



Consequences of BAU and evolving national policies

- Results from the **Green-X** model

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... based on calculations made with the help of the computer model **Green-X**

www.green-x.at



Content

The regional / national perspective ...

- *Core objective / Method of approach*
- *Background information*
 - the **Green-X** model & database
- *Results* of the assessment of potentials and prospects for RES-Electricity
- *Summary*

(1) Objective / Approach

1. Introduction: *Objective*

The core objective of the *project Green-X* was to develop a computer model allowing an assessment of the future deployment of RES-E in the 'real world'.

Derived objectives are:

- to describe the potential & the accompanying cost of the various RES-E options in a brief and suitable manner for model implementation;
- to model the impact of policy instruments;
- to address dynamic aspects in a proper way, including:
 - Future technological changes - e.g. a reduction of investment costs or efficiency improvements due to technological learning
 - Technology diffusion - i.e. the impact of non-economic barriers for RES-E

*... to derive a picture of a likely future
as close as possible to reality*



(1) Objective / Approach

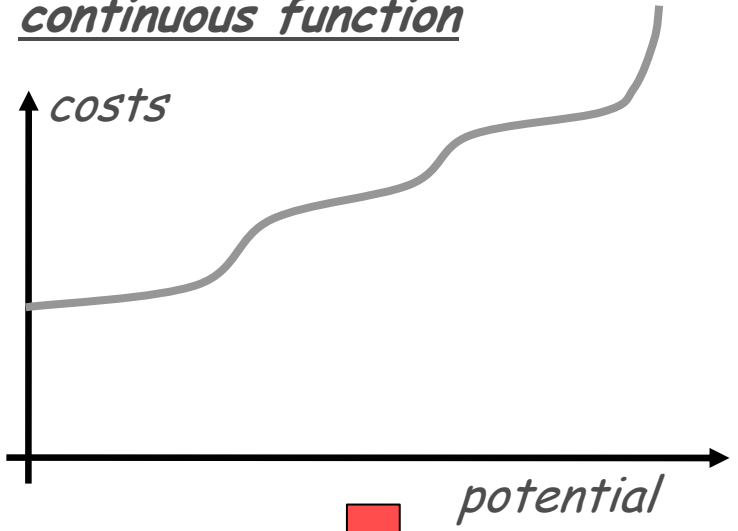
Basic principles:

Static cost-resource curves

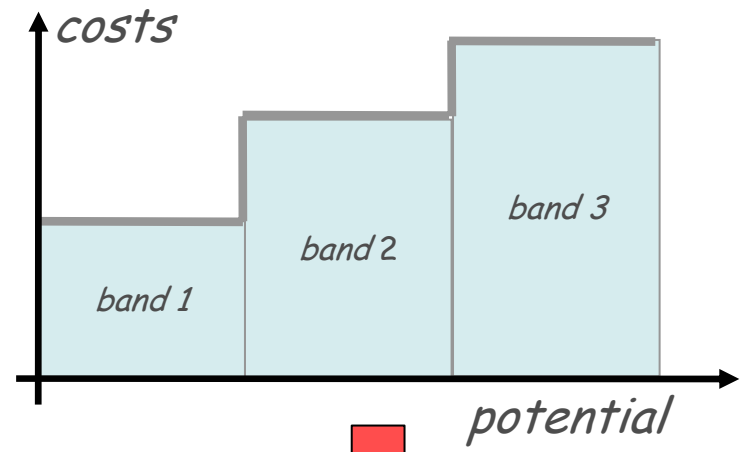
- Combines information on the **potential** and the according **costs** (of electricity for a specific energy source).
- For **limited resources** (as RES-E) costs rise with increased utilization.
- All costs/potentials-bands are **sorted in a least cost way**

costs = f (potential); t = constant

continuous function



stepped (discrete) function



.....every location is slightly different"

Practical approach: Sites with



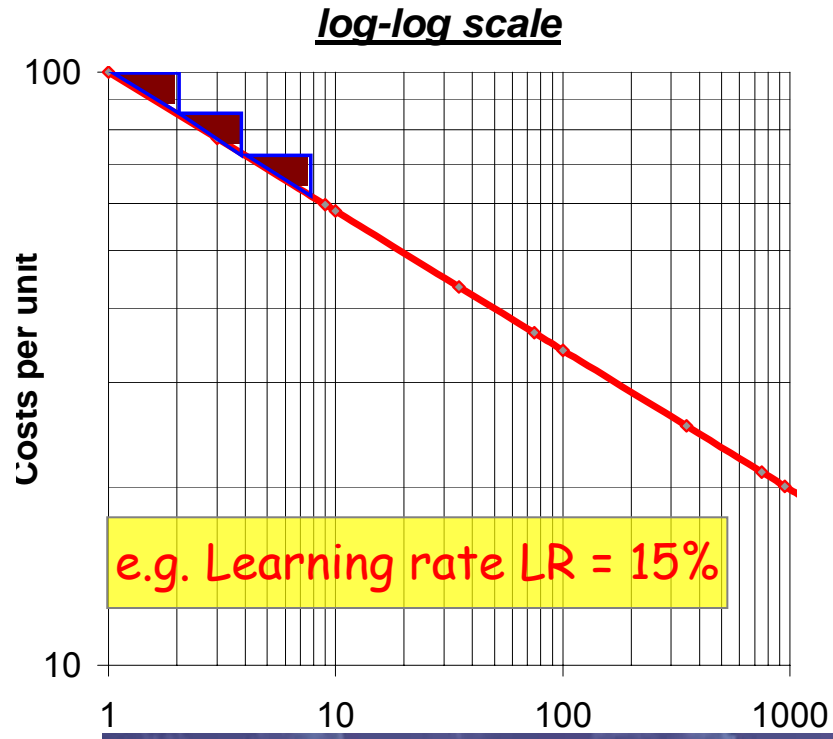
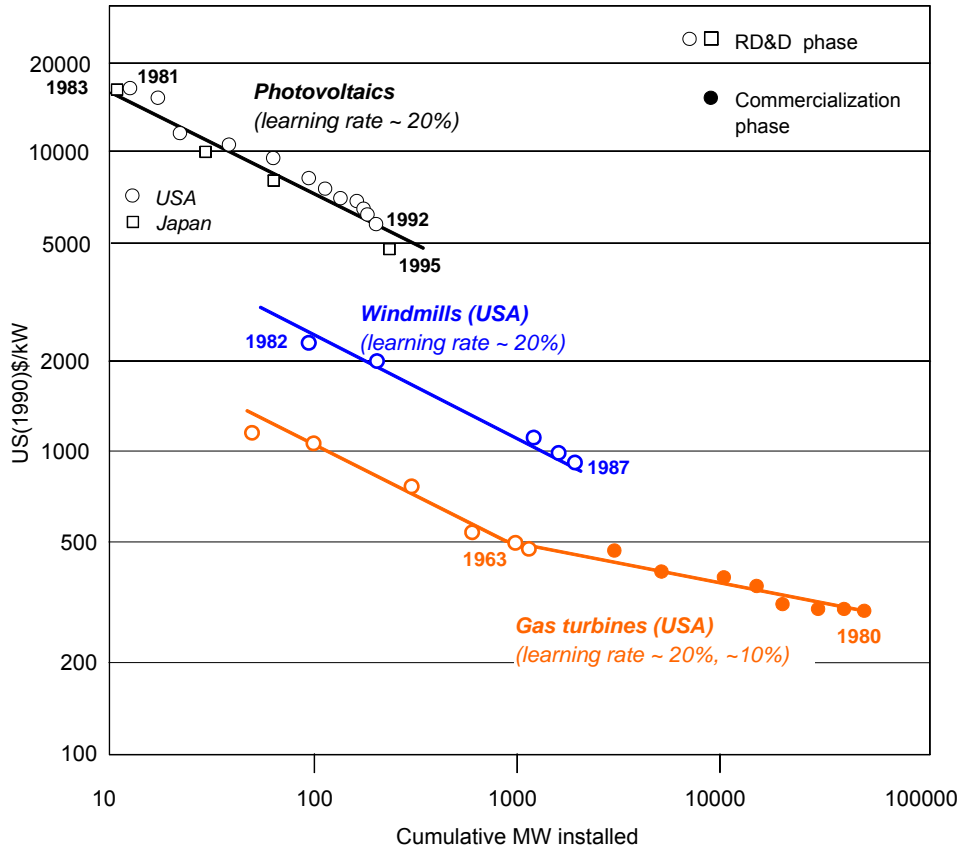
(1) Objective / Approach

Basic principles: Experience curves

- describe how costs decline with cumulative production.
- costs decline by a constant percentage with each doubling of the units produced or applied.

$$C_{CUM} = C_0 * CUM^b$$

C_{CUM} Costs per unit
 C_0 Costs of the first unit
 CUM Cumulative production
 b Experience index
 LR Learning rate ($LR=1-2^b$)





(1) Objective / Approach

Basic principles:

Technology diffusion

General diffusion theory

$$F = \frac{1}{1 + e^{-d*(t-t_0)}}$$

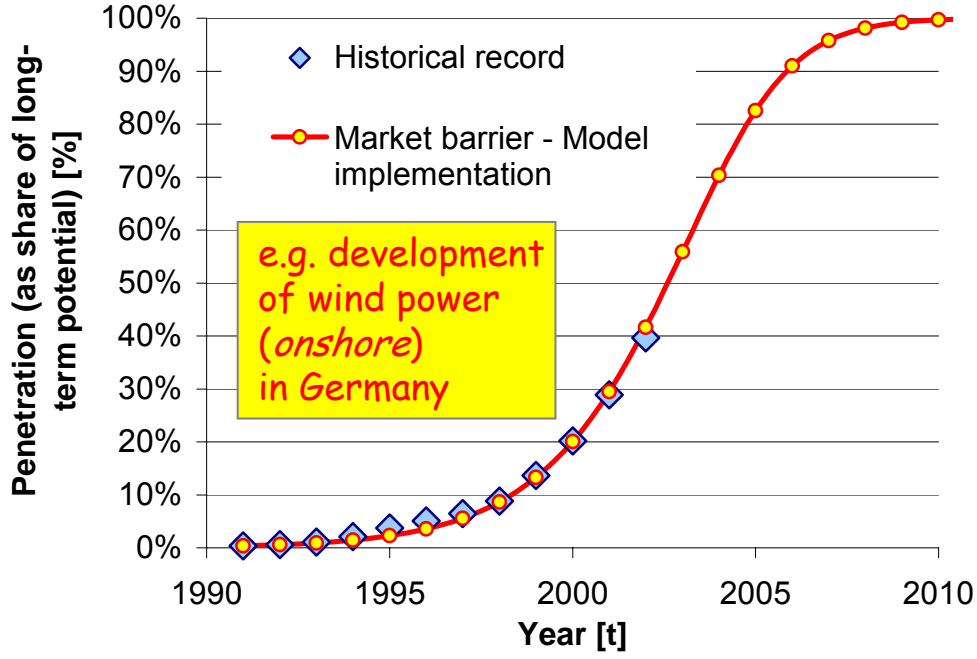
- ... in accordance with general diffusion theory, penetration of a market by any new commodity typically follows an 'S-curve' pattern
- ... applied within the model to describe the impact of non-economic barriers on RES-E deployment

- F Markt penetration
- d Diffusion rate
- ΔP_{Mn} Yearly realisable potential (according to market barrier)
- P Long-term realisable potential

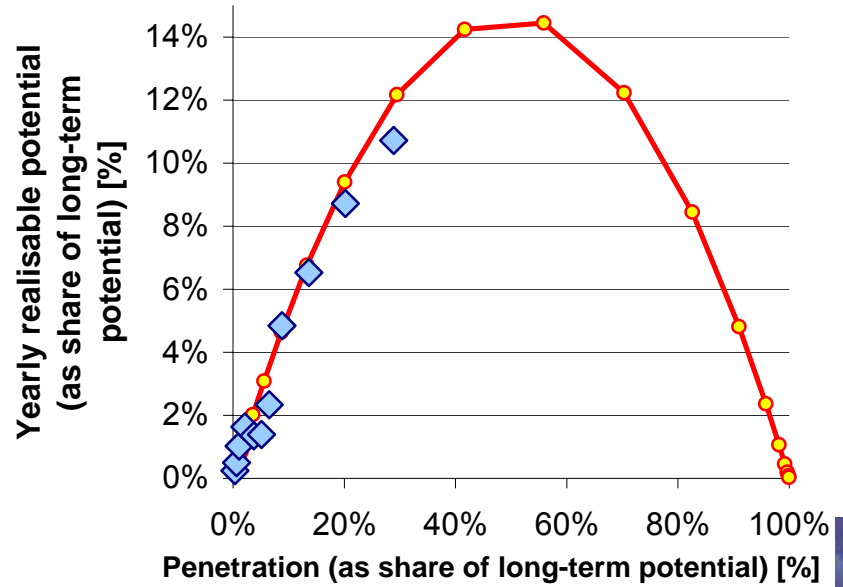
Model implementation of dynamic non-economic market barriers

$$\Delta P_{Mn} = P * d * F * (1 - F)$$

Deployment



Realisable potential due to non-economic Market barriers



(2) Background information - Green-X

The Green-X approach:

Dynamic cost-resource curves

Potentials

- by RES-E technology (*by band*)
- by country

Costs of electricity

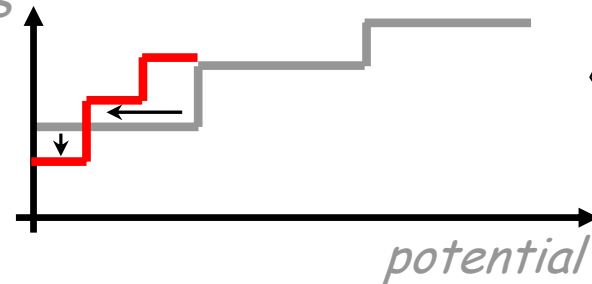
- by RES-E technology (*by band*)
- by country

DYNAMIC

COST-RESOURCE CURVES

- by RES-E technology
- by country
- **by year**

costs



Dynamic aspects

- **Costs: Dynamic cost assessment**
- **Potentials: Dynamic restrictions**

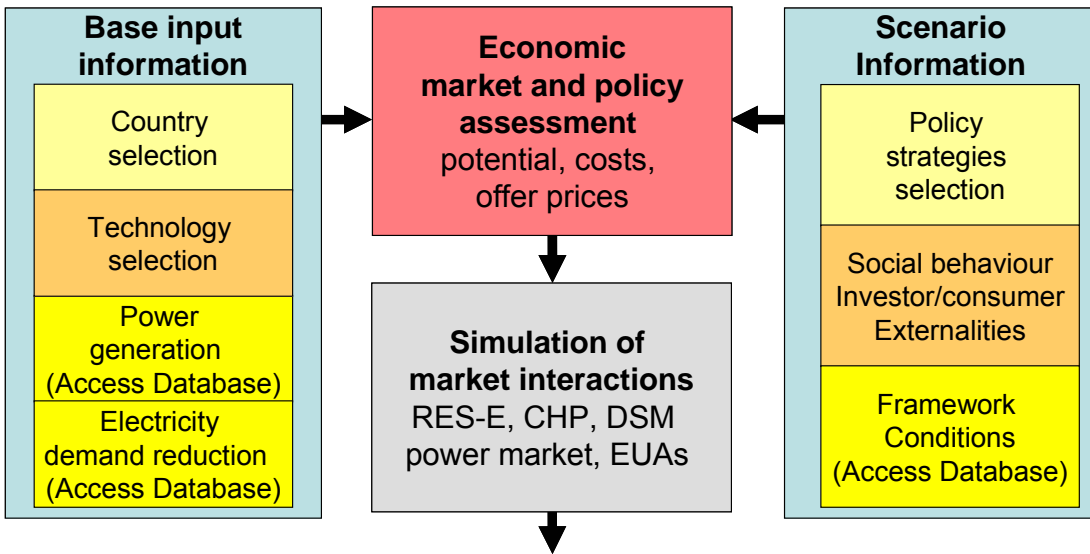


(2) Background information - Green-X

The Green-X model

Simulation model for energy policy instruments in the European energy market

- RES-E, RES-H, RES-T and CHP, conventional power
- Based on the concept of dynamic cost-resource curves
- Allowing forecasts up to 2020 on national / EU-25 level



The research project is supported by the European Commission, DG Research under the Fifth Framework Programme and contributing to the implementation of the key Action "Socio-Economic aspects of energy within the perspective of sustainable development. Methodologies for global systems analysis" within the thematic programme "Energy, Environment and Sustainable Development".
Contract No. EN5G-CT-2002-0067

Green-X
Deriving optimal promotion strategies for increasing the share of RES-E in a dynamic European electricity market

Platform Win2000 SP3
Win XP SP1
Version 4.4.3

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Vienna University of Technology

Energy policy instruments - Electricity

Select: Germany | Wind onshore

Germany Wind onshore

Feed in tariff | Tendering system | Tradable Green Certificates | Additional instruments

Feed in tariff

Fixed tariff

Premium tariff

Valid for plants not older than 19 year(s)

Guaranteed tariff for 20 year(s)

Flat rate

Value: €/MWh

Stepped rate

Maximum value: 85.26 €/MWh Full load hours to: 1800

Minimum value: 61.74 €/MWh Full load hours to: 3275

OK Cancel

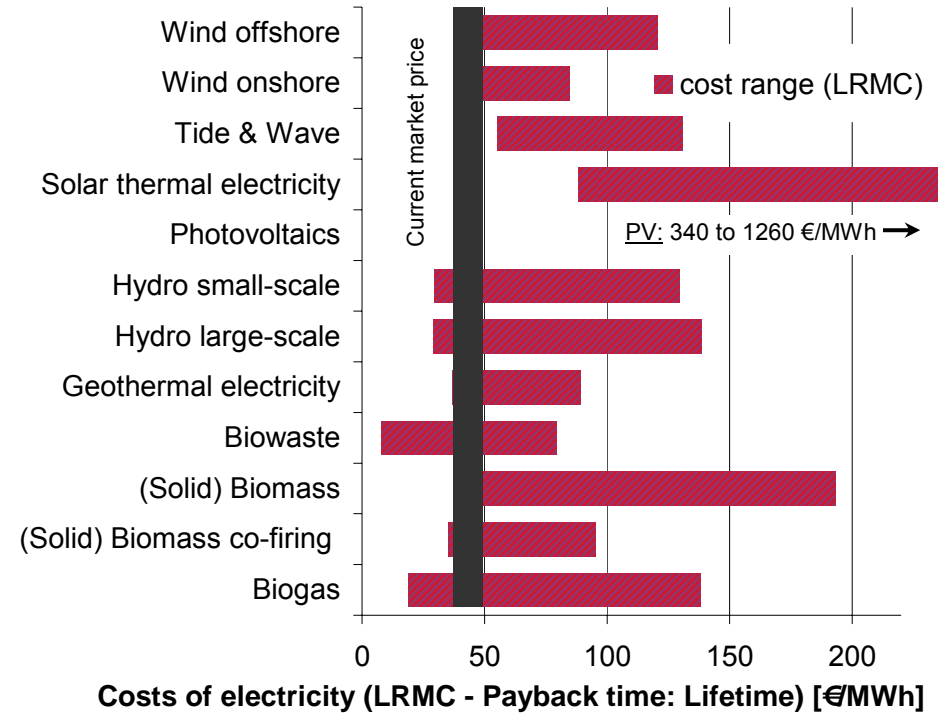
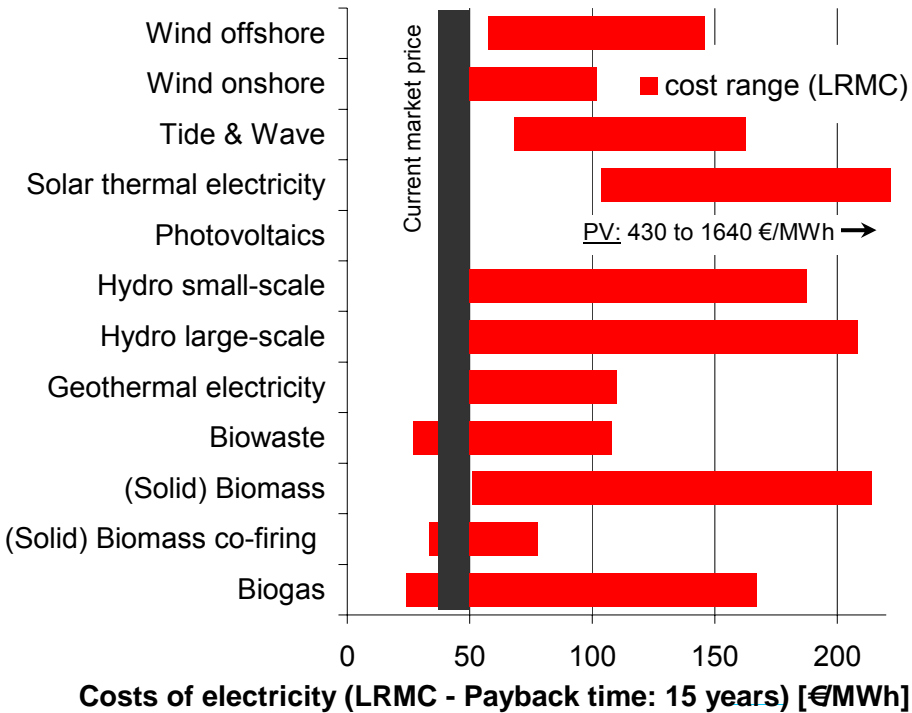
Results - Country specific - Cross-section

Select: European Union 15

General Results:	
Total Electricity Consumption	19.96 %
Share of total electricity consumption	19.96 %
Total Electricity Generation	558,582,81 GWh
Share of total electricity consumption	17.97 %
Share of total electricity generation	17.80 %
Share of total electricity consumption	51,991.61 GWh
Share of total electricity generation	1.80 %
Share of total electricity consumption	1.97 %
Generation Costs	
Total Generation Costs due to renewable energy sources (RES)	2,4335,04 MBl. Euro per year
of which due to electricity plants (ELs)	76,741,35 MBl. Euro per year
Share of total generation costs	83.51 %
of which due to combined heat and power plants (CHP)	4,694,172 MBl. Euro per year
Share of total generation costs	16.49 %
Total Costs for Society	

(2) Background information - Green-X

Cost of electricity by RES-E option Bandwith on European level



...based on default common payback time (15 years)

...based on technology-specific lifetime



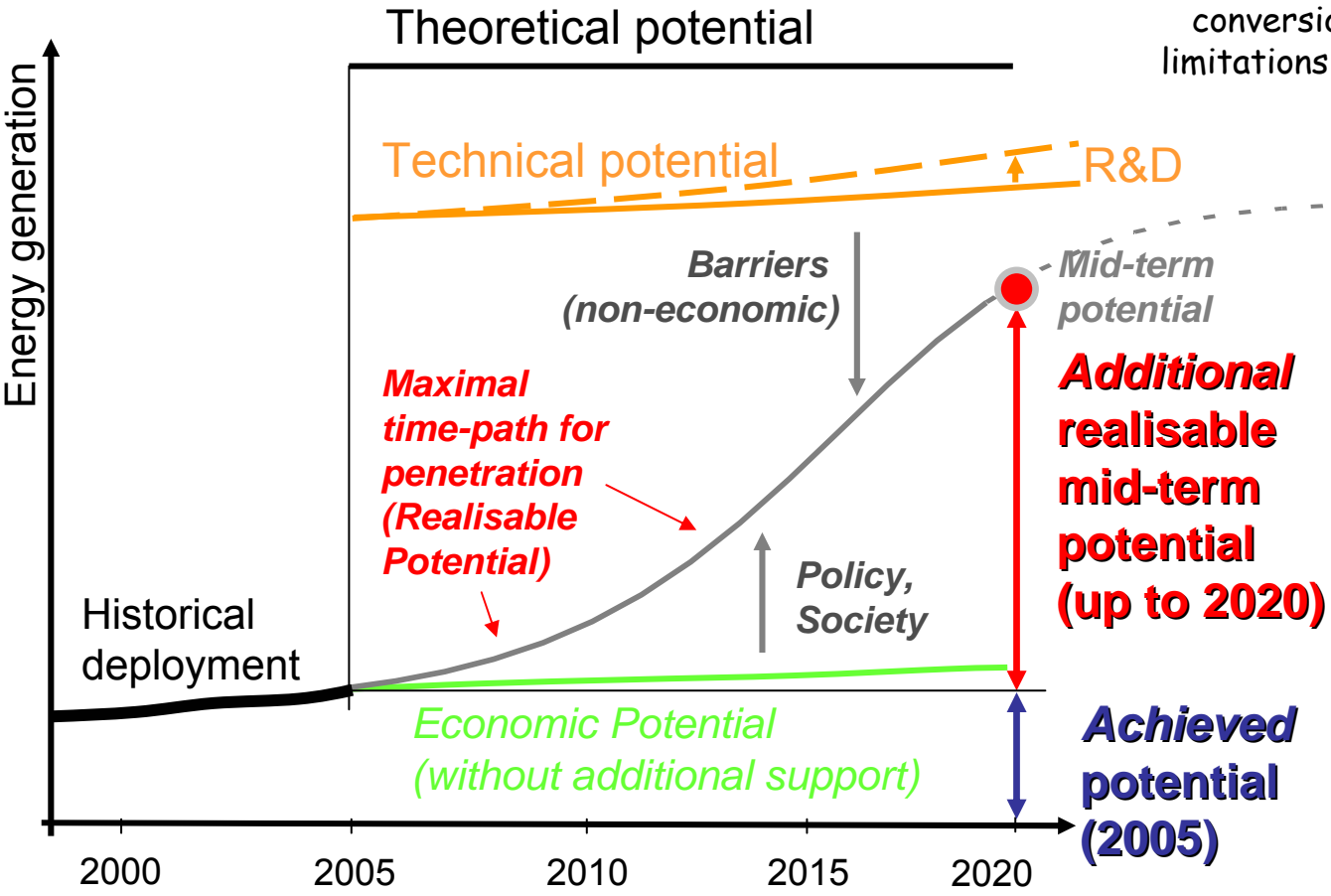
(2) Background information - Green-X

Definition of the (additional) realisable mid-term potential (up to 2020)

Definition of potential terms

Theoretical potential ... based on the determination of the energy flow.

Technical potential ... based on technical boundary conditions (i.e. efficiencies of conversion technologies, overall technical limitations as e.g. the available land area to install wind turbines)



● Long-term potential

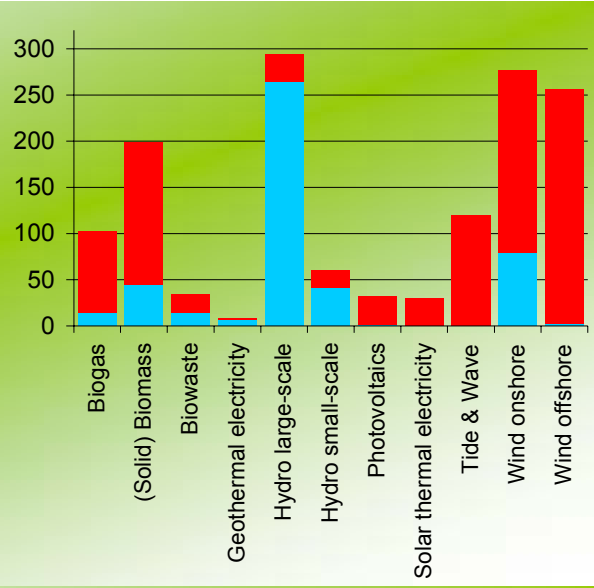
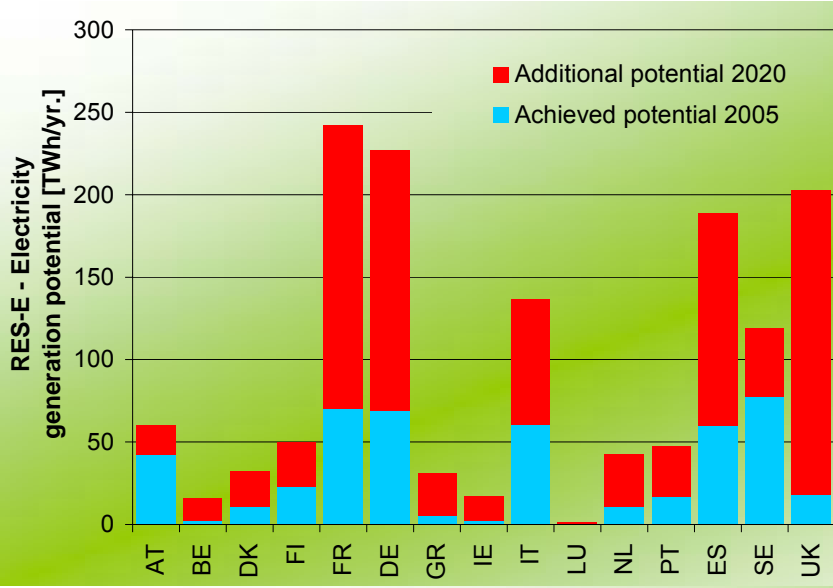
Realisable potential ...

The realisable potential represents the maximal achievable potential assuming that all existing barriers can be overcome and all driving forces are active.

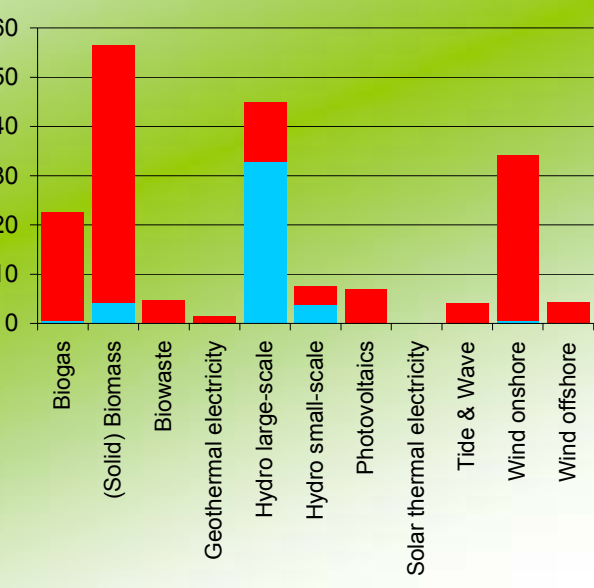
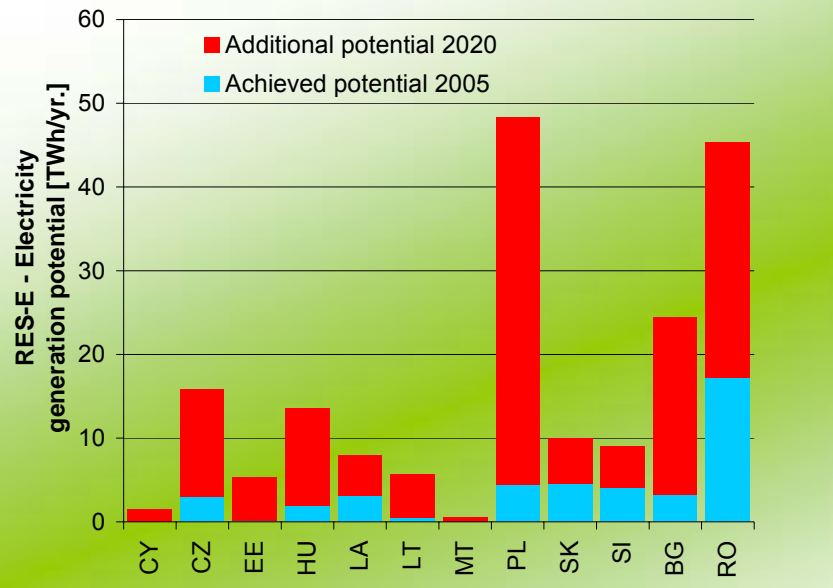
Thereby, general parameters as e.g. market growth rates, planning constraints are taken into account in a dynamic context - i.e. the realisable potential has to refer to a certain year.

(2) Background information - Green-X

*Mid-term
realisable
potential
for RES-E
in the EU27*



EU15 countries

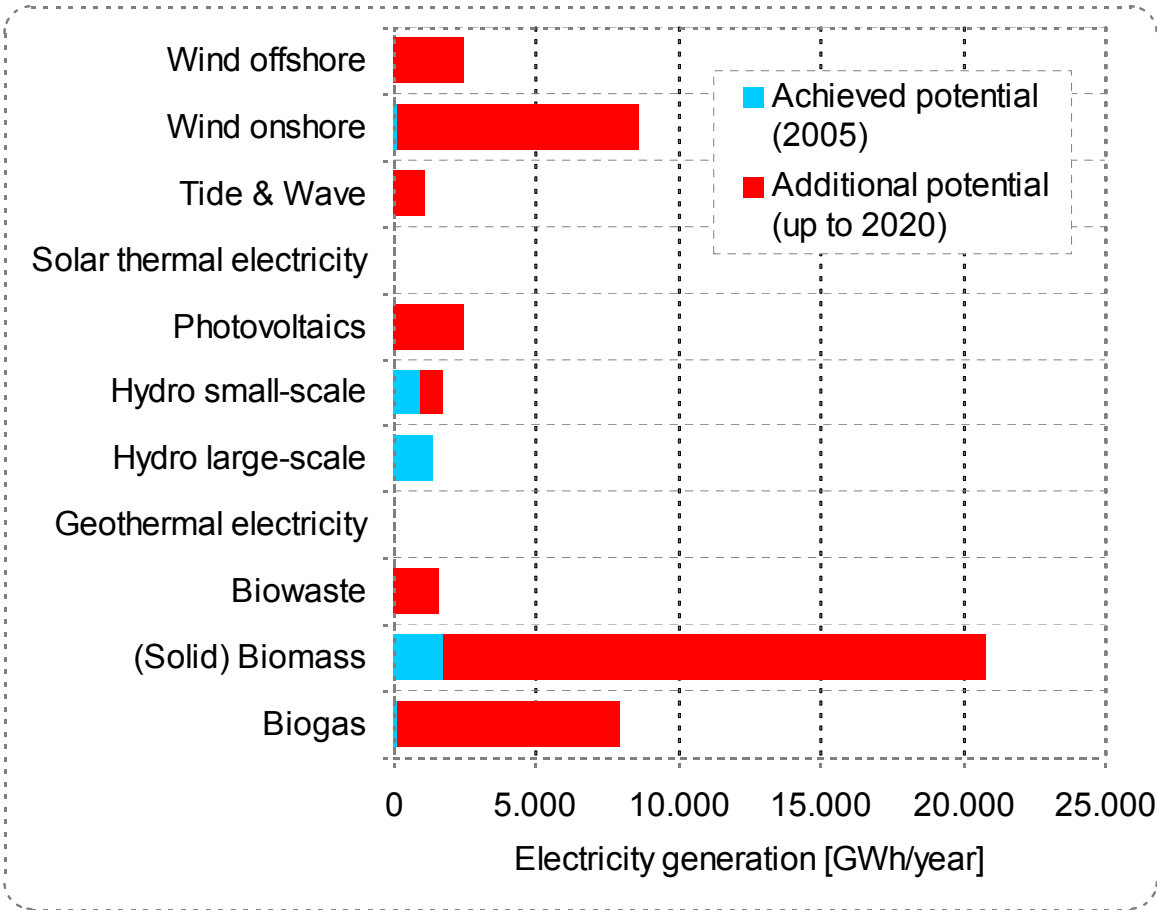


New Member States

(3) Potentials and Prospects

Realisable mid-term (2020) potential for RES-E

Poland

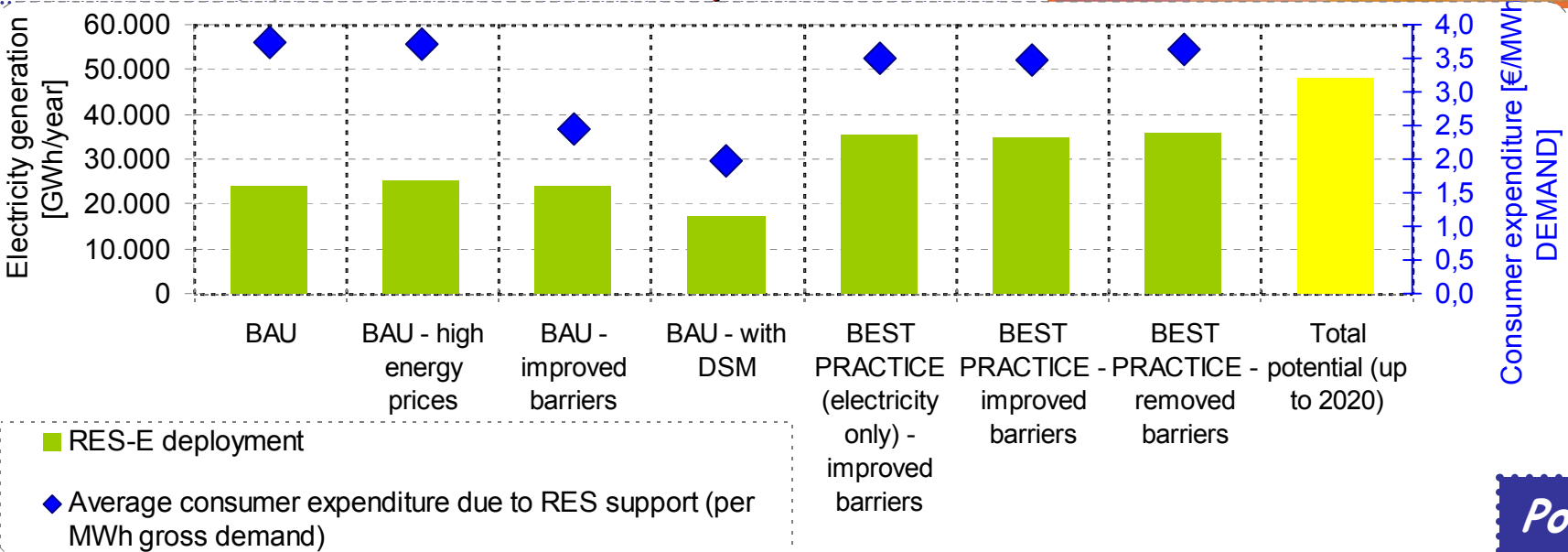


Gross electricity demand 2005	BAS	33,5%
Gross electricity demand 2020	BAS	24,5%
Final energy demand 2005	BAS	6,7%
Final energy demand 2020	BAS	5,0%
Gross electricity demand 2005	EFF	33,5%
Gross electricity demand 2020	EFF	27,9%
Final energy demand 2005	EFF	6,7%
Final energy demand 2020	EFF	5,9%

Proposed RES target for 2020 **15%**



(3) Potentials and Prospects



Poland

Future prospects for RES-E

2020

RES-E deployment

Breakdown by RES-E category

[Unit]	BAU	BAU - high energy prices	BAU - improved barriers	BAU - with DSM	BEST PRACTICE (electricity only) - improved barriers	BEST PRACTICE - improved barriers	BEST PRACTICE - removed barriers
Biogas	GWh	4.469	4.479	3.477	2.849	5.648	5.729
(Solid) Biomass	GWh	10.520	11.243	11.596	7.122	19.795	19.454
Biowaste	GWh	1.487	1.487	1.478	1.487	1.478	1.476
Geothermal electricity	GWh	0	0	0	0	0	0
Hydro large-scale	GWh	1.404	1.404	1.404	1.401	1.404	1.404
Hydro small-scale	GWh	1.241	1.241	1.742	1.241	1.742	1.743
Photovoltaics	GWh	0	0	0	0	90	99
Solar thermal electricity	GWh	0	0	0	0	0	0
Tide & Wave	GWh	0	0	0	0	0	0
Wind onshore	GWh	4.754	5.201	4.186	2.960	5.065	5.602
Wind offshore	GWh	270	270	234	198	486	529
RES-E TOTAL	GWh	24.144	25.325	24.116	17.259	35.708	36.037

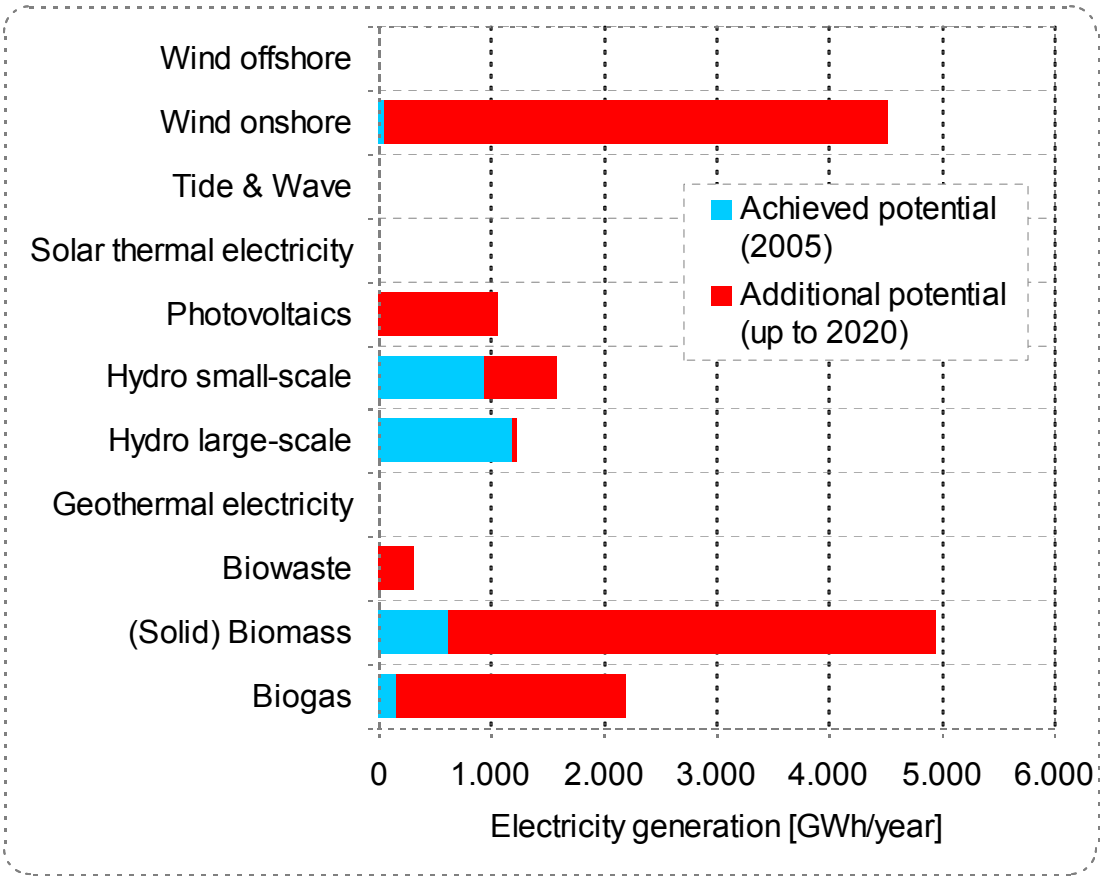
RES-E TOTAL - share on gross demand

%	12,3%	12,9%	12,2%	10,0%	18,1%	17,7%	18,3%
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(3) Potentials and Prospects

Realisable mid-term (2020) potential for RES-E

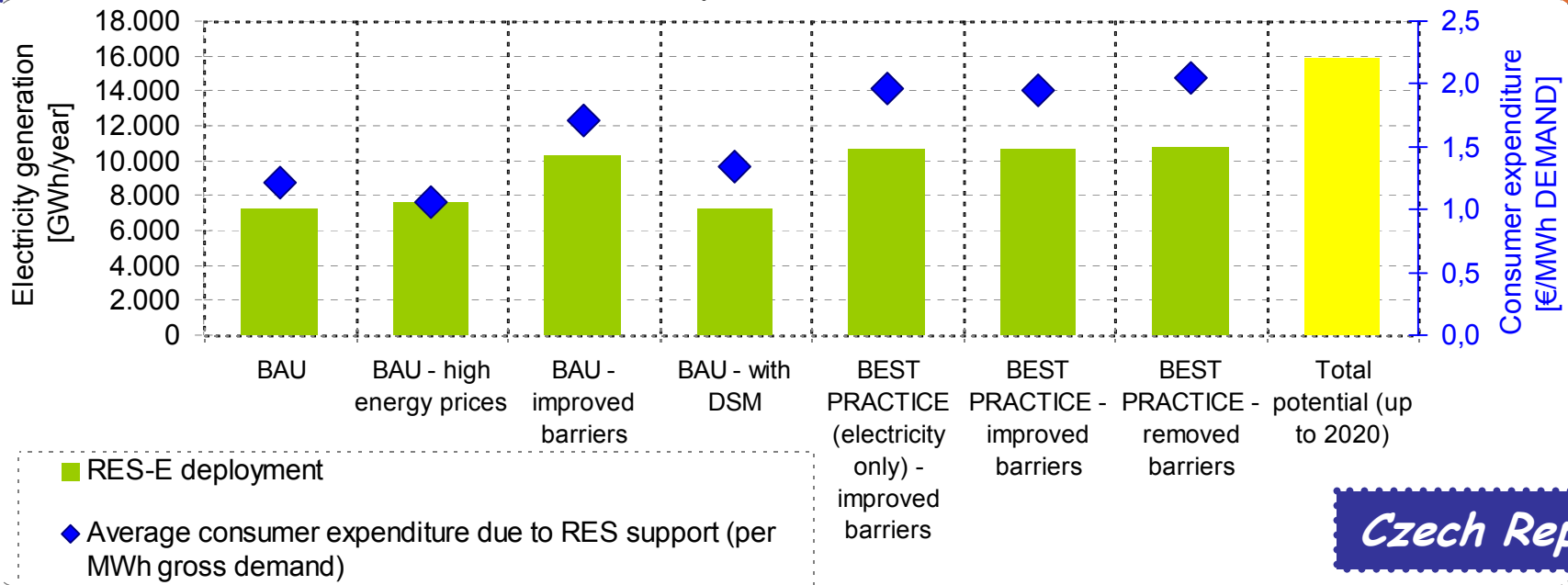
Czech Republic



Gross electricity demand 2005	BAS	22,9%
Gross electricity demand 2020	BAS	17,3%
Final energy demand 2005	BAS	5,0%
Final energy demand 2020	BAS	4,0%
Gross electricity demand 2005	EFF	22,9%
Gross electricity demand 2020	EFF	20,0%
Final energy demand 2005	EFF	5,0%
Final energy demand 2020	EFF	4,8%

Proposed RES target for 2020 **13%**

(3) Potentials and Prospects



Czech Republic

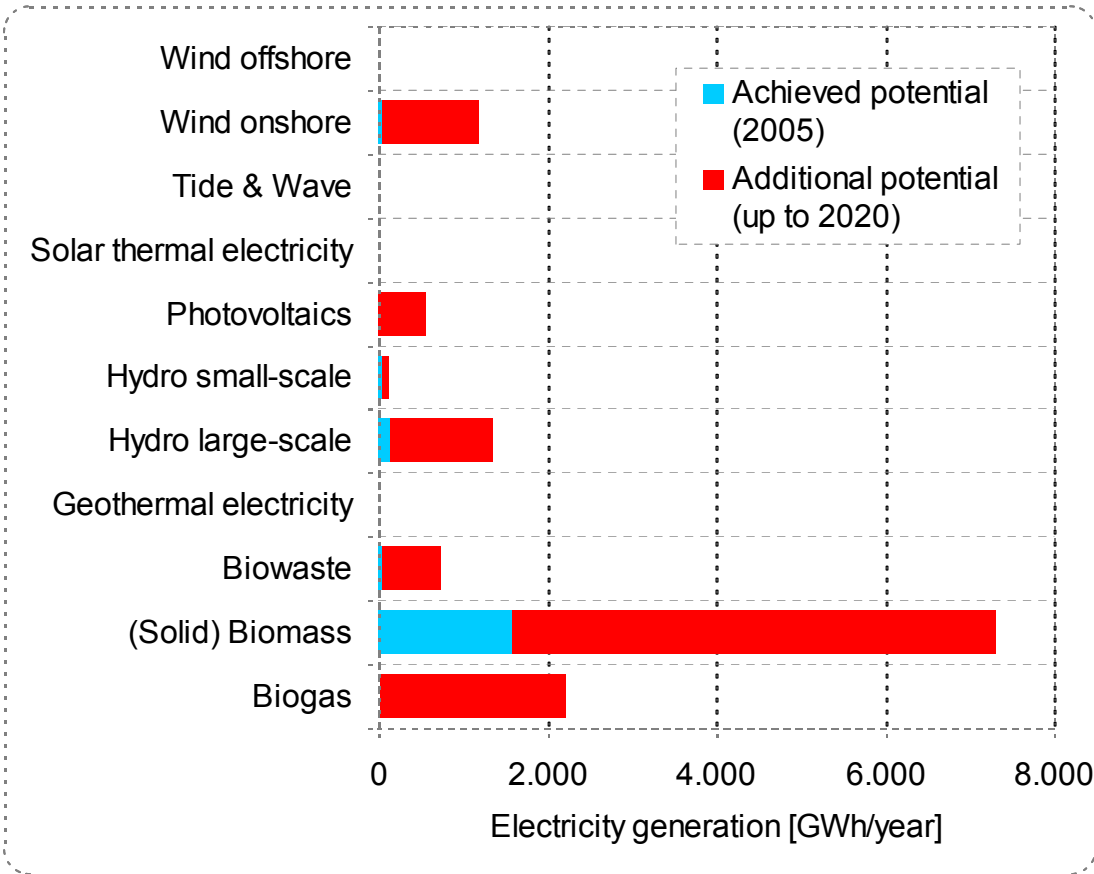
2020 Future prospects for RES-E

RES-E deployment Breakdown by RES-E category	[Unit]	PRACTICE (electricity only) - improved barriers						
		BAU	BAU - high energy prices	BAU - improved barriers	BAU - with DSM	PRACTICE - improved barriers	BEST PRACTICE - improved barriers	BEST PRACTICE - removed barriers
Biogas	GWh	677	910	1.044	677	1.573	1.573	1.610
(Solid) Biomass	GWh	2.892	2.988	3.056	2.882	4.412	4.350	4.364
Biowaste	GWh	239	239	235	239	235	235	235
Geothermal electricity	GWh	0	0	0	0	0	0	0
Hydro large-scale	GWh	1.196	1.220	1.196	1.196	1.196	1.196	1.196
Hydro small-scale	GWh	1.165	1.179	1.240	1.165	1.308	1.308	1.308
Photovoltaics	GWh	7	7	86	7	86	86	104
Solar thermal electricity	GWh	0	0	0	0	0	0	0
Tide & Wave	GWh	0	0	0	0	0	0	0
Wind onshore	GWh	1.070	1.070	3.399	1.070	1.889	1.889	1.951
Wind offshore	GWh	0	0	0	0	0	0	0
RES-E TOTAL	GWh	7.247	7.613	10.255	7.236	10.698	10.636	10.769
RES-E TOTAL - share on gross demand	%	7,9%	8,3%	11,2%	9,1%	11,7%	11,6%	11,8%

(3) Potentials and Prospects

Realisable mid-term (2020) potential for RES-E

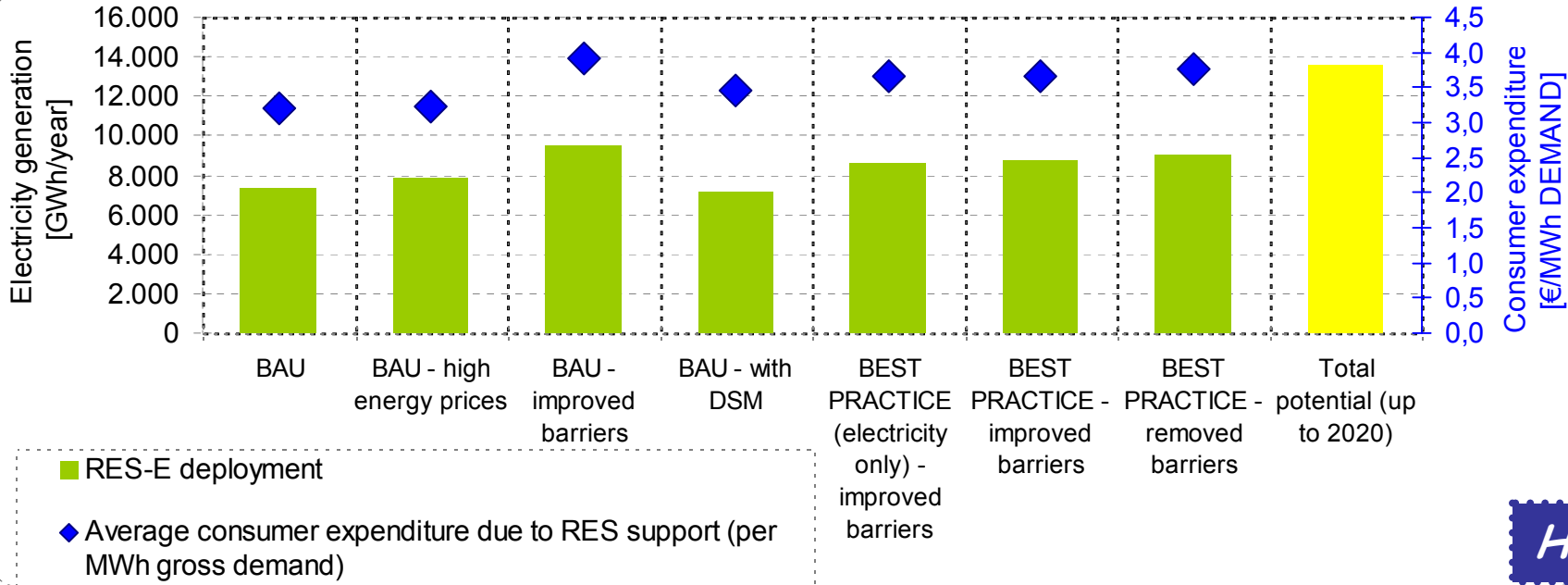
Hungary



Gross electricity demand 2005	BAS	32,2%
Gross electricity demand 2020	BAS	24,1%
Final energy demand 2005	BAS	6,1%
Final energy demand 2020	BAS	5,0%
Gross electricity demand 2005	EFF	32,2%
Gross electricity demand 2020	EFF	27,3%
Final energy demand 2005	EFF	6,1%
Final energy demand 2020	EFF	6,0%

Proposed RES target for 2020 **13%**

(3) Potentials and Prospects



Hungary

Future prospects for RES-E

2020

RES-E deployment

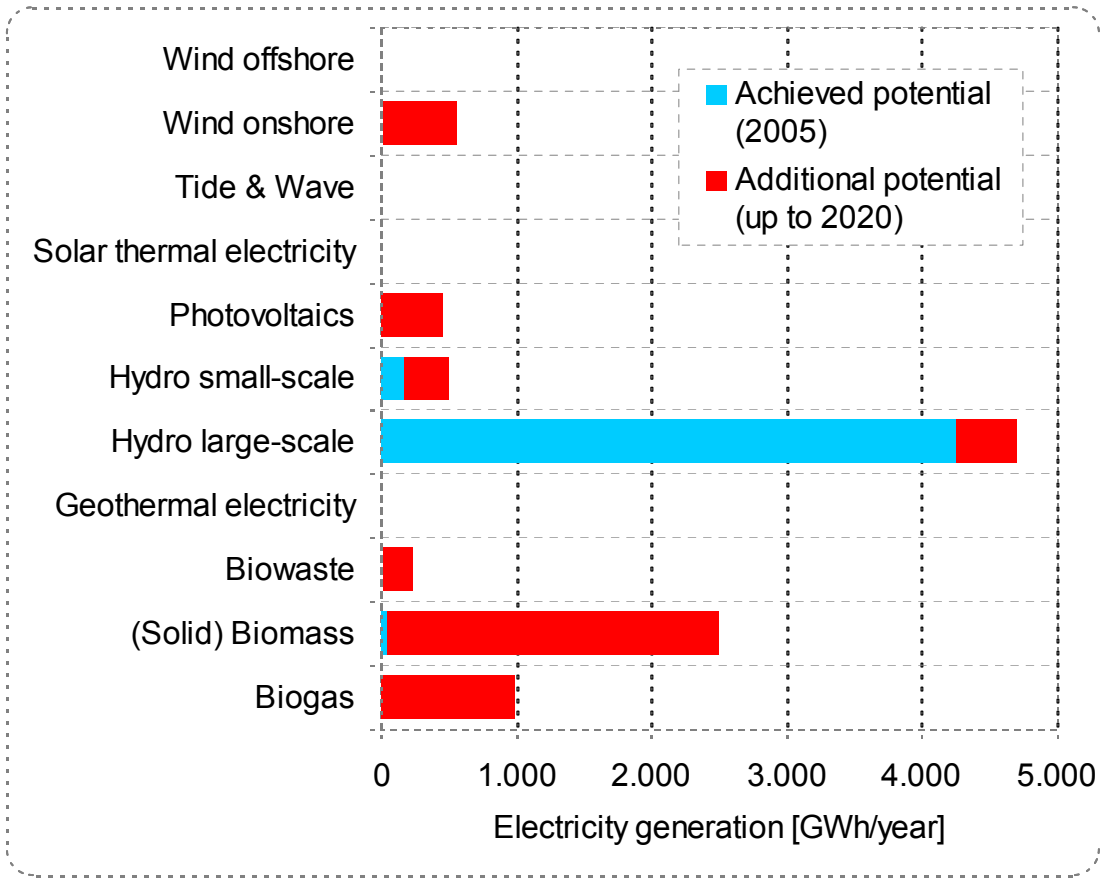
Breakdown by RES-E category

	[Unit]	BAU	BAU - high energy prices	BAU - improved barriers	BAU - with DSM	BEST PRACTICE (electricity only) - improved barriers	BEST PRACTICE - improved barriers	BEST PRACTICE - removed barriers
Biogas	GWh	509	509	1.333	509	1.277	1.277	1.581
(Solid) Biomass	GWh	5.073	5.356	5.474	5.049	5.503	5.628	5.599
Biowaste	GWh	442	442	680	442	680	680	694
Geothermal electricity	GWh	0	0	0	0	0	0	0
Hydro large-scale	GWh	671	937	671	517	671	671	671
Hydro small-scale	GWh	69	69	88	69	74	74	74
Photovoltaics	GWh	0	0	0	0	35	35	38
Solar thermal electricity	GWh	0	0	0	0	0	0	0
Tide & Wave	GWh	0	0	0	0	0	0	0
Wind onshore	GWh	527	527	1.216	527	361	361	394
Wind offshore	GWh	0	0	0	0	0	0	0
RES-E TOTAL	GWh	7.290	7.840	9.463	7.113	8.601	8.727	9.051
RES-E TOTAL - share on gross demand	%	13,0%	13,9%	16,8%	14,4%	15,3%	15,5%	16,1%

(3) Potentials and Prospects

Realisable mid-term (2020) potential for RES-E

Slovakia

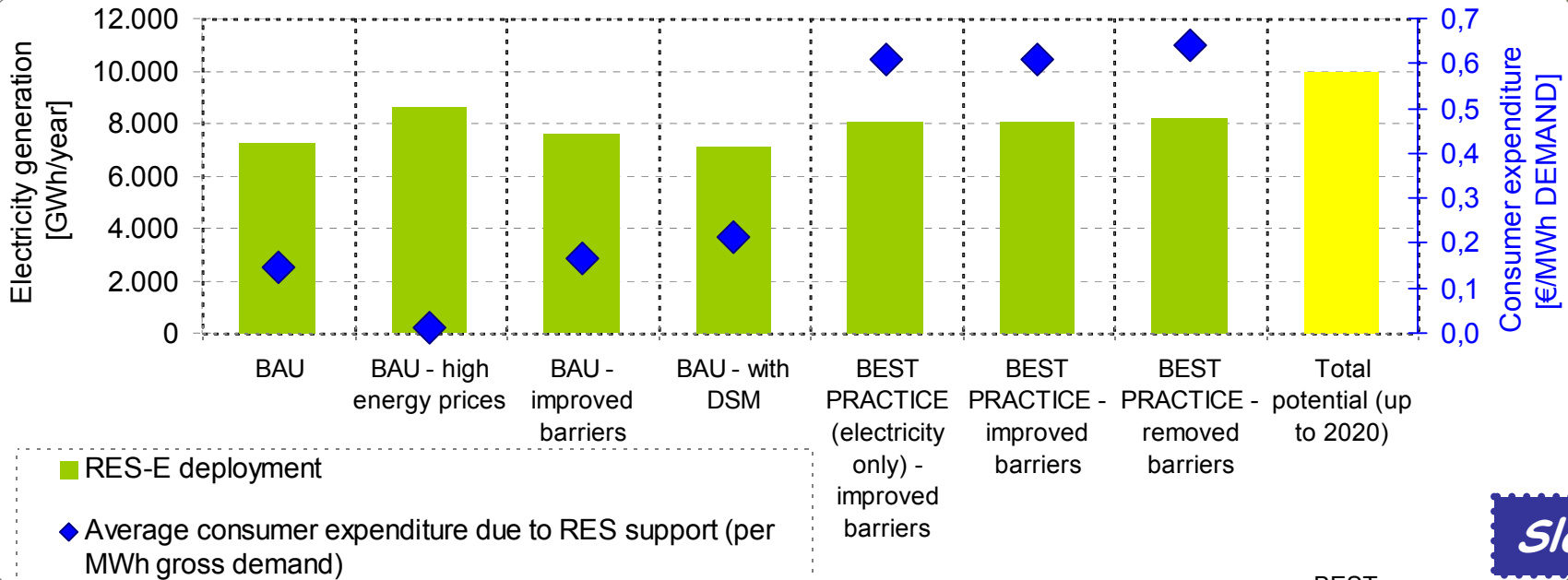


Gross electricity demand 2005	BAS	35,4%
Gross electricity demand 2020	BAS	23,4%
Final energy demand 2005	BAS	7,6%
Final energy demand 2020	BAS	6,0%
Gross electricity demand 2005	EFF	35,4%
Gross electricity demand 2020	EFF	26,2%
Final energy demand 2005	EFF	7,6%
Final energy demand 2020	EFF	7,3%

Proposed RES target for 2020 **14%**



(3) Potentials and Prospects



Slovakia

Future prospects for RES-E

2020

RES-E deployment

Breakdown by RES-E category

	[Unit]	BAU	BAU - high energy prices	BAU - improved barriers	BAU - with DSM	BEST PRACTICE (electricity only) - improved barriers	BEST PRACTICE - improved barriers	BEST PRACTICE - removed barriers
Biogas	GWh	260	574	258	217	687	687	687
(Solid) Biomass	GWh	1.698	2.158	2.038	1.684	2.040	2.023	2.155
Biowaste	GWh	148	148	148	148	148	148	148
Geothermal electricity	GWh	0	0	0	0	0	0	0
Hydro large-scale	GWh	4.522	4.667	4.522	4.522	4.558	4.558	4.558
Hydro small-scale	GWh	503	503	503	503	503	503	503
Photovoltaics	GWh	0	0	0	0	41	41	48
Solar thermal electricity	GWh	0	0	0	0	0	0	0
Tide & Wave	GWh	0	0	0	0	0	0	0
Wind onshore	GWh	109	534	109	75	102	102	106
Wind offshore	GWh	0	0	0	0	0	0	0
RES-E TOTAL	GWh	7.239	8.584	7.577	7.148	8.079	8.062	8.204
RES-E TOTAL - share on gross demand	%	17,0%	20,2%	17,8%	18,8%	19,0%	19,0%	19,3%

Regional potentials and prospects

- Biomass as the key contributor in future RES(-Electricity) deployment*
- Besides wind energy appears of relevance*
- Non-economic barriers (administrative, technical (grid), social) are a major hindrance to achieve ambitious RES targets at low cost*
- Obviously, in terms of size Poland is of dominance in the regional market, but also all other countries lack only less behind.*
- In all countries the applied support schemes need to be strengthened to meet the proposed future targets*



Advertisement



Forthcoming events: Regional workshops ...

Ljubljana, 11 April 2008

*London, 25 April 2008 ... Focus: joint efforts to promote
offshore wind in the North Sea?*

Italy, May 2008

Germany, June 2008

Final conference ... Brussels, November 2008

Thanks for your attention!

In case of questions / remarks ...

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