Seminario

STREAM Energy Model

Scenarios and Future Energy Strategies for the Baltic Sea Region

University of Pavia, 26th april 2012

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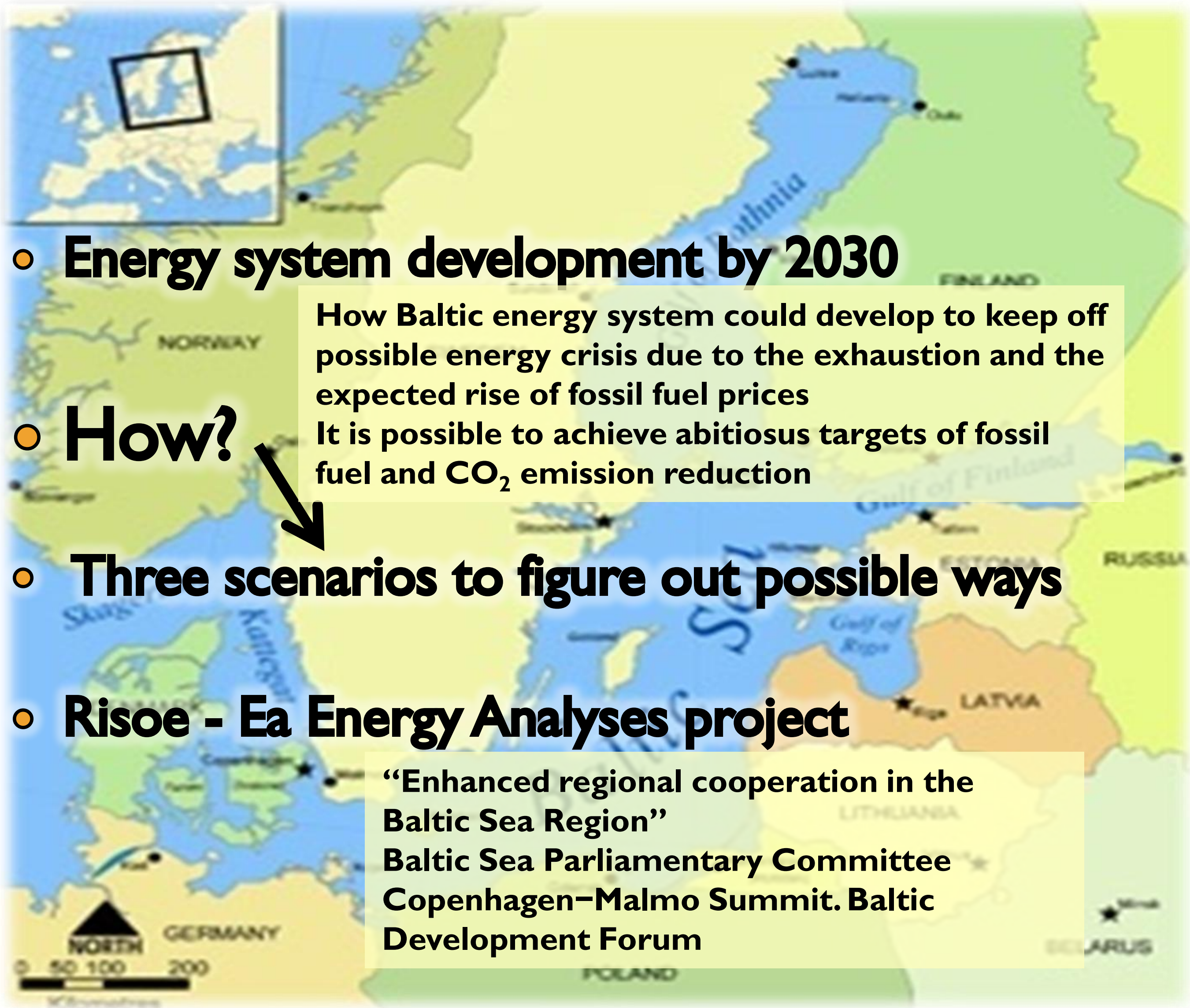
Preface

- Introduction of the BSR project
- Goals and targets
- STREAM Energy Model description
- Analysis and scenarios of BSR project
- Main results
- Limitations and future developments

Baltic Sea Region



- **Energy system development by 2030**

How Baltic energy system could develop to keep off possible energy crisis due to the exhaustion and the expected rise of fossil fuel prices
It is possible to achieve abitiosus targets of fossil fuel and CO_2 emission reduction

- **How?**
- **Three scenarios to figure out possible ways**
- **Risoe - Ea Energy Analyses project**

"Enhanced regional cooperation in the Baltic Sea Region"
Baltic Sea Parliamentary Committee
Copenhagen–Malmo Summit. Baltic Development Forum

Baltic Sea Region framework

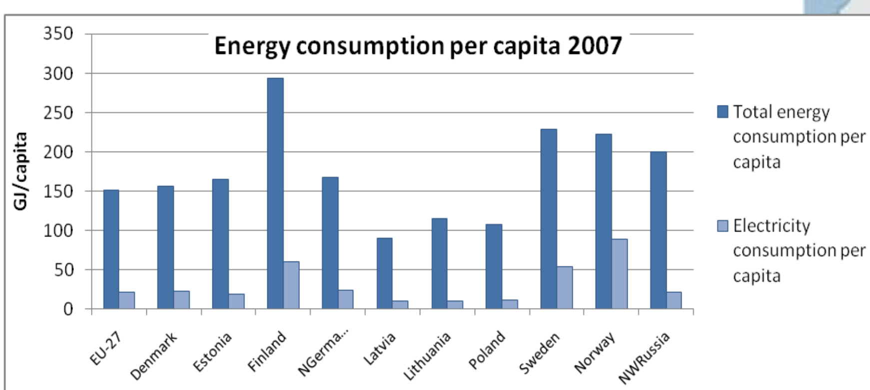
- EU particular point

"the European Council invites the Co[...] strategy for the Baltic Sea at latest b[...] inter alia help to address the urgent [...] to the Baltic Sea"

14 December 2007, the conclusio[...]

- Two contrasting situations

- Resources: fossil vs. renewable



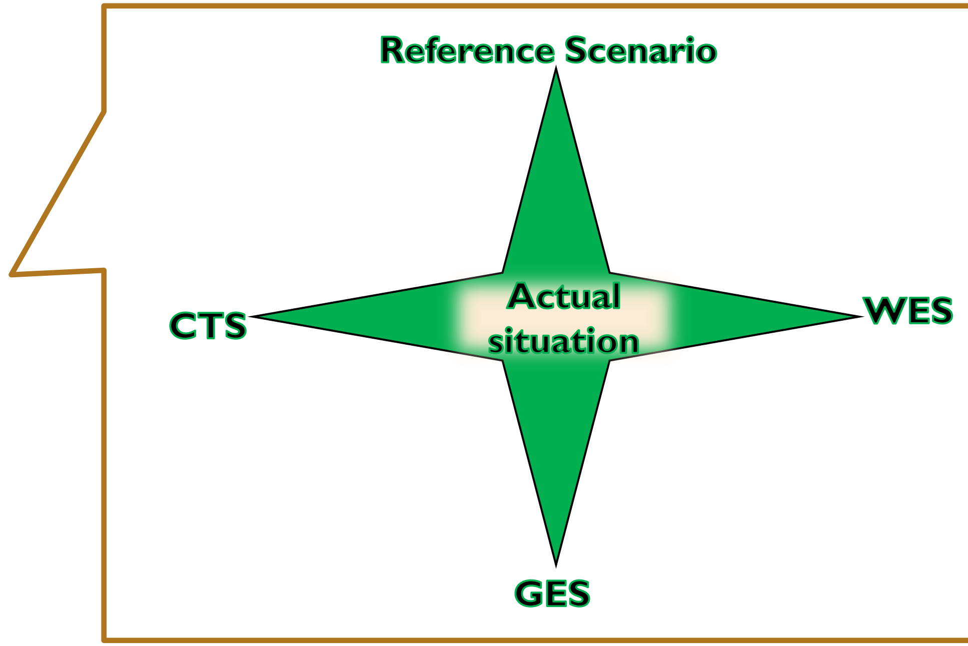
Energy targets and aims

GOALS to 2030

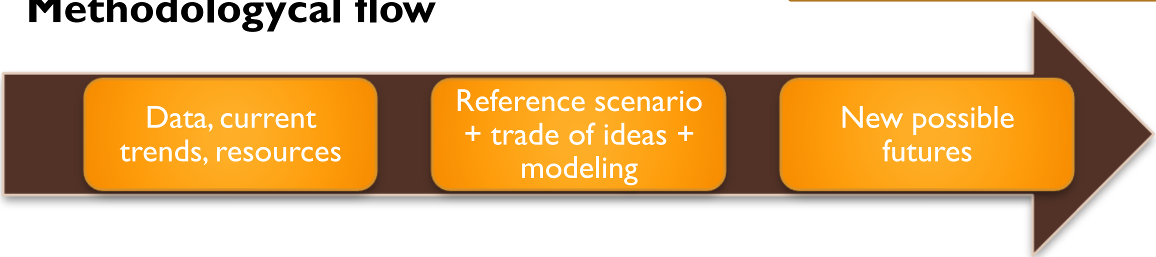
- Oil consumptions→ 50% 2005 level
- CO2 emissions → 50% 1990 level

Key aspects and scenarios

- Potential BSR energy resources
- Cleaned and more efficient technologies
- Diversification in energy mix
- Security of energy supply



Methodologycal flow



New future perspectives for the BSR energy changelles

Sustainable growth, competitiveness and security of supply

Reminder of scenarios analysis techniques

	Generating techniques	Integrating techniques	Consistency techniques
Predictive Scenarios			
Forecasts	Surveys	Time series analysis	
	Workshops	Optimisation models	
	Original Delphi metho		
What-if	Surveys		
	Workshops		
	Delphi methods		
Explorative Scenarios			
External	Surveys		al field analysis
			Cross impact
	odified		
		Optimisation models	Morphological field analysis
		System dynamics	
			ysis
		System dynamics	
Transforming	Surveys		
	Workshops	Optimisation models	Morphological field analysis
	Backcasting Delphi	System dynamics	

Based on historical values and trends. Forecasts are produced by extending the curves up from the past to the future using the same past equations to generate values.
The same structure of the past/system is reproduced into the future

Mathematical structures in which, typically, the objective functions express the cost minimization or maximization of benefits in energy system analysis. Widely used in the energy sector are MarkAL and TIMES (The Integrated MarkAl-Efom System)

Comprehensive and dynamic approach to solve complex systems (internal feedback loops, time delays, stocks, flows,etc.)

General review of energy modeling

An example of classification of types of models is follow represented [Jebaraj, 2004]:

- energy planning models
- energy supply–demand models
- forecasting models (commercial energy models, renewable energy models, etc.)
- emission reduction models
- optimization models (MARKAL/TIMES, OSeMOSYS, PRIMES, EFOM, MESSAGE, etc.)
- models based on neural network and fuzzy theory

Modeling tools allow to conduct numerical and technical studies for the development of the energy system analyzed

STREAM Energy Model

Sustainable Research and Energy Analysis Model

General aspects

- STREAM model is the model tool used in the BSR project to quantify scenarios and give them a structure and credibility in the analysis.
- Use and development of the model in such field renders credible and transparent results and assures a climate of dialogue for solving different problems in the energy field.
- STREAM model uses a bottom-up approach, so the user defines endogenous variables and inputs the demand of energy for the future, e. g. the district heating share in the residential sector or the usage of biofuels in future cars, and the model calculates the supply side, such as the operating hours of each technology.

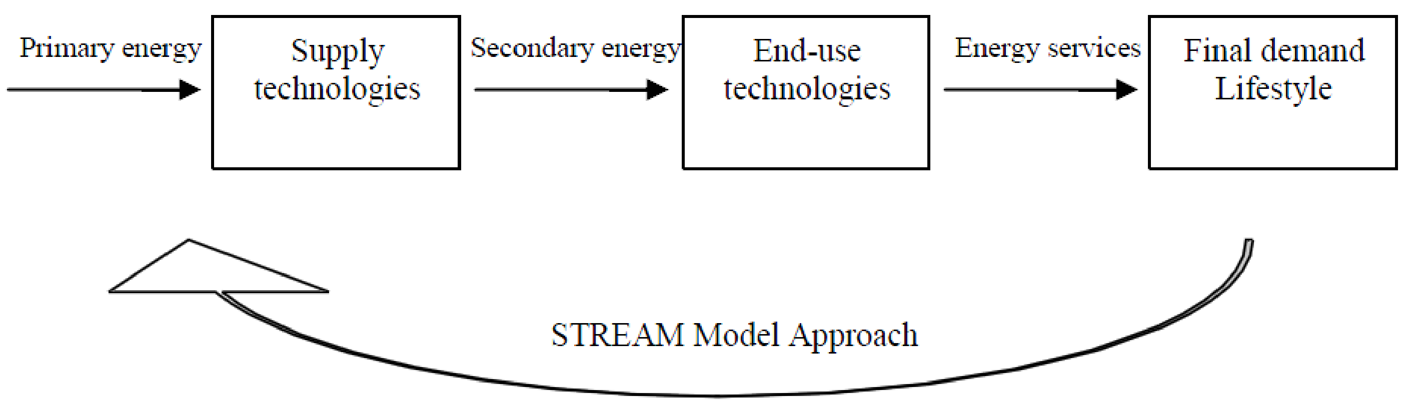
Origin and projects

- STREAM model was initially developed to support the debate, in a quantitative and scientific way, on the development of the Danish energy sector. The framework of its construction was collaboration and cooperation of different players, such as universities, energy consultants, transmission system operators and energy companies.
- The model was created for the "Future Danish Energy System" project carried out by the Danish Board of Technology from 2004 to 2007 in cooperation with Risø DTU, Energinet.dk, EA Energy Analyses, and DONG Energy researchers and experts.
- It was used and further developed in the project "Future Energy Systems in Europe - Scenarios towards 2030" commissioned by STOA (Scientific Technology Options Assessment), which is the European Parliament's Scientific and Technological Options Assessment unit, and carried out by Danish Board of Technology in conjunction with EA Energy Analyses, Denmark and Risø National Laboratory for Sustainable Energy/Technical University of Denmark. Finally, it has been used for the definition of an "EU strategy for the Baltic Sea Region" for the Baltic Development Forum.

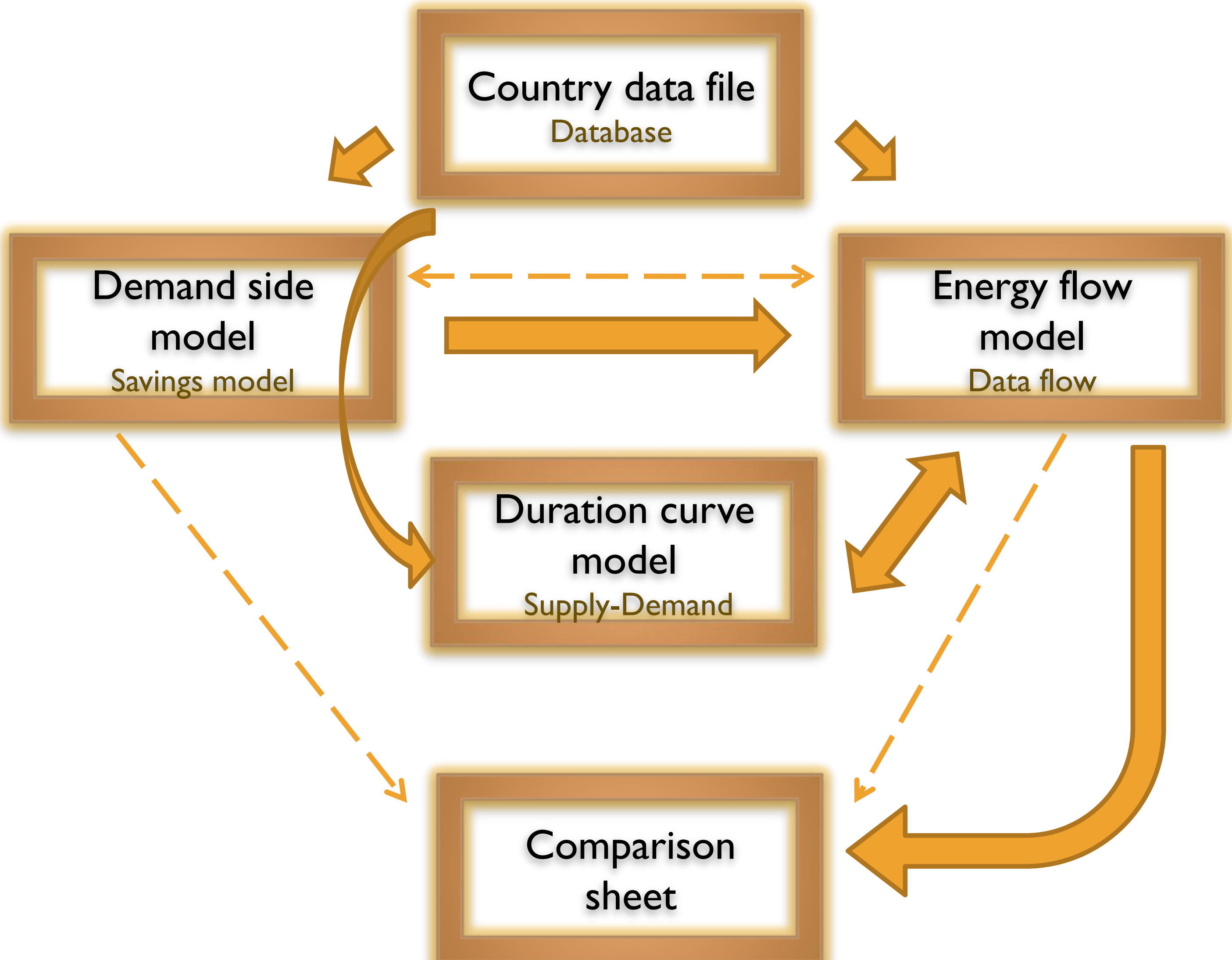
Energy chain of the model

•In the STREAM Model the main idea is to explore new possible scenarios for the whole future energy system and to make comparisons of the results by defining the future energy demand for each energy system sector of one or more regions, assuming technological future situations (efficiency improvements and introduction of new technologies in the future energy market) and establishing an energy sector growth for each region linked to economic indicators.

•The uncertainties and limitations of energy planning are mostly connected to the assumptions that were made during the modeling of each part of the energy chain (below).



STREAM structure

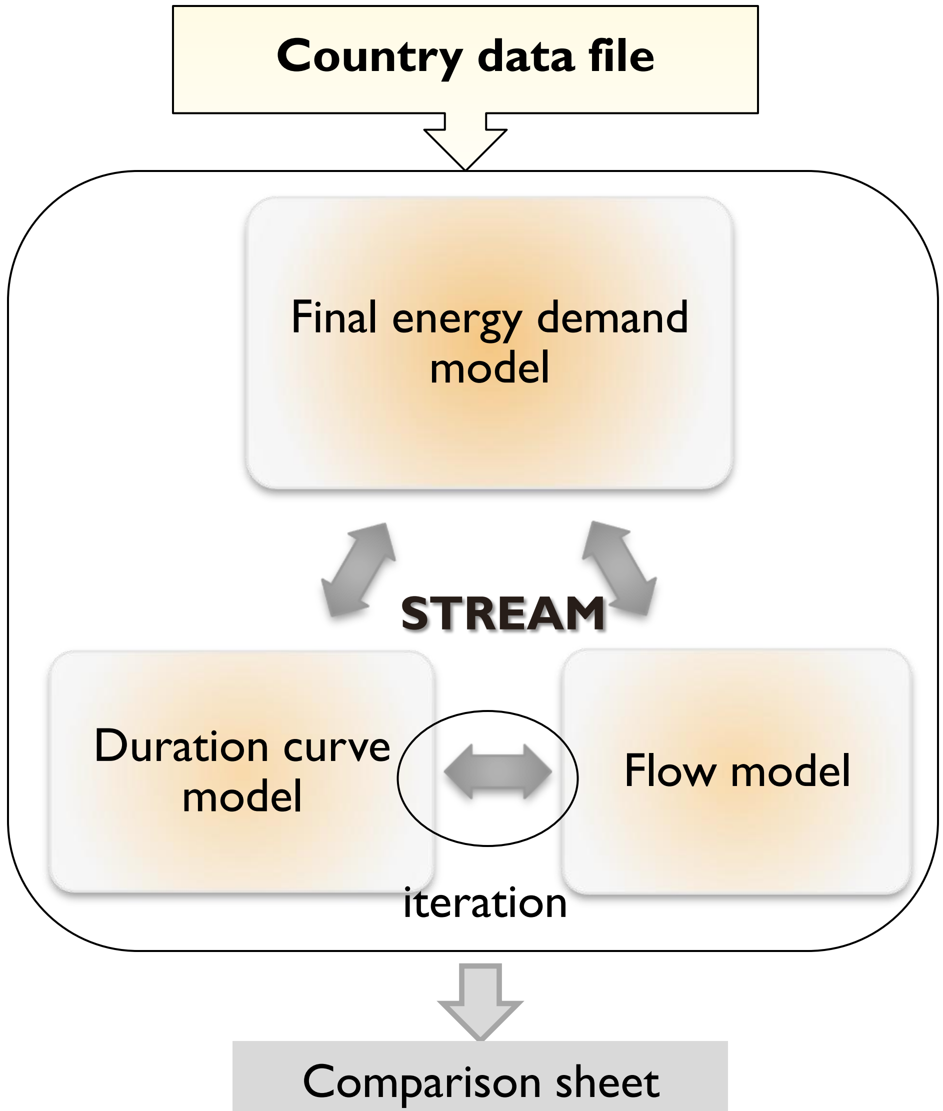


STREAM energy model

Sustainable Research and Energy Analysis Model

Input

- Energy final demand
- Energy sector growths
- Technological actual efficiencies and improvments
- Energy conversion and emission factors
- Fuel and CO2 prices
- Energy balance and transport current data
- Times series of energy consumptions and generations
- Potential resources



Output

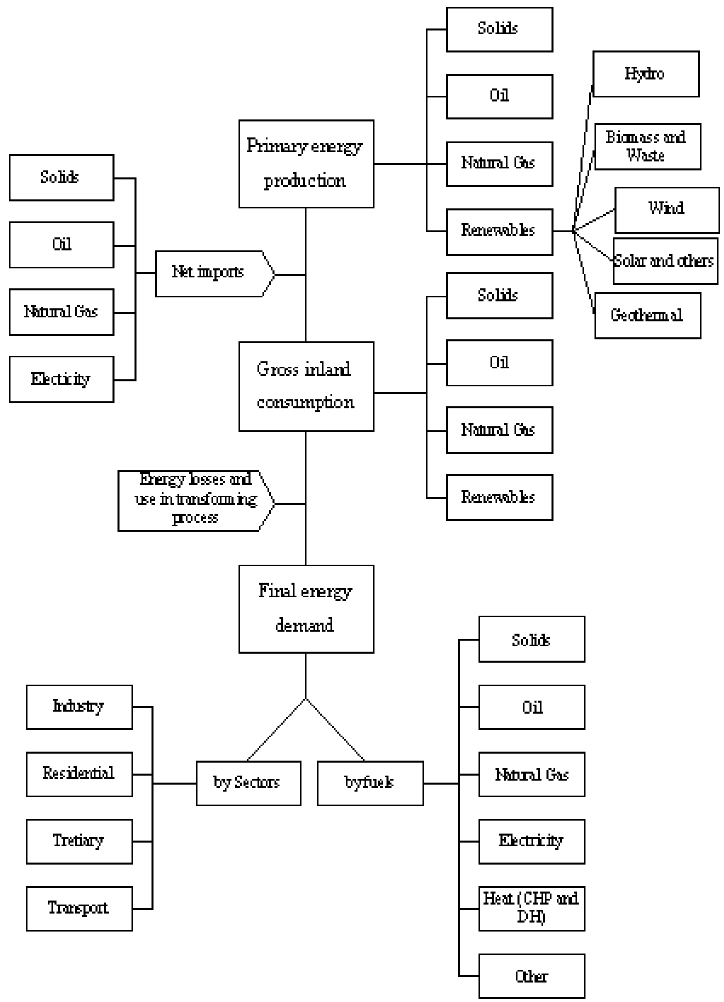
- Energy supply system
- Scenarios of energy system balances
- How the heat and electricity system will work to 2030
- Economic evaluations
- Indicators of system efficiency
- Possible exports of electricity

STREAM – mean features

- STREAM model is able to deal with energy system as a whole but not a specific part of it. It means that it is able to give generic results for the whole system but its disadvantage is that it is not able to focus on a specific problem, such as electricity grid interconnections between different states, which are better modelled by models like Balmorel, MarkAl or others.
- It is not an optimisation model, so it is not able to give minimum-cost solution, but it is used for making different scenarios that can delineate interesting results and comparisons.
- The improving of efficiency in the end-use technologies or the possibility of new fuels utilizations, such as in the transport sector, has been analyzed and the assumptions are really important for the results of scenarios, but maybe, the most difficult choice is to decide how the lifestyle might change in the future. Changes in the lifestyle are able to radically transform the utilization of transport sector or to achieve more energy savings in the households. All of these aspects are included in the STREAM Model and have been dealt with in the BSR project.

Country data file

It takes into account the whole energy system



- Input info
- Economic informations
- Possibility of aggregations
- EU 27 and other for possibility of aggregations
- Enerdata, DGTrends outlooks, IEA
- Form1990 to 2005
- Transport data
- Baseline scenario 2030 (models PRIMES e ACE e altri)
- Energy and efficiency indicators
- Emissions
- Risoe waste model data
- Green X, EIA e other indicators
- Hour demand profile

Country data file

- The historical data and forecasts come from ENERDATA database, IEA and DG Trend outlooks.
- The municipal waste energy forecasts are drawn by a specific Risø model [Andersen, 2006].
- BASELINE Projection: the "European Energy and Transport Trends to 2030" outlook was built in an integrated approach by linking energy supply and management of demand. It contains a baseline projection of the energy and transport sector to 2030, based on the current market trends and existing policies. The main key assumptions are:
  - the world energy prices develop moderately for the next 30 years;
  - economic modernisation, technological progress and existing sustainable policies will continue;
  - future fuel efficiency agreement with the car industry and the decisions of phasing-out of nuclear production in certain EU countries;
  - no new policies for reduction of greenhouse gas emissions;
  - not ambitious GDP growths in macro-economic field, similar to the historical values.
- The results of DGTrends outlook came from a quantitative analysis, developed by PRIMES11 and ACE mathematical models, and a qualitative analysis, developed by the communication and cooperation with energy experts and diverse organisations. It can be noted that in the DGTrends analysis the projections of fuel prices utilised were not as high as the forecasts of today and for that reason the baseline DGTrends scenario could be more conservative compared to other more actual estimations.
- DGTrends projections have been done for EU countries and also for Norway, since it is included in the EU economy as active part of it, but not for the North-western part of Russia. Thus, for Russia the main sources have been "Russia Energy Strategy for 2020" and IEA forecasts.
- Russia case: in this project it was very difficult to obtain reliable data for the North-western part of Russia. The reason behind the low data availability could be a political-economic decision of Russian Federation not to spread a lot of information abroad.

Country data file

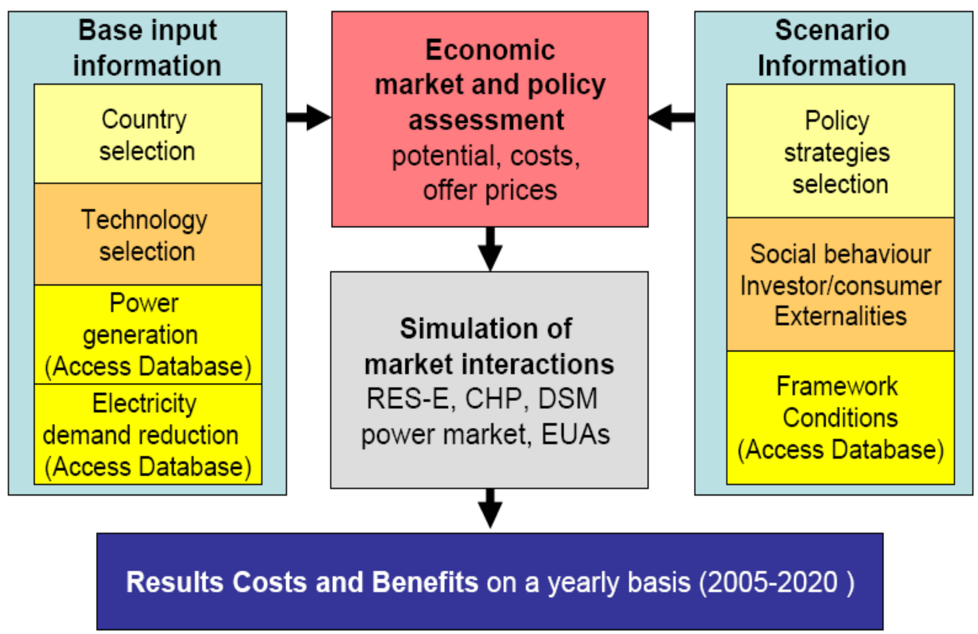
Renewable Potential Resources

- European Environmental Agency

  Biomass levels data referred to environmental impact on the site

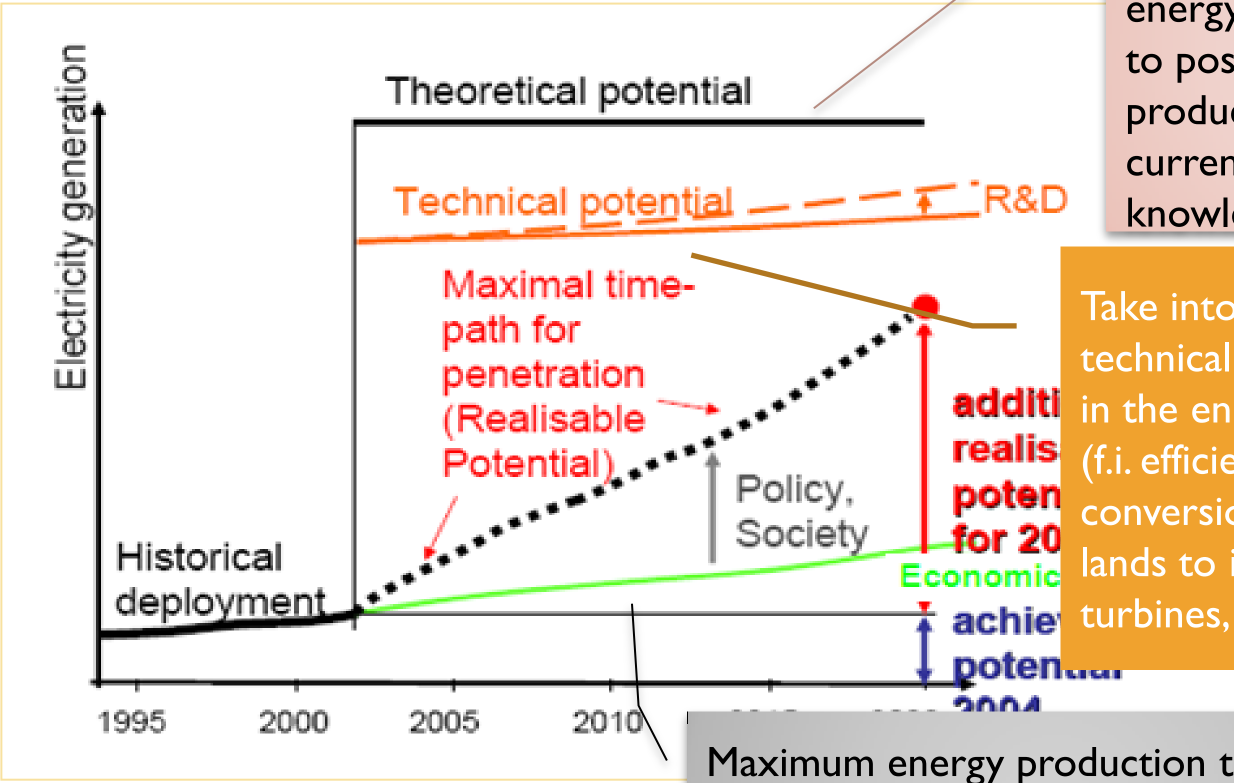
- Green X project

  Identification of the development of renewable electricity in the EU countries taking into account different aspects, barriers and limitations (f.i. cost-resource curve, experience curve of production decline, technology diffusion curves)



Country data file

- Green X project - REpotential



It is the upper limit of usage of a renewable energy resource in relation to possible energy production from it at the current level of scientific knowledge

Take into account the technical process conditions in the energy production (f.i. efficiencies in energy conversion or the available lands to install wind turbines, etc.)

Maximum energy production taking into account all existing technical and economic barriers

Demand side model

- DSM aims at defining the demand for energy services in the scenario year of analysis (in this case 2030).
- Calculation of the end-use energy consumption by sector and fuel.
- The demand for energy services follows a factor given by the multiplication of economic growth and energy intensity.
- Case of projections in "frozen efficiency" (end-use energy consumption in 2030 if no energy savings with respect to the actual situation).
- Reference and Scenario cases (2030) based on percentages of savings.
- The energy demand is divided between four sectors, which are residential, tertiary, industrial and transport, and each of them is associated to different savings related to different appliances or processes.
- Original savings evaluations based on Denmark potential savings percentages come from the "Action plan for renewed energy savings and market measures" report, Danish Energy Authority, December 2004.
- The model gives also the possibility of choosing the distribution of person and good transport work, since the users define the share of the different fuels, as also hydrogen or ethanol, in each mean of transport.

Demand side model

Residential, tertiary and industrial sectors

$$Frozen\ consumption = base\ year\ consumption \cdot (1 + Intensity\ factor \cdot Economic\ growth)^N$$

$$Scenario\ consumption = (1 - \%savings) \cdot base\ year\ consumption \cdot (1 + Intensity\ factor \cdot Economic\ growth)^N$$

Reference
Scenario step 1
Scenario step 2

Transport sector

$$Energy\ specific\ consumption\ 2030\left[\frac{TJ}{km}\right]_{i,j} = Energy\ demand\ 2005_{i,j} \cdot (1 - \eta_{tech_i})$$

$$Energy\ demand\ 2030\left[\frac{TJ}{year}\right]_{i,j} = Energy\ specific\ consumption\ 2030_{i,j} \cdot TFTD \cdot \%W_j \cdot \frac{\%U_{j\ 2005}}{\%U_{j\ 2030}}$$

$$TFTD[km] = base\ year\ consumption \cdot (1 + Intensity\ factor \cdot Economic\ growth)^N$$

$$Total\ energy\ demand\ 2030\left[\frac{TJ}{year}\right]_{i,j} = \sum_j \sum_i Energy\ demand\ 2030\left[\frac{TJ}{year}\right]_{i,j}$$

with i the fuels corresponding to a defined technology of conversion, j the different means of transport, Wj % the percentage of transport person or good work of each mean of transport and Uj2005/Uj2030 the share of the utilisation percentage in the beginning and last year of analysis of each mean of transport

Demand side model

- Examples

Fuel consumption	2005 TJ	2005 %	Frozen efficiency TJ	Frozen efficiency %	Ref_Scandinavia TJ	Ref_Scandinavia %	Scenario_WindScandinavia TJ	Scenario_WindScandinavia %
Electricity	**594227**	**24%**	**904366**	**25%**	**791273**	**27%**	**534223**	**30%**
- Appliances	279909		443152		330981		193266	
- Space heating	314317	14%	461213	14%	460292	18,00%	324721	20,00%
District heat	731002	33%	1072634	33%	767153	30,00%	568261	35,00%
Coal	202957	9%	297809	9%	153431	6,00%	32472	2,00%
Oil	233714	11%	342941	11%	76715	3,00%	24354	1,50%
Natural gas	405587	18%	595138	18%	639294	25,00%	292249	18,00%
Biomass	325398	15%	477472	15%	460292	18,00%	324721	20,00%
Solar Heating		0%		0%	0	0,00%	8118	0,50%
Heat pumps	0	0%	0	0%	0	0,00%	48708	3,00%
Total	**2492885**	**100%**	**3690359**	**100%**	**2888157**	**100%**	**1784397**	**100%**

Ref_Scandinavia — **Distribution of transport work**

2030		Electricity	Gasoline	Diesel	Natural gas	Ethanol	Methanol	Bio-diesel	Hydrogen	Total
Persons	TJ	%	%	%	%	%	%	%	%	%
Car	1.308.997	0%	50%	45%	0%	2%	0%	3%	0%	100%
Bus	111.606	0%	0%	95%	5%	0%	0%	0%	0%	100%
Train	28.147	70%	0%	30%	0%	0%	0%	0%	0%	100%
Aviation and ferries	247.667	0%	100%	0%	0%	0%	0%	0%	0%	100%
Total	**1.696.418**	**14.461**	**959.079**	**653.270**	**5.580**	**28.456**	**0**	**35.571**	**0**	**1.696.418**
		Electricity	Gasoline	Diesel	Natural gas	Ethanol	Methanol	Bio-diesel	Hydrogen	Total
Goods	TJ	%	%	%	%	%	%	%	%	%
Trucks and cargo vans	940.828			95%		0%	0%	5%	0%	100%
Train*	45.993	70%		30%		0%	0%	0%	0%	100%
Ship*	34.412			100%		0%	0%	0%	0%	100%
Air transport	0		100%			0%	0%	0%	0%	100%
Total	**1.021.233**	**23.423**	**0**	**950.769**	**0**	**0**	**0**	**47.041**	**0**	**1.021.233**
		Electricity	Gasoline	Diesel	Natural gas	Ethanol	Methanol	Bio-diesel	Hydrogen	Total
	TJ	%	%	%	%	%	%	%	%	%
Transport total consumption	**2.717.651**	**2%**	**33%**	**61%**	**0%**	**1%**	**0%**	**3%**	**0%**	**100%**
	1,37	37.884	959.079	1.604.039	5.580	28.456	0	82.612	0	2.717.651
			2.563.118							

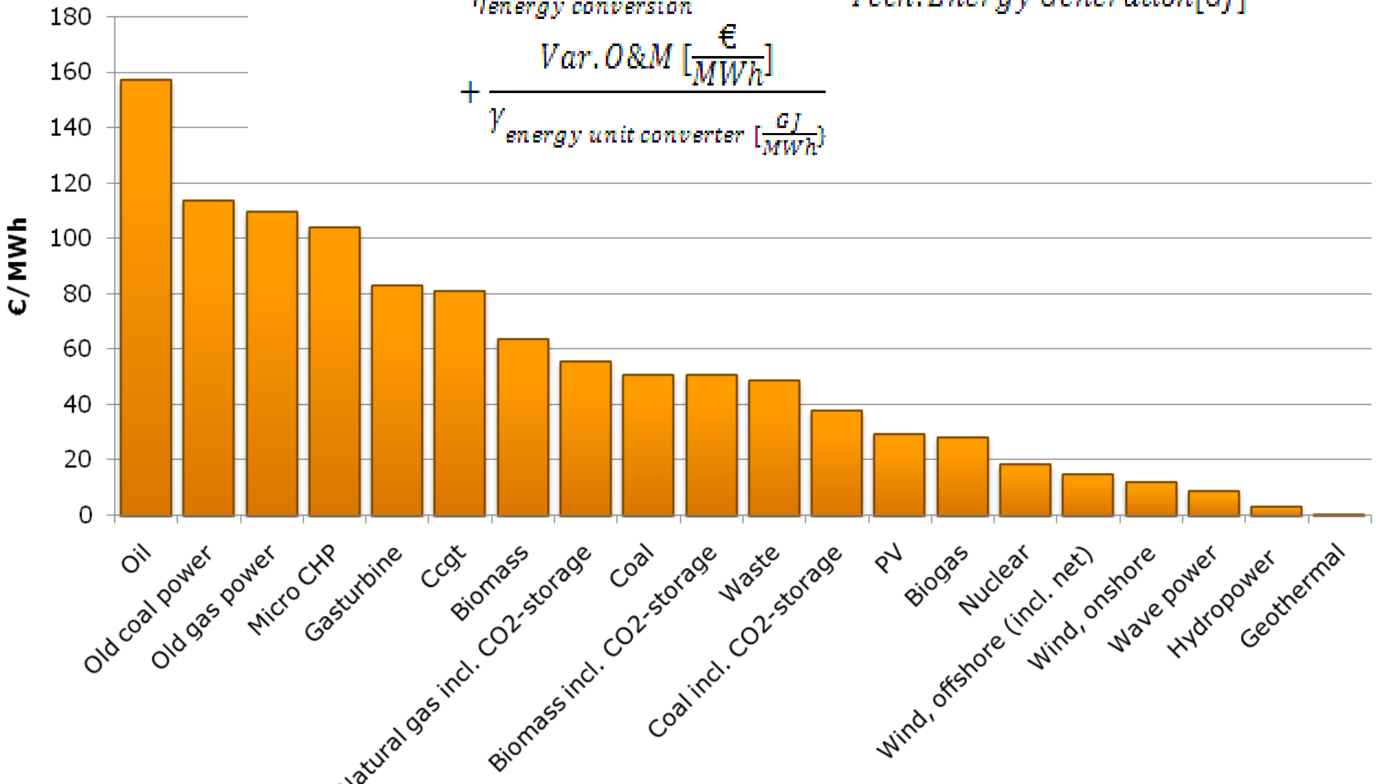
Energy flow model

- Purposes: to figure out fuel consumptions, achievement of environmental targets and economic evaluations of scenarios
- Definition of modality of demand satisfaction
- Technological park defined in relation to the different energy resources (fossil and renewable)
- Allocation of the different fuels in the electricity and district heating sector
- Energy system conversion/generation efficiencies for each area/region of analysis
- Loss and electric and thermal grid features and structures for each region
- Emission factors, pumps COP, other technical aspects, etc.
- Economical aspects and information

Energy flow model

Short-term marginal costs

$$SRMC\ [€/GJ] = \frac{Fuel\ cost\ [\frac{€}{GJ}]}{\eta_{energy\ conversion}} + \frac{Fixed\ O\&M \cdot Tech.Size\ \left[\frac{€}{MW}\right] * Tech.size[MW]}{Tech.Energy\ Generation[GJ]} + \frac{Var.O\&M\ [\frac{€}{MWh}]}{\gamma_{energy\ unit\ converter\ [\frac{GJ}{MWh}]}}$$

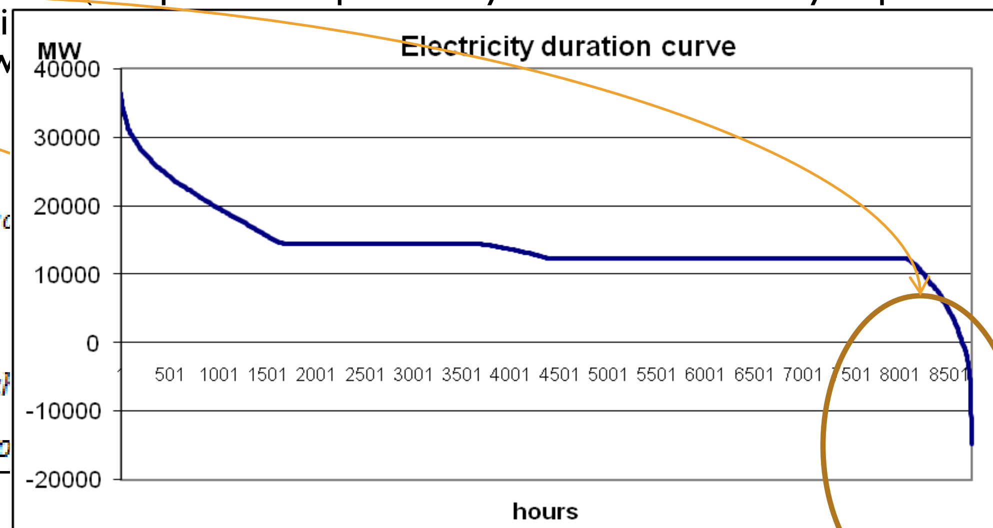


The users choose the conversion plant size [MW] and the corresponding investment price [€/MW], the technical lifetime of each technology [year], the energy conversion efficiency, the CO2 removal degree for CCS (Carbon Capture and Storage) plants and the fixed [€/MW/year] and variable [€/MWh] O&M (operating and maintenance cost).

Duration curve ↔ Flow

Iteration:

- the number of full load hours in the analysed year of each technology for heat and electricity production
- the share of condensing electricity production in the combined heat and power plants
- the potential electricity overflow (it represents a potentially enforced electricity export when the electricity producti[...] system, for example due to w[...]



- COGENERATION

$$Tot\ electricity\ in\ condensing\ production = \sum_i tot\ electicity\ pro\ldots$$

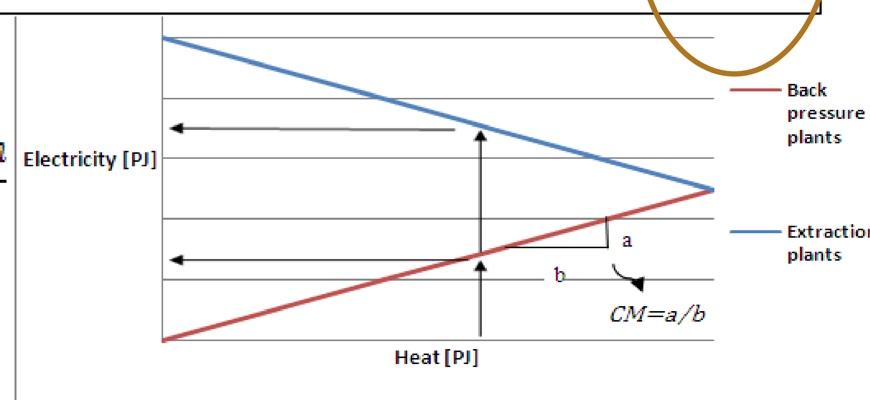
$$Tot\ CHP\ electicity\ production = \sum_i (Total\ electicity\ production\ tech\ldots$$

$$Tot\ CHP\ heat\ production = \sum_i \frac{CHP\ fuel\ consumptio\ldots}{\eta_{tot-chp_i} - \eta_{e-chp_i}}$$

$$CM\ value = \frac{Tot\ CHP\ electicity\ production}{Tot\ CHP\ heat\ production}$$

- EFFICIENCY CHP+Cond.+DH

$$\eta_{tot} = \frac{Total\ electricity\ and\ heat\ production}{Total\ fuel\ consumption}$$



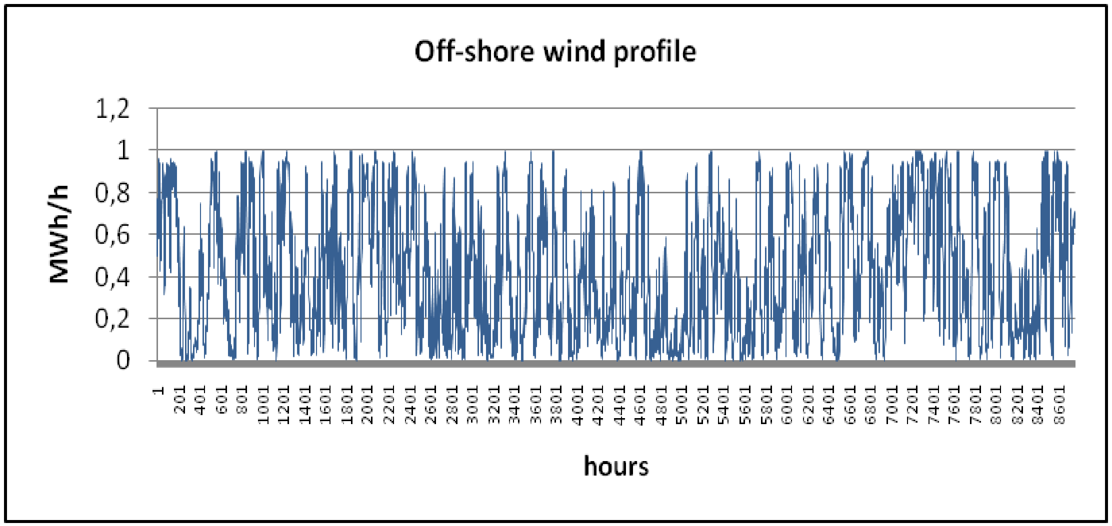
Duration curve model

- The duration curve model is a tool for analysing the energy supply system on an hourly basis in the scenario year considered.
- Duration curve model calculates the operating load hours of each technology, but, it does not operate a market optimisation for defining it. Calculations are based on a fixed priority of the technologies for heat production, and variable priority of technologies and fuel in the electricity production.
- Supply field is modeled by big technology blocks which aggregate the different technologies. Therefore the supply system is represented by a power plant, a heat plant, a combined heat and power plant, a heat storage plant, a heat pump plant, a heat boiler and a wind plant and also other plants for the remaining renewable technologies (PV, waves, etc.).
- The duration curve model is based on historic time series (hourly values in one year of reference) of electricity and heat consumption and energy generation (MWh consumed or generated for each hour of the year).
- The priority of energy production can be defined by the users as input data in the duration curve spreadsheet for some technologies and it is fixed by the model for the remaining technologies.
- Regolation of consumptions and generation flexibility into the system.
- This model allows visualising the electricity overflow that the system is not able to use and has to be exported to other regions, the share of condensing electricity production in the combined heat and power plants, the potential electricity overflow (the electricity overflow is an important result but it also highlights a model limitation, since it is not possible to establish a possible electricity trade market with the other regions but only to know this potential export of electricity).
- Output: Duration curves and chronological curve of production.

Duration curve model

Production profiles (wind example)

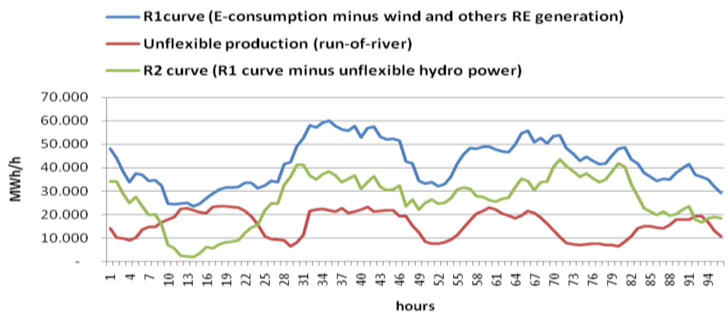
$$Hour\ Energy\ production\left[\frac{MWh}{h}\right]_i = Tot\ yearly\ production\left[\frac{MWh}{y}\right]_i \cdot \frac{Generation\ Profil\left[\frac{MWh}{h}\right]_i}{\sum_{i=1}^{8670} Generation\ Profil\left[\frac{MWh}{h}\right]_i}$$

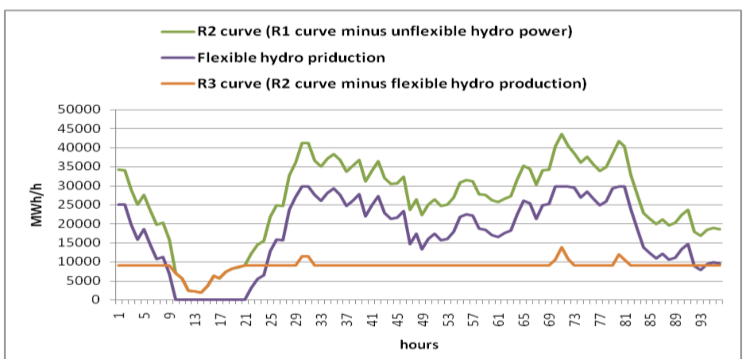


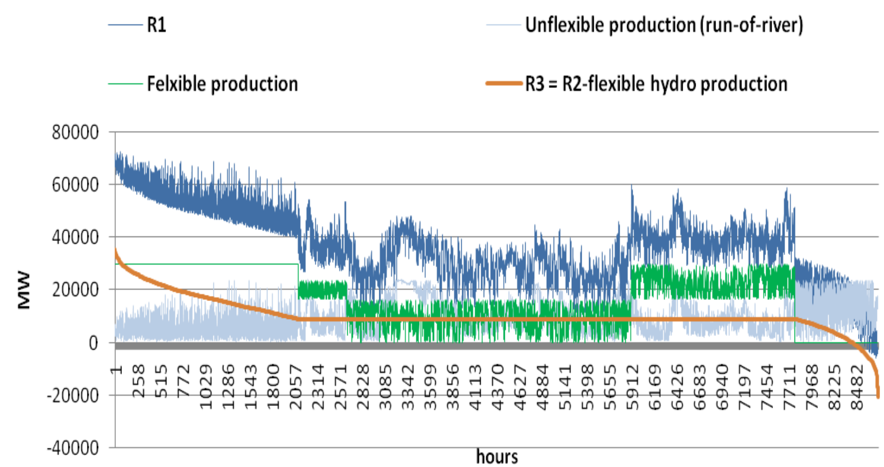
The integral of the profile curves, scaled on the effective installed capacity of each technology, gives the yearly energy generation.

Duration curve model

Hydro power example







Duration curve model

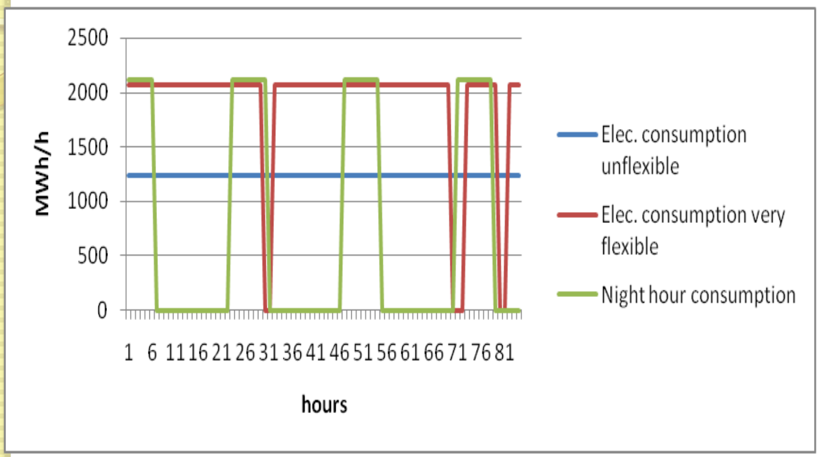
The duration curve model is able to distribute the electricity consumption from transport sectors, such as electrical vehicles, electrolysis, train service, according to the established flexibility of the demand for the services. Three cases of flexibility are considered and the percentage of them with respect to the total energy production is chosen by the users:

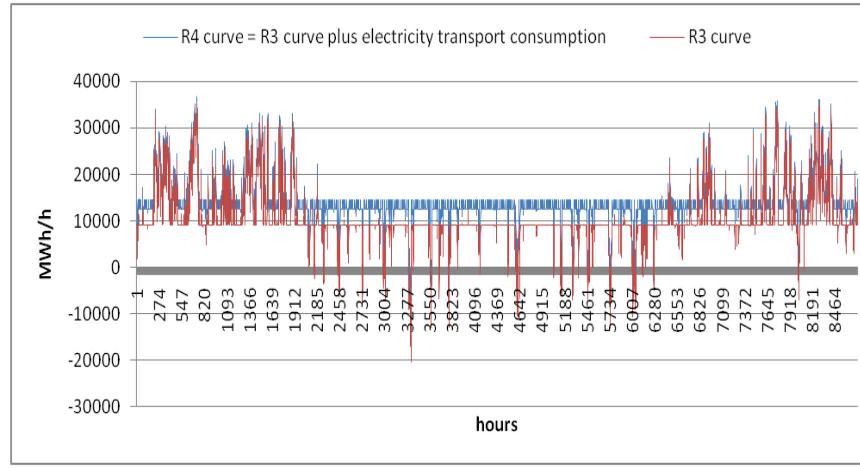
- unflexible production, distributed evenly on all hours of the year;
- very flexible production, when it is best for the system, so moving consumptions from the pick load versus when the system is not on pressure;
- night production, in the frame hours 23-06

The value of intersection defines the number of hours in which there is very flexible transport consumption.

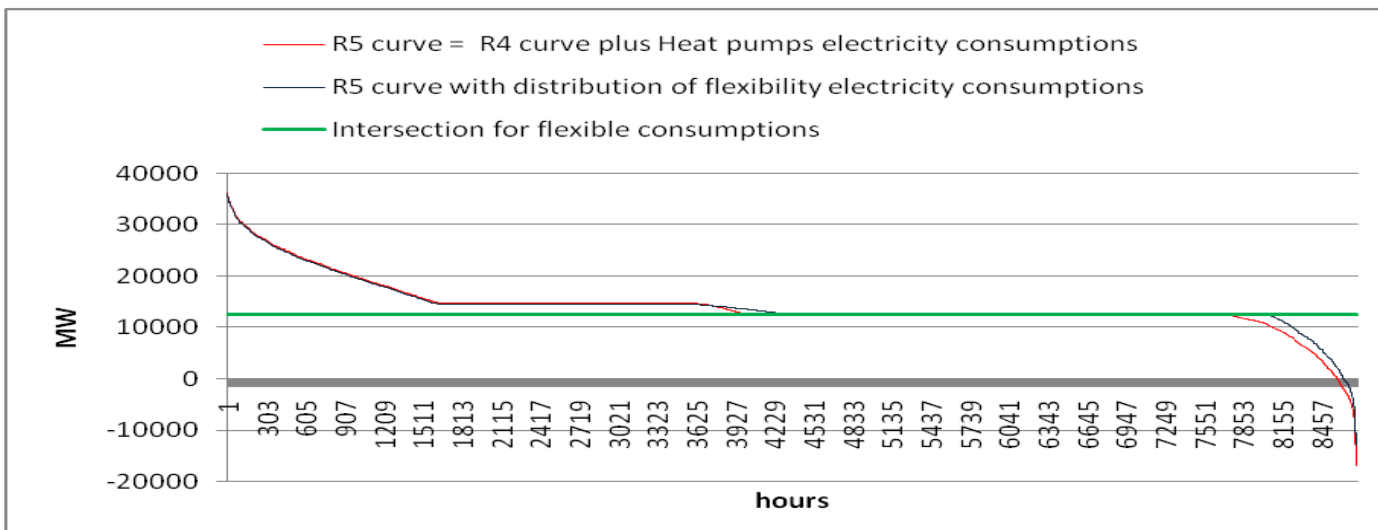
Duration curve model

Transportation flexibility



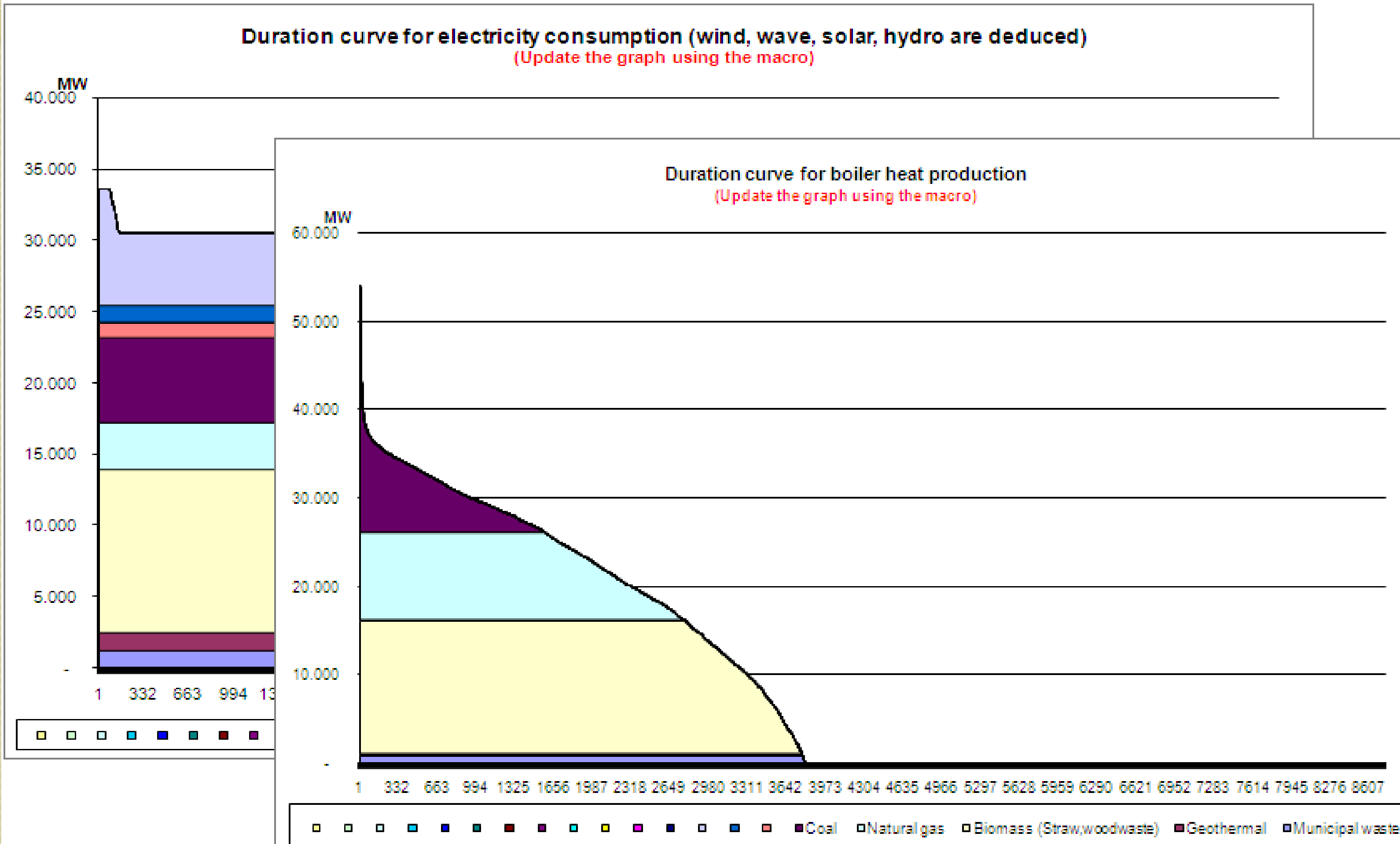


Flexibility on total electrical consumptions

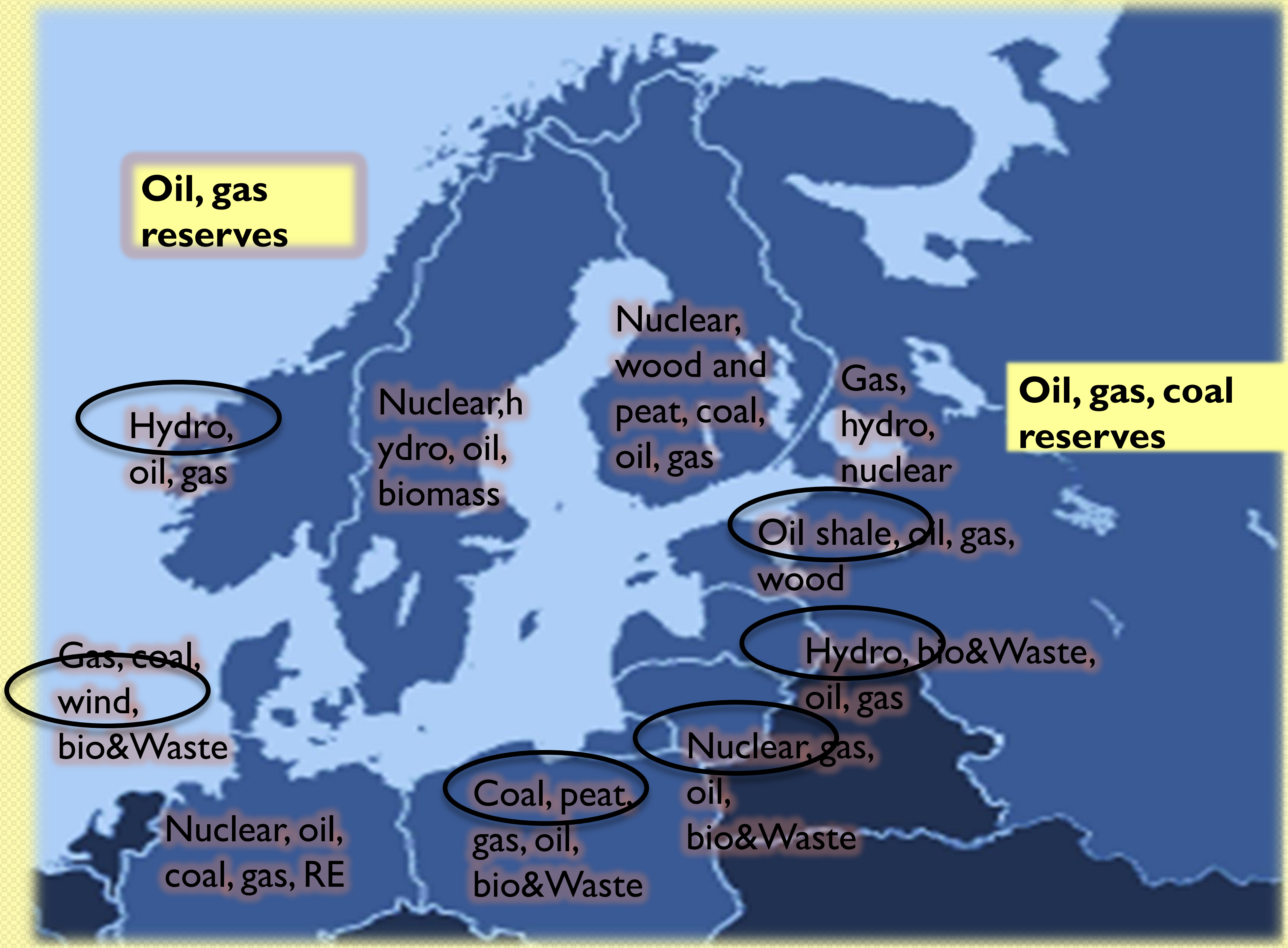


Duration curve model

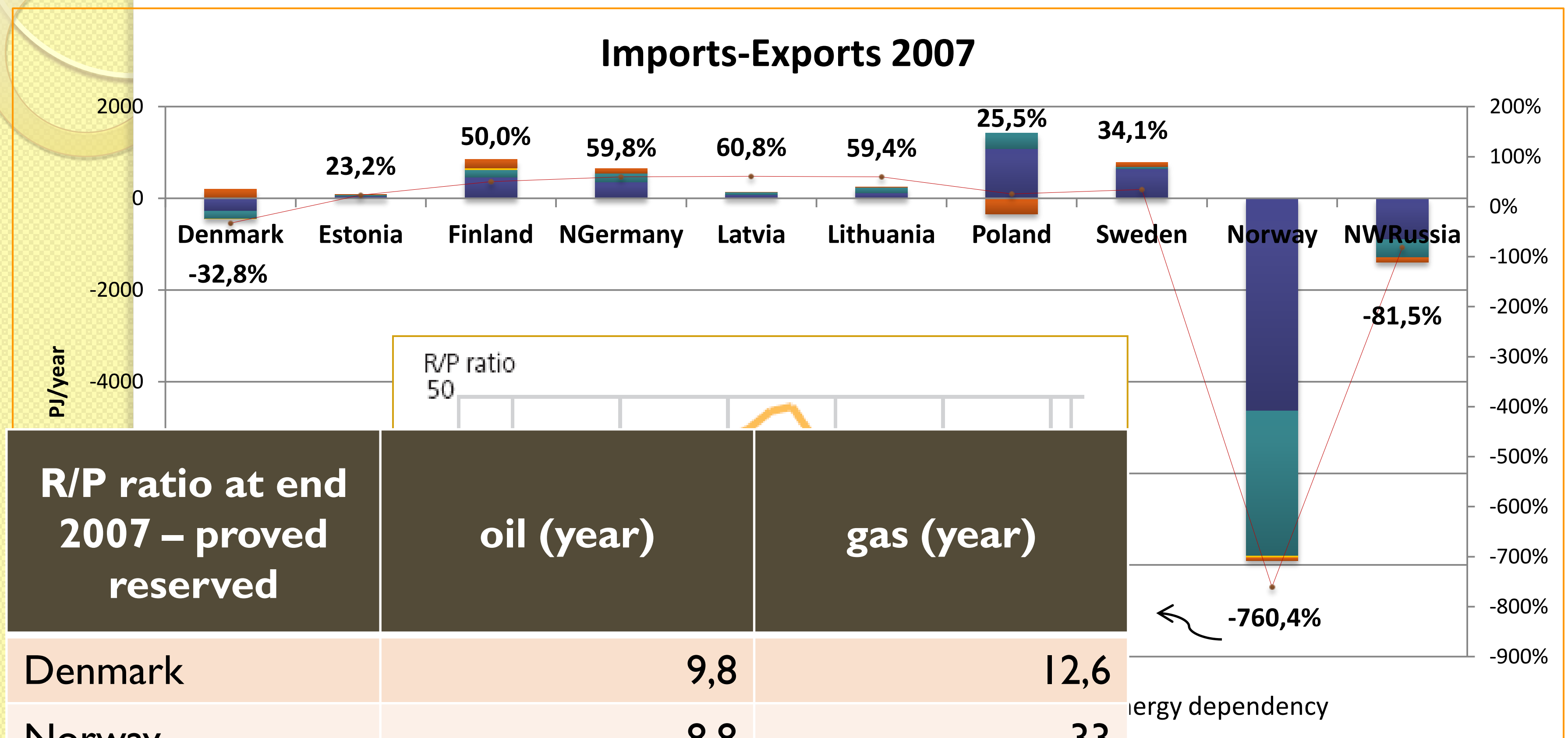
Duration curves - examples



BSR ENERGY SYSTEM - 2007



Security of supply

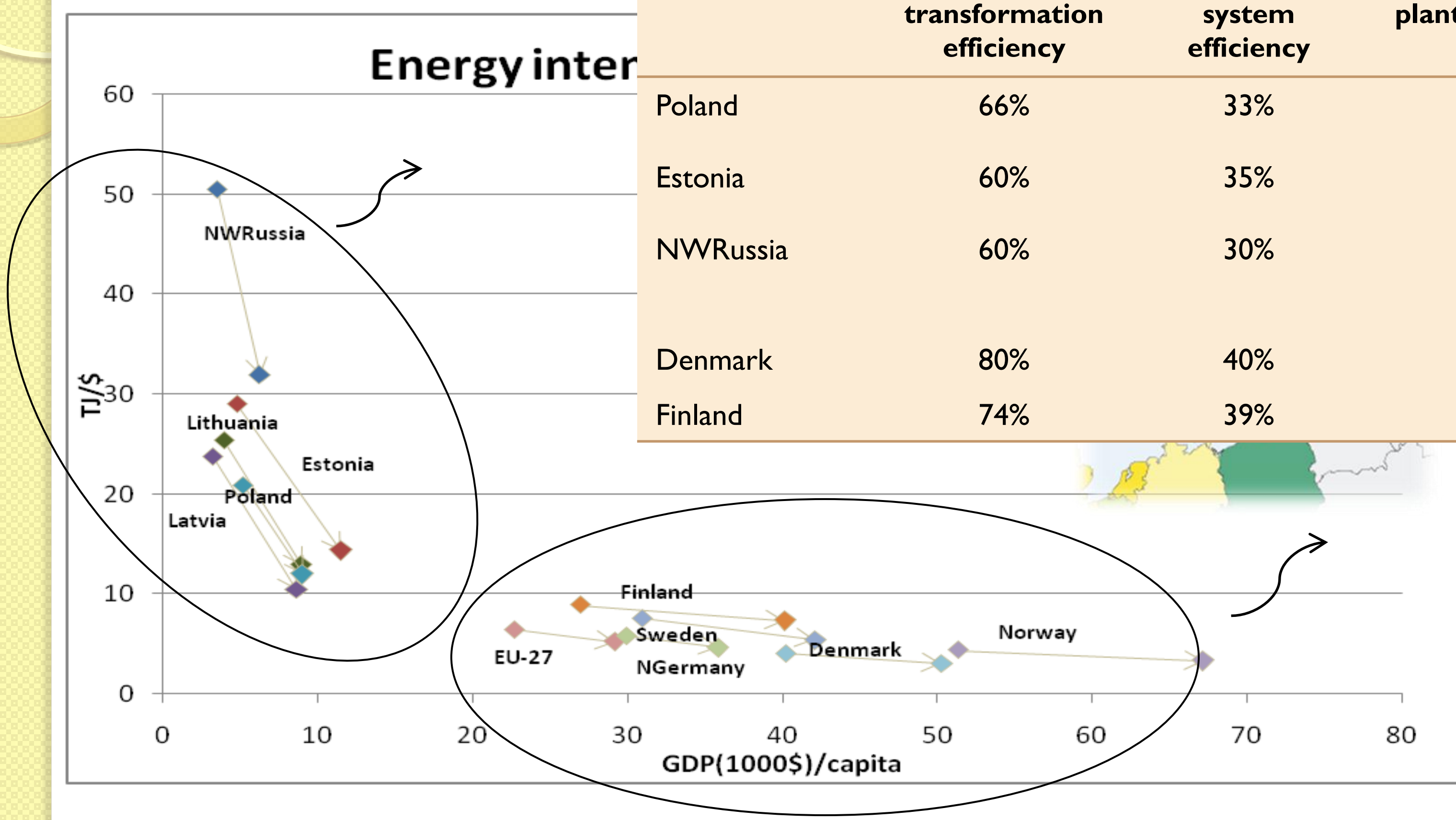


R/P ratio at end 2007 – proved reserved	oil (year)	gas (year)
Denmark	9,8	12,6
Norway	8,8	33
Russia	21,8	73,5

Source: Statistics Norway and Norwegian Petroleum Directorate
Source: BP 2008

Energy intensity

	Overall energy transformation efficiency	Electricity system efficiency	Thermal power plant efficiency
Poland	66%	33%	32%
Estonia	60%	35%	34%
NWRussia	60%	30%	25%
Denmark	80%	40%	35%
Finland	74%	39%	34%



Figure's Legend (Data2006)

Gross inland consumption of energy divided by GDP (kilogram of oil equivalent per 1000 Euro)

95.54 - 160.96

160.96 - 193.25

193.25 - 250.82

250.82 - 521.03

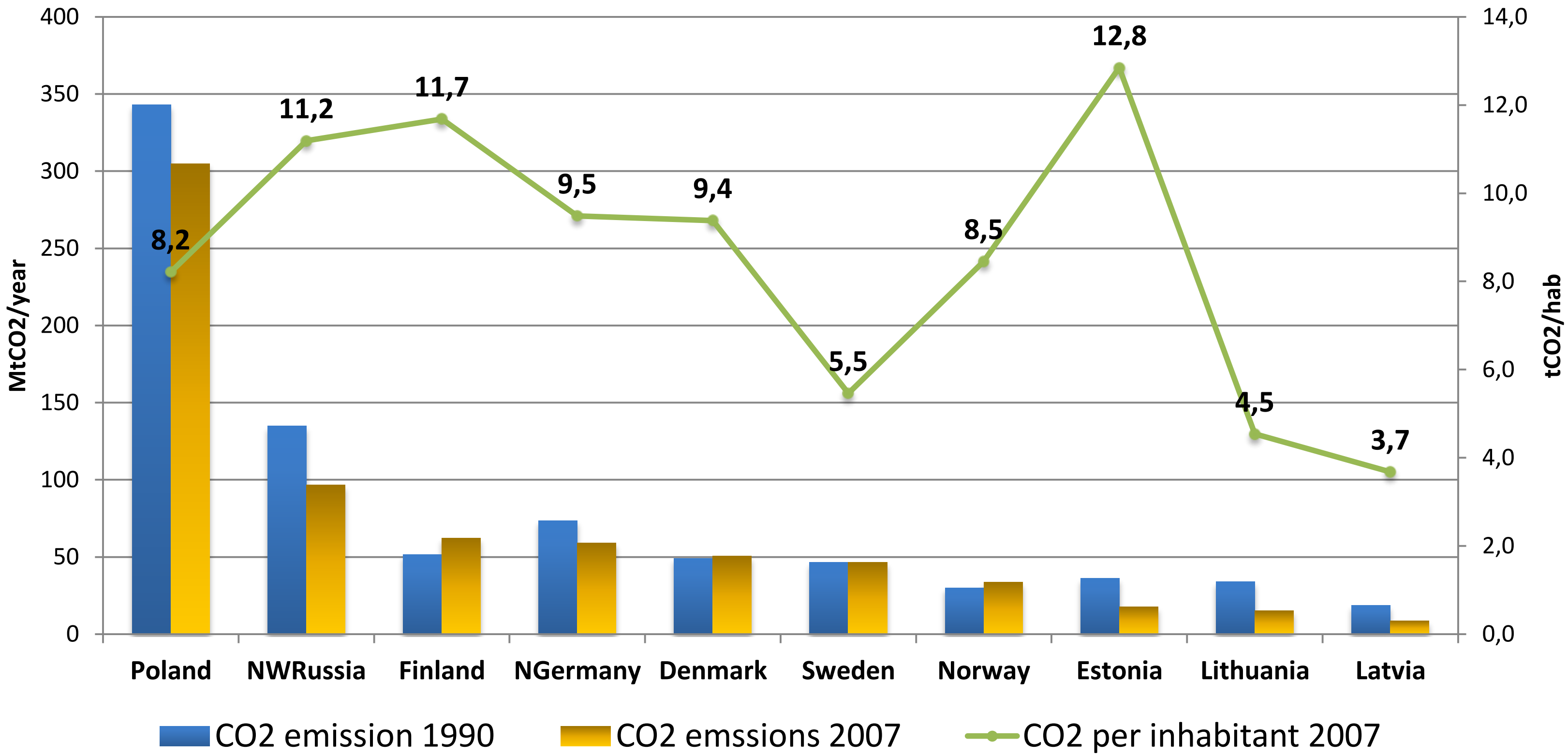
521.03 - 1554.01

N/A

Source: Eurostat, Enerdata - Global Energy & CO2 Data

CO_2 emissions

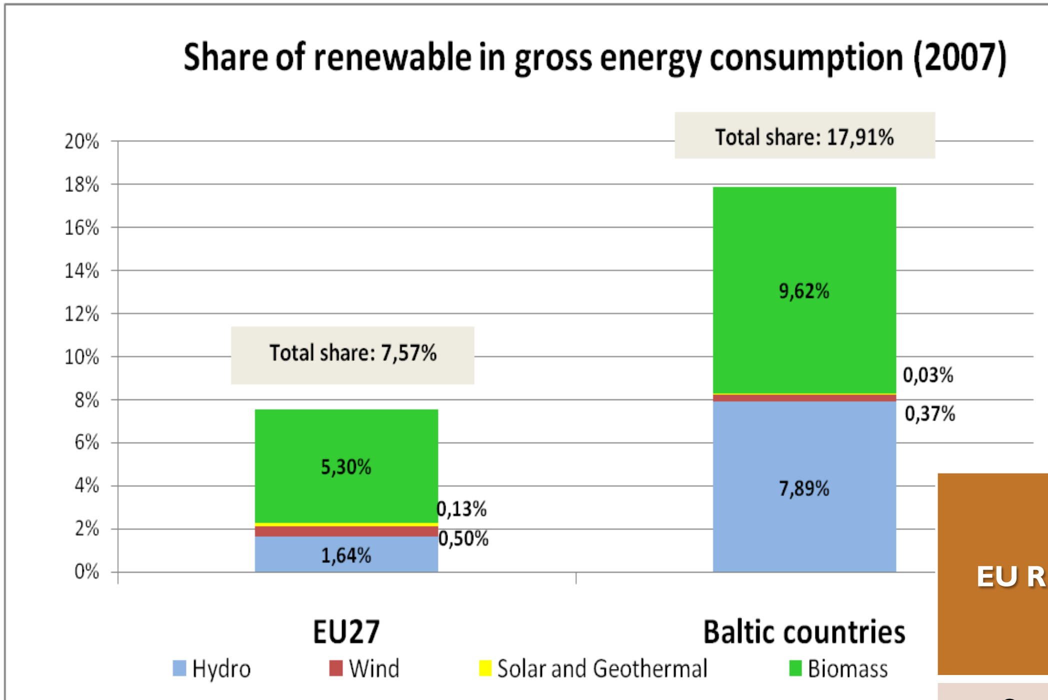
EU 27 level: 7,88 ktCO2/hab



Source: Eurostat, Enerdata - Global Energy & CO2 Data

*EU's BSR target: reduction of **21%** compared to 2005 level by 2030*

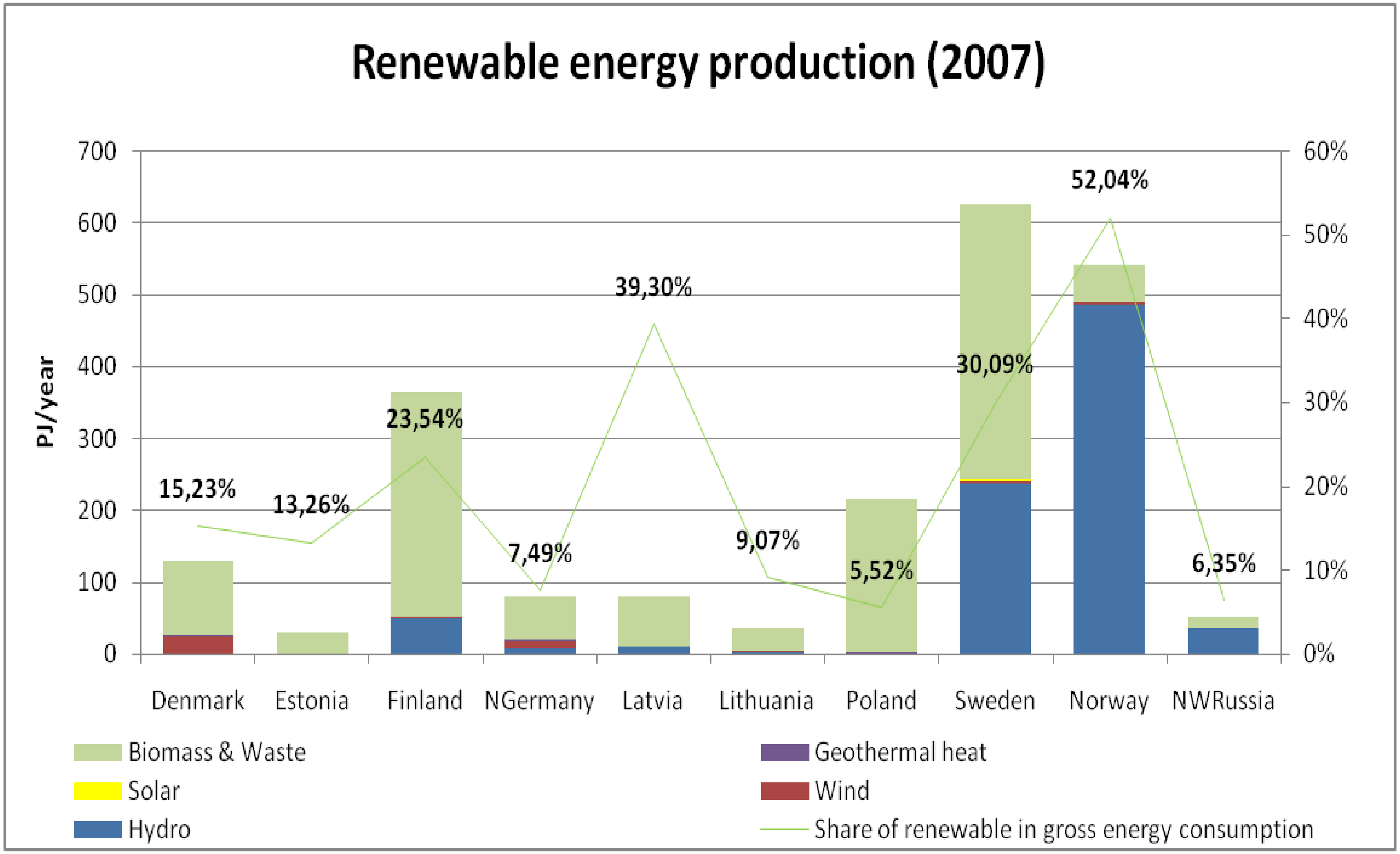
BSR Renewable production



EU RE goals	Share RE in the final energy demand 2005	Share RE in the final energy demand by 2020
Sweden	39%	49%
Latvia	35%	42%
Finland	28%	38%
Denmark	17%	30%
Germany	6%	28%
Estonia	16%	25%
Lithuania	15%	23%
Poland	7%	15%

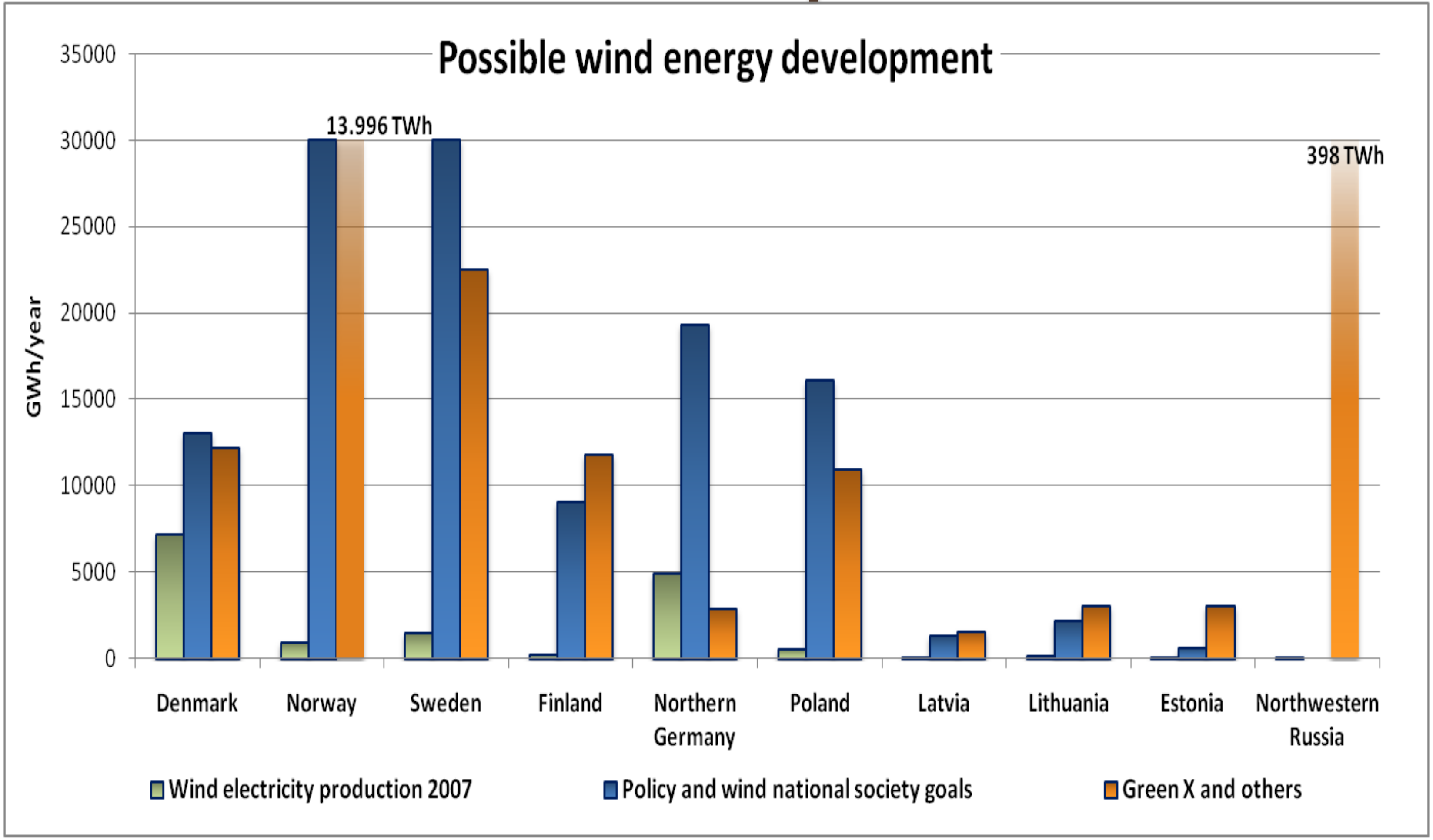
Source: Enerdata - Global Energy & CO2 Data

BSR Renewable production



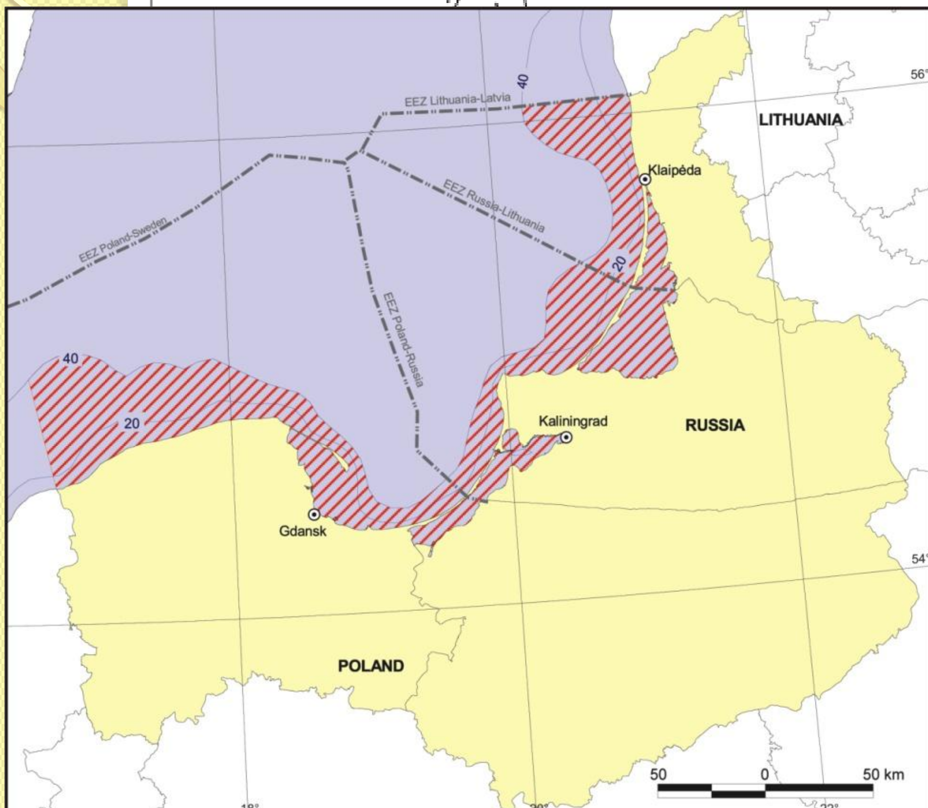
Source: Enerdata - Global Energy & CO2 Data

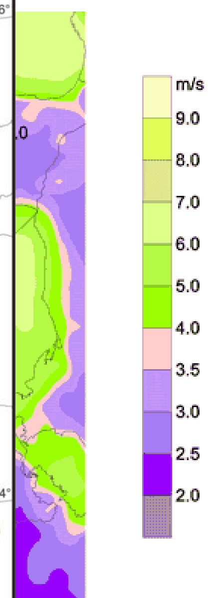
Wind BSR potential



Source: Enerdata - Global Energy & CO2 Data, Countries Governments, National Energy Society and Wind power Societies, IEA, Dimitriev, 2001, Enova and others.

Wind BSR potential





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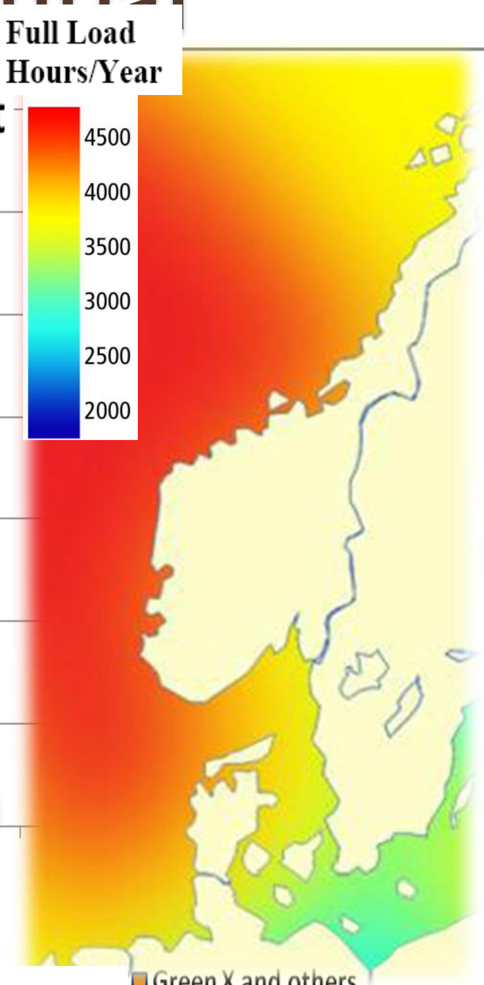
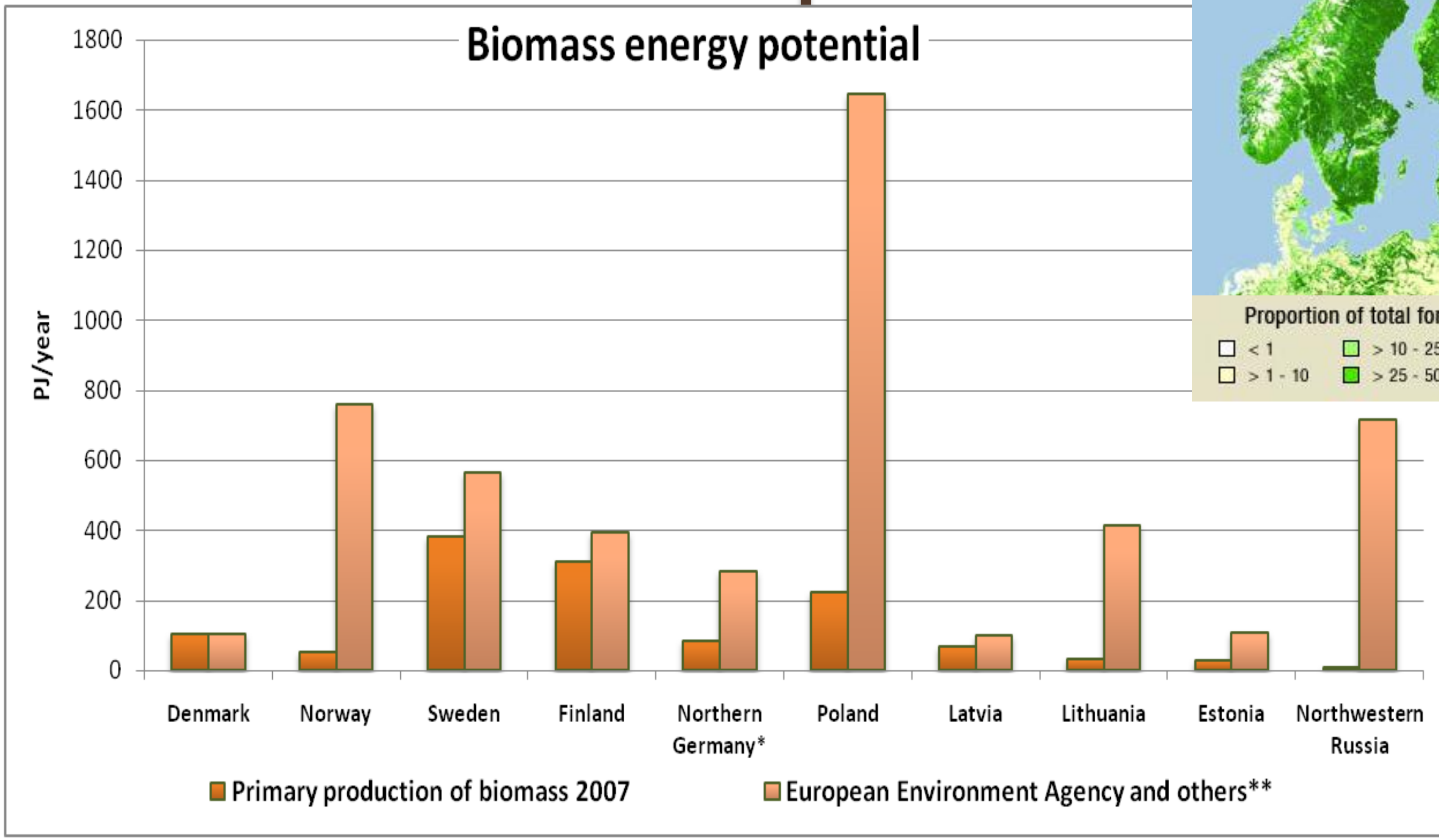


PERSPECTIVES OF OFFSHORE WIND ENERGY DEVELOPMENT IN MARINE AREAS OF LITHUANIA, POLAND AND RUSSIA

imitriev, 2001, Enova and others.

Biomass BSR potential

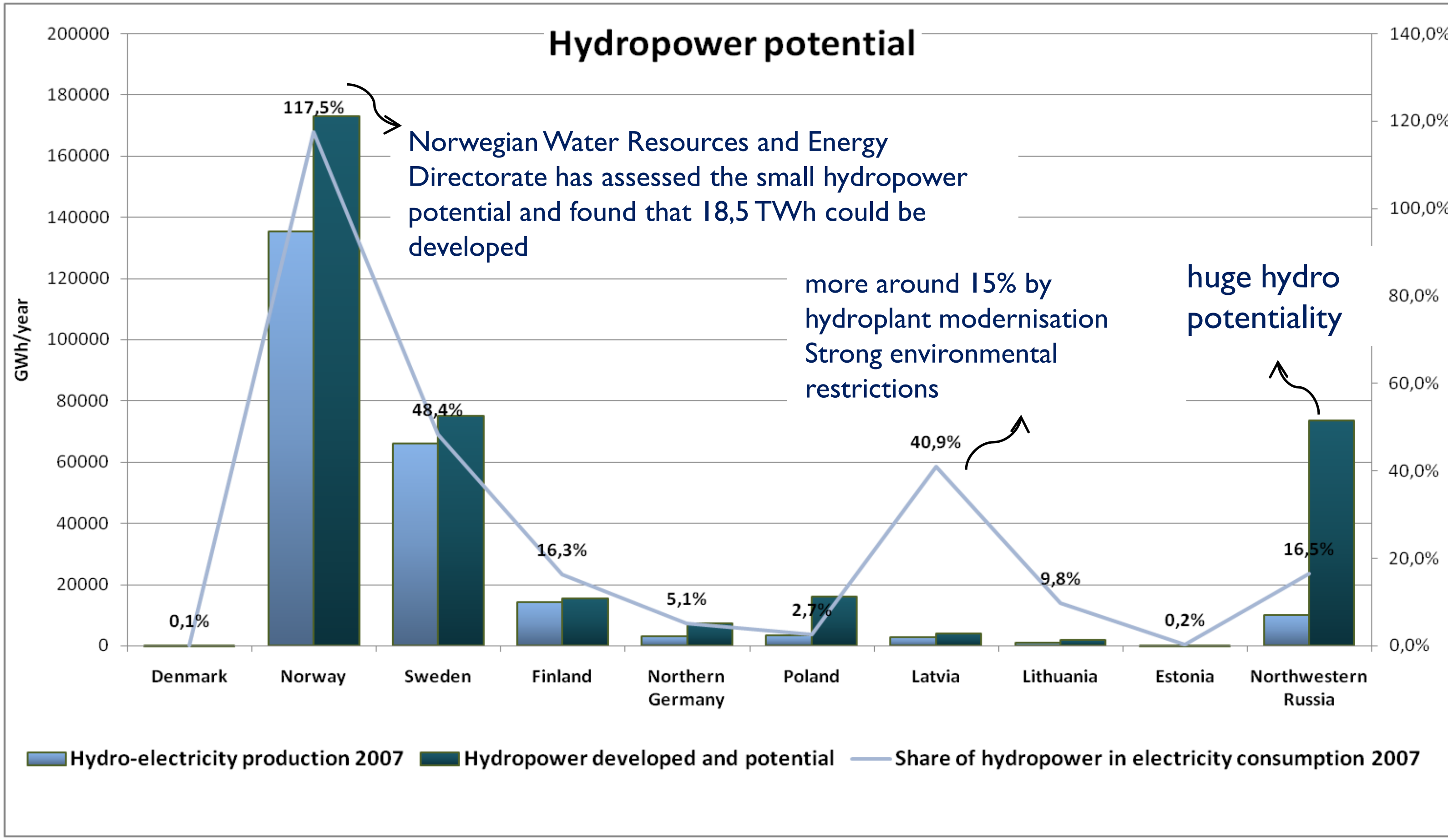


*by calculations respect to the whole nations data; ** EEA s includes as biomass a wide range of products and by-products from forestry and agriculture as well as municipal and industrial waste streams

Source: Enerdata - Global Energy & CO2 Data, European Environmental Agency, Finnish Forest Research Institute and others

Environmentally-compatible primary biomass potential
Current + increased shares of protected areas

Hydropower potential



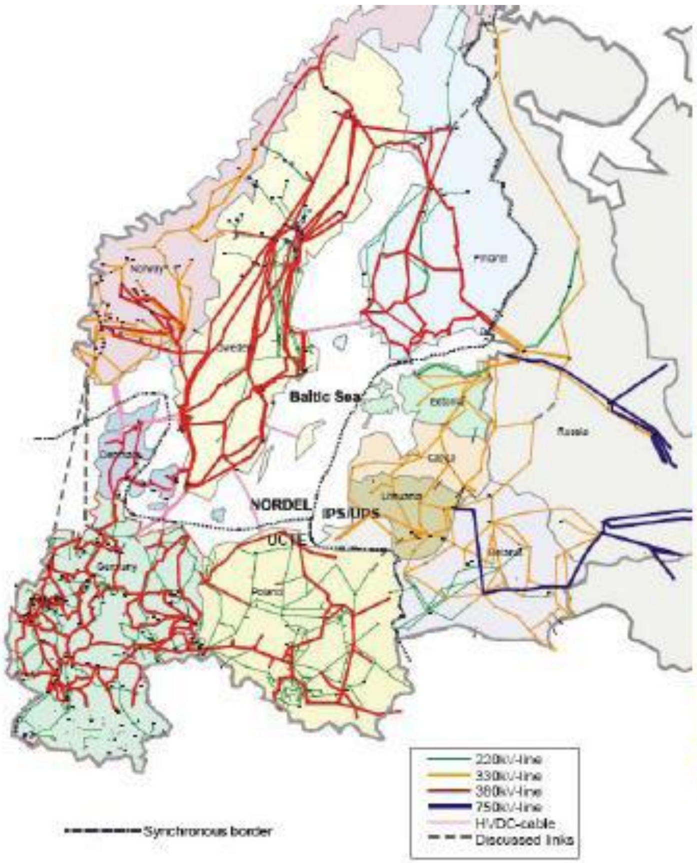
Source: Enerdata - Global Energy & CO2 Data,Green X, Elistratov, 2007 and others

MACROREGIONS

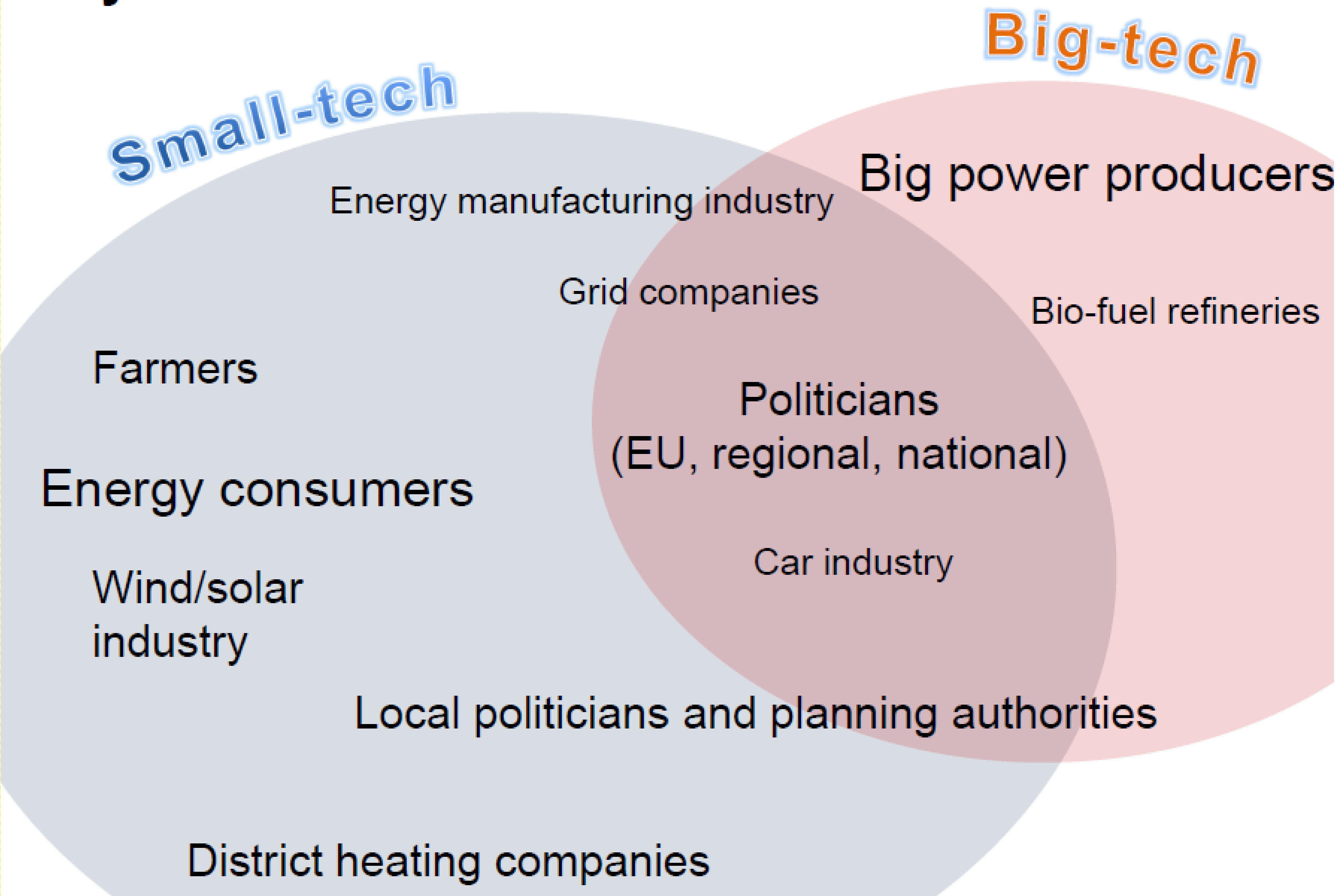
- Aggregation in connection with the actual trends of cooperation in the energy field
- Nordel, Baltso and political agreements
- North-western Russia case
- GDP Economic growth's assumptions

Regions	GDP Economic growth %				
	Tertiary	Industrial	Residential	Transport, person	Transport, good
Nordic countries	2,0	1,9	1,9	1,2	1,3
NGermany-Poland	1,9	1,5	1,7	2,5	2,6
LT-LV-ES	3,5	3,2	3,1	1,7	3,0
NWRussia	3,7	4,0	2,5	0,9	0,9

Grid infrastructures

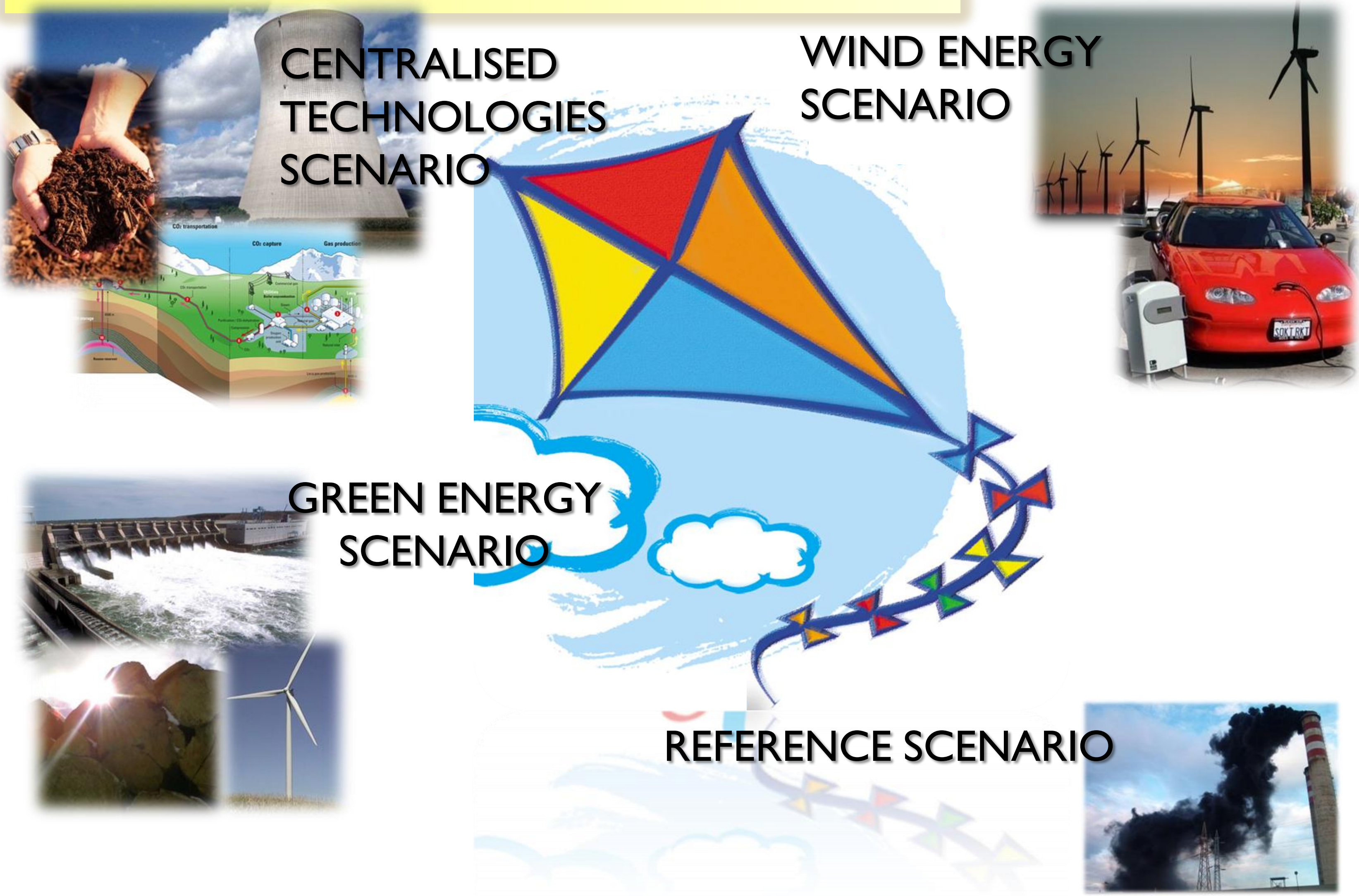


Key decision makers



Energy Scenarios

Oil target → **50% 2005 level by 2030**
CO2 emission target→ **50% 1990 level by 2030**



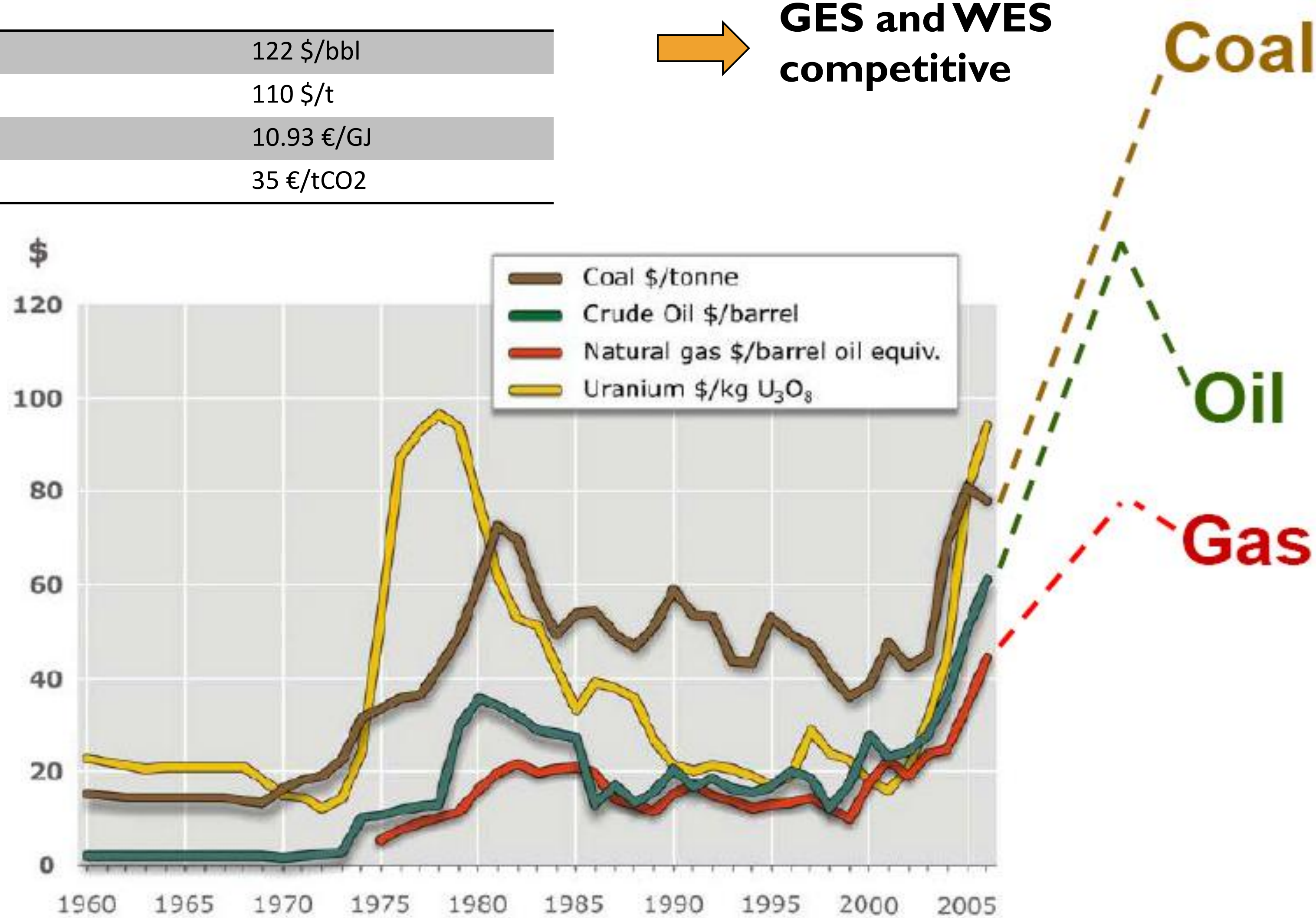
Scenarios features

Reference Scenario (RS)	Centralised (CTS)	Green (GES)	Wind (WES)
Future on the trail of the past	*Centralised energy generation solutions*	*Renewable energy exploitation*	*Wind development*
likely future	Spread of CCS plants	Energy savings measures	Energy savings (more than in GES)
No policies for achieving EU´s goals on climate change and renewable energy…but bussiness as usual	More nuclear generation compared to RS and no shutting down nuclear policies	Changes in transport industry	Changes in transport industry
Based on DGTrends and IEA assumptions for 2030	Use of coal, oil shale and other fossil fuels in relevant shares	Less of nuclear production compared to RS	Less of nuclear production compared to RS
	Biofuels and natural gas in transport sector	Security of supply by domestic resources	Security of supply by domestic resources and enhancing the grid
	High level of biomass in heat and electricity generation	Enhancing the electricity grid	
	No additional energy savings compared to RS	Political efforts towards sustainable development	Political efforts towards a sustainable development
		Biomass and hydropower exploitation	More flexibility in the electricity demand
		More district heating demand	Heat pumps and hydropower for balancing the electricity system

Fuel prices

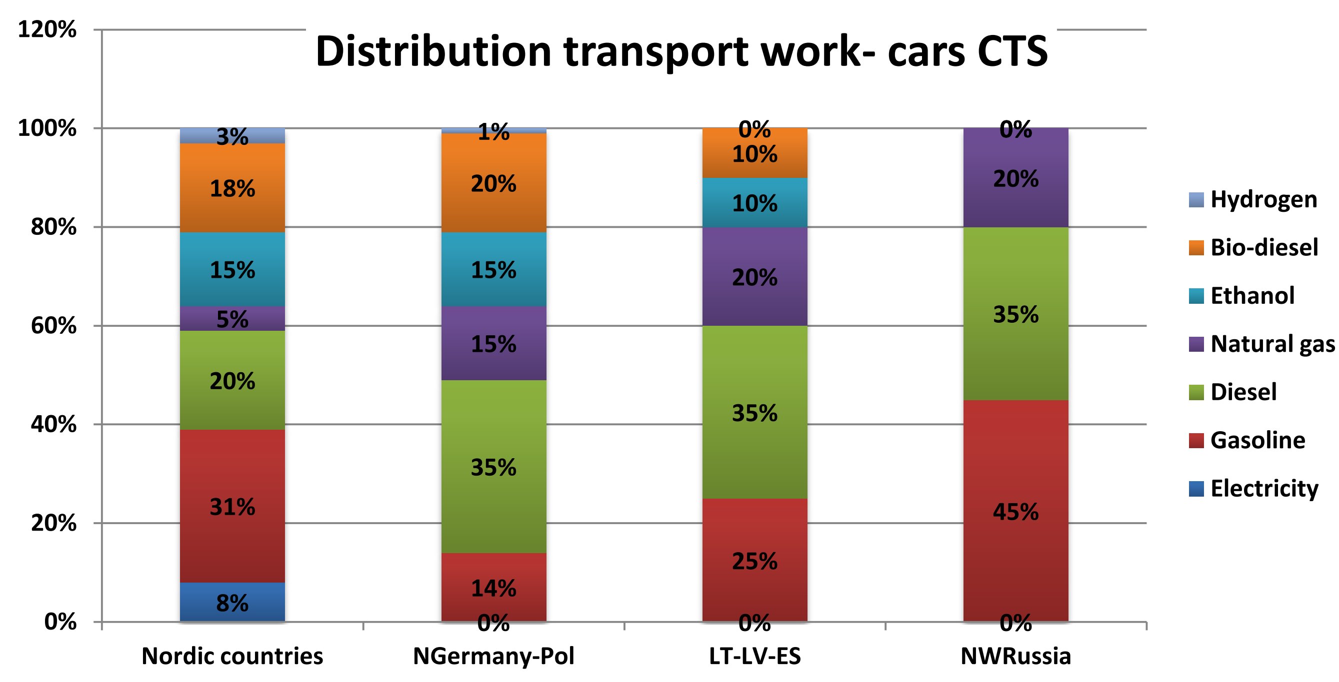
	Prices (2007 prices)
Oil	122 $/bbl
Coal	110 $/t
Gas	10.93 €/GJ
CO2	35 €/tCO2

→ **GES and WES competitive**



Centralised Technologies Scenario

- Nuclear share in BSR gross energy consumption increases from 16% in RS to 19,5% in CTS. Nuclear development instead of phase out policies
- Carbon and Capture Storage: solution for Poland and Estonia thermal plants
- CO_2 emission reduction by CCS: 122,6 mill.ton CO_2 in the BSR
- Important improvments in thermal plant efficiency in Poland and North-western Russia
- Usage of biomass and waste: from 12,5% in RS to 23,1% in CTS
- Heat pumps for district heating in Northwestern Russia and Nordic countries
- Biofuel spread. More usage of natural gas in transport sector



Scenario

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- Important impr

western Russia

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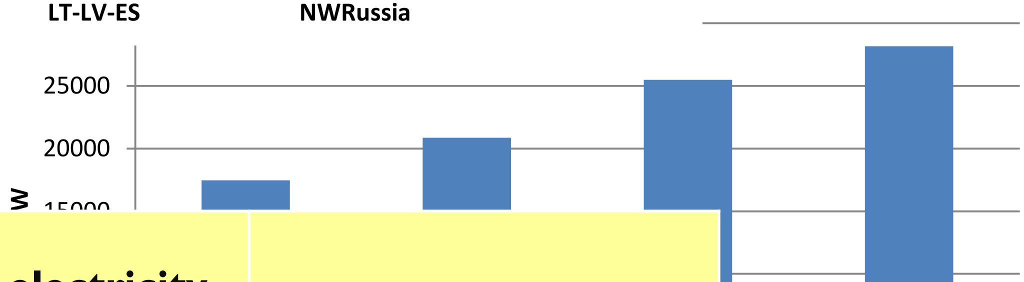
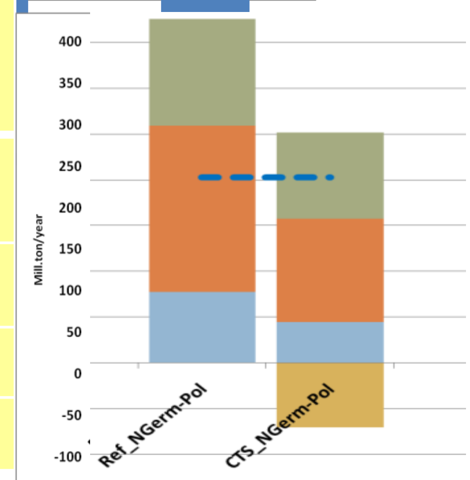
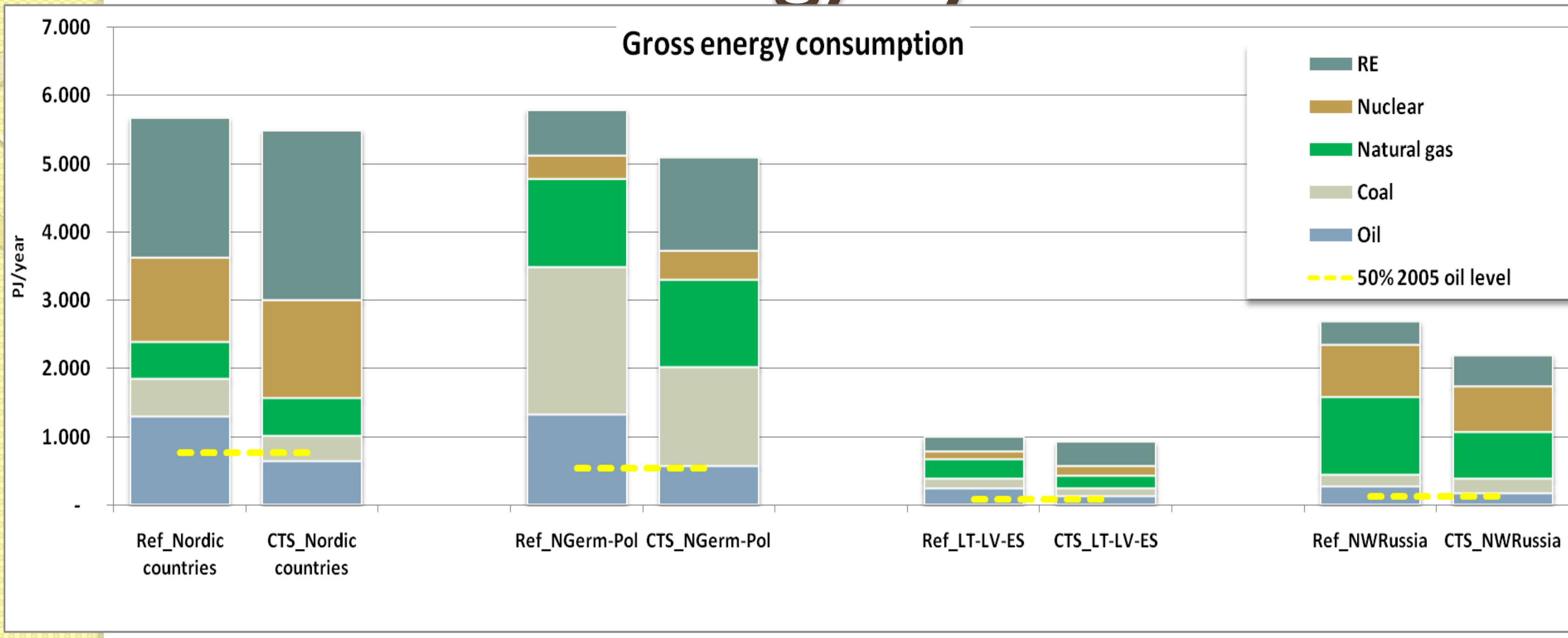
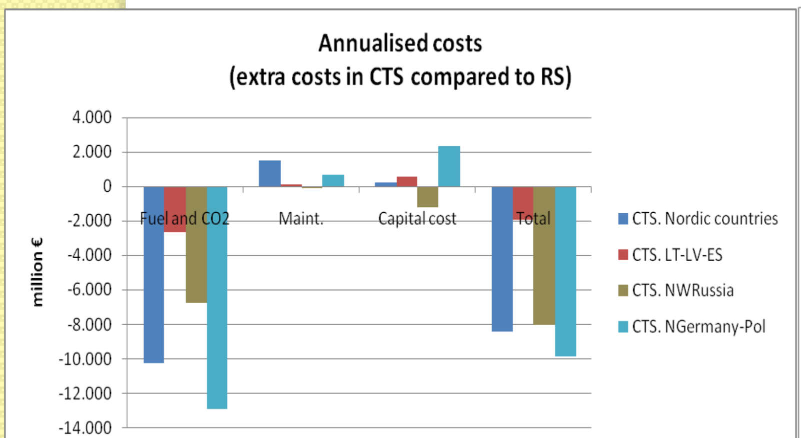


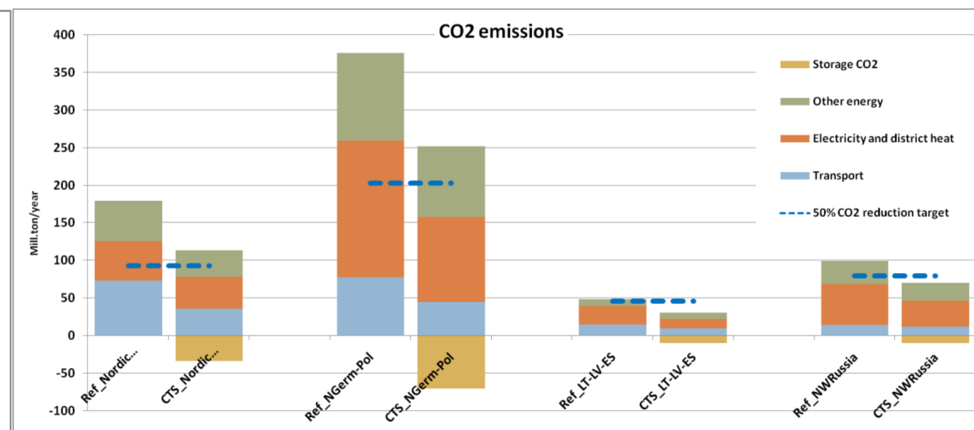
CCS	Share in electricity production	MW installed 2030
Nordic countries	9%	5.069
NGermany-Pol	43%	9.445
LT-LV-ES	25%	1.152
NWRussia	11,5%	1.640



CTS energy system

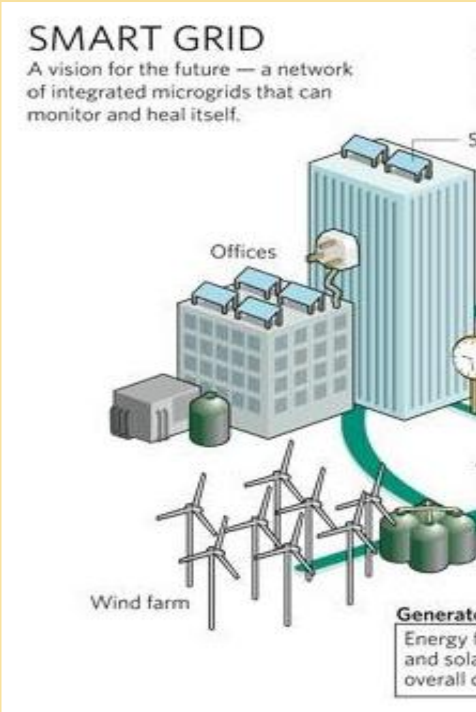






Green Energy Scenario

- Extensive exploitation of renewable resources according to the potential within each countries
- Security of supply – usage of local resources instead of fossil fuels
- High levels of energy savings in residential, industry and tertiary sectors
- More efficient heat system: district heating and combined heat and power generation.
- Smart grid for supporting a more distributed energy generation
- Flexibility in energy consumptions: flexible electric devices and electric and hybrids vehicles
- Nuclear shutting down policy. No new Ignalina in Lithuania and less capacity in the other nuclear countries
- Drastic reduction of CO_2 emissions



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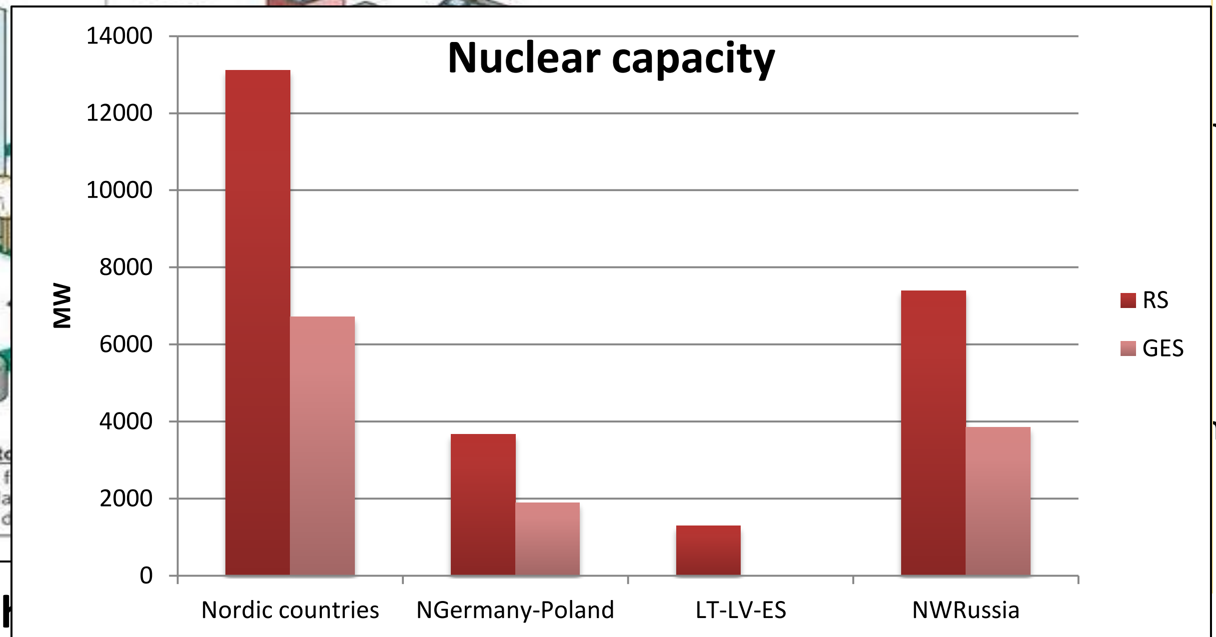
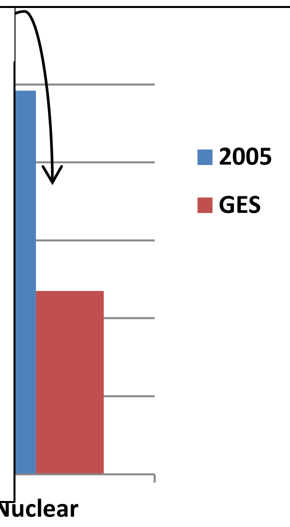
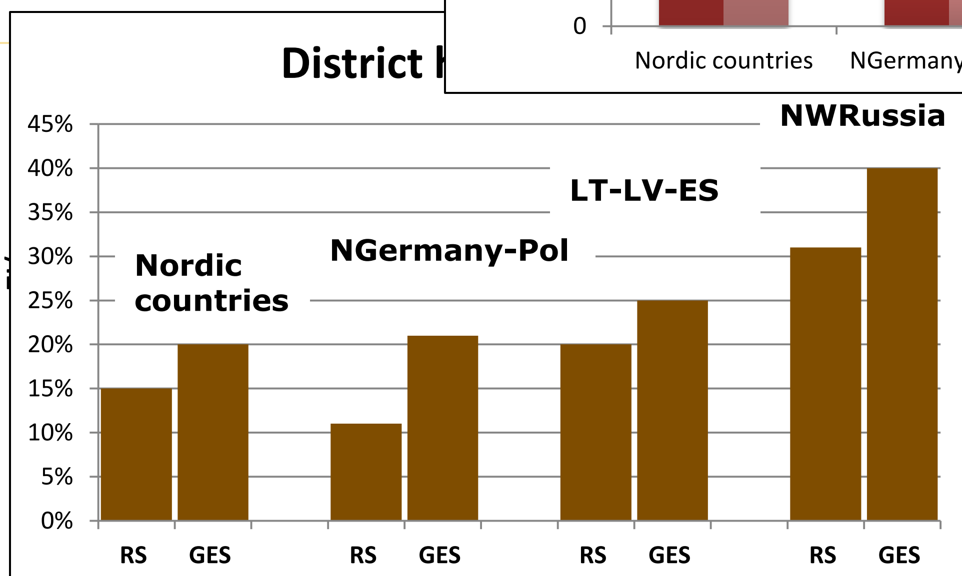
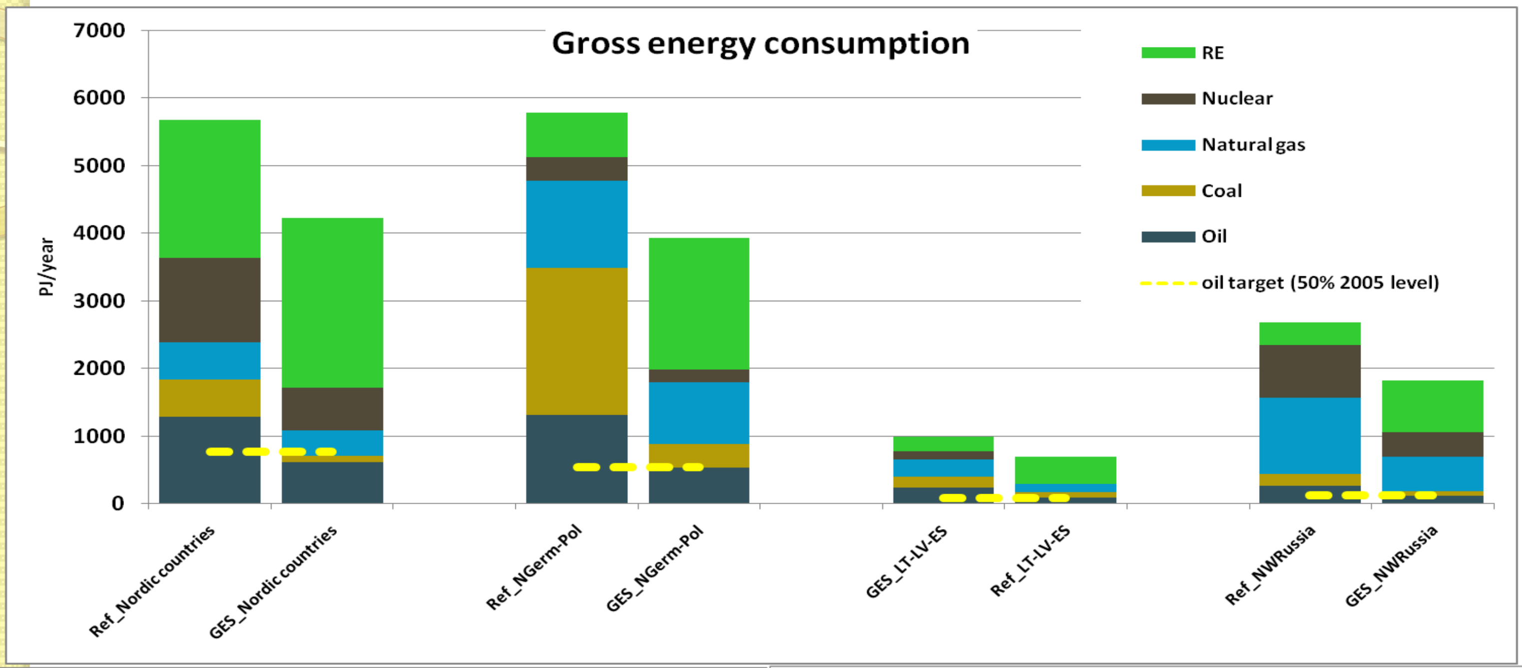


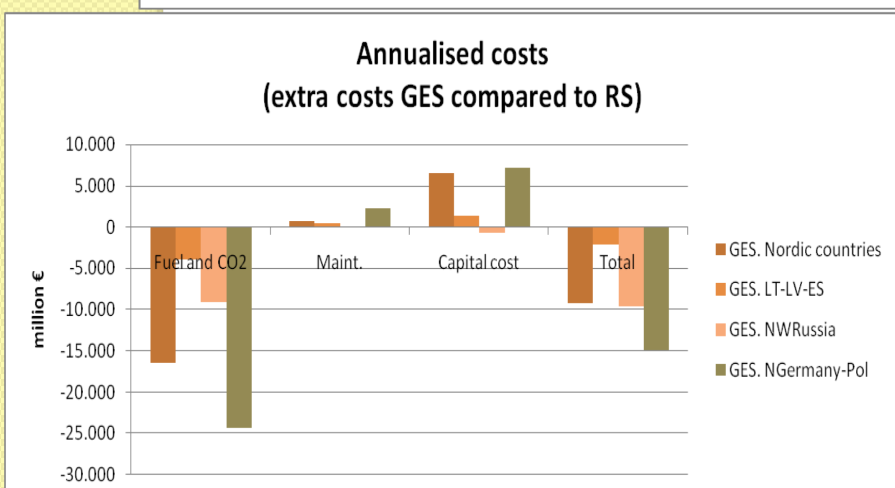
nd less capacity in the other

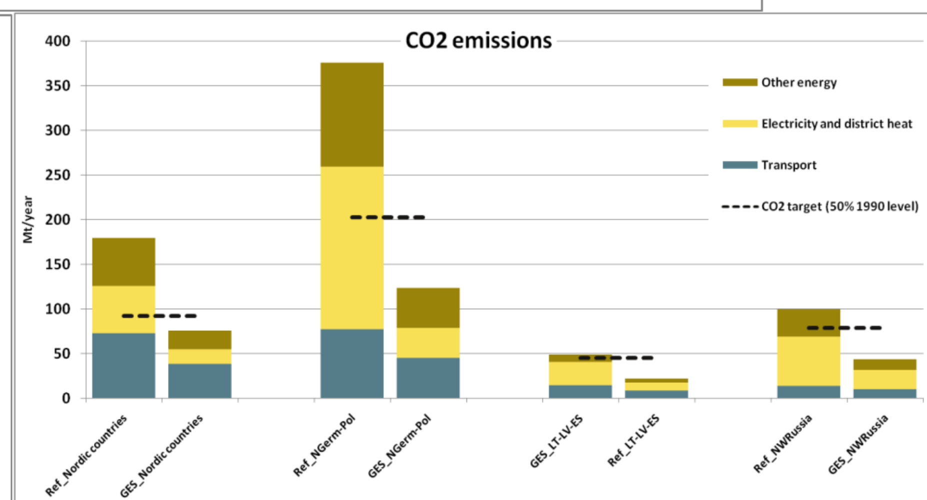




GES energy system

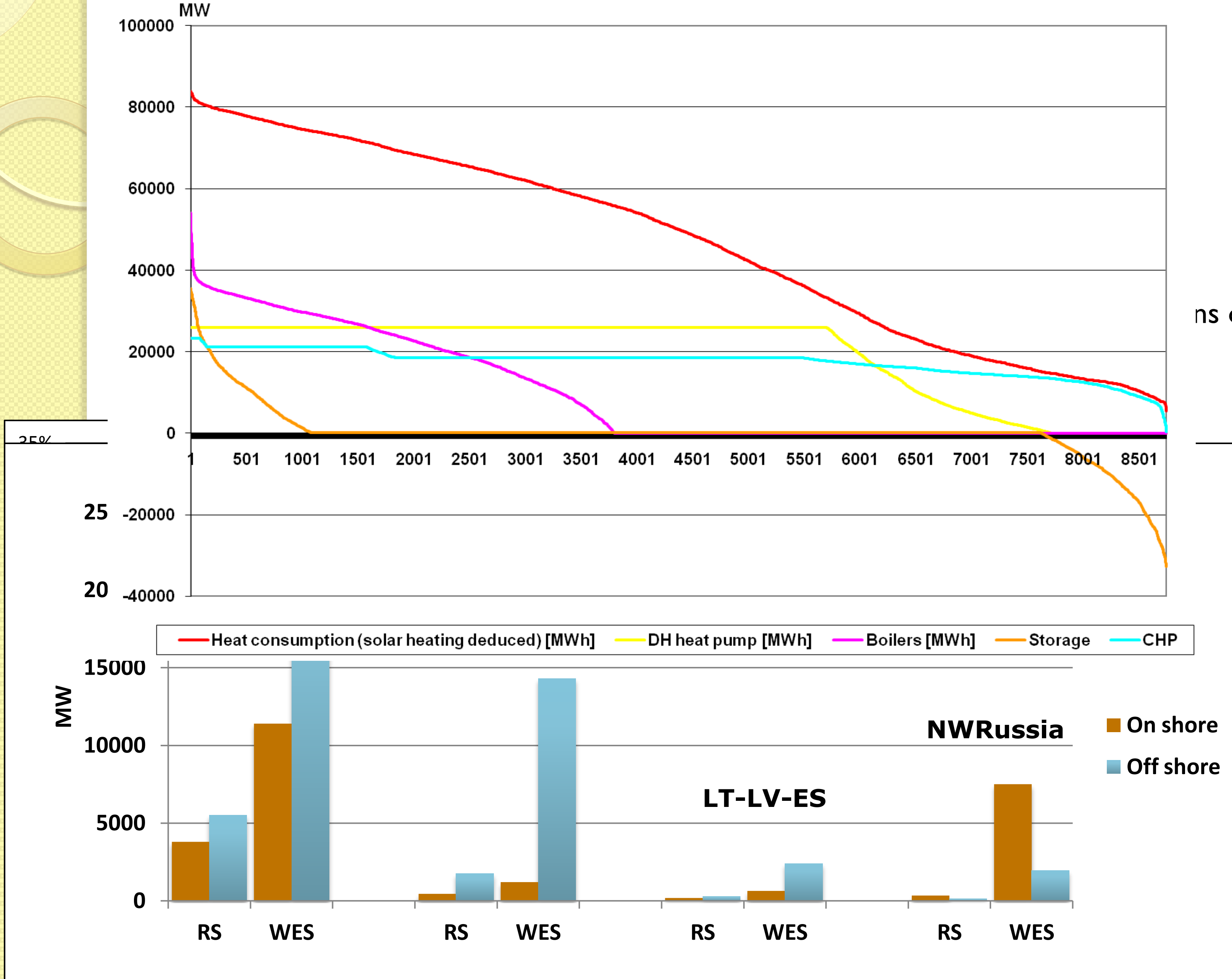






Wind Energy Scenario

- Large diffusion of wind turbines
- Around 25% of the total electricity production pf BSR in 2030 by wind
- Flexibility in the electricity demand: electric devices,and spread of electric means of transport (also improvemnts in the eastern BSR train system)
- Energy savings measures in larger share compared to GES
- Exploitation of small and big hydro potential in each country
- WES nuclear around 40% of the nuclear generation of RS
- Collective and individual heat pumps large usage and space heating for balancing the electricity system
- No detailded study on the grid system development
- In Nordic countries 3 PJ forced electricity export, not in BSR as one system


MW
100000
80000
60000
40000
20000
0
-20000
-40000
1 501 1001 1501 2001 2501 3001 3501 4001 4501 5001 5501 6001 6501 7001 7501 8001 8501
Heat consumption (solar heating deduced) [MWh]
DH heat pump [MWh]
Boilers [MWh]
Storage
CHP
25
20
MW
15000
10000
5000
0
NWRussia
LT-LV-ES
On shore
Off shore
RS WES RS WES RS WES RS WES

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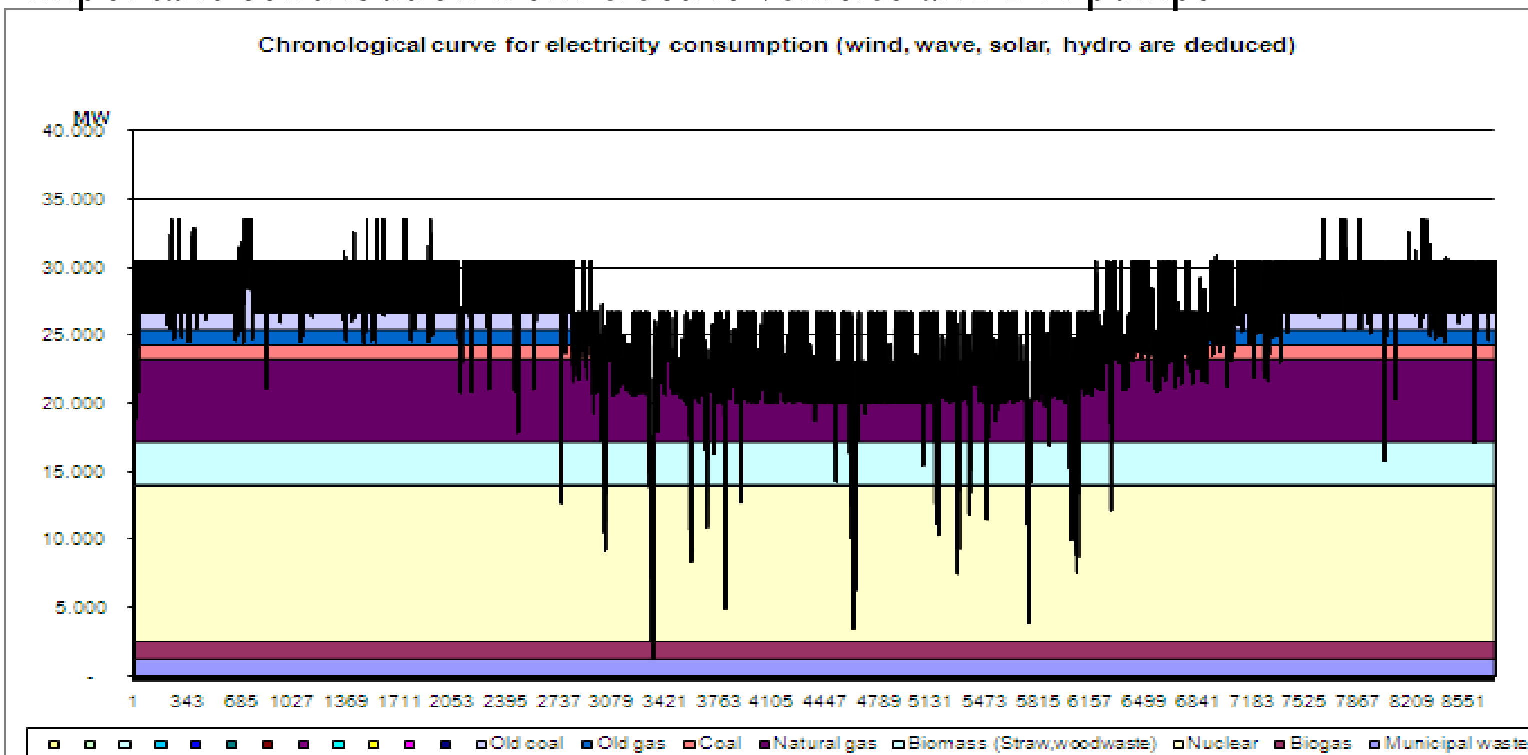
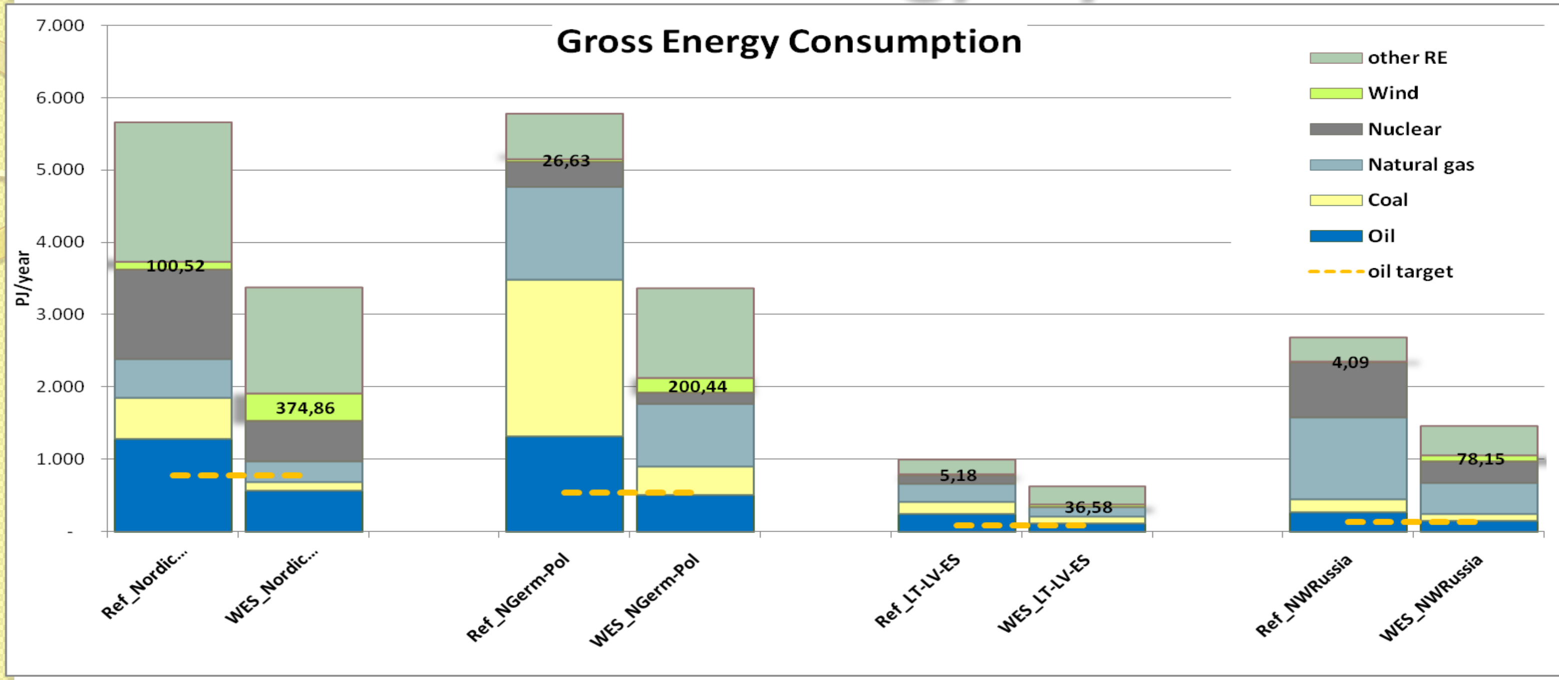
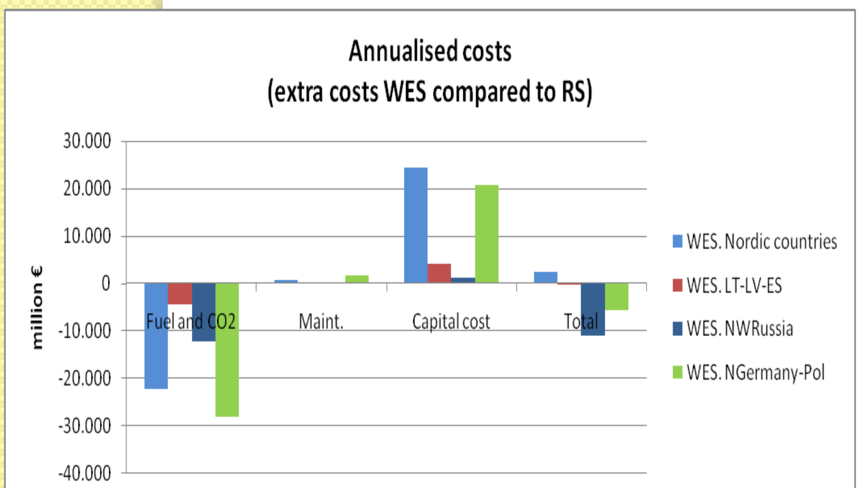
Whole baltic WES

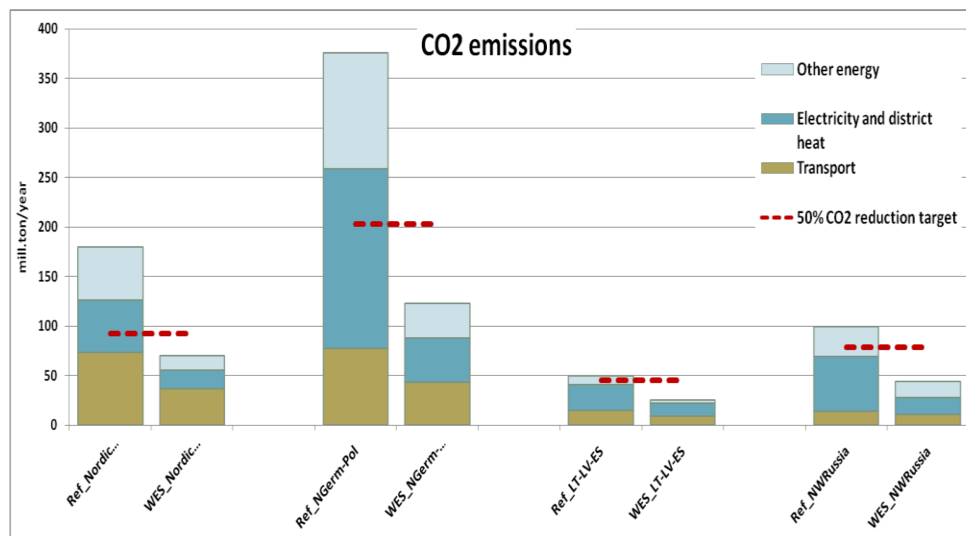
•NO forced electricity exports in this global system-no limitation in the transmission rid capacity in the whole BSR
•The electricity system works, but…
•Large production by hydro (42% of BSR el. production) and also flexible
•Important contribution from electric vehicles and DH pumps



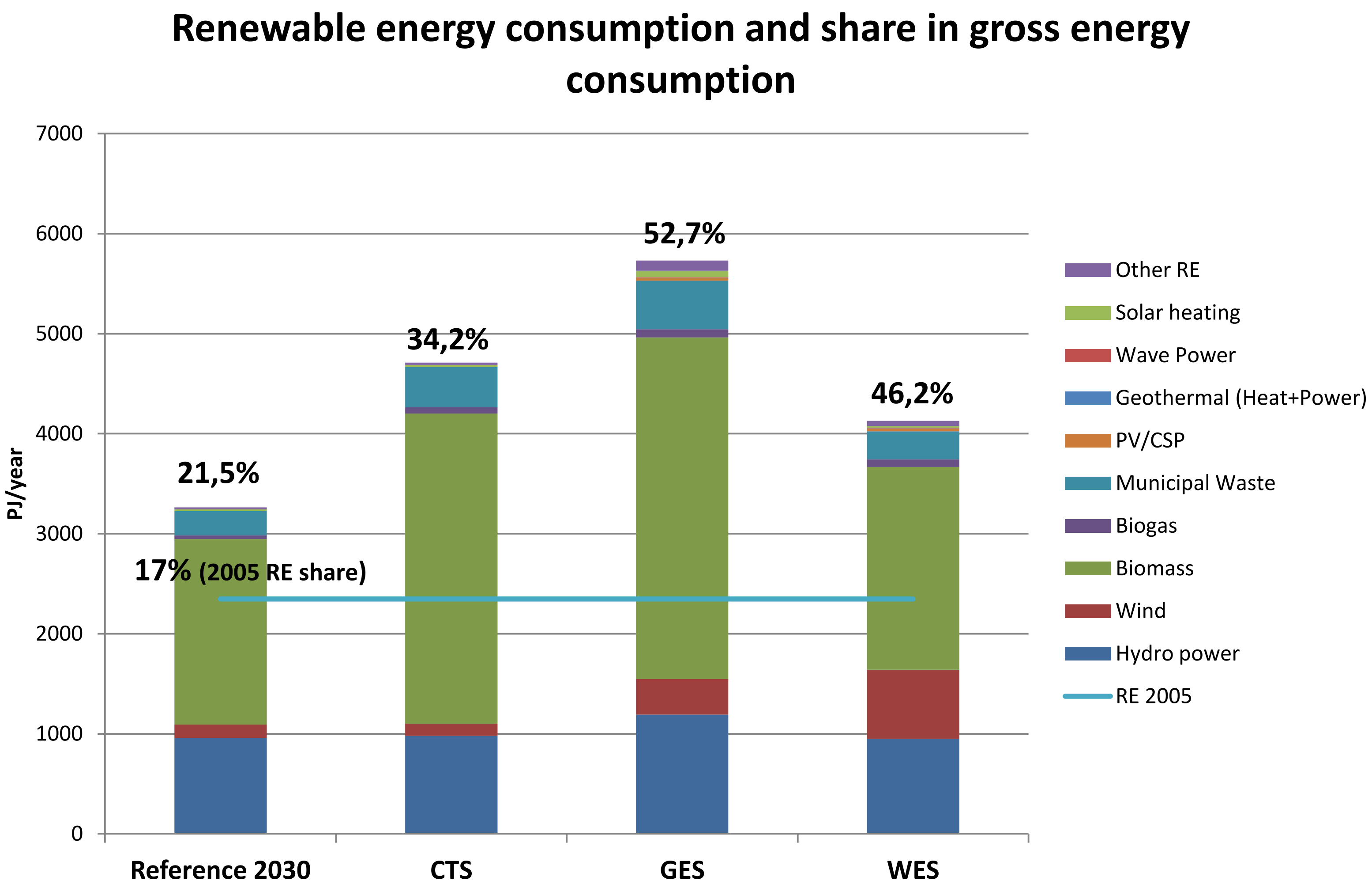
WES energy system



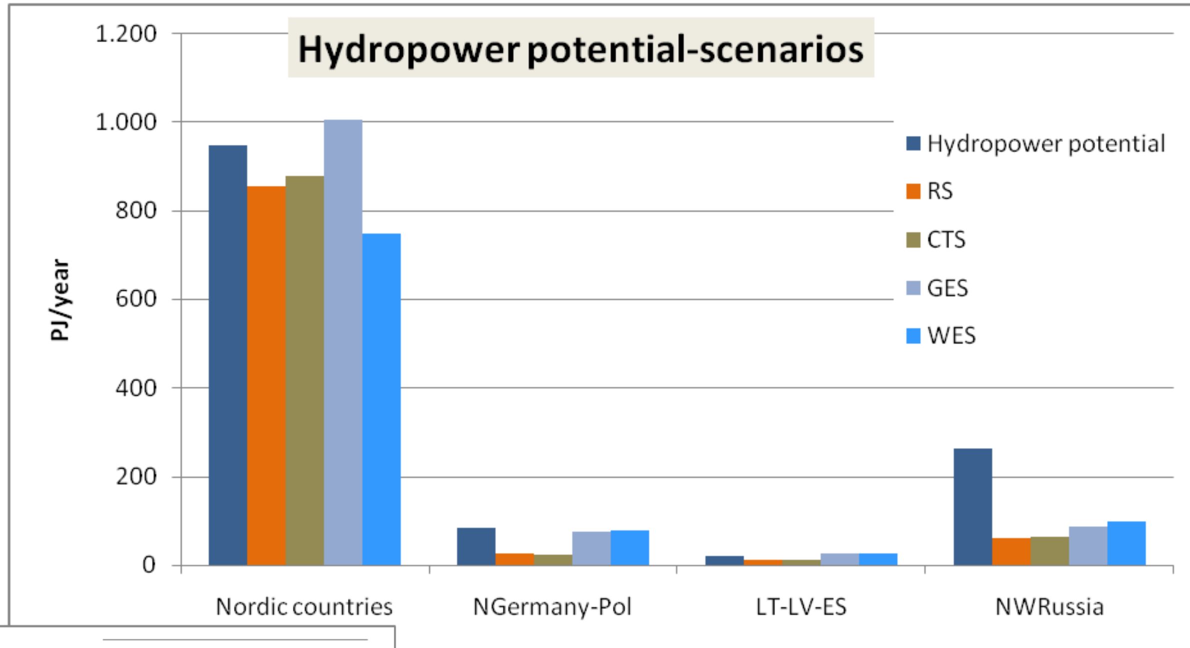




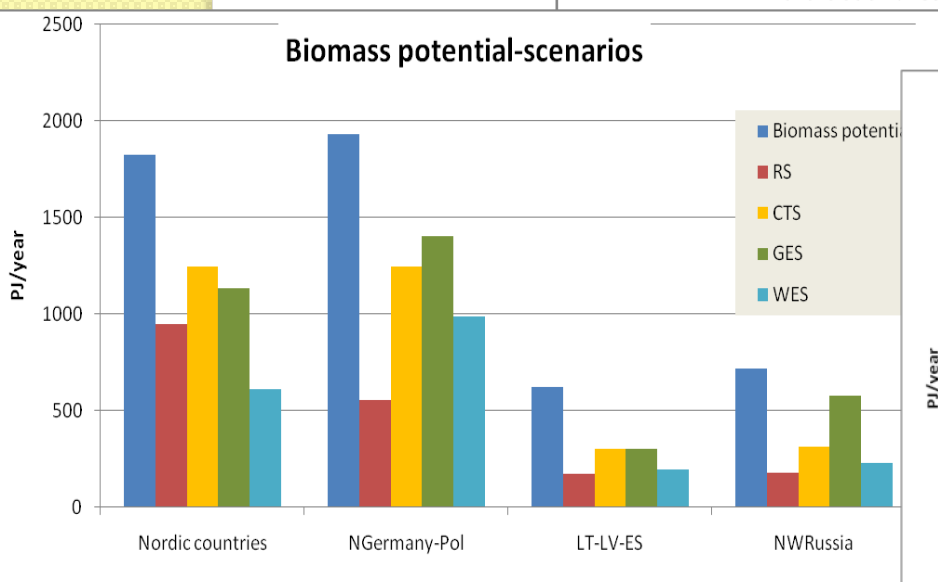
Renewable resources in the energy scenarios



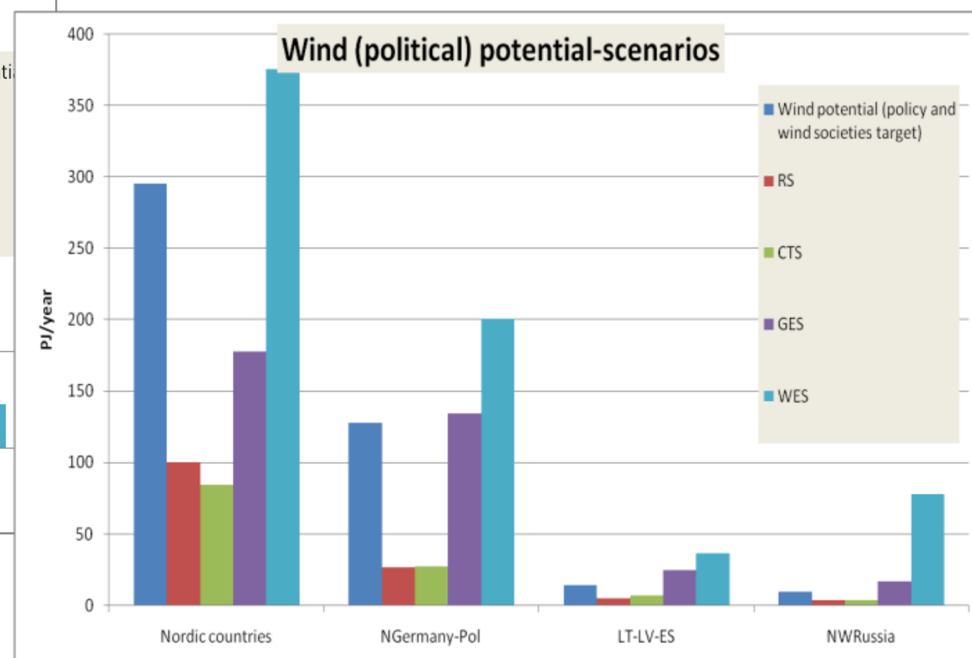
RE output



Hydropower potential-scenarios
PJ/year
1.200
1.000
800
600
400
200
0
Hydropower potential
RS
CTS
GES
WES
Nordic countries
NGermany-Pol
LT-LV-ES
NWRussia

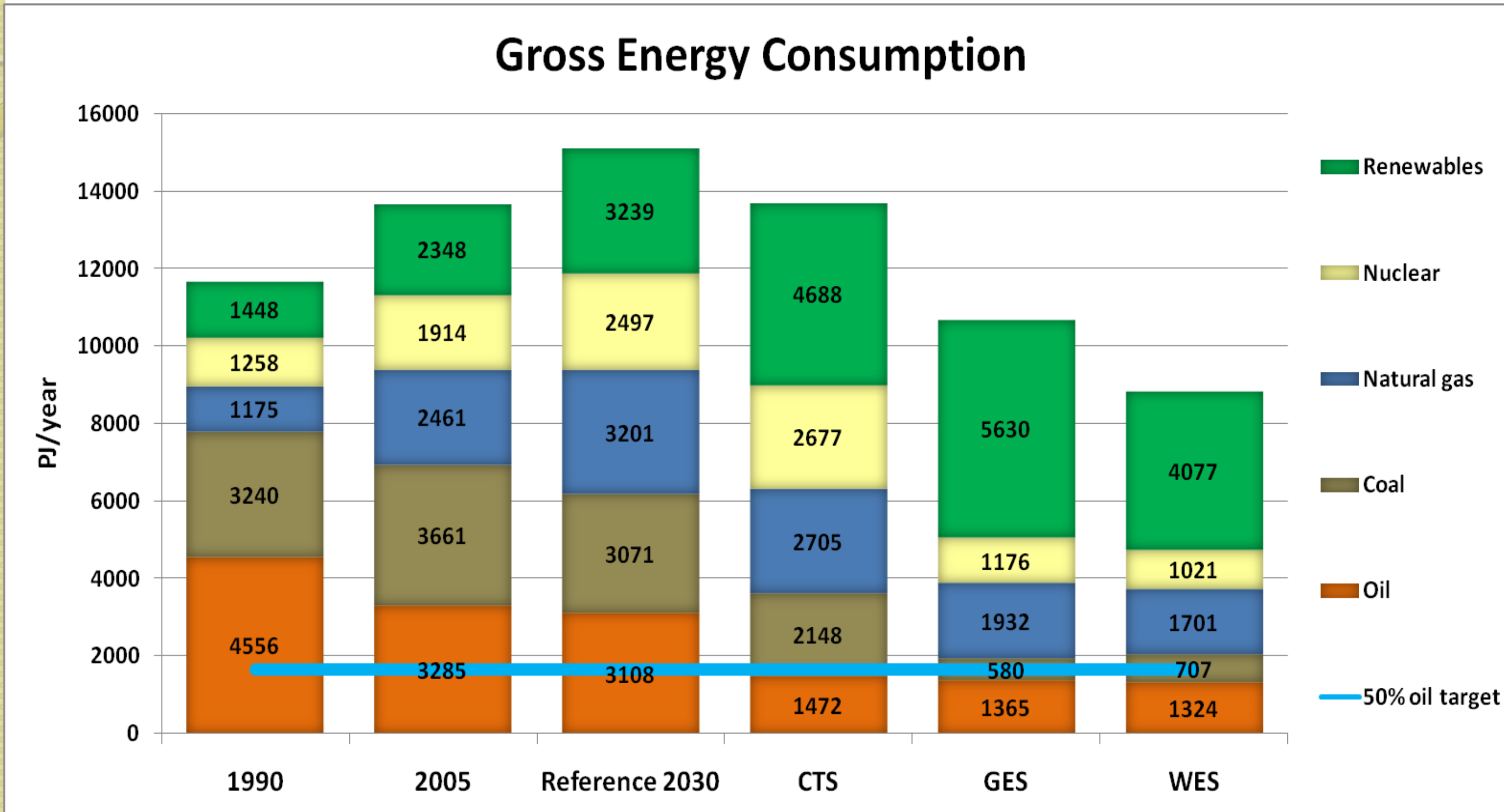


Biomass potential-scenarios
PJ/year
2500
2000
1500
1000
500
0
Biomass potenti
RS
CTS
GES
WES
Nordic countries
NGermany-Pol
LT-LV-ES
NWRussia



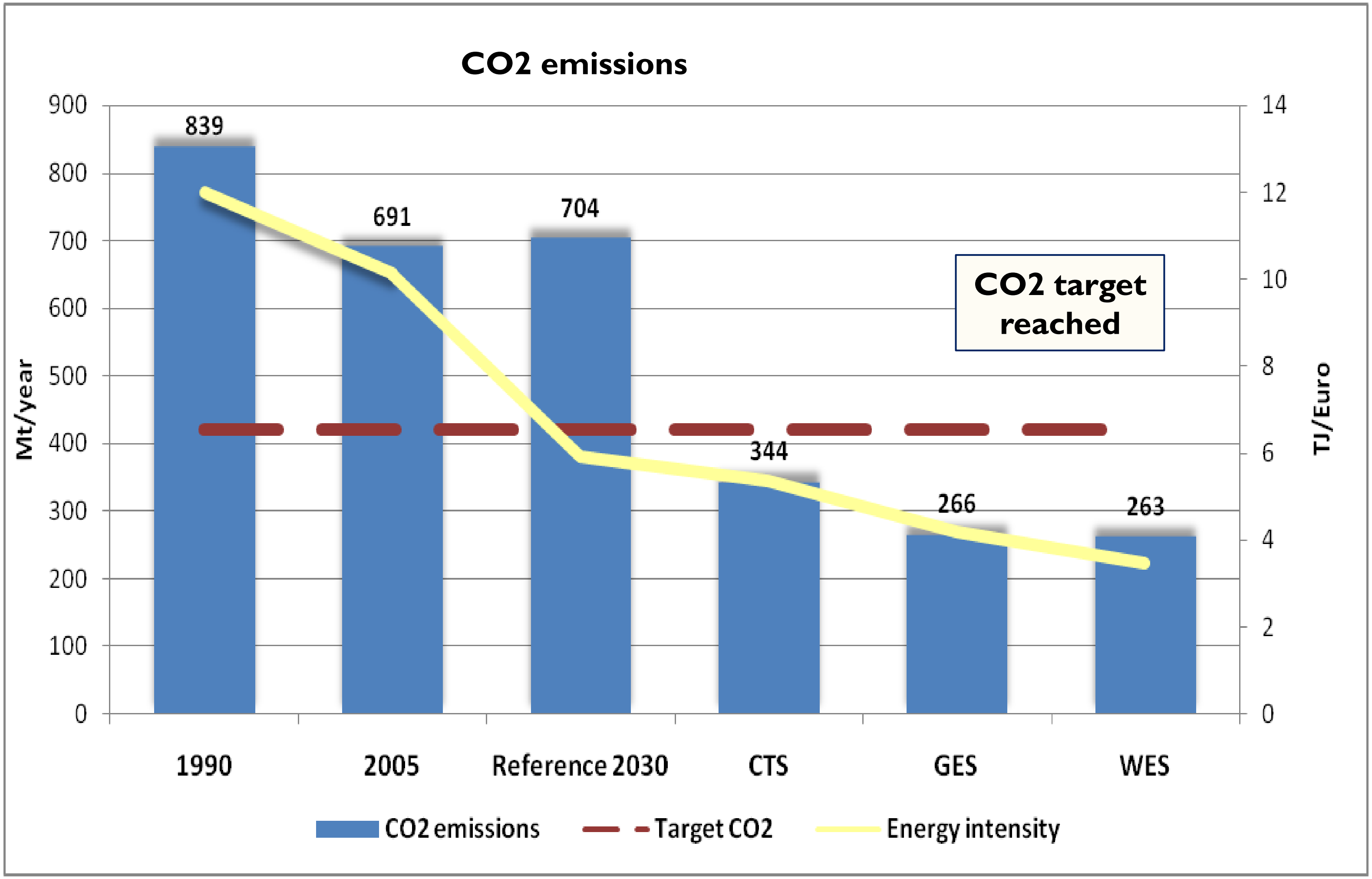
Wind (political) potential-scenarios
PJ/year
400
350
300
250
200
150
100
50
0
Wind potential (policy and wind societies target)
RS
CTS
GES
WES
Nordic countries
NGermany-Pol
LT-LV-ES
NWRussia

Results - Consumptions

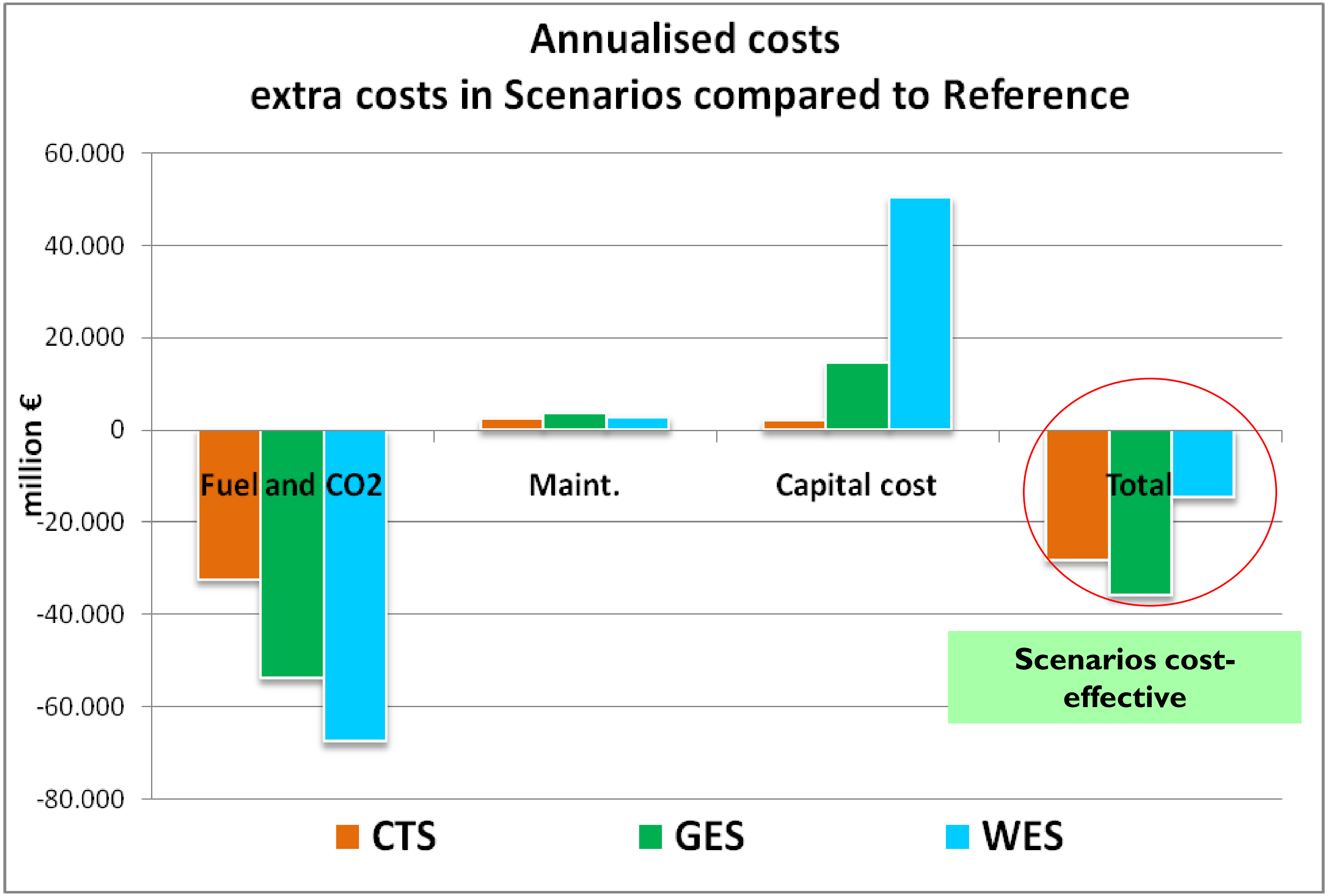


Oil target reached
+
security of supply objectives
+
more diversification in the energy source

Results - Emissions



Results - Costs



Conclusions

- Different and feasible ways for the BSR development by 2030 are provided
- The three scenarios aim and achieve the ambitiosus oil and CO2 targets
- It is possible to shift from a fossil fuel dependence to a distributed generation by renewables
- A cleaner future is possible
- Great efforts are requiered from the whole society
- Strong assumptions in energy savings potential, car industry strategy, CCS diffusion, off-shore infrastructures, fossil fuel and CO_2 prices
- The limitation of the model tool can be solved by an accurate analysis by more detailed models

Big changes are possible

This is the time to do them!

Possible futures model developments

STREAM energy model

Advantages	**Limitations**
Transparency and possibility to check results and calculations (publicity available)	Not able to deal with specific problems (e.g. limitations in grid capacity)
Simple and quick analysis	No minimum cost solution but different alternatives shown in scenarios
Feasible use during workshops and meetings (more cooperation with politicians)	Not possible to follow the energy system development in all years of the time horizon
Analysis of the whole energy system	

- More detailed analysis of electric system/grid with specific models (f.i. Balmorel)
- Stream improvements by optimization techniques
- More specific demand analysis
- More detailed economic aspects and analysis
- Possible new technologies to add
- Development of renewable energy modeling

THANKS