ENTSO-E 2030 VISIONS

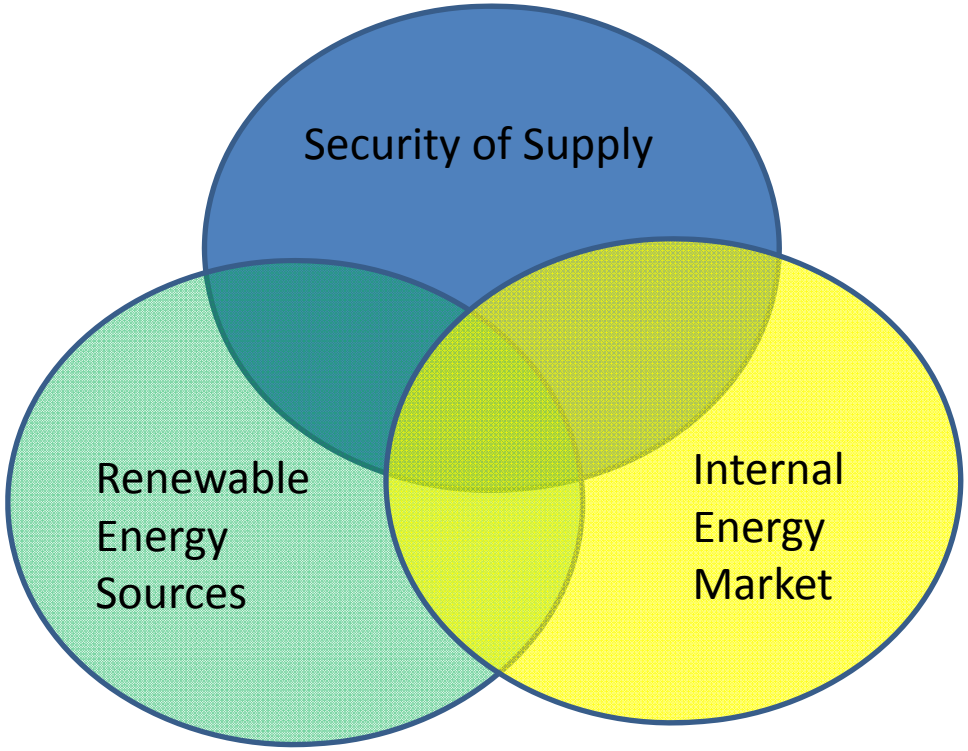
BRAINSTORMING WITH STAKEHOLDERS

17 April 2012

entsoe

Reliable Sustainable Connected

Challenges

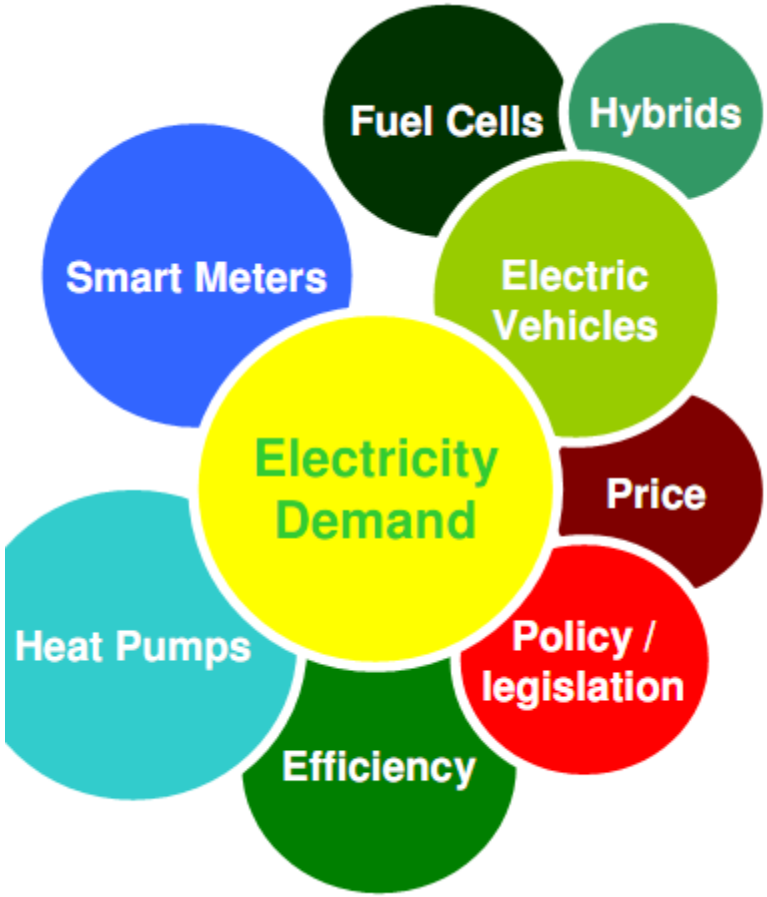

Security of Supply
Renewable Energy Sources
Internal Energy Market

A Pan European View

- When answering the questions consider the impact on Europe as a whole
- We are not seeking national views

Challenges Demand side

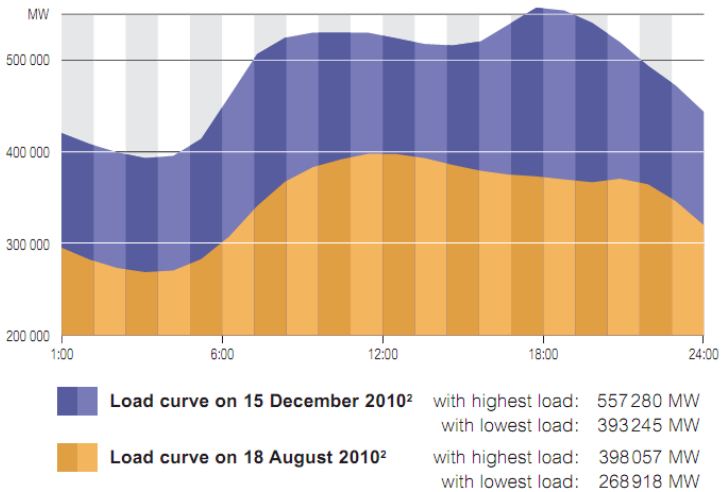
- Many factors with the intension of:
  - more efficient consumption
  - "green" consumption
- To which level will it be implemented?



Electricity demand

Consumption on the 3rd Wednesday 2010

ENTSO-E load diagram on the 3rd Wednesday of August and December 2010[1]



Highest and lowest load of each country on 15 December 2010 in MW[2]

	Lowest value	Highest value
AT	6 852	9 548
BA	1 207	2 051
BE	10 361	13 810
BG	4 320	6 640
CH	8 185	10 835
CY	390	746
CZ	7 918	10 307
DE	64 738	83 090
DK	3 653	6 312
EE	925	1 367
ES	25 275	42 301
FI	11 501	13 923

	Lowest value	Highest value
FR	76 197	96 710
GB	35 869	59 008
GR	4 590	7 869
HR	1 886	3 116
HU	3 901	5 937
IE	2 638	4 664
IS	1 903	2 113
IT	30 472	54 927
LT	1 025	1 680
LU	739	971
LV	687	1 243
ME	351	575

	Lowest value	Highest value
MK	1 022	1 535
NI	874	1 684
NL	10 489	18 187
NO	17 165	21 852
PL	15 742	23 081
PT	5 212	8 814
RO	5 856	8 313
RS	4 849	7 034
SE	19 868	25 807
SI	1 349	1 919
SK	3 381	4 326
UA-W	691	1 087

ENTSO-E Electric consumption in 2010 : 3376,8 TWh

entsoe

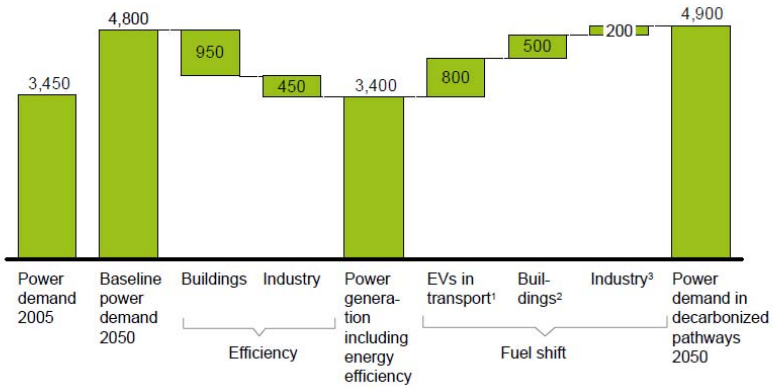
Electricity consumption

European Climate Foundation

EXHIBIT 10

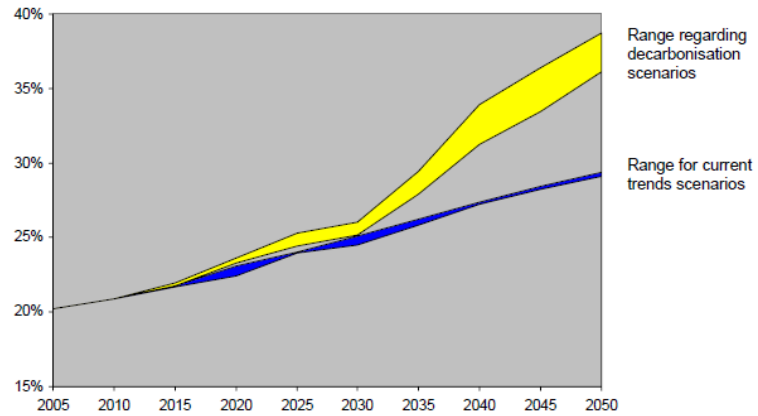
Power demand will go down due to higher efficiency and up due to additional demand from transport and building heating

EU-27, Norway and Switzerland power demand, TWh per year



1 Electrification of 100% LDVs and MDVs (partially plug-in hybrids); HDVs remain emitting ~10% while switching largely to biofuel or hydrogen fuel cells
2 90% of remaining primary energy demand converted to electricity (heating/cooling from heat pumps, assumed 4 times as efficient as primary fuel)
3 10% of remaining primary energy demand for combustion converted to electricity (heating from heat pumps, assumed 2.5 times as efficient as primary fuel)

Graph 2: Share of electricity in current trend and decarbonisation scenarios (in % of final energy demand)



EUROPEAN COMMISSION

Energy Roadmap 2050

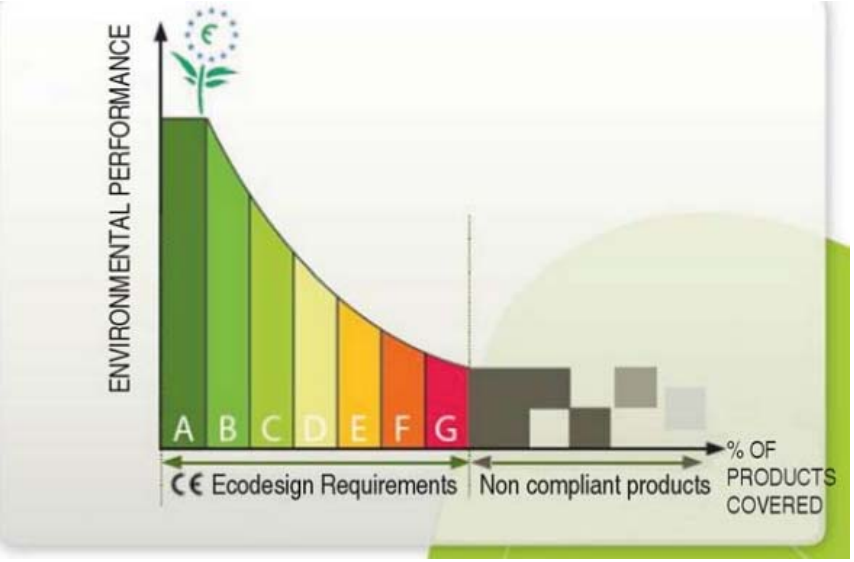
entsoe

Electricity consumption : Question 1

Electricity consumption: What will be the economic growth profile in the next decade?

a. Downturn
b. Stagflation
c. Slow recovery and lower long-term potential output
d. Slow recovery with no in-depth effect on production
e. Rapid recovery (by 2013-2014) to reach before-crisis GDP levels
f. no view

Electricity consumption : energy efficiency



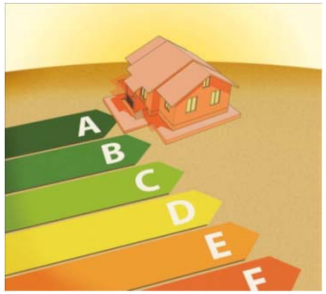


EXHIBIT 2

Energy and power intensity reduce by 1% to 1.5% per year

Mtoe per € of sector value added[1]

Service
Industry
Residential & Transport

Sub-sectors	Energy intensity 2010	Energy intensity 2050	Energy intensity CAGR[2]	Power intensity 2010	Power intensity 2050	Power intensity CAGR[2]
Basic metals	1,080	585	-1.5	274	189	-1.0
Industry overall	118	70	-1.3	39	28	-0.8
Electronic engineering	66	37	-1.4	37	24	-1.1
Mechanical engineering	65	50	-0.6	N/A	N/A	N/A
Construction	55	33	-1.3	20	13	-1.1
Retail trade	37	23	-1.2	28	20	-0.9
Wholesale trade	34	21	-1.2	15	11	-0.9
Transport	33	21	-1.2	N/A	N/A	N/A
Residential	33	18	-1.6	10	6	-1.1
Services overall	20	11	-1.5	10	7	-1.1
Finance	12	7	-1.3	6	4	-1.0
Business Services	10	6	-1.2	6	4	-0.8

1 Value added is GDP for the whole economy; value added in industry; value added in services; GDP for transport; and households income for residential
2 Compounded Annual Growth Rate
SOURCE: IEA WEO 2009; team analysis

entsoe

Electricity consumption : Smart metering

- Reduction in energy consumption from <u>different trials</u> on smart meter installation (+ other interventions):

Annual Savings	**2.8% - 8.5%**
Peak Reduction/ Peak demand shift	**4.7% - 10.25%**

Electricity consumption : Question 2

Electricity consumption: In the absence of any other energy initiatives what will be the annual level of total electricity consumption in 2030, when compared to 2011 in Europe?

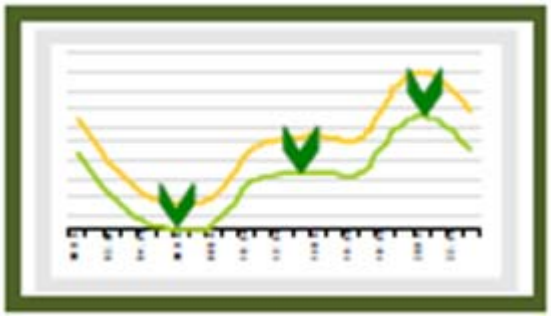
a. <20% lower
b. 10-20% lower
c. ±10% of 2011 levels
d. 10-20% higher
e. more than 20% higher
f. no view

Electricity consumption : Question 3

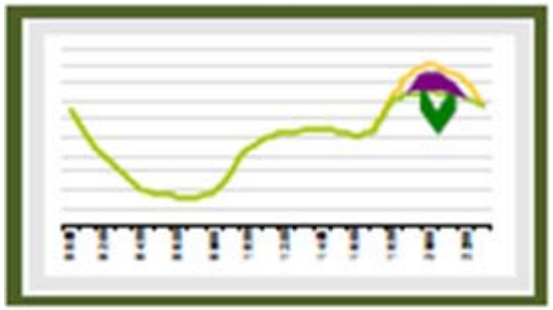
Electricity consumption: What will be the contribution to the total electricity consumption in 2030, when compared to 2011 in Europe assuming that the full technological potential of smart metering and energy efficiency is deployed?

a. 0%
b. 0 – 5%
c. 5 – 10%
d. 10 – 15%
e. 15 – 20%
f. > 20%
g. no view

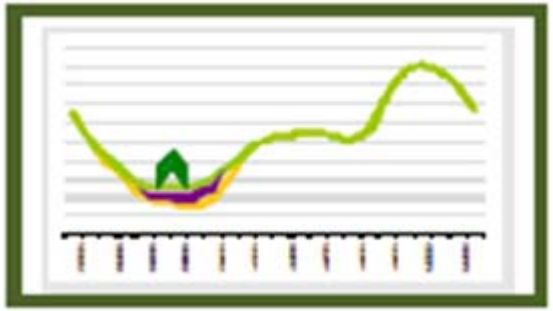
Electricity demand Smart metering



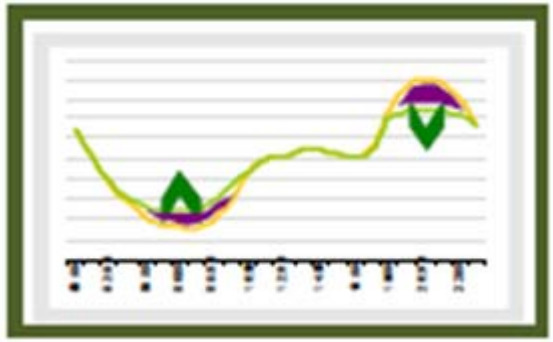
Load pattern 1



Load pattern 2



Load pattern 3



Load pattern 4

Electrcity demand : Question 4

<u>Peak demand: By 2030, what impact will smart meters have on the load pattern in Europe?</u>

a. impact according to load pattern 1
b. impact according to load pattern 2
c. impact according to load pattern 3
d. impact according to load pattern 4
e. other impact : ……
f. No view

Electric vehicles

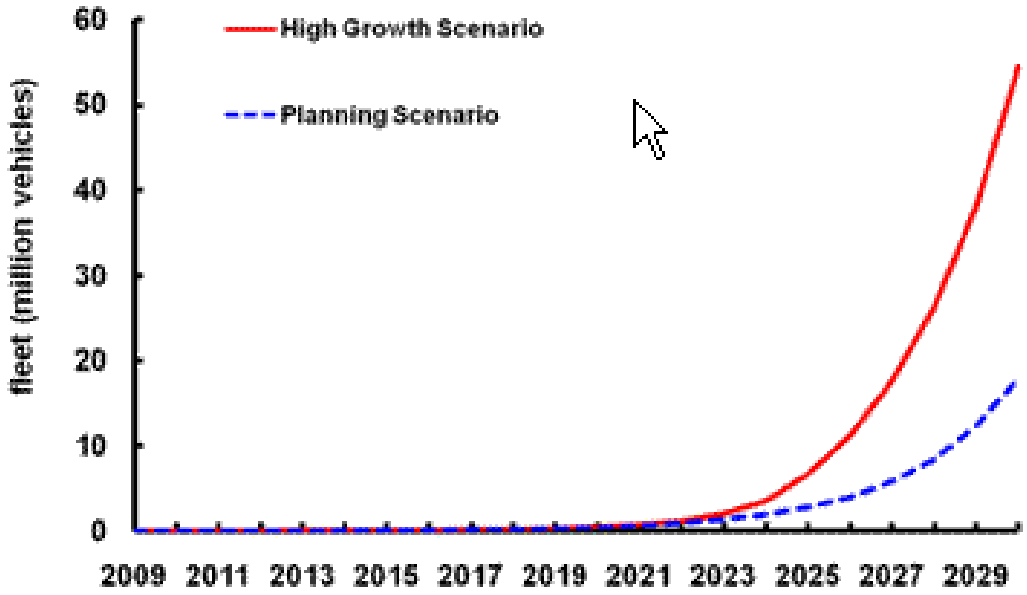
- Penetration level & impact on electricity consumption
- Penetration level & impact on daily peak demand

Electric vehicles

	2009	2030
population forecast EU (27 countries) - source EUROSTAT (in million)		522
Cars per 1000 inhabitants	473	
Number of cars (in million)		247
Number of EV if 5% (in million)		12
Number of EV if 10% (in million)		25
Number of EV if 15% (in million)		37
Number of EV if 20% (in million)		49

Electric vehicles

EV Fleet to Take-off After 2025



CERA

Source: IHS Cambridge Energy Research Associates.

© 2009, Cambridge Energy Research Associates, Inc. No portion of this presentation may be reproduced, reused, or otherwise distributed in any form without prior written consent.

entsoe

Electric vehicles : Question 5

<u>Demand: By 2030, what will be the minimum market share of electric vehicles on the total fleet of vehicles in Europe?</u>

a. <5%
b. 5 – 10%
c. 10 – 15%
d. 15 – 20%
e. 20 – 25%
f. 25 – 30%
g. >3 0%
h. no view

Electric vehicles : Question 6

<u>Demand: By 2030, what will be the maximum market share of electric vehicles on the total fleet of vehicles in Europe?</u>

a. <5%
b. 5 – 10%
c. 10 – 15%
d. 15 – 20%
e. 20 – 25%
f. 25 – 30%
g. >3 0%
h. no view

Electric vehicles : charging profiles

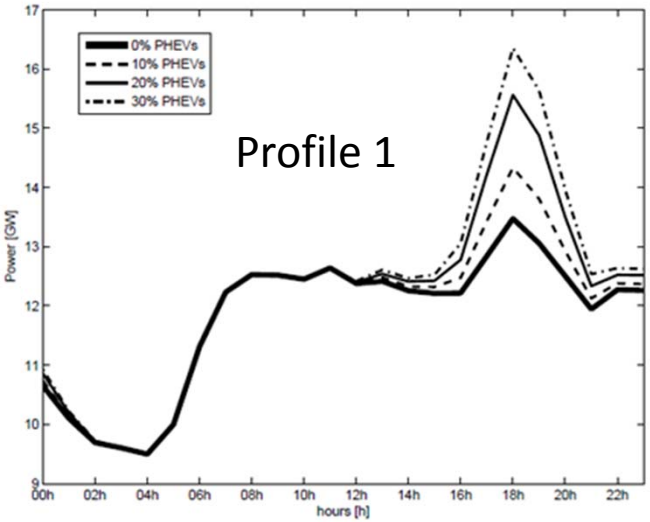


Fig. 6.1: Total load for uncoordinated charging.

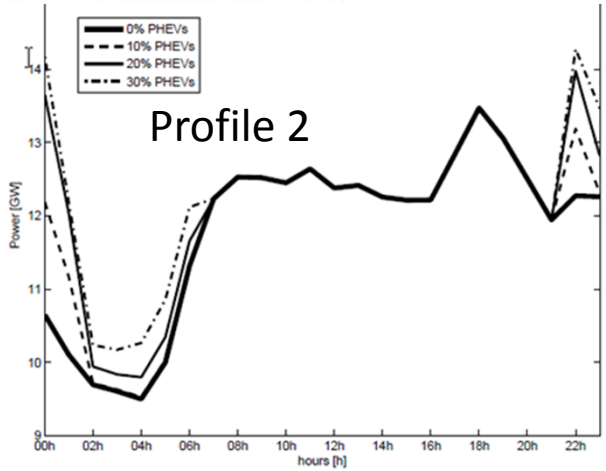


Fig. 6.5: Total load for coordinated charging and minimization of charging cost.

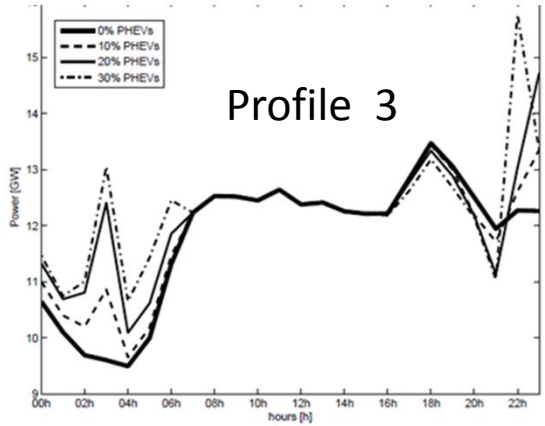


Fig. 6.2: Total load for coordinated charging and discharging and minimization of charging cost.

entsoe

Electric vehicles : Question 7

<u>Peak demand: By 2030, what impact will electric vehicles have on peak in Europe assuming current tariff systems?</u>

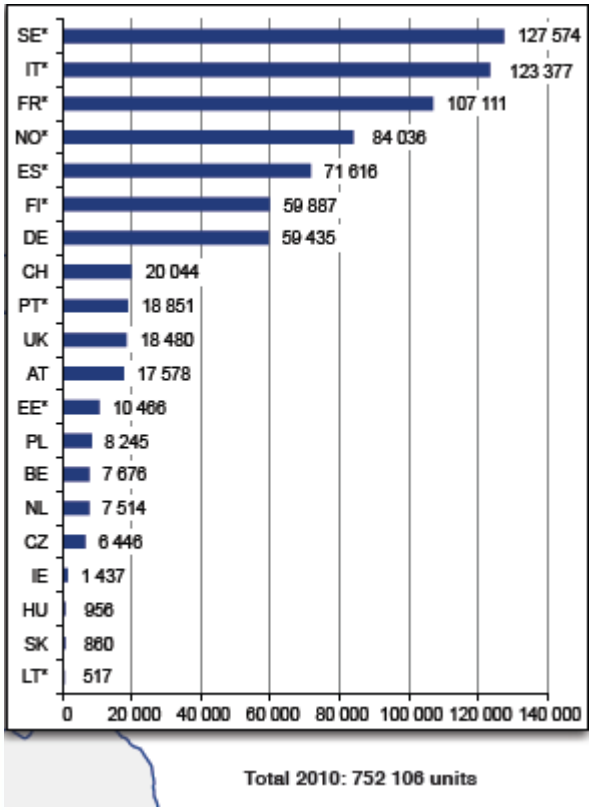
a. no impact
b. impact of charging type 1
c. impact of charging type 2
d. impact of charging type 3
e. other impact : ……..
f. no view

Electric vehicles : Question 8

<u>Peak demand: By 2030, what impact will electric vehicles have on peak in Europe assuming adaptation of tariff systems to smart meter possibilities?</u>

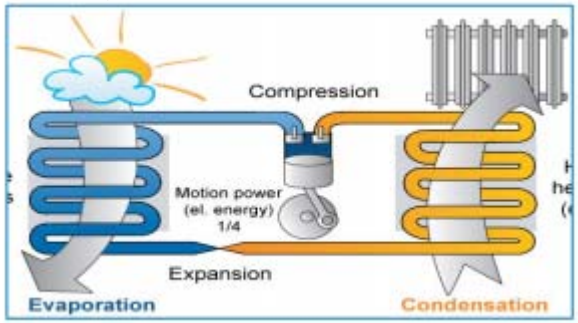
a. no impact
b. impact of charging type 1
c. impact of charging type 2
d. impact of charging type 3
e. other impact : ……..
f. no view

Heat pumps

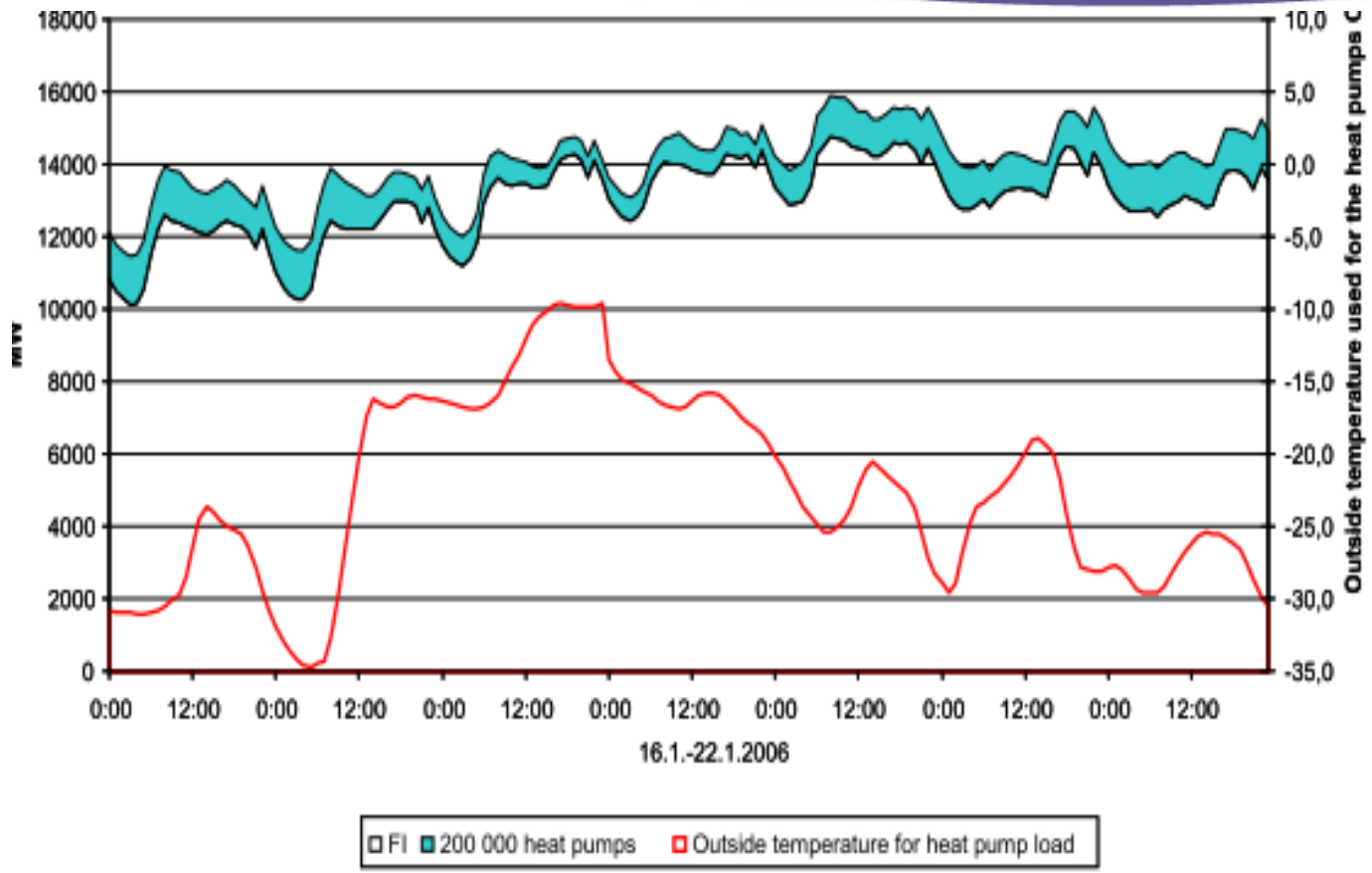


	Number of Private housholds in 2001 (source EUROSTAT -except Sweden)	Percentage of private households that installed an heat pump in 2010
Belgium	4.296.486	0,2%
Czech Republic	4.216.085	0,2%
Germany	37.957.000	0,2%
Estonia	582.089	1,8%
Ireland	1.287.958	0,1%
Greece	3.664.392	
Spain	14.187.169	0,5%
France	23.808.072	0,4%
Italy	21.801.809	0,6%
Kypros	223.790	
Latvia	802.848	
Lithuania	1.356.826	
Luxembourg	171.953	
Hungary	3.862.702	0,0%
Netherlands	6.866.302	0,1%
Austria	3.339.663	0,5%
Poland	13.337.040	0,1%
Portugal	3.650.757	0,5%
Romania	7.336.256	
Slovenia	684.847	
Slovakia	1.666.246	0,1%
Sweden (source SCB 1990)	3829973	3,3%
Finland	2.295.386	2,6%
United Kingdom	24.479.439	0,1%
Liechtenstein	13.282	
Norway	1.961.548	4,3%
Switzerland	3.115.399	0,6%

The installed number of Norwegian heat pumps are 600 000. This is about 30 % of the households. Source : Norwegian Heat Pumps Association (Norsk Varmepumpeforening).

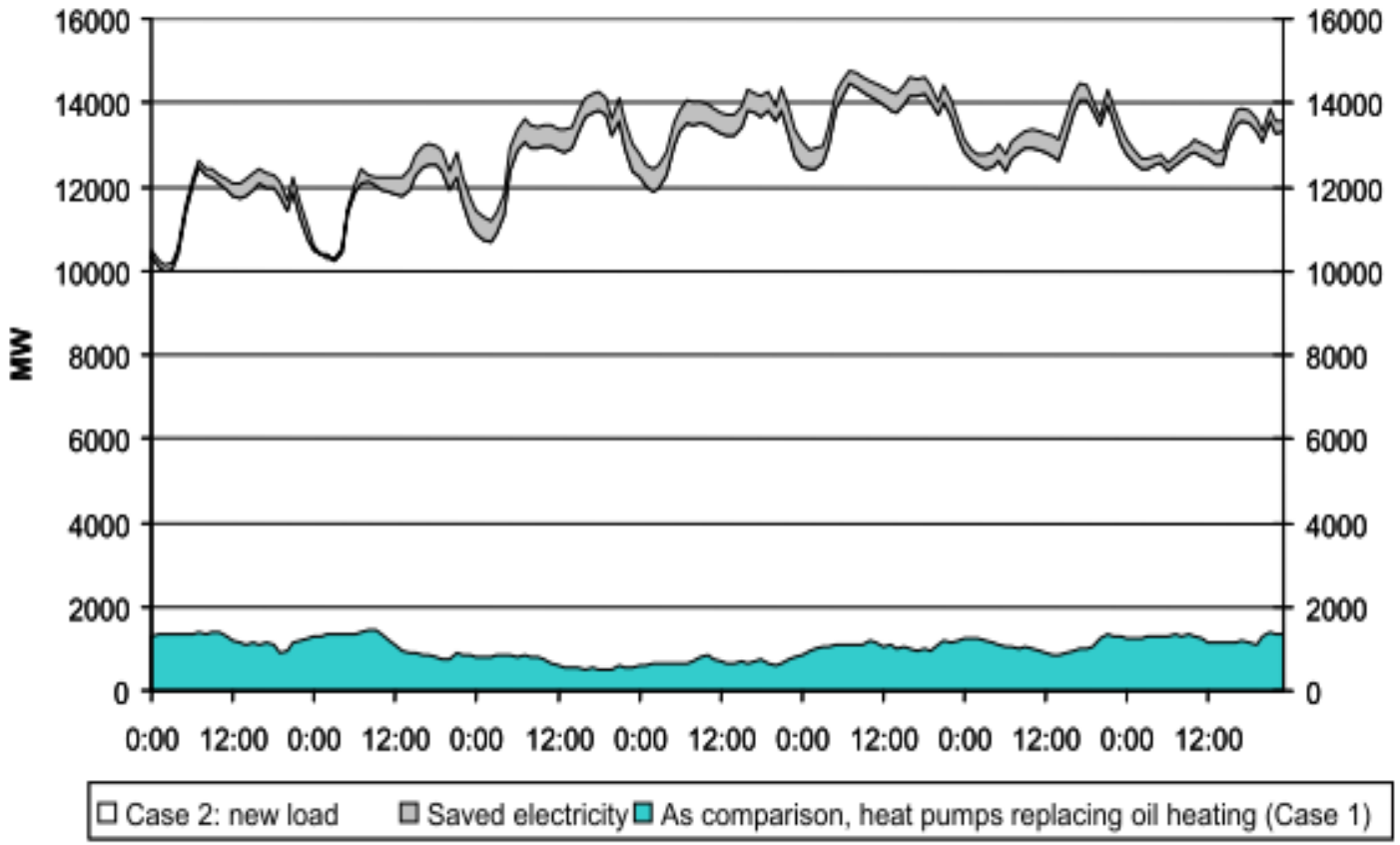


Simulation for case 1 : 200 000 oil heated houses change to heat pumps in Finland - Source: "Future development trends in electricity demand", VTT Technical Research Centre of Finland, 2009



- Electricity demand increased by 2.2 TWh => + 11 MWh / oil heated house
- peak electricity load increased by up to 1 100 MW => + 5,5 kW / oil heated house

Simulation for case 2 : 200 000 electric heated houses changed to heat pumps in Finland Source: "Future development trends in electricity demand", VTT Technical Research Centre of Finland, 2009



- Electricity demand decreased by 2.3 TWh => -11,5 MWh / electric heated house
- peak load decreased by 400 MW => +2 kW / electric heated house

Heat pumps: Question 9

Demand: By 2030, what is the minimum proportion of households that will have electric heat pumps in Europe?

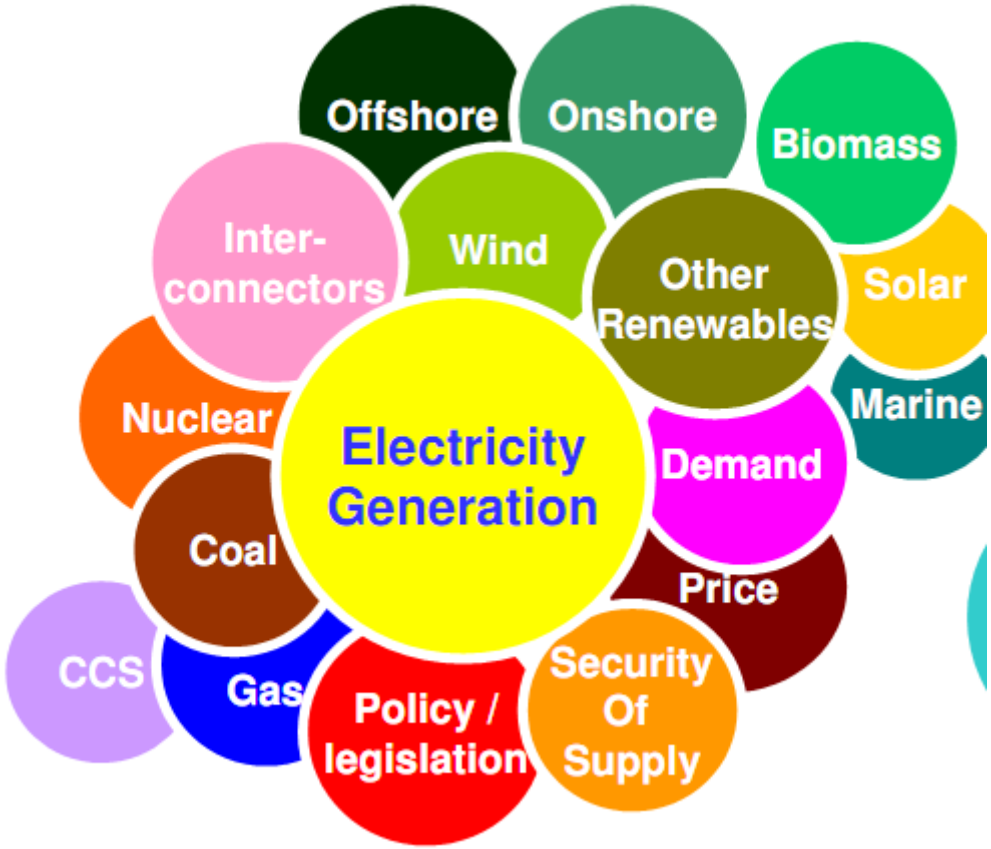
a. < 1%
b. 1-5%
c. 5-10%
d. 10-15%
e. 15-20%
f. 20-25%
g. 25-30%
h. > 30%
i. No view

Heat pumps: Question 10

<u>Demand: By 2030, what is the maximum proportion of households that will have electric heat pumps in Europe?</u>

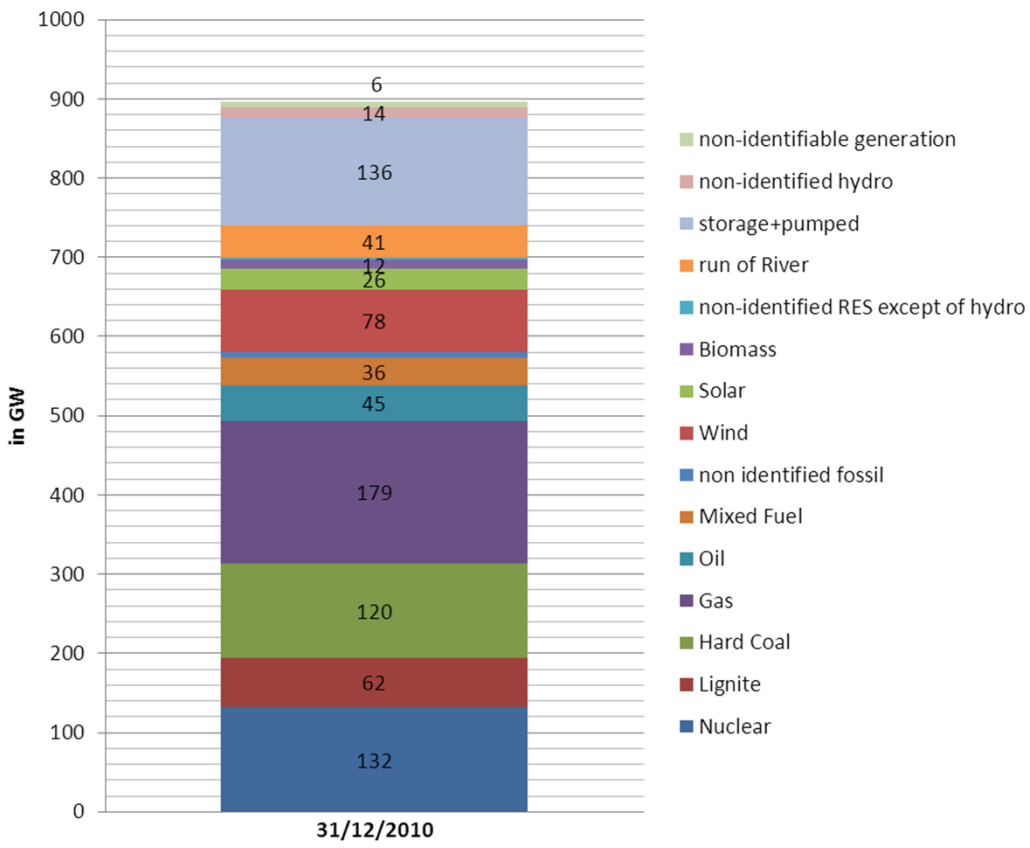
a. < 1%
b. 1-5%
c. 5-10%
d. 10-15%
e. 15-20%
f. 20-25%
g. 25-30%
h. > 30%
i. No view

Challenges Generation side



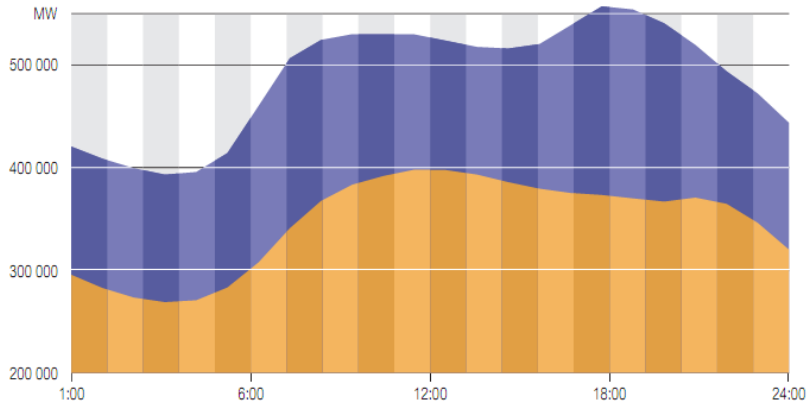
- Many factors with the intension of:
  - More efficient generation
  - Reach RES-goals
  - Security of Supply
- To which level will it be implemented?

Electric generation



Consumption on the 3rd Wednesday 2010

ENTSO-E load diagram on the 3rd Wednesday of August and December 2010[1]



Load curve on 15 December 2010[2] with highest load: 557 280 MW
with lowest load: 393 245 MW

Load curve on 18 August 2010[2] with highest load: 398 057 MW
with lowest load: 268 918 MW

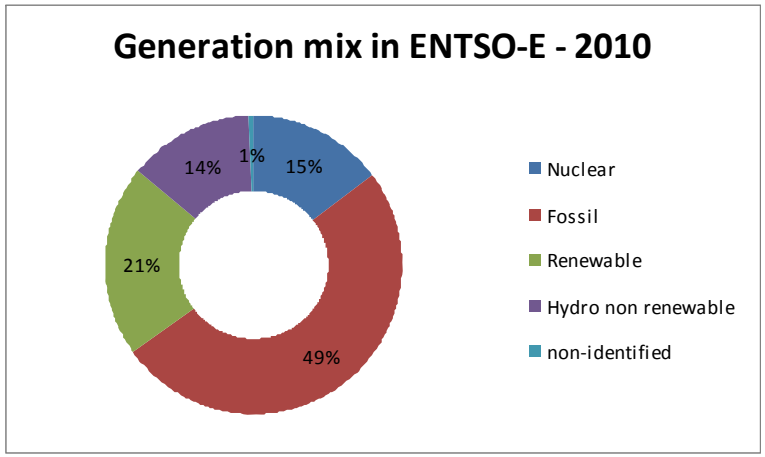
entsoe

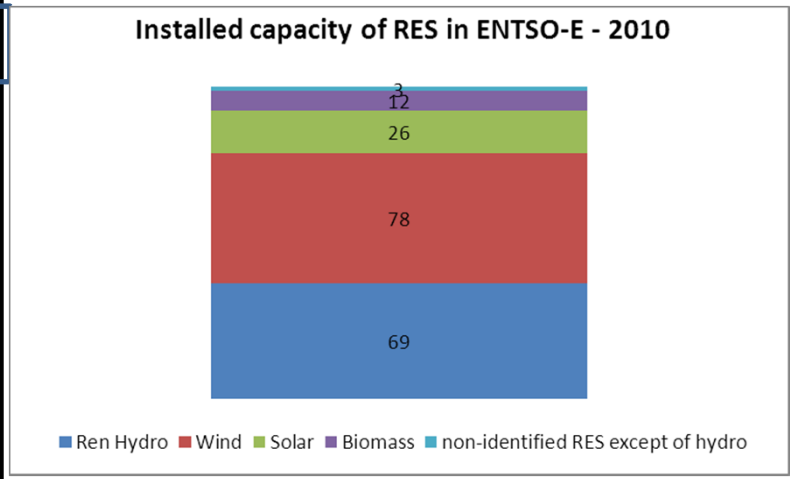
RES generation

Table 1: Selected results of scenario analysis[12]

		2005	Current trends		Decarbonisation scenarios				
			Reference scenario	*Current Policy Initiatives*	*High Energy Efficiency*	*Diversified Supply Techno-logies*	*High Renewables*	*Delayed CCS*	*Low nuclear*
Primary energy demand reduction (in % from 2005)[13]	2030		-5.3	-10.8	-20.5	-16	-17.3	-16.1	-18.5
	2050		-3.5	-11.6	-40.6	-33.3	-37.9	-32.2	-37.7
Electrification	2030	20.2	25.1	24.5	25.2	26.0	25.4	26.0	25.7
	2050	-	29.1	29.4	37.3	38.7	36.1	38.7	38.5
Fuels (in %)									
Renewables in gross final energy	2030	8,6	23.9	24.7	27.6	27.7	31.2	28	28.8
	2050	-	25.5	29	57.3	54.6	75.2	55.7	57.5
CCS in power generation	2030	0	2.9	0.8	0.7	0.8	0.6	0.7	2.1
	2050	-	17.8	7.6	20.5	24.2	6.9	19	31.9
Nuclear energy in primary energy	2030	14,1	14.3	12.1	11.1	13.9	9.7	13.2	8.4
	2050	-	16.7	13.5	13.5	15.3	3.8	17.5	2.6
Fuels in electricity generation (in%)									
RES	2030	14.3	40.5	43.7	52.9	51.2	59.8	51.7	54.6
	2050	-	40.3	48.8	64.2	59.1	86.4	60.7	64.8
CCS	2030	0.0	2.9	0.8	0.7	0.8	0.6	0.7	2.1
	2050	-	17.8	7.6	20.5	24.2	6.9	19.0	31.9
NUC	2030	30.5	24.5	20.7	18.6	21.2	15.8	21.5	13.4
	2050	-	26.4	20.6	14.2	16.1	3.6	19.2	2.5
Average electricity prices (in EUR'08 per MWh, after tax)[14]	2030	109,3	154,8	156,0	154,4	159,6	164,4	160,4	168,2
	2050	-	151,1	156,9	146,7	146,2	198,9	151,9	157,2
Annual energy system costs related to GDP (in % 2011 – 2050)		-	14.37	14.58	14.56	14.11	14.42	14.06	14.21
Import dependency (in %)	2030	52,5	56.4	57.5	56.1	55.2	55.3	54.9	57.5
	2050	-	57.6	58.0	39.7	39.7	35.1	38.8	45.1

Source: PRIMES modelling

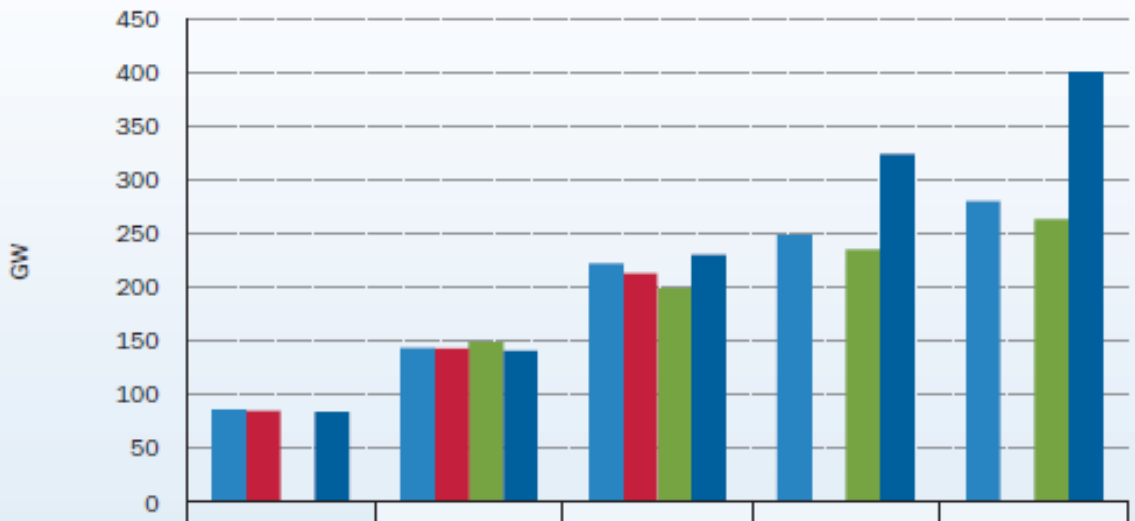




entsoe

RES : wind

FIGURE 4.1 LATEST WIND ENERGY SCENARIOS FOR EU-27 FROM THE EUROPEAN COMMISSION, THE MEMBER STATES, THE IEA AND EWEA (GW TOTAL INSTALLED CAPACITY)

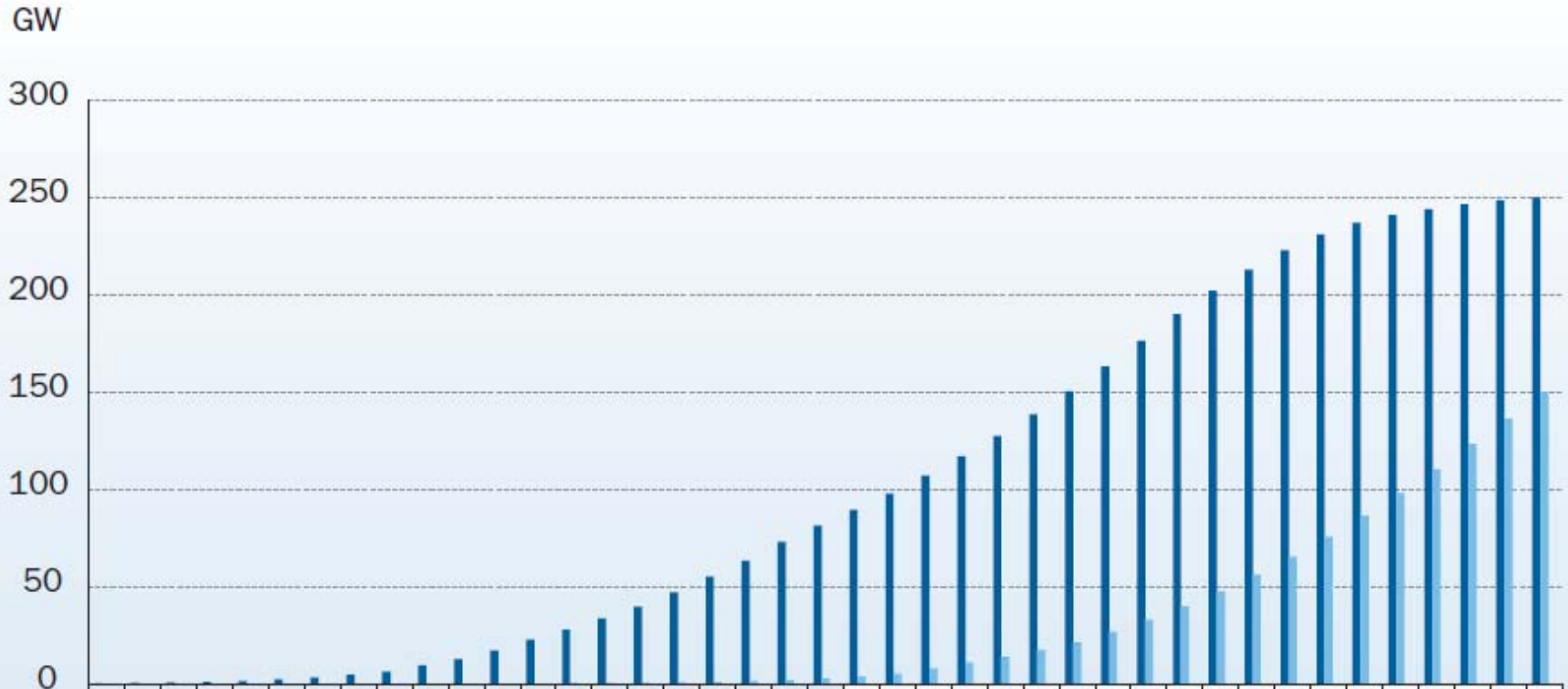


	2010	2015	2020	2025	2030
EC 2009	86	144	222	248	280
NREAPs	85	143	213	-	-
IEA 2010		149	199	235	263
EWEA 2011	84	141	230	324	400

Source: EWEA, European Commission, International Energy Agency, National Renewable Energy Action Plans.

RES : wind

FIG 6.1 CUMULATIVE ONSHORE AND OFFSHORE WIND POWER IN THE EU (1990-2030)



	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Onshore	0.4	0.6	0.8	1.2	1.7	2.5	3.4	4.7	6.4	9.6	12.9	17.2	22.8	28.0	33.8	39.8	47.1	55.4	63.2	73.0	81.4	89.6	98.0	107.1	117.0	127.5	138.6	150.4	163.0	176.4	190.0	202.0	213.0	223.0	231.0	237.0	241.0	244.0	246.5	248.5	250.0
Offshore	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.5	0.6	0.7	0.9	1.1	1.5	2.1	2.9	3.9	5.3	8.1	10.9	14.0	17.4	21.6	26.7	33.1	40.0	47.7	56.2	65.5	75.6	86.5	98.1	110.4	123.2	136.4	150.0
Total	0.4	0.6	0.8	1.2	1.7	2.5	3.5	4.8	6.5	9.7	12.9	17.3	23.1	28.5	34.4	40.5	48.0	56.5	64.7	75.1	84.3	93.6	103.3	115.2	128.0	141.5	156.0	172.0	189.7	209.5	230.0	249.7	269.2	288.5	306.6	323.5	339.1	354.4	369.7	384.9	400.0

Source: EWEA 2011

Onshore wind capacity: Question 11

Onshore Wind capacity: By 2030, what will be the minimum increase of installed capacity of onshore wind in Europe?

a. stagnation
b. < 50%
c. 50 - 100%
d. 100 - 150%
e. 150 - 200 %
f. 200 - 250 %
g. >250%
h. no view

Onshore wind capacity: Question 12

Onshore Wind capacity: By 2030, what will be the maximum increase of installed capacity of onshore wind in Europe?

a. stagnation
b. < 50%
c. 50 - 100%
d. 100 - 150%
e. 150 - 200 %
f. 200 - 250 %
g. >250%
h. no view

Offshore wind capacity: Question 13

Offshore Wind capacity: By 2030, what will be the minimum installed capacity of offshore wind in Europe?

a. <10 GW of installed generation capacity
b. 10 GW – 50 GW of installed generation capacity
c. 50 GW – 90 GW of installed generation capacity
d. 90 GW – 130 GW of installed generation capacity
e. 130 GW – 170 GW of installed generation capacity
f. >170 GW of installed generation capacity

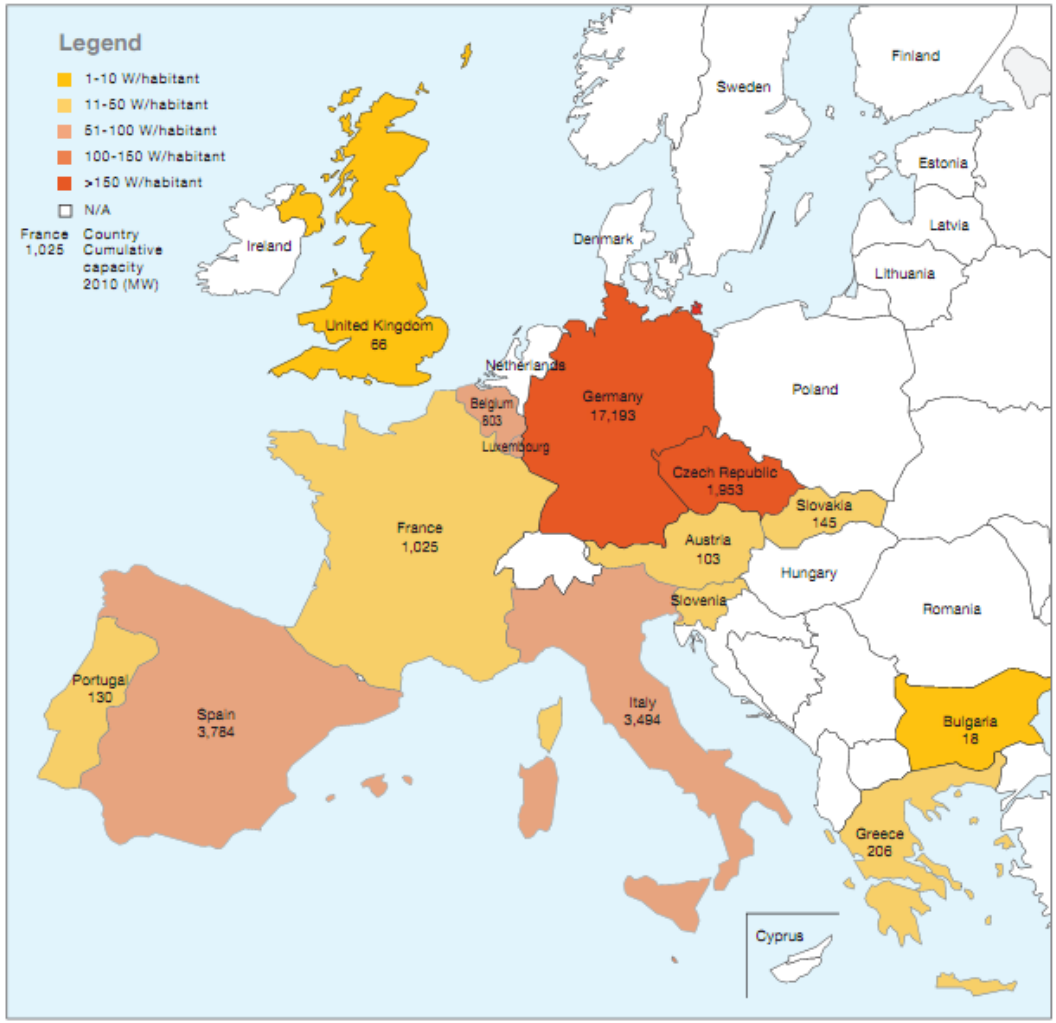
Offshore wind capacity: Question 14

<u>Offshore Wind capacity: By 2030, what will be the maximum installed capacity of offshore wind in Europe?</u>

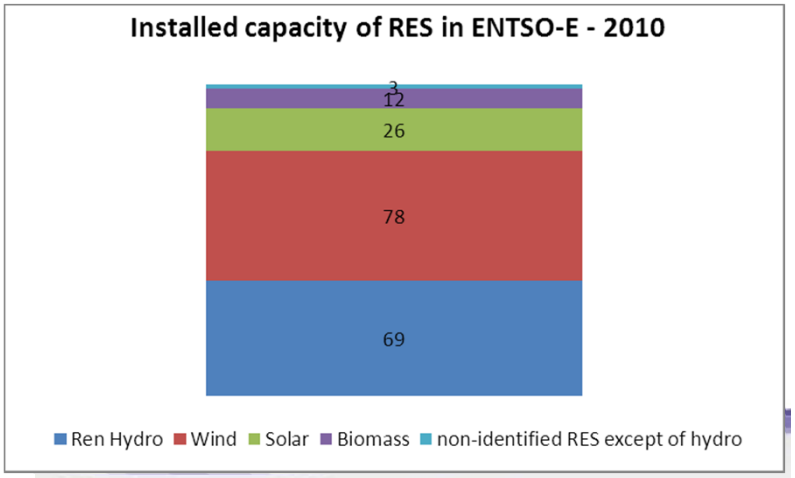
a. <10 GW of installed generation capacity
b. 10 GW – 50 GW of installed generation capacity
c. 50 GW – 90 GW of installed generation capacity
d. 90 GW – 130 GW of installed generation capacity
e. 130 GW – 170 GW of installed generation capacity
f. >170 GW of installed generation capacity

RES : solar

3.1.a. EU PV Power Map and world-wide figures



EU	Market 2009 (MW)	Cumulative 2009 (MW)	Market 2010 (MW)	Cumulative 2010 (MW)	W/habitant
Austria	20	53	50	103	12.6
Belgium	285	379	424	803	73
Bulgaria	6	7	11	18	2.4
Czech Republic	398	463	1,490	1,953	191.5
France	219	306	719	1,025	15.5
Germany	3,806	9,785	7,408	17,193	211
Greece	36	56	150	206	19.3
Italy	717	1,173	2,321	3,494	60.2
Portugal	55	114	16	130	11.5
Slovakia	0	0	145	145	26.4
Spain	17	3,415	369	3,784	80.5
United Kingdom	10	21	45	66	1.1
Rest of the EU	50	235	98	333	



RES : solar

EPIA
European Photovoltaic Industry Association

3.2.g. Reaching 2020 targets

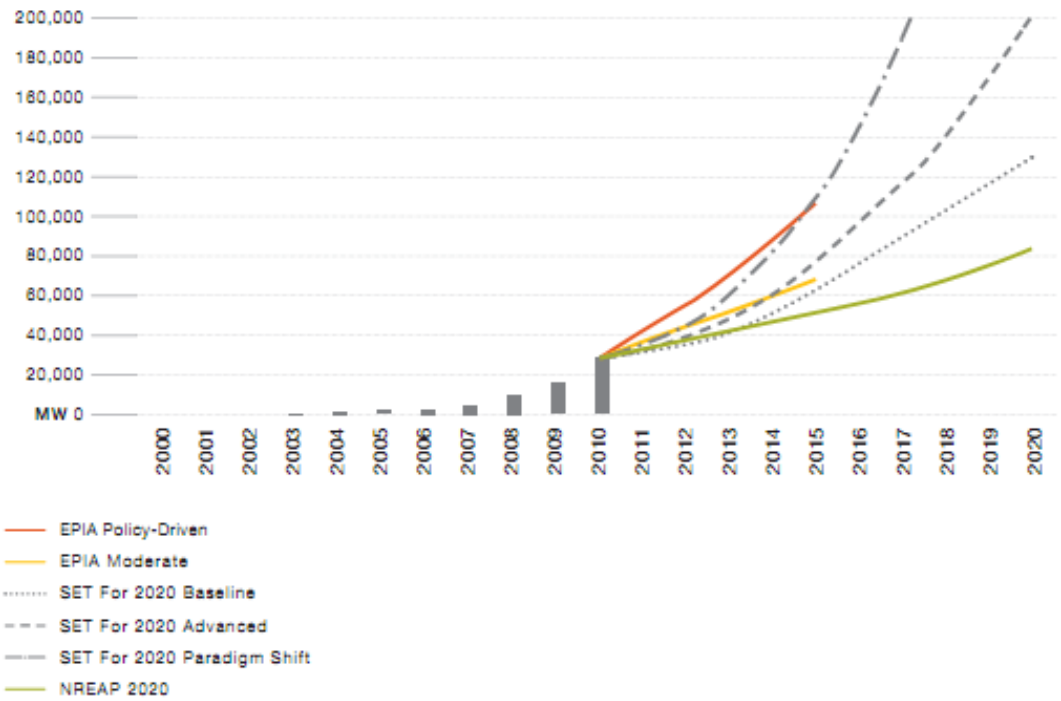


Figure 20 - Market forecasts compared to 'SET For 2020' targets and NREAPS

entsoe

Solar capacity: Question 15

Solar capacity: By 2030, By what will be the minimum installed capacity of solar in Europe?

a. stagnation
b. < 100GW
c. 100 – 200GW
d. 200 – 300GW
e. 300 – 400GW
f. 400 – 500GW
g. 500 – 600GW
h. >600GW
i. no view

Solar capacity: Question 16

Solar capacity: By 2030, By what will be the maximum installed capacity of solar in Europe?

a. stagnation
b. < 100GW
c. 100 – 200GW
d. 200 – 300GW
e. 300 – 400GW
f. 400 – 500GW
g. 500 – 600GW
h. >600GW
i. no view

RES : Ocean Energy – Wave & Tidal

ORECCA European Offshore Renewable Energy Roadmap

Figure I: Photograph of a tidal stream device currently being tested in Northern Ireland. (Source: Marine Current turbines)

		2050 Target
Offshore wind	European target [1]	460 GW
	International target [2]	1150 GW
Ocean energy	European target [3]	188 GW
	International target [4]	748 GW

Figure B: Some deployment targets which have been set out in the offshore renewable energy sector. [[1]EWEA (European Wind Energy Association), [2]IEA (International Energy Agency), [3] EU-OEA (EU Ocean Energy Association), [4]Greenpeace Advanced Energy [R]evolution]

Figure K: Photograph of the Oyster 1 wave energy device under testing at EMEC (Source: Aquamarine Power)

Figure J: Photograph of Pelamis Wave Power device (Source: Pelamis Wave Power)

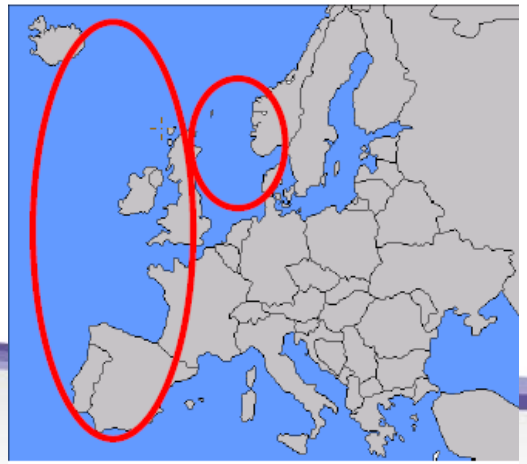


Figure L: Artist's impression of an array of Hammerfest Strom tidal stream devices. (Source: Hammerfest Strom)

entsoe

Ocean energy capacity: Question 17

<u>Ocean energy capacity: By 2030, what is the minimum % of energy in Europe that will be delivered by marine sources?</u>

a. 0 – 1%
b. 1 – 3%
c. 3 – 5%
d. 5 – 7%
e. 7 – 9%
f. > 9 %
g. no view

Ocean energy capacity: Question 18

<u>Ocean energy capacity: By 2030, what is the maximum % of energy in Europe that will be delivered by marine sources?</u>

a. 0 – 1%
b. 1 – 3%
c. 3 – 5%
d. 5 – 7%
e. 7 – 9%
f. > 9 %
g. no view

RES : Biomass/pellets

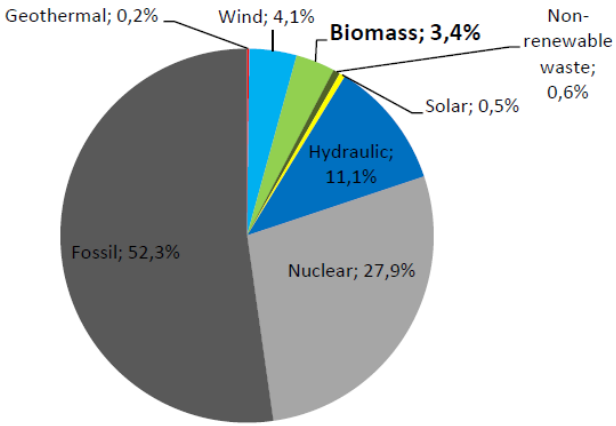
AEBIOM
EUROPEAN BIOMASS ASSOCIATION

Table 6.1 Electricity production (TWh) by biomass in 2009 in EU27

	Electricity production (TWh) by biomass
Biomass	109,0
Solid biomass share	63,3
Biogas share	25,5
Liquid biomass share	4,2
Municipal waste share	15,9

Source: Observ´ER, "Renewable origin electricity production", Edition 2010

Figure 6.1 Structure of electricity production in 2009 in EU27

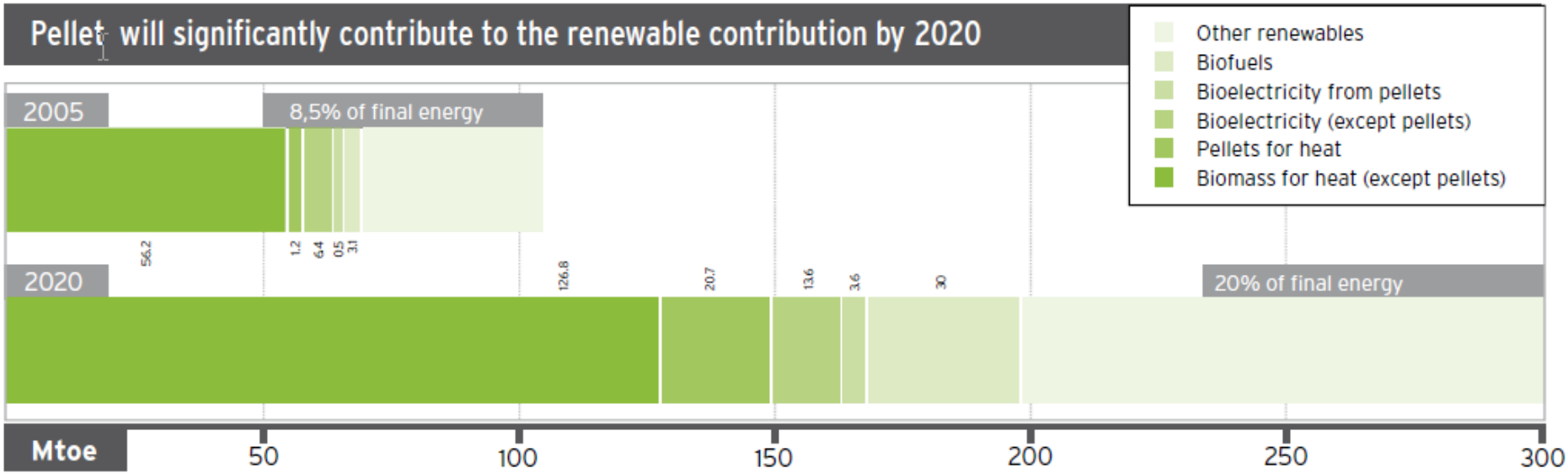


Source: Observ´ER, "Renewable origin of electricity production", Edition 2010

entsoe

RES : Biomass/pellets

AEBIOM
EUROPEAN BIOMASS ASSOCIATION



Outlook for bioenergy sources in Mtoe

Source	2004		2020*	
Forest based biomass	61,5	(85%)	75	(34%)
Agriculture based biomass	3,5	(5%)	97	(44%)
Waste	7,3	(10%)	23	(11%)
Imports	-		25	(11%)
Total	72,3		220	

* AEBIOM estimates

Production based on biomass/pellets could be multiplied with 2,5 by 2020

entsoe

biomass/pellets for electricity generation: Question 19

Biomass/pellets for electricity generation: By 2030, what will be the minimum increase of installed capacity of biomass/pellets for electricity generation in Europe?

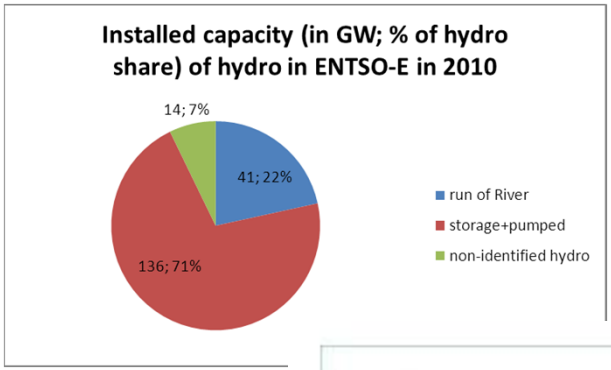
a. stagnation
b. < 50%
c. 50 – 100%
d. 100 – 150%
e. 150 – 200%
f. 200 – 250%
g. 250 – 300%
h. >300%
i. no view

biomass/pellets for electricity generation : Question 20

Biomass/pellets for electricity generation : By 2030, what will be the maximum increase of installed capacity of biomass/pellets for electricity generation in Europe?

a. stagnation
b. < 50%
c. 50 – 100%
d. 100 – 150%
e. 150 – 200%
f. 200 – 250%
g. 250 – 300%
h. >300%
i. no view

RES : Renewable hydro



The European Small Hydropower Association

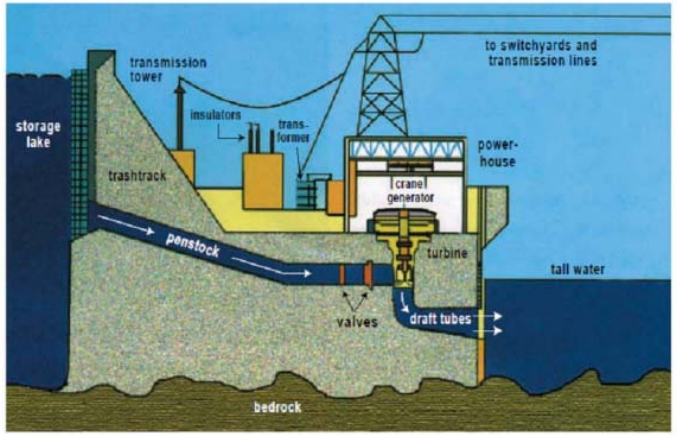


Fig. 11 Principle of a Hydropower Plant.

Source: IEA[30]

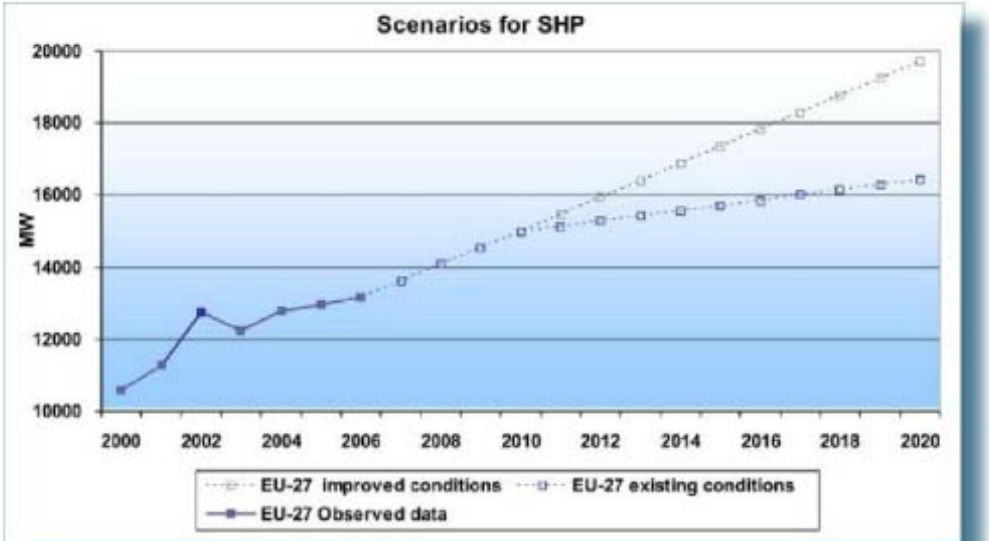


Figure 7. SHP Capacity 2000-2006 and forecast to 2010 for SHP in EU-27.

entsoe

Renewable hydro capacity: Question 21

Renewable hydro capacity: By 2030, what will be the minimum increase of installed capacity of renewable hydro capacity in Europe?

a. stagnation
b. < 25%
c. 25 – 50%
d. 50 – 75%
e. 75 – 100%
f. >100%
g. no view

Renewable hydro capacity: Question 22

Renewable hydro capacity: By 2030, what will be the maximum increase of installed capacity of renewable hydro capacity in Europe?

a. stagnation
b. < 25%
c. 25 – 50%
d. 50 – 75%
e. 75 – 100%
f. >100%
g. no view

Remaining Margin

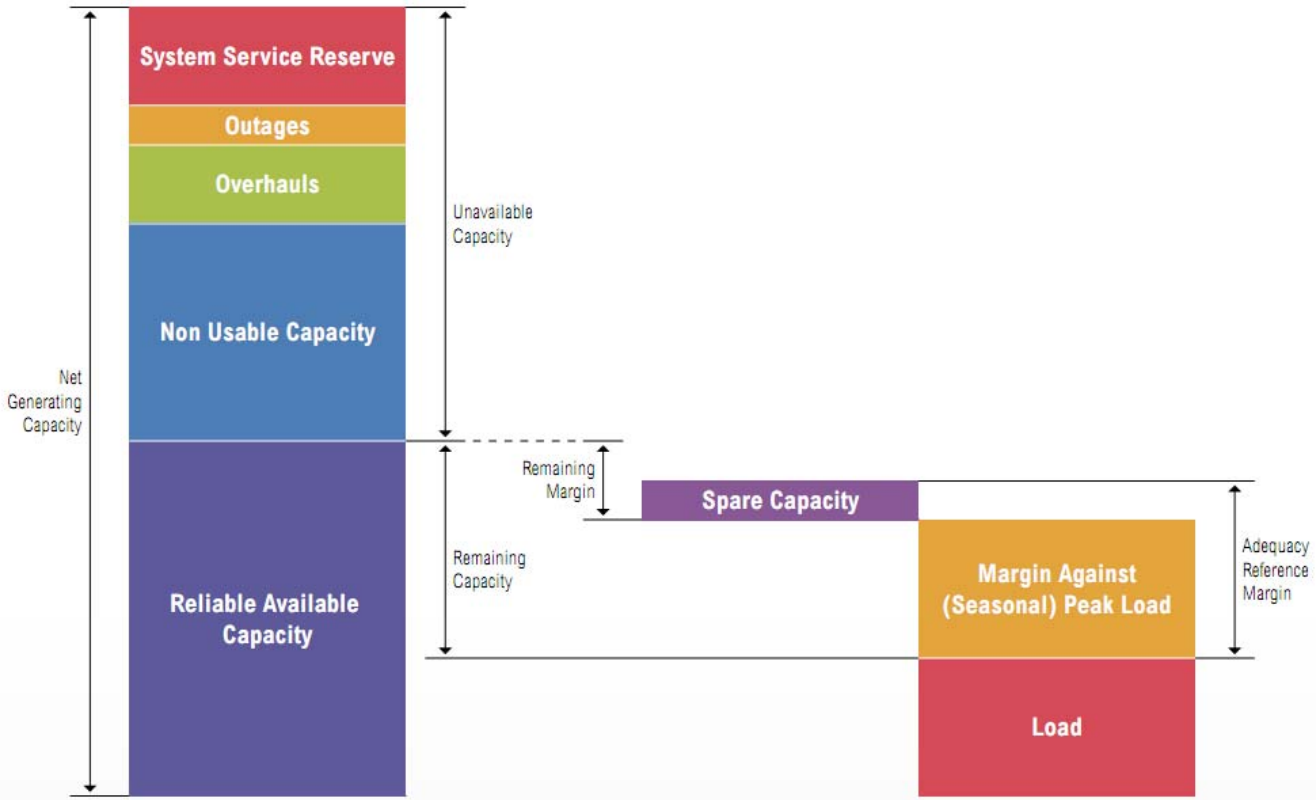
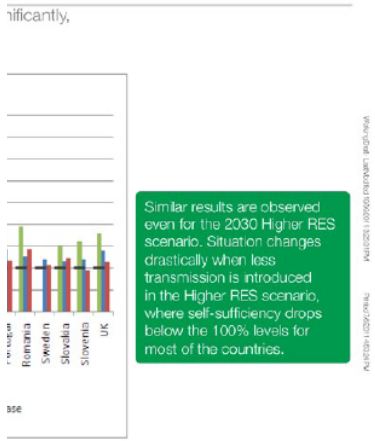


Figure 5.1:
Generation Adequacy Analysis

Self – sufficiency1 is preserved despite the increase in RES



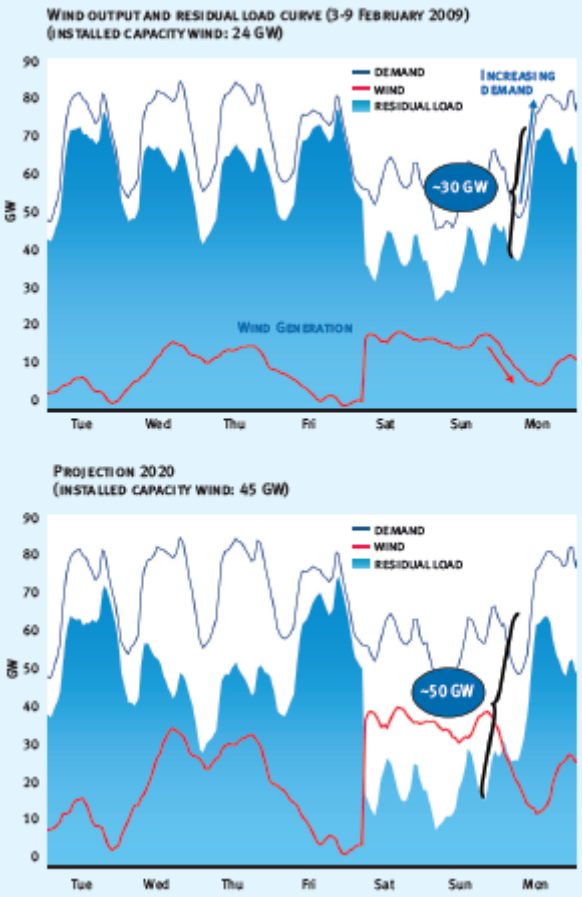
Similar results are observed even for the 2030 Higher RES scenario. Situation changes drastically when less transmission is introduced in the Higher RES scenario, where self-sufficiency drops below the 100% levels for most of the countries.

sources (coal, gas, OCGT) (at load factor of 90%) plus the
icity demand.

entsoe

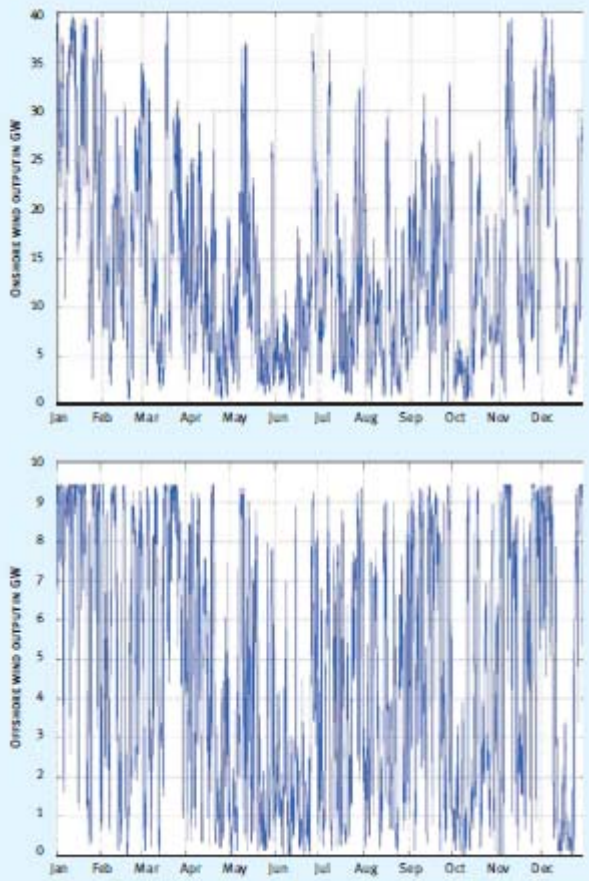
Remaining Margin

Figure 11: Current and future flexibility and back-up capacity requirements in Germany



Source: BDEW

Figure 4: Wind onshore and offshore generation over a whole calendar year



Source: Fraunhofer IWES

Remaining Margin

TABLE 3: FLEXIBILITY OF CONVENTIONAL POWER GENERATION TECHNOLOGIES

	NPP	HC	LIGN	CCG	PS
Start-up Time "cold"	~ 40H	~ 6H	~ 10H	< 2H	~ 0,1H
Start-up Time "warm"	~ 40H	~ 3H	~ 6H	< 1,5H	~ 0,1H
Load Gradient ↗ "nominal Output"	~ 5%/M	~ 2%/M	~ 2%/M	~ 4%/M	> 40%/M
Load Gradient ↘ "nominal Output"	~ 5%/M	~ 2%/M	~ 2%/M	~ 4%/M	> 40%/M
Minimal Shutdown Time	←		NO	→	~ 10H
Minimal possible Load	50%	40%	40%	<50%	~ 15%

Source: EURELECTRIC/VGB enquiry

Title	Multi-mode operation of combined-cycle gas turbines with increasing wind penetration
Author(s)	Troy, Niamh; Flynn, Damian; O'Malley, Mark
Publication Date	2010-08
Publication information	IEEE Transactions on Power Systems, [forthcoming] :

TABLE III
CHARACTERISTICS OF CCGT UNITS (CAPABLE OF MULTI-MODE OPERATION) IN COMBINED- AND OPEN-CYCLE MODES

CCGT	1	2	3	4	5
Configuration	1+1	2+1	1+1	1+1	2+1
	Characteristics in combined-cycle mode				
Max output (MW)	445	480	404	343	480
Min output (MW)	240	232	260	220	280
Max efficiency (%)	57.6	58.9	53.9	52.9	52.3
Min up time (Hours)	4	4	6	4	4
Min down time (Hours)	1	2	4	4	2
Start-up time (Hours)	2	1	1	2	4
Hot start-up fuel (GJ)	2600	2000	1080	1732	2000
Max spinning reserve contribution (MW)	42	37	40	25	40
Efficiency at max spinning reserve (%)	57.4	58.1	52.8	52.2	51.3
	Characteristics in open-cycle mode				
Max output (MW)	280	160	256	265	160
Max efficiency (%)	39.5	38	39.3	39.3	38
Min up time (Hours)	0	0	0	0	0
Min down time (Hours)	0	0	0	0	0
Start-up time (Hours)	0	0	0	0	0
Hot start-up fuel (GJ)	14	8	13	13	8
Max spinning reserve contribution (MW)	20	20	20	20	20
Efficiency at max spinning reserve (%)	39.3	37.5	39.1	39.2	37.5

Remaining margin: Question 23

<u>Remaining margin: By 2030, what will be the level of remaining margin compared to the peak load , interconnected system as today?</u>

a. < 5% of total generation capacity
b. 5 - 10% of total generation capacity
c. 10 – 15% of total generation capacity
d. 15 – 20% of total generation capacity
e. 20 – 25% of total generation capacity
f. 25 – 30% of total generation capacity
g. > 30% of total generation capacity
h. No view

Remaining Margin: Question 24

<u>Remaining Margin: By 2030, what will be the level of remaining margin compared to the peak load in a Europe, in a stronger interconnected Europe than today?</u>

a. < 5% of total generation capacity
b. 5 - 10% of total generation capacity
c. 10 – 15% of total generation capacity
d. 15 – 20% of total generation capacity
e. 20 – 25% of total generation capacity
f. 25 – 30% of total generation capacity
g. > 30% of total generation capacity
h. No view

Centralized pumped hydro Storage

Installed capacity

In the EU-27 and non-EU Member States of the EEA, about 40 GW of hydropumped storage are in operation, with Italy, Spain, Germany and France having the largest installed base in Europe. Currently, it is estimated that about 75 % of the global potential for hydropower is already developed in Europe.

European Commission
SETIS Strategic energy technologies information system

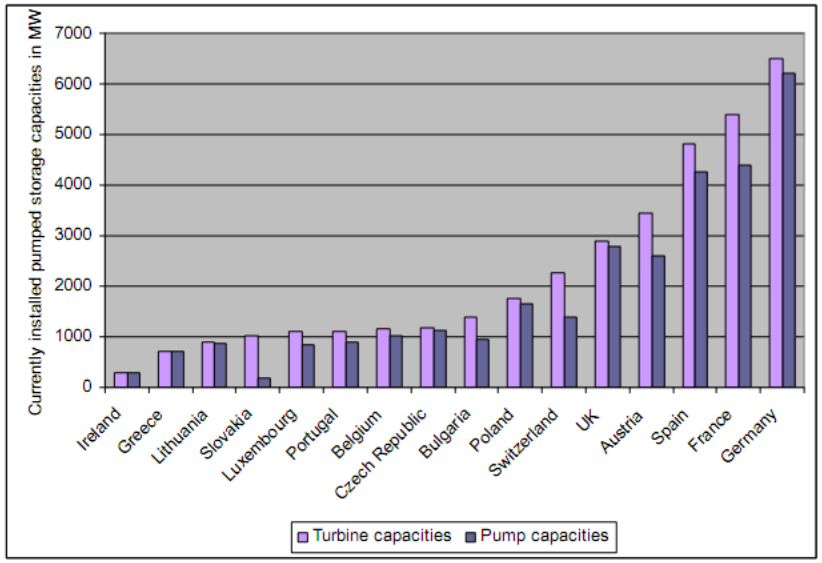


Fig. 5 Installed pumped storage capacities in MW in turbine and pumping modes
Source: EURELECTRIC[11]

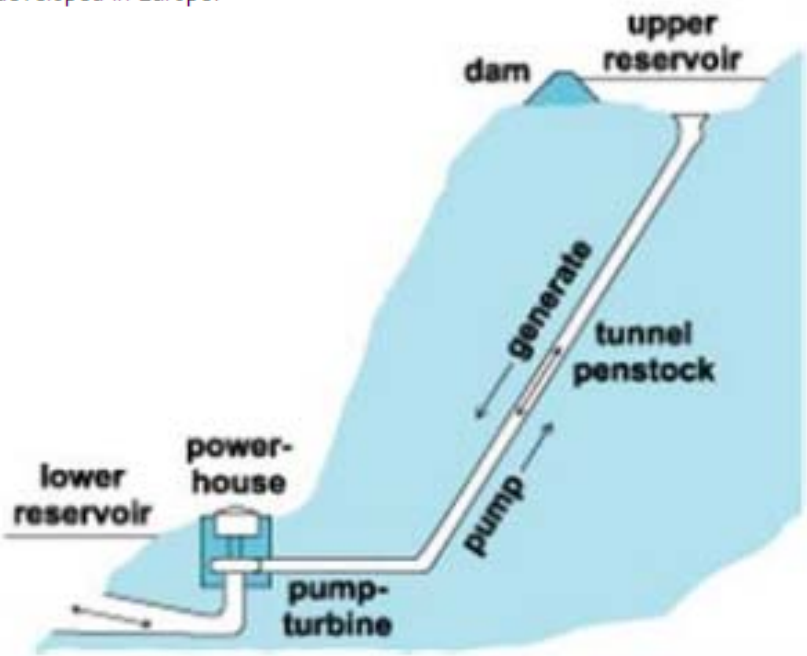


Fig. 13 Illustration of the operating principle of a pumped storage hydropower plant.
Source: Mechanical Writings [31]

Centralized pumped hydro storage : Question 25

Centralized pumped hydro storage : By 2030, what will be the minimum additional installed capacity of centralized pumped hydro storage in Europe?

a. No additional capacity
b. 1 GW – 5 GW

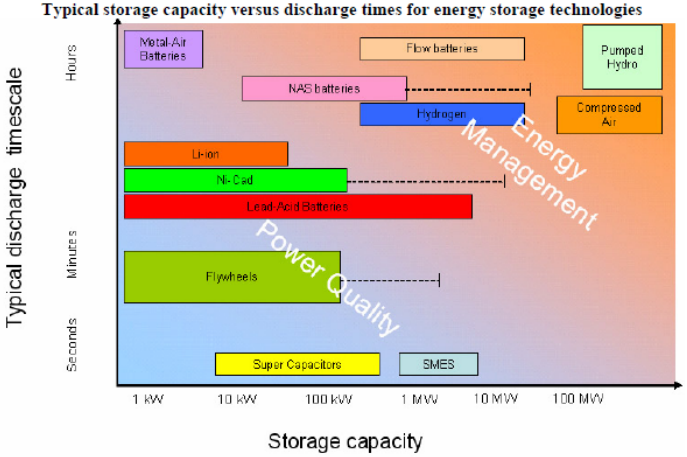
Centralized pumped hydro storage : Question 26

Centralized pumped hydro storage : By 2030, what will be the maximum additional installed capacity of centralized pumped hydro storage in Europe?

a. stagnation

Decentralized Storage

Typical storage capacity versus discharge times for energy storage technologies



(Figure adapted from: Electricity Storage Association. http://www.electricitystorage.org/tech/technologies_comparisons_ratings.htm)

Figure 3: A 100 kW Li-ion energy storage system

Source: Saft America

Decentralized storage capacity: Question 27

Decentralized storage capacity: By 2030, what will be the minimum level of decentralized storage capacity compared to the peak load in a Europe interconnected as today?

a. none
b. <1% of the peak load
c. 1– 4% of the peak load
d. 4 – 8% of the peak load
e. 8 – 12% of the peak load
f. 12– 16% of the peak load
g. > 16% of the peak load
h. No view

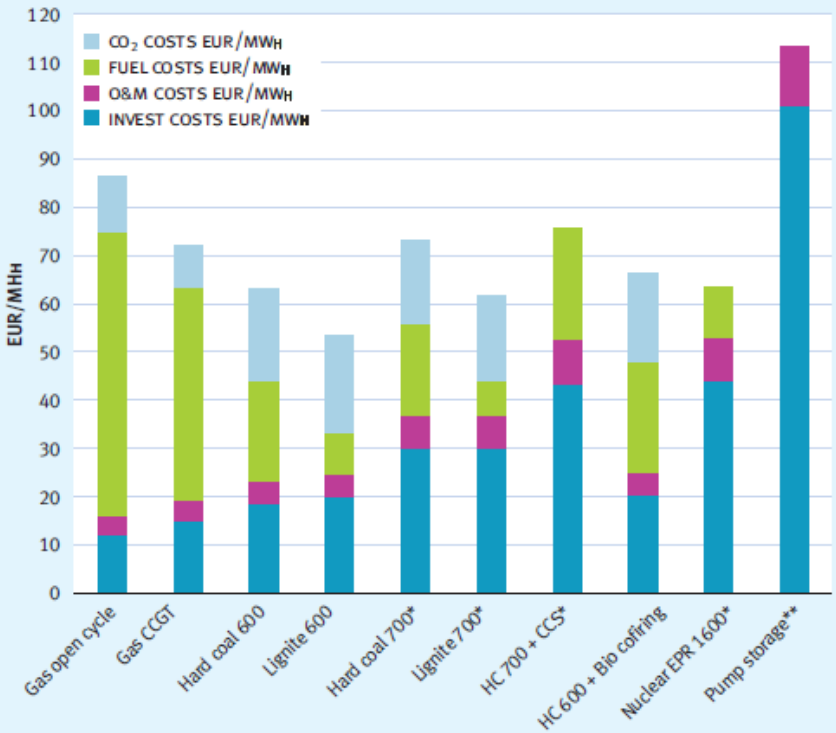
Decentralized storage capacity: Question 28

Decentralized storage capacity: By 2030, what will be the maximum level of decentralized storage capacity compared to the peak load in a Europe interconnected as today?

a. none
b. <1% of the peak load
c. 1– 4% of the peak load
d. 4 – 8% of the peak load
e. 8 – 12% of the peak load
f. 12– 16% of the peak load
g. > 16% of the peak load
h. No view

Thermal capacity

FIGURE 26: LEVELISED COSTS OF ELECTRICITY FOR THE MAIN POWER GENERATION TECHNOLOGIES



* for > 2015 ** without pumping costs

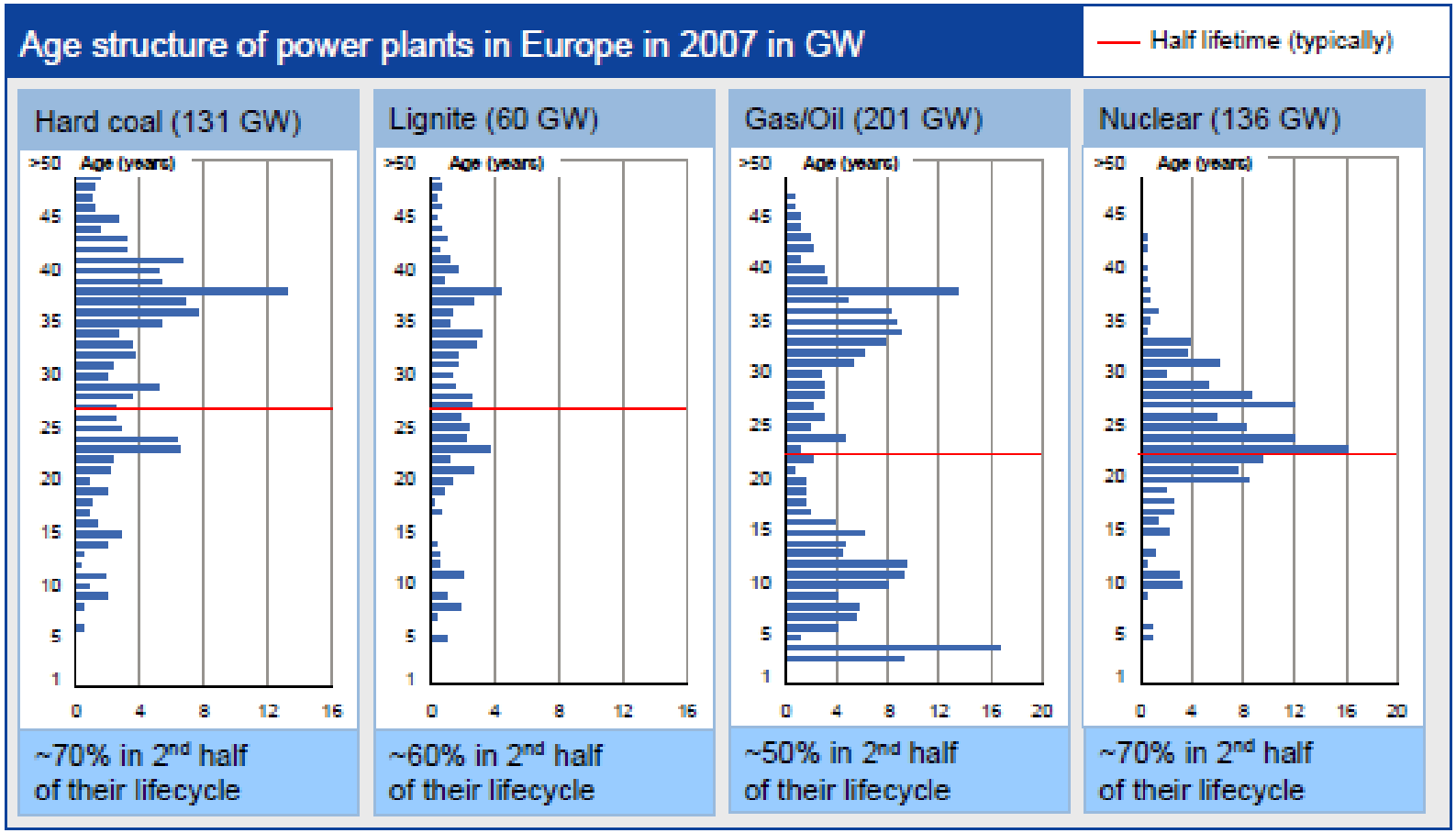
	TWH NET			SHARES IN %		
	2000	2010	2020	2000	2010	2020
NUCLEAR ENERGY	892	880	849	31.7	28.5	24.5
FOSSIL FUELS	1 503	1597	1 511	53.5	51.7	43.5
Solids fired	870	786	707	31.0	25.5	20.4
Oil fired	158	62	63	5.6	2.0	1.8
Natural gas	449	722	704	16.0	23.4	20.3
Derived gasses	26	27	37	0.9	0.9	1.1
RENEWABLE ENERGY	416	612	1 112	14.8	19.8	32.0
Hydro (pumping excluded)	348	318	335	12.4	10.3	9.7
Wind on-shore	22	147	349	0.8	4.8	10.1
Wind off-shore	0	14	174	0.0	0.5	5.0
Solar	0	17	50	0.0	0.5	1.4
Other renewables (tidal etc.)	0	0	3	0.0	0.0	0.1
Geothermal heat	4	6	12	0.2	0.2	0.3
Biomass-waste fired	42	110	188	1.5	3.5	5.4
TOTAL	2 812	3 090	3 473	100	100	100

Table 8: Net Power Generation by Source in the Power Choices Scenario until 2020

Source: VGB, Investment and Operation Costs Figures – generation portofolio

entsoe

Thermal capacity



Sources: BCG, RWE

Thermal capacity

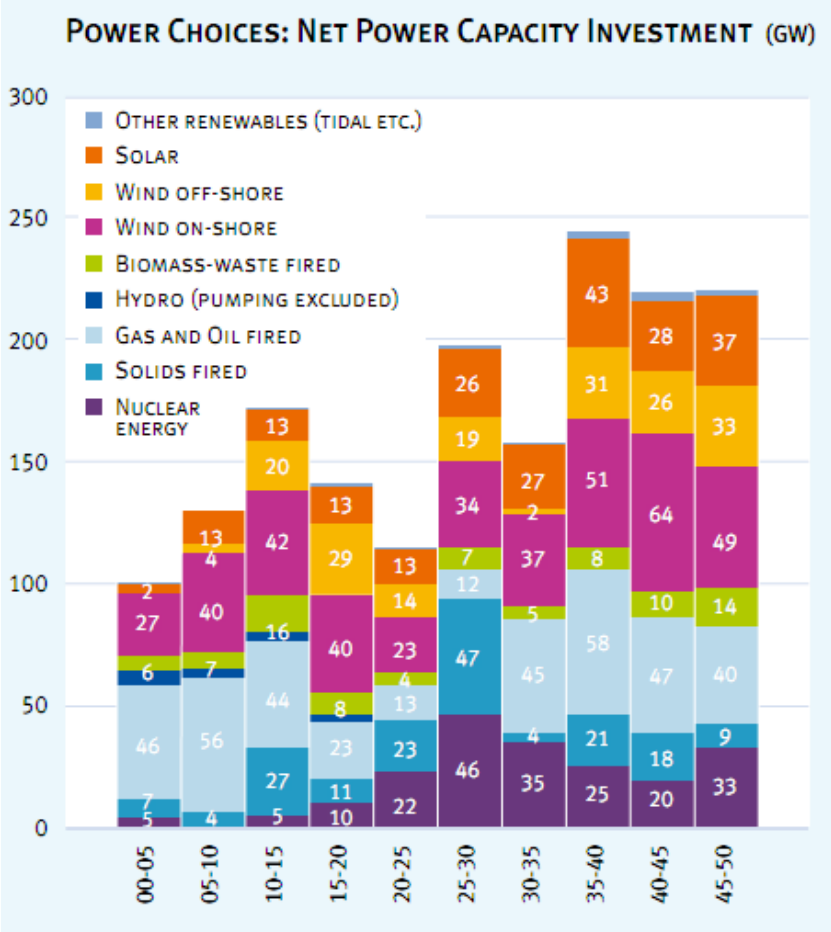
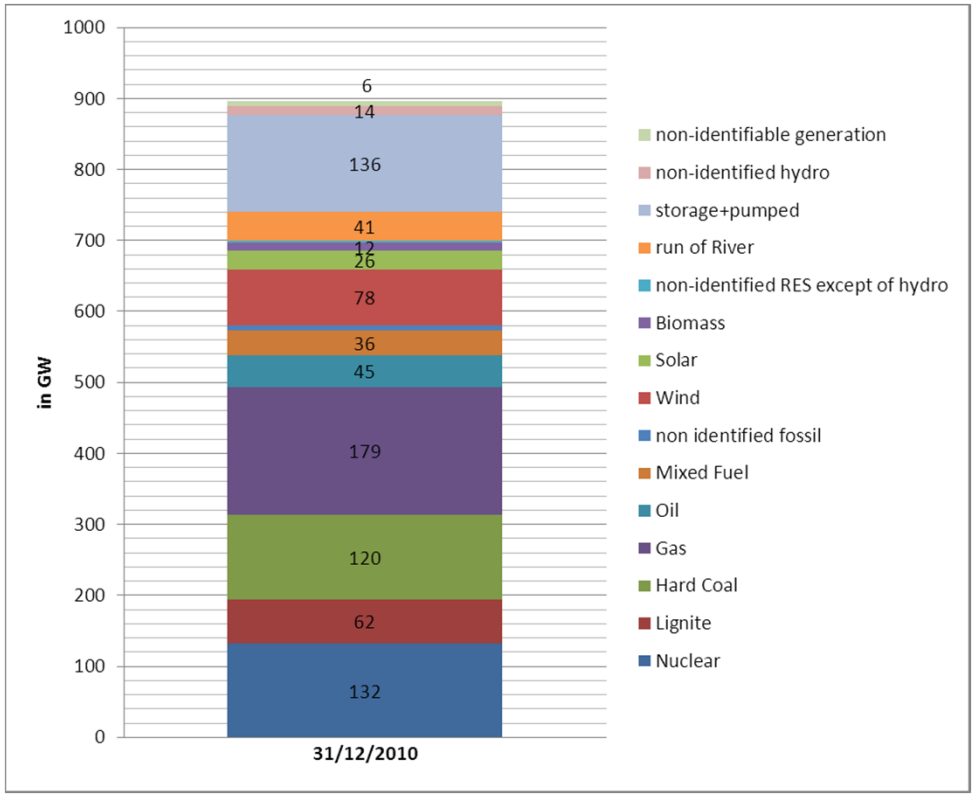
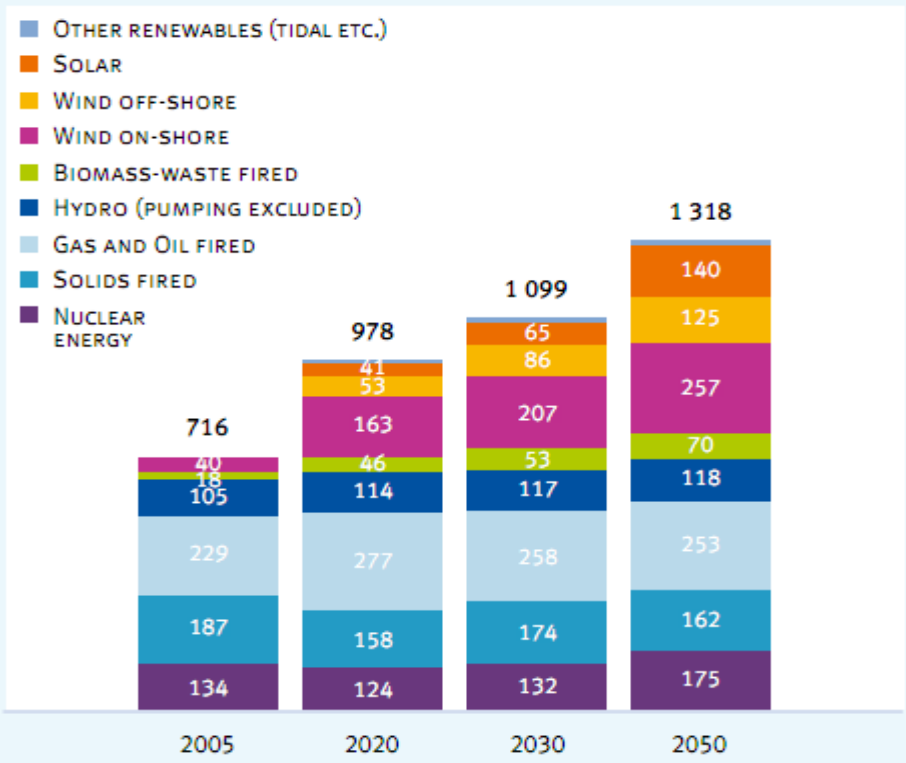


Figure 23: Power Generation Investment in Power Choices



entsoe

Thermal capacity



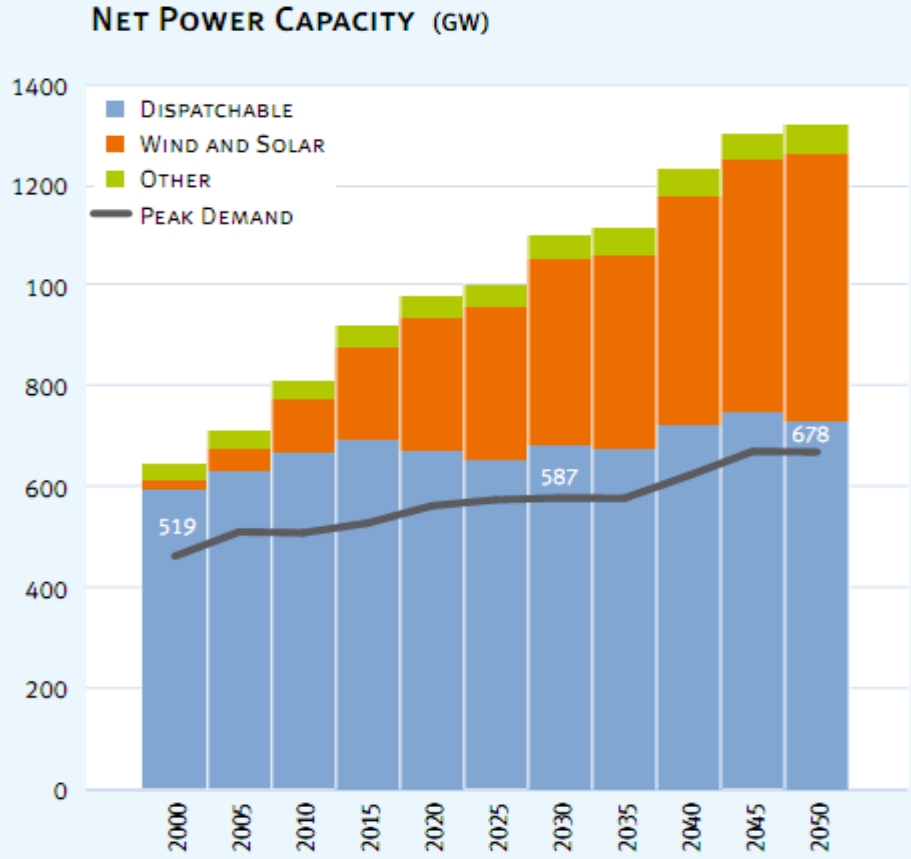


Figure 24: Operating Power Capacity in Power Choices

entsoe

Nuclear

Table 3: The place of nuclear in current outlooks for the EU electricity mix by 2050

	Eurelectric	IAE (Blue Map)	European Climate Fundation (ECF) with RES = 60 %
Final electricity consumption	4776 TWh	4306 TWh	4600 TWh
Share of nuclear	28.4 %	29.3 %	20 %

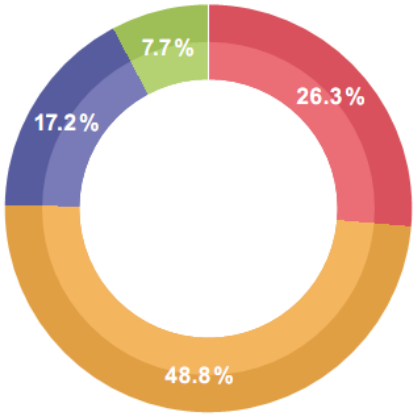
Table 4: Nuclear new built between 2020 and 2050 implied by the three long term outlooks for the EU electricity mix and with a 40 years lifetime for NPPs

	Eurelectric	IAE (Blue map)	ECF RES - 60 %
Nuclear generation (TWh)	1361	1262	920
Nuclear capacity (GWe and with LF = 85 %)	183	169	124
#NPPs by 2050 (1600 MW)	114	106	77
# new-built between 2020 and 2050	**100**	**92**	**63**

Generation

Generation mix in ENTSO-E member TSOs' countries[1]

	GWh
Thermal nuclear	895 887
Fossil fuels (lignite and hard coal, gas, fuel oil, mixed fuels, peat)	1 660 915
Hydraulic generation (storage, run of river, pumped storage)	584 143
Other sources (wind, solar, geothermal, waste, bio fuels, non identifiable generation)	263 692



entsoe

Nuclear capacity: Question 29

<u>Nuclear capacity: By 2030, what will be the change of installed nuclear capacity in Europe assuming that the political vision after Fukushima is maintained?</u>

a. decrease by more than 40%
b. decrease between 40% and 20%
c. decrease between 20% and 0%
d. no change
e. increase between 20% and 0%
f. increase between 40% and 20%
g. increase by more than 40%
h. no view

Nuclear capacity: Question 30

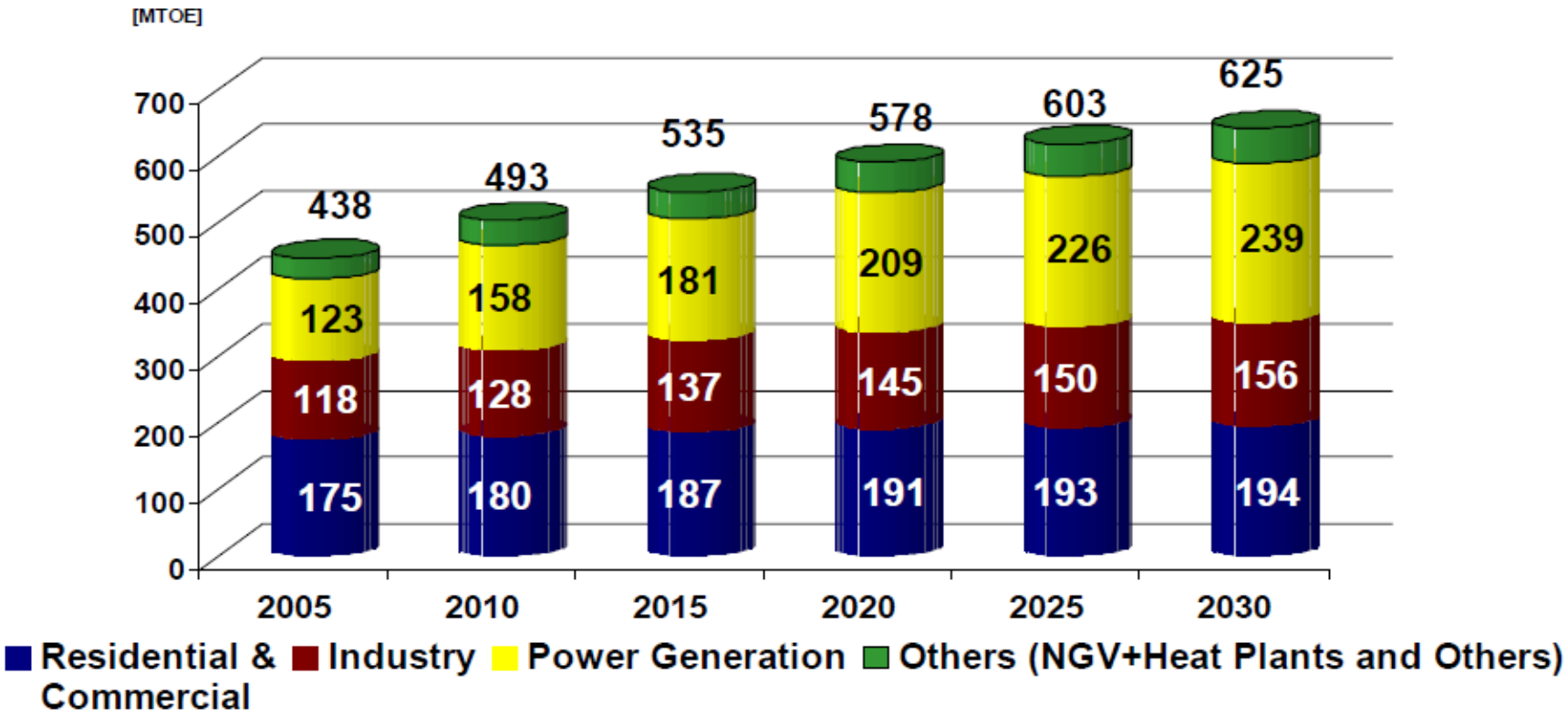
Nuclear capacity: By 2030, what will be the change of installed nuclear capacity in Europe assuming that the emphasis of policy is put on CO2 neutrality of nuclear generation?

a. decrease by more than 40%
b. decrease between 40% and 20%
c. decrease between 20% and 0%
d. no change
e. increase between 20% and 0%
f. increase between 40% and 20%
g. increase by more than 40%
h. no view

Gas

euro gas
THE EUROPEAN UNION OF THE NATURAL GAS INDUSTRY

EU27 Natural Gas demand outlook by sector



entsoe

Gas power units: Question 31

<u>Gas for electricity generation: By 2030, what will be the minimum increase of installed capacity of Gas for electricity generation in Europe?</u>

a. stagnation
b. < 50%
c. 50 – 100%
d. 100 – 150%
e. 150 – 200%
f. >200%
g. no view

Gas power units: Question 32

<u>Gas for electricity generation: By 2030, what will be the maximum increase of installed capacity of Gas for electricity generation in Europe?</u>

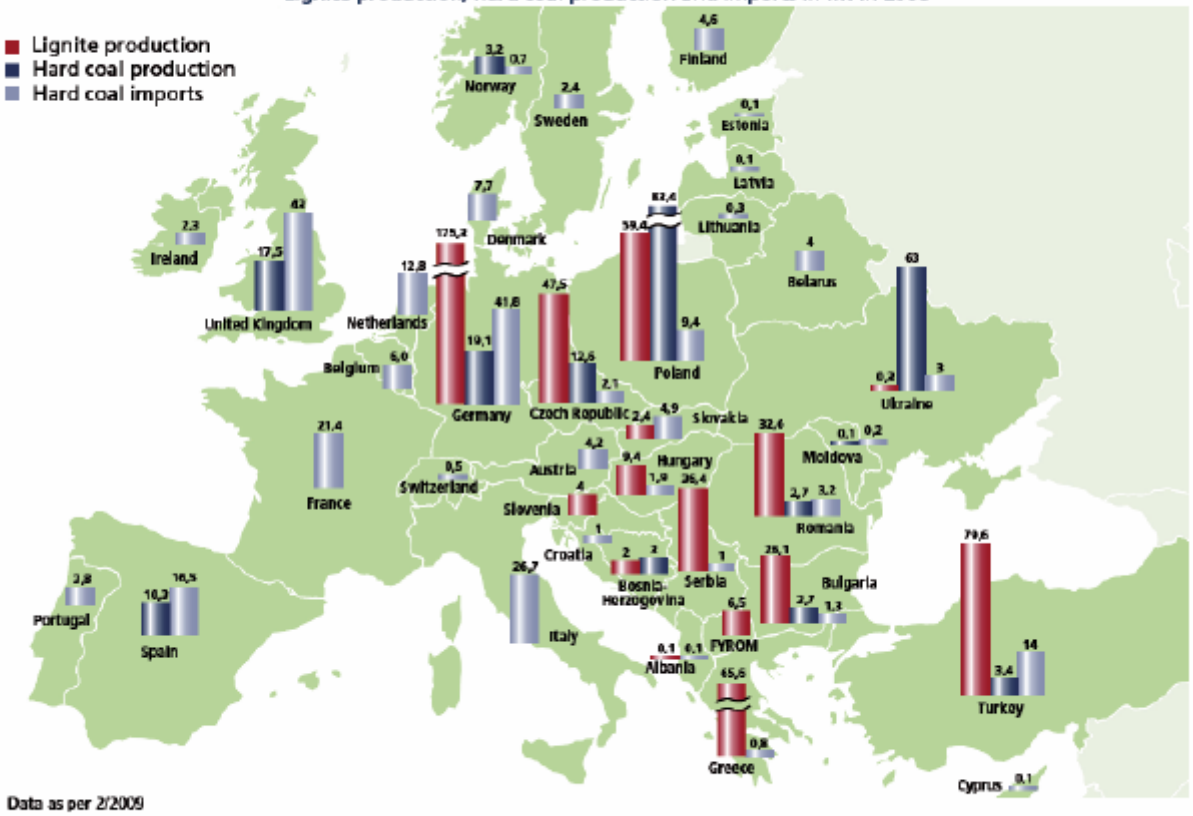
a. stagnation
b. < 50%
c. 50 – 100%
d. 100 – 150%
e. 150 – 200%
f. >200%
g. no view

Lignite &Coal

EURACOAL
European Association for Coal and Lignite

Coal in Europe

Lignite production, hard coal production and imports in Mt in 2008



Bonn, 25th June 2009, Figure 2

EURACOAL

entsoe

Coal & Lignite power units: Question 33

<u>Coal & lignite for electricity generation: By 2030, what will be the minimum change of installed capacity of coal & lignite for electricity generation in Europe?</u>

a. decrease by more than 40%
b. decrease between 40% and 20%
c. decrease between 20% and 0%
d. no change
e. increase between 20% and 0%
f. increase between 40% and 20%
g. increase by more than 40%
h. no view

Coal & Lignite power units: Question 34

<u>Coal & lignite for electricity generation: By 2030, what will be the maximum change of installed capacity of coal & lignite for electricity generation in Europe?</u>

a. decrease by more than 40%
b. decrease between 40% and 20%
c. decrease between 20% and 0%
d. no change
e. increase between 20% and 0%
f. increase between 40% and 20%
g. increase by more than 40%
h. no view

Oil power units: Question 35

<u>Oil for electricity generation: By 2030, what will be the minimum change of installed capacity of oil for electricity generation in Europe?</u>

a. decrease by more than 40%
b. decrease between 40% and 20%
c. decrease between 20% and 0%
d. no change
e. increase between 20% and 0%
f. increase between 40% and 20%
g. increase by more than 40%
h. no view

Oil power units: Question 36

<u>Oil for electricity generation: By 2030, what will be the maximum change of installed capacity of oil for electricity generation in Europe?</u>

a. decrease by more than 40%
b. decrease between 40% and 20%
c. decrease between 20% and 0%
d. no change
e. increase between 20% and 0%
f. increase between 40% and 20%
g. increase by more than 40%
h. no view

Merit order fossil fuels for electricity generation: Question 37

Merit order : What will be the effect of the combination of the level of primary fuel prices and CO2 price on the merit order in 2030 assuming a current policy continuation? :

a. Merit order 1
   1. Nuclear
   2. New gas CCGT
   3. New coal
   4. New Lignite
   5. Old gas CCGT
   6. Old coal
   7. Old lignite

b. Merit order 2
   1. Nuclear
   2. New coal
   3. New gasCCGT
   4. New Lignite
   5. Old coal
   6. Old lignite
   7. Old gas CCGT

c. Merit order 3
   a. Nuclear
   b. New gas CCGT
   c. Old gas CCGT
   d. New coal
   e. New Lignite
   f. Old coal
   g. Old lignite

d. Merit order 4
   a. Nuclear
   b. New gas CCGT
   c. Old gas CCGT
   d. New Lignite
   e. New coal
   f. Old lignite
   g. Old coal

e. Other

f. No view

Merit order fossil fuels for electricity generation: Question 38

Merit order : What will be the effect of the combination of the level of primary fuel prices and CO2 price on the merit order in 2030 assuming a timely realization of the roadmap 2050? :

a. Merit order 1
   1. Nuclear
   2. New gas CCGT
   3. New coal
   4. New Lignite
   5. Old gas CCGT
   6. Old coal
   7. Old lignite

b. Merit order 2
   1. Nuclear
   2. New coal
   3. New gasCCGT
   4. New Lignite
   5. Old coal
   6. Old lignite
   7. Old gas CCGT

c. Merit order 3
   a. Nuclear
   b. New gas CCGT
   c. Old gas CCGT
   d. New coal
   e. New Lignite
   f. Old coal
   g. Old lignite

d. Merit order 4
   Nuclear
   a. New gas CCGT
   b. Old gas CCGT
   c. New Lignite
   d. New coal
   e. Old lignite
   f. Old coal

e. Other
f. No view

Additional issues

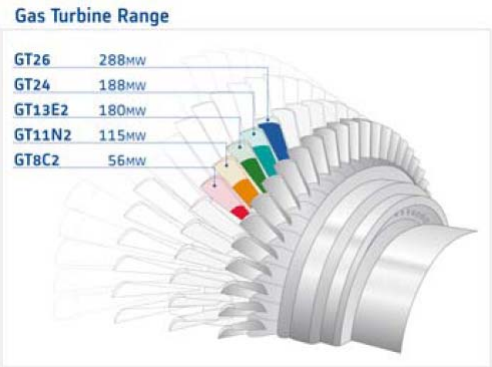
- New gas capacity
  - OCGT versus CCGT

TABLE III
CHARACTERISTICS OF CCGT UNITS (CAPABLE OF MULTI-MODE OPERATION) IN COMBINED- AND OPEN-CYCLE MODES

CCGT	1	2	3	4	5
Configuration	1+1	2+1	1+1	1+1	2+1
	Characteristics in combined-cycle mode				
Max output (MW)	445	480	404	343	480
Min output (MW)	240	232	260	220	280
Max efficiency (%)	57.6	58.9	53.9	52.9	52.3
Min up time (Hours)	4	4	6	4	4
Min down time (Hours)	1	2	4	4	2
Start-up time (Hours)	2	1	1	2	4
Hot start-up fuel (GJ)	2600	2000	1080	1732	2000
Max spinning reserve contribution (MW)	42	37	40	25	40
Efficiency at max spinning reserve (%)	57.4	58.1	52.8	52.2	51.3
	Characteristics in open-cycle mode				
Max output (MW)	280	160	256	265	160
Max efficiency (%)	39.5	38	39.3	39.3	38
Min up time (Hours)	0	0	0	0	0
Min down time (Hours)	0	0	0	0	0
Start-up time (Hours)	0	0	0	0	0
Hot start-up fuel (GJ)	14	8	13	13	8
Max spinning reserve contribution (MW)	20	20	20	20	20
Efficiency at max spinning reserve (%)	39.3	37.5	39.1	39.2	37.5

Table 2.1 Characterising fluctuation of wind output for 26GW of installed capacity of wind generation

Lead Time [Hours]	Standard Deviation [MW]	Likely maximum change [MW]	Extreme change [MW]
0.5	360	1,090 – 1,450	2,600
1	700	2,100 – 2,800	3,950
2	1,350	4,050 – 5,400	6,550
4	2,400	7,200 – 9,650	13,500



dti

THE FUTURE VALUE OF STORAGE IN THE UK WITH GENERATOR INTERMITTENCY

CONTRACT NUMBER: DG/DTI/00040/00/00

URN NUMBER: 04/1877

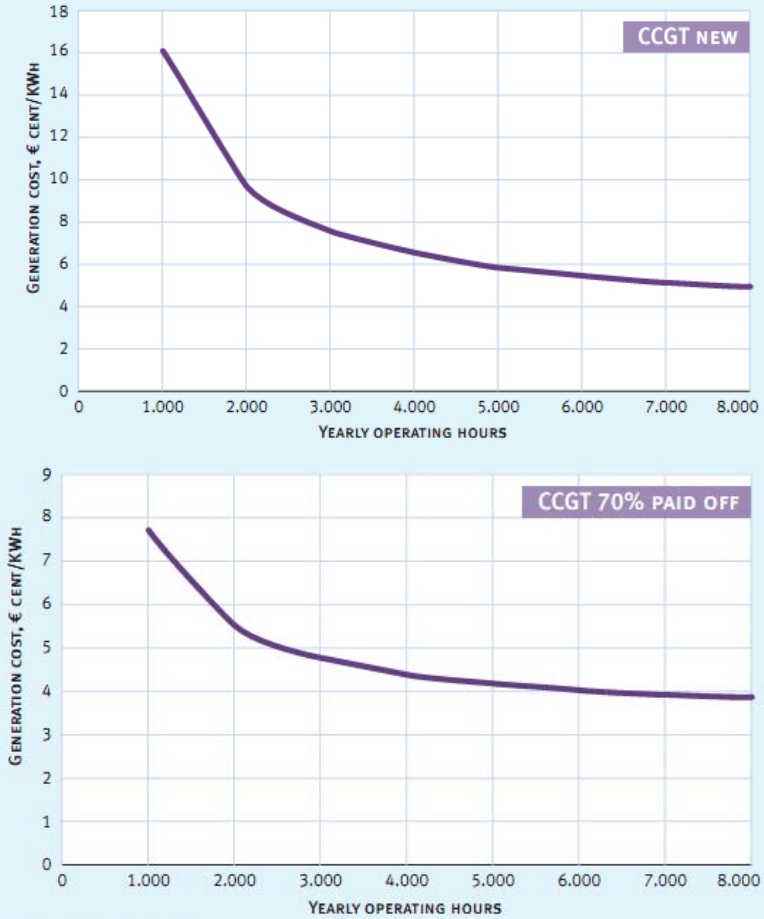
Title	Multi-mode operation of combined-cycle gas turbines with increasing wind penetration
Author(s)	Troy, Niamh; Flynn, Damian; O'Malley, Mark
Publication Date	2010-08
Publication information	IEEE Transactions on Power Systems, [forthcoming] :

entsoe

Additional issues

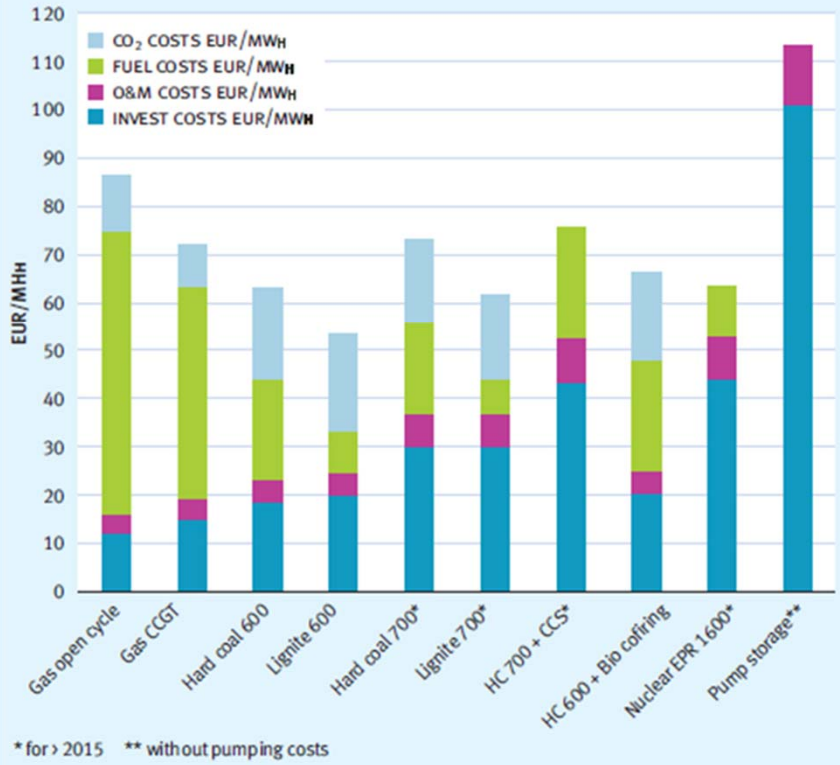
- Renting of new thermal generation units

FIGURE 27: EXAMPLES OF LEVELISED COST OF ELECTRICITY FOR A BRAND NEW CCGT AND AN OLDER CCGT WHOSE INVESTMENT HAS BEEN 70% PAID OFF



Source: VGB PowerTech

FIGURE 26: LEVELISED COSTS OF ELECTRICITY FOR THE MAIN POWER GENERATION TECHNOLOGIES



Source: VGB, Investment and Operation Costs Figures – generation portofolio