Clarification on the data used to estimate RES production profiles.
Suggestions for the TYNDP2016 report (draft in summer 2016)	• Countries modelled with higher granularity / more nodes. ENTSO-E comment: In the project assessments some areas will be studies with a more detailed model. • Contribution of RES to Security of Supply should be clarified. ENTSO-E comment: we are exploring how to enrich the information in the TYNDP report as to provide a broad view on what SoS means in a well-designed long term grid. • Look beyond 2030. ENTSO-E comment: These scenario developments did not (yet) look at longer time frames, though the Electricity Highways 2050 project does not provide an intermediate step between the TYNDP scenarios for 2030 and the 2050 horizon.
Suggestions for TYNDP 2018 or beyond	• Improve the consistency between countries for the Vision 1 & 3. • Use the scenarios from the IEA and the EC as benchmark (or reference point) for the long term visions. • Other axes to develop the scenarios could be considered, for instance: technological development and demand response, RES and technology development/penetration (European project GridTech http://www.gridtech.eu), demand level (low vs. high etc.). • Economic growth and development of climate and energy policies should be considered separately.

ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

	• Before including new fossil-fired condensing capacity, a cost-benefit comparison with new interconnection capacity should be made. Also more demand response would be a cheaper solution for peaking and reserve needs than new oil-fired capacity. Only a real optimization (generation in combination with interconnections) with the help of generation expansion planning tools will result in good top-down scenarios. • Contribution of renewables to Security of Supply should be clarified. • Look beyond 2030. • Provide more clarity on how the generation fleet are constructed in the bottom-up scenarios (one specific comment is to take into account realistic timing of construction process of nuclear units (> 10 years) in the storyline of the scenarios) • Model specific countries with more nodes • Improve modelling of demand response and storages • Consider the emergence of nuclear fusion and the development of the biomass (ENTSO-E comment: nuclear fusion is not relevant for 2030 scenarios which represent possible futures). • Include more countries in the scenario, the following are suggested: Turkey, Malta, Iceland, Ukraine, and clarify the assumption used in terms of connection and exchanges with non-ENTSO-E countries. • Further improve stakeholder engagement so that more inputs can be taken on board and greater common understanding can be reached.

In addition to the suggestions raised in the public consultation, ENTSO-E and ACER interacted on the draft scenarios in context of the overall TYNDP process as well as past discussions and public opinions. ENTSO-E appreciated many of the comments given, and even if these are informal notes that they contributed to improved clarity of the final Scenario Development Report.

ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

C. Annex – Background tables

The following tables represent the dataset as visualized in Section 6 of this report. Note that and Iceland, which is at present isolated systems within the ENTSO-E perimeter, has not been included explicitly in these scenarios. For the purpose of project assessments particular market modelling assumptions are made. Also Albania and Cyprus are now explicitly modelled.

TABLE 2 ANNUAL DEMAND ACROSS THE SCENARIOS (GWH)

Country	Expected progress 2020	2030 Vision 1	2030 Vision 2	2030 Vision 3	2030 Vision 4
AL	9109	11508	10864	10753	11850
AT	72243	74073	69851	70399	74095
BA	13965	15308	14574	15146	15693
BE	91885	93152	87862	86184	93247
BG	38661	40705	38831	35254	40728
CH	64852	69417	65402	63084	69533
CY	4427	5704	5433	4610	6222
CZ	67490	73381	69798	68389	73358
DE	534566	546765	518757	508708	547178
DK	36546	38853	36776	39810	41219
EE	9327	10194	9590	9506	10661
ES	282378	315948	301130	364239	381237
FI	90187	91236	86825	84751	91551
FR	488309	445972	424817	479198	496036
GB	333802	329349	310117	354408	368084
GR	53836	60401	57462	47724	60481
HR	21139	21966	20786	21605	22304
HU	43480	48000	45738	44785	48336
IE	27444	28783	27319	31462	32567
IT	327286	354227	330272	311285	354710
LT	11576	12517	11562	10259	12516
LU	7144	7501	7263	7661	7778
LV	8387	8982	8453	7006	9097
ME	4194	4628	4225	3142	4713
MK	9226	11249	10670	11095	11457
NI	9420	9802	9209	10391	10742
NL	115785	122012	114551	116399	122577
NO	131506	131506	124907	140384	145806
PL	162352	173922	165619	159945	174560
PT	50476	56267	53189	57303	59342
RO	54678	60305	57078	55938	60605
RS	41660	45416	42745	37708	45721
SE	146318	146762	138860	130838	147296
SI	14055	15888	14982	15094	16029
SK	28432	31576	30095	30275	31723
Total	**3406141**	**3513275**	**3325612**	**3444738**	**3699052**

TABLE 3 2020 EXPECTED PROGRESS - INSTALLED CAPACITIES (MW)

Country	*Biofuels*	*Gas*	*Hard coal*	*Hydro and other storage*	*Lignite*	*Nuclear*	*Oil*	*Others non-RES*	*Others RES*	*Solar*	*Wind*
AL	0	100	0	2446	0	0	0	0	0	0	0
AT	0	5119	598	14588	0	0	196	990	630	2000	3880
BA	0	0	0	2042	2158	0	0	0	0	0	350
BE	0	5400	0	1438	0	5060	0	3200	1700	4050	4900
BG	0	797	710	3050	4197	2000	0	0	0	1250	900
CH	0	0	0	18510	0	2845	0	520	380	1750	120
CY	0	975	0	0	0	0	470	0	20	280	200
CZ	0	1610	1500	2170	6600	4000	0	308	900	2560	580
DE	0	28166	26914	9149	21846	8107	3680	6390	7880	46860	56070
DK	1591	1772	1179	9	0	0	735	0	250	840	6040
EE	656	94	0	10	0	0	1291	150	180	0	400
ES	0	24948	9533	20890	0	7573	0	7390	1250	8090	27650
FI	580	0	565	3200	0	4350	1360	2310	3340	100	2500
FR	0	6951	2900	25200	0	63020	2905	5500	1400	8500	13900
GB	0	35552	7217	4754	0	8981	109	3670	5680	7460	26250
GR	0	5202	0	3669	2876	0	0	0	320	4000	2800
HR	0	1300	700	2500	0	0	300	200	100	0	700
HU	223	3794	0	56	849	1892	407	850	500	60	750
IE	0	3434	850	508	0	0	324	150	240	10	3600
IT	0	35213	7056	22635	0	0	1386	11350	7240	24580	13400
LT	0	1260	0	1256	0	0	0	270	310	70	500
LU	0	375	0	1344	0	0	0	90	10	120	90
LV	0	1036	0	1621	0	0	0	150	220	60	360
ME	0	0	0	785	210	0	0	0	0	0	120
MK	0	290	330	666	410	0	0	0	30	30	100
NI	0	1290	175	0	0	0	369	20	110	150	1220
NL	4610	11772	0	38	0	486	0	5230	420	5100	5900
NO	0	425	0	38900	0	0	0	0	0	0	2080
PL	6234	1911	6159	2386	7816	0	0	10510	950	500	6450
PT	0	3829	576	7859	0	0	0	1340	720	720	5300
RO	0	4689	786	6632	4014	2630	0	0	300	2000	4200
RS	0	593	0	3142	5567	0	0	0	0	20	530
SE	0	0	0	16203	0	7031	660	1020	4790	0	7840
SI	45	509	0	1854	545	696	0	110	70	280	40
SK	204	843	0	2556	223	2880	0	990	280	550	60

TABLE 4 2020 EXPECTED PROGRESS - ANNUAL GENERATION (GWH)

Country	Biofuels	Gas	Hard coal	Hydro and other storage	Lignite	Nuclear	Oil	Others non-RES	Others RES	Solar	Wind
AL	0	67	0	3302	0	0	0	0	0	0	0
AT	0	140	2416	41584	0	0	0	4158	3494	2592	6812
BA	0	0	0	4844	15590	0	0	0	0	0	550
BE	0	57	0	434	0	35471	0	18605	10336	4518	13347
BG	0	0	1539	2498	29164	13734	0	0	0	1723	1438
CH	0	0	0	42532	0	20151	0	1957	1406	2339	198
CY	0	3052	0	0	0	0	0	0	96	546	151
CZ	0	393	2569	3090	46348	28124	0	2278	5134	3025	967
DE	0	15466	115563	16627	154248	56549	1338	26650	42693	54282	110431
DK	5467	4948	7714	27	0	0	0	0	1589	833	17013
EE	1716	0	0	70	0	0	2495	460	558	0	805
ES	0	16071	54448	32391	0	53185	0	33556	6556	18912	60291
FI	3682	0	1944	13875	0	32555	27	10752	10752	78	5451
FR	0	81	15268	58560	0	440555	0	12826	6002	10648	29847
GB	0	29693	43716	12582	0	63213	0	9286	29187	7343	79084
GR	0	2950	0	5966	20833	0	0	0	1179	6426	7058
HR	0	206	3438	4996	0	0	0	874	612	0	1123
HU	1423	932	0	248	6081	13322	0	3835	2256	79	1616
IE	0	9301	5142	705	0	0	0	717	1642	10	10416
IT	0	52015	33935	46477	0	0	301	35319	30803	34997	26689
LT	0	327	0	523	0	0	0	547	1082	68	921
LU	0	0	0	131	0	0	0	381	68	131	129
LV	0	2468	0	2956	0	0	0	755	1125	56	686
ME	0	0	0	1880	1475	0	0	0	0	0	188
MK	0	0	1608	1421	2953	0	0	0	131	44	163
NI	0	1174	1131	0	0	0	0	102	707	141	3181
NL	30255	7643	0	105	0	3413	0	24982	2900	5521	13755
NO	0	3244	0	134833	0	0	0	0	0	0	4369
PL	27579	2	31790	2294	55474	0	0	47533	4292	557	11862
PT	0	2590	4357	13254	0	0	0	6090	3282	1130	11563
RO	0	3749	3438	15911	24900	18411	0	0	1446	2693	8822
RS	0	2598	0	9468	39988	0	0	0	0	27	849
SE	0	0	0	66444	0	48527	45	2660	16208	0	16499
SI	267	621	0	4998	3963	5013	0	398	248	380	80
SK	1146	1182	0	4707	1399	22264	0	4065	1464	693	120

TABLE 5 2030 VISION 1 - INSTALLED CAPACITIES (MW)

Country	Biofuels	Gas	Hard coal	Hydro and other storage	Lignite	Nuclear	Oil	Others non-RES	Others RES	Solar	Wind
AL	0	500	0	3152	0	0	0	0	0	50	150
AT	0	4271	598	16418	0	0	196	990	800	2500	4000
BA	0	0	0	2107	2158	0	0	300	0	100	640
BE	0	7370	0	1438	0	0	0	3200	1700	4050	4900
BG	0	810	710	3150	4000	2000	0	0	0	1800	1200
CH	0	0	0	18510	0	2115	0	850	600	2550	220
CY	0	1470	0	0	0	0	190	0	30	630	230
CZ	0	2020	310	2170	5330	4140	0	0	1110	3690	880
DE	0	21138	23365	13257	12610	0	1026	8650	6960	57240	74050
DK	1460	2604	410	9	0	0	735	0	260	840	6190
EE	656	94	0	10	0	0	413	160	230	0	400
ES	0	24948	5900	23450	0	7120	0	10480	2400	16800	35750
FI	580	0	805	3400	0	5550	1360	1770	3760	100	2500
FR	0	6051	1740	25200	0	57644	819	5400	1400	12300	21700
GB	0	43327	2897	4754	0	4552	109	4050	5450	8270	21870
GR	0	6252	0	4259	2876	0	0	0	480	4250	6200
HR	0	1700	1200	2700	0	0	200	300	300	200	1300
HU	210	4185	0	56	470	4108	407	720	550	60	750
IE	0	3575	750	508	0	0	260	210	250	200	4420
IT	0	38974	7926	22635	0	0	1394	10160	7240	24580	13400
LT	0	740	0	1265	0	1303	0	270	310	80	650
LU	0	375	0	1344	0	0	0	90	70	150	130
LV	0	1036	0	1621	0	0	0	150	250	10	800
ME	0	0	0	1215	450	0	0	0	0	0	120
MK	0	440	530	716	410	0	0	0	30	30	150
NI	0	1690	0	0	0	0	200	20	110	200	1450
NL	0	8757	4610	38	0	486	0	5080	300	4000	7000
NO	0	425	0	38900	0	0	0	0	0	0	2080
PL	5867	2804	5492	2426	7031	3000	0	7550	1210	1500	8900
PT	0	4156	0	7858	0	0	0	1340	720	720	5300
RO	0	4757	786	7737	4014	2630	0	0	500	2500	5000
RS	0	593	0	4308	4965	0	0	0	0	20	530
SE	0	0	0	16203	0	7992	0	470	5340	0	7840
SI	45	505	0	1929	545	696	0	120	60	290	30
SK	204	843	0	3140	223	4004	0	990	310	610	90

ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

TABLE 6 2030 VISION 1 - ANNUAL GENERATION (GWH)

Country	Biofuels	Gas	Hard coal	Hydro and other storage	Lignite	Nuclear	Oil	Others non-RES	Others RES	Solar	Wind
AL	0	485	0	3770	0	0	0	0	0	74	244
AT	0	725	3190	45189	0	0	0	4158	4429	3240	7023
BA	0	0	0	5089	15574	0	0	874	0	133	1005
BE	0	2527	0	434	0	0	0	18605	10336	4518	13347
BG	0	0	2119	2627	27964	14118	0	0	0	2481	1918
CH	0	0	0	42089	0	14701	0	3189	2263	3409	363
CY	0	6045	0	0	0	0	0	0	140	1205	174
CZ	0	2593	1166	3091	37793	29199	0	0	6685	4360	1467
DE	0	22911	135246	17552	90716	0	1322	33537	37678	66306	153476
DK	5678	3659	3033	27	0	0	0	0	1750	832	18262
EE	3289	0	0	70	0	0	193	483	713	0	805
ES	0	22627	33224	33677	0	49943	0	46438	12587	39313	78223
FI	3188	0	3132	13875	0	41470	0	8602	11996	78	5451
FR	0	312	9574	58560	0	404566	0	12826	6002	15409	48595
GB	0	91067	19366	12582	0	31696	0	10247	26881	8140	65069
GR	0	4177	0	5955	20114	0	0	0	2140	6902	15573
HR	0	632	6199	5186	0	0	0	874	1223	451	2086
HU	1337	1944	0	248	3458	28701	0	3249	2482	79	1616
IE	0	12025	4536	705	0	0	0	1007	1747	197	12788
IT	0	94020	43973	46638	0	0	0	27728	30803	34997	26689
LT	0	365	0	559	0	9112	0	547	1082	78	1198
LU	0	186	0	131	0	0	0	381	475	164	186
LV	0	2804	0	2956	0	0	0	781	1302	9	1595
ME	0	0	0	3242	3283	0	0	0	0	0	188
MK	0	529	2738	1562	2963	0	0	0	131	44	244
NI	0	3435	0	0	0	0	0	102	707	189	3964
NL	0	18769	31930	105	0	3467	0	25814	2070	4330	17599
NO	0	3290	0	134833	0	0	0	0	0	0	4369
PL	28957	359	30003	2387	49431	21186	0	34595	5377	1671	16256
PT	0	9118	0	13344	0	0	0	6090	3282	1130	11563
RO	0	4244	3691	18070	25608	18323	0	0	2408	3367	10502
RS	0	2727	0	11145	35752	0	0	0	0	27	849
SE	0	0	0	66444	0	54884	0	1370	18016	0	16499
SI	320	750	0	5333	3813	4937	0	441	233	394	60
SK	1144	1179	0	4632	1429	30962	0	4064	1704	769	179

ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

TABLE 7 2030 VISION 2 - INSTALLED CAPACITIES (MW)

Country	Biofuels	Gas	Hard coal	Hydro and other storage	Lignite	Nuclear	Oil	Others non-RES	Others RES	Solar	Wind
AL	0	400	0	3152	0	0	0	0	0	0	0
AT	0	3915	598	16418	0	0	196	990	800	2000	3880
BA	0	0	0	2107	2158	0	0	300	0	0	350
BE	0	7370	0	1438	0	0	0	3200	1700	4050	4900
BG	0	760	710	3150	4000	2000	0	0	0	1250	900
CH	0	0	0	18510	0	2115	0	850	600	1750	120
CY	0	1045	0	0	0	0	190	0	30	590	200
CZ	0	915	310	2170	5330	4140	0	0	1110	2560	580
DE	0	15463	23365	13257	12610	0	1026	8650	6960	46860	61200
DK	1460	2604	410	9	0	0	735	0	260	840	8410
EE	656	94	0	10	0	0	413	160	230	0	400
ES	0	21572	5900	23450	0	7120	0	10480	2400	33150	27650
FI	580	0	805	3400	0	5550	1360	1770	3760	100	2500
FR	0	6051	1740	25200	0	57644	819	5400	1400	8500	13900
GB	0	36736	2897	4754	0	4552	109	4050	5450	7460	57300
GR	0	3111	0	4259	2876	0	0	0	480	4050	4880
HR	0	1200	1200	2700	0	0	200	300	300	100	700
HU	210	2980	0	56	470	4108	407	720	550	60	750
IE	0	3575	750	508	0	0	260	210	250	10	3600
IT	0	34886	7926	22635	0	0	1394	10160	7240	27140	13400
LT	0	740	0	1265	0	1303	0	270	310	70	500
LU	0	375	0	1344	0	0	0	90	70	120	90
LV	0	1036	0	1621	0	0	0	150	250	60	360
ME	0	0	0	1215	450	0	0	0	0	0	120
MK	0	440	530	716	410	0	0	0	30	30	100
NI	0	1142	0	0	0	0	200	20	110	150	1220
NL	0	7776	4610	38	0	486	0	5080	300	5100	6160
NO	0	425	0	38900	0	0	0	0	0	0	2080
PL	5867	2804	5492	2426	7031	3000	0	7550	1210	500	6450
PT	0	3693	0	7858	0	0	0	1340	720	2010	5300
RO	0	3331	786	7737	4014	2630	0	0	500	2000	4200
RS	0	296	0	4308	4965	0	0	0	0	20	530
SE	0	0	0	16203	0	7992	0	470	5340	0	7840
SI	45	505	0	1929	545	696	0	120	60	280	40
SK	204	256	0	3140	223	4004	0	990	310	550	60

TABLE 8 2030 VISION 2 - ANNUAL GENERATION (GWH)

Country	*Biofuels*	*Gas*	*Hard coal*	*Hydro and other storage*	*Lignite*	*Nuclear*	*Oil*	*Others non-RES*	*Others RES*	*Solar*	*Wind*
AL	0	340	0	3770	0	0	0	0	0	0	0
AT	0	242	2233	45189	0	0	0	4158	4429	2592	6812
BA	0	0	0	5089	15484	0	0	874	0	0	550
BE	0	810	0	434	0	0	0	18605	10336	4518	13347
BG	0	0	1168	4205	26951	13849	0	0	0	1723	1438
CH	0	0	0	42089	0	14918	0	3189	2263	2339	198
CY	0	5568	0	0	0	0	0	0	140	1141	151
CZ	0	1991	745	3091	37075	28603	0	0	6685	3025	967
DE	0	19437	110363	17552	88747	0	1322	33537	37678	54282	128877
DK	5671	3653	2891	27	0	0	0	0	1750	832	26602
EE	2149	0	0	70	0	0	15	483	713	0	805
ES	0	16809	24025	33677	0	49821	0	46438	12587	69870	60291
FI	2421	0	1398	13875	0	40623	7	8602	11996	78	5451
FR	0	63	6978	58560	0	401833	0	12826	6002	10648	29847
GB	0	29787	13928	12582	0	31369	0	10247	26881	7343	160922
GR	0	2717	0	5955	20015	0	0	0	2140	6601	12302
HR	0	215	4945	5186	0	0	0	874	1223	314	1123
HU	1201	420	0	248	3323	28765	0	3249	2482	79	1616
IE	0	9773	3723	705	0	0	0	1007	1747	10	10416
IT	0	57769	36869	46612	0	0	0	27728	30803	38576	26689
LT	0	65	0	561	0	9096	0	547	1082	68	921
LU	0	100	0	131	0	0	0	381	475	131	129
LV	0	2335	0	2956	0	0	0	781	1302	56	686
ME	0	0	0	3242	3045	0	0	0	0	0	188
MK	0	248	2228	1562	2968	0	0	0	131	44	163
NI	0	3236	0	0	0	0	0	102	707	141	3181
NL	0	9710	28836	105	0	3339	0	25814	2070	5521	14663
NO	0	3255	0	136188	0	0	0	0	0	0	4369
PL	23715	7	25836	2387	49169	21047	0	34595	5377	557	11862
PT	0	2363	0	13399	0	0	0	6090	3282	2969	11563
RO	0	4108	3254	18082	23843	18644	0	0	2408	2693	8822
RS	0	2280	0	11151	35444	0	0	0	0	27	849
SE	0	0	0	66444	0	50542	0	1370	18016	0	16499
SI	328	661	0	5333	3765	4928	0	441	233	380	80
SK	1077	1126	0	4776	1444	31052	0	4064	1704	693	120

ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

TABLE 9 2030 VISION 3 - INSTALLED CAPACITIES (MW)

Country	Biofuels	Gas	Hard coal	Hydro and other storage	Lignite	Nuclear	Oil	Others non-RES	Others RES	Solar	Wind
AL	0	500	0	3162	0	0	0	0	0	100	200
AT	0	6030	0	18471	0	0	196	990	1200	3500	5500
BA	0	373	0	2317	2158	0	0	0	0	100	900
BE	0	6840	0	2730	0	0	0	3200	2500	5800	8500
BG	0	1500	710	3468	3300	2000	0	0	0	2300	1700
CH	0	0	0	20160	0	1145	0	990	1120	4250	370
CY	0	800	0	0	0	0	285	0	30	600	230
CZ	0	1990	310	2170	5330	1880	0	0	1110	3690	880
DE	0	34429	14940	17637	10209	0	871	10630	9340	60740	100750
DK	1460	3746	410	9	0	0	735	0	260	1970	10750
EE	656	94	0	20	0	0	0	1010	300	100	650
ES	0	29208	4160	25050	0	7120	0	12210	5100	25000	39300
FI	580	970	0	4350	0	3350	2165	1390	4670	2500	5000
FR	0	14051	1740	27200	0	37646	819	5400	4800	24100	36600
GB	0	36616	0	7682	0	9022	75	4110	8420	15560	51090
GR	0	6252	0	4699	2212	0	0	0	650	5300	7800
HR	0	1700	1200	3000	0	0	200	300	300	200	1500
HU	210	4977	0	100	0	3000	407	720	1040	200	1000
IE	0	4270	0	558	0	0	260	710	1200	500	5500
IT	0	37993	7056	23535	0	0	1386	10160	10750	40400	18990
LT	0	923	0	1265	0	0	0	270	330	80	850
LU	0	375	0	1344	0	0	0	140	100	200	180
LV	0	1036	0	1621	0	0	0	150	400	20	1000
ME	0	0	0	1271	450	0	0	0	0	20	190
MK	0	720	330	716	410	0	0	0	30	40	200
NI	0	1590	0	50	0	0	150	180	320	300	1730
NL	4610	9358	0	38	0	486	0	5080	470	15400	12700
NO	0	855	0	40800	0	0	0	0	0	0	2910
PL	5240	1911	5389	3176	6571	0	0	9860	1210	4000	11000
PT	0	3717	0	9717	0	0	0	1560	850	910	6400
RO	0	4757	786	8087	4014	2630	0	0	800	2800	5500
RS	0	593	0	4308	5659	0	0	0	0	50	1000
SE	0	950	0	16203	0	7142	660	0	5340	1000	11400
SI	45	425	0	2005	545	1796	0	130	70	310	70
SK	204	843	0	3266	223	2880	0	810	520	720	260

ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

TABLE 10 2030 VISION 3 - ANNUAL GENERATION (GWH)

Country	*Biofuels*	*Gas*	*Hard coal*	*Hydro and other storage*	*Lignite*	*Nuclear*	*Oil*	*Others non-RES*	*Others RES*	*Solar*	*Wind*
AL	0	952	0	3779	0	0	0	0	0	148	325
AT	0	6822	0	45442	0	0	0	4158	8422	4536	9656
BA	0	461	0	5571	5731	0	0	0	0	133	1413
BE	0	9637	0	434	0	0	0	18605	15201	6471	23168
BG	0	56	0	6568	9	13839	0	0	0	3170	2717
CH	0	0	0	43630	0	7243	0	3687	4202	5681	611
CY	0	3635	0	0	0	0	0	0	140	1063	174
CZ	0	6600	0	3091	16934	13023	0	0	6685	4360	1467
DE	0	82502	10059	17633	35374	0	1344	38127	50599	70360	211794
DK	5637	3652	2519	27	0	0	0	0	1750	1952	31518
EE	1039	0	0	138	0	0	0	8190	931	90	1308
ES	0	54881	7127	33915	0	49943	0	54103	26748	58266	86414
FI	1774	0	0	13874	0	22656	0	6451	15053	1960	11739
FR	0	14801	0	58560	0	256372	0	12826	18123	30191	87438
GB	0	71372	0	17692	0	61539	0	10413	39120	15316	159785
GR	0	7502	0	6326	5969	0	0	0	2944	8584	19607
HR	0	4652	134	5653	0	0	0	874	1223	451	2407
HU	1305	8467	0	445	0	20886	0	3249	4692	265	2154
IE	0	12893	0	705	0	0	0	2220	4964	492	15997
IT	0	99223	24	50498	0	0	288	27728	44213	61616	37693
LT	0	3278	0	598	0	0	0	547	1152	78	1566
LU	0	648	0	131	0	0	0	592	679	218	258
LV	0	3557	0	2956	0	0	0	781	2083	19	2017
ME	0	0	0	3301	584	0	0	0	0	64	298
MK	0	2866	67	1562	2963	0	0	0	131	59	325
NI	0	2385	0	0	0	0	0	502	1309	283	4791
NL	22850	18293	0	105	0	2767	0	24597	3285	16670	34361
NO	0	3288	0	140201	0	0	0	0	0	0	6113
PL	5246	12886	15406	2387	15116	0	0	44253	5377	4457	21927
PT	0	12156	0	13657	0	0	0	7091	3835	1524	13962
RO	0	5793	2128	18722	2862	17740	0	0	3854	3771	11552
RS	0	4548	0	11141	24610	0	0	0	0	69	1602
SE	0	0	0	66445	0	41614	0	0	16931	821	24674
SI	146	782	0	5955	1376	12213	0	466	246	421	140
SK	926	2066	0	5441	1177	21518	0	3187	2432	907	518

Table 11 2030 Vision 4 - Installed capacities (MW)

Country	Biofuels	Gas	Hard coal	Hydro and other storage	Lignite	Nuclear	Oil	Others non-RES	Others RES	Solar	Wind
AL	0	500	0	3162	0	0	0	0	0	449	175
AT	0	6030	0	22244	0	0	196	990	1200	3000	4750
BA	0	373	0	2618	943	0	0	0	0	100	770
BE	0	6840	0	2226	0	0	0	3200	2500	4925	7518
BG	0	1500	710	3468	0	2000	0	0	0	2598	1450
CH	0	0	0	20160	0	1145	0	990	1120	3692	295
CY	0	800	0	0	0	0	285	0	30	590	230
CZ	0	1990	310	2170	4424	1880	0	0	1110	3690	880
DE	0	34429	14940	14505	9026	0	871	10630	9340	58990	96967
DK	1460	3746	410	9	0	0	735	0	260	1405	12825
EE	656	94	0	20	0	0	0	1010	300	50	525
ES	0	29208	4160	25635	0	7120	0	12210	5100	54130	40604
FI	580	970	0	3400	0	3350	2165	1390	4670	1300	4057
FR	0	14051	1740	27200	0	37646	819	5400	4800	18200	44851
GB	0	36616	0	5470	0	9022	75	4110	8420	11915	57901
GR	0	6252	0	4366	1070	0	0	0	650	8384	12335
HR	0	1700	1200	3200	0	0	200	300	300	929	1400
HU	210	4977	0	100	0	3000	407	720	1040	339	7114
IE	0	4270	0	558	0	0	260	710	1200	350	5090
IT	0	37993	5667	23535	0	0	1386	10160	10750	42169	23459
LT	0	923	0	1265	0	0	0	270	330	80	750
LU	0	375	0	1344	0	0	0	140	100	175	155
LV	0	1036	0	1621	0	0	0	150	400	15	900
ME	0	0	0	1271	450	0	0	0	0	20	155
MK	0	720	330	716	0	0	0	0	30	736	175
NI	0	1590	0	0	0	0	150	180	320	250	1590
NL	4610	9358	0	38	0	486	0	5080	470	9700	9995
NO	0	855	0	48700	0	0	0	0	0	0	2495
PL	5240	1911	5389	3176	6571	0	0	9860	1210	2750	9950
PT	0	3717	0	9717	0	0	0	1560	850	3280	8572
RO	0	4757	786	8100	465	2630	0	0	800	2650	9371
RS	0	593	0	4308	1609	0	0	0	0	512	765
SE	0	950	0	16203	0	7142	660	0	5340	500	9620
SI	45	425	0	2005	545	1796	0	130	70	444	931
SK	204	843	0	3266	0	2880	0	810	520	665	831

ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

TABLE 12 2030 VISION 4 - ANNUAL GENERATION (GWH)

Country	Biofuels	Gas	Hard coal	Hydro and other storage	Lignite	Nuclear	Oil	Others non-RES	Others RES	Solar	Wind
AL	0	1739	0	3779	0	0	0	0	0	665	285
AT	0	11993	0	44958	0	0	0	4158	8422	3888	8339
BA	0	1114	0	6730	6387	0	0	0	0	133	1209
BE	0	15261	0	434	0	0	0	18605	15201	5494	21149
BG	0	582	161	6575	0	13981	0	0	0	3581	2317
CH	0	0	0	43630	0	7931	0	3687	4202	4935	487
CY	0	2585	0	0	0	0	0	0	140	1047	174
CZ	0	3918	12	3091	17913	13012	0	0	6685	4360	1467
DE	0	103125	16412	17633	39628	0	1344	38127	50599	68333	217037
DK	5682	3657	2777	27	0	0	0	0	1750	1392	41273
EE	1433	4	0	138	0	0	0	8190	931	45	1056
ES	0	48169	705	33677	0	47510	0	54103	26748	112707	89032
FI	3918	234	0	13874	0	24768	93	6451	15053	1019	9231
FR	0	17907	811	58561	0	257029	0	12826	18123	22801	121980
GB	0	89141	0	17692	0	57099	0	10413	39120	11728	168886
GR	0	12688	0	6324	5820	0	0	0	2944	13233	31040
HR	0	5940	663	5941	0	0	0	874	1223	1449	2247
HU	1417	10207	0	445	0	21023	0	3249	4692	449	15326
IE	0	11748	0	705	0	0	0	2220	4964	344	14769
IT	0	132368	537	50579	0	0	290	27728	44213	63821	46735
LT	0	5753	0	570	0	0	0	547	1152	78	1382
LU	0	1016	0	131	0	0	0	592	679	191	222
LV	0	5827	0	2956	0	0	0	781	2083	14	1806
ME	0	0	0	3301	991	0	0	0	0	64	243
MK	0	4159	379	1562	0	0	0	0	131	1089	285
NI	0	501	0	0	0	0	0	502	1309	236	4377
NL	25257	27495	0	105	0	3041	0	24597	3285	10500	26487
NO	0	1967	0	135085	0	0	0	0	0	0	5241
PL	22418	14411	26175	2387	7663	0	0	44253	5377	3064	19091
PT	0	8268	0	13702	0	0	0	7091	3835	4874	18701
RO	0	8242	2320	18757	1844	17948	0	0	3854	3569	19682
RS	0	3882	0	11143	11373	0	0	0	0	704	1226
SE	0	258	0	66444	0	49361	50	0	16931	411	20586
SI	163	806	0	5955	814	12243	0	466	246	602	1861
SK	74	1498	0	5567	0	22161	0	3187	2432	838	1657

ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

D. Annex – Addendum to the final report

Element	Title	Correction	Date
Table 1	Summary of characteristic elements of 4 visions	correction of misprint of the row name	11/12/2015
Table 2	Annual demand across the scenarios (GWh)	Correction of a misprint of the annual demand for Slovenia and Slovekia	11/12/2015

ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu