



The Dynamic Computer-model *Green-X*

Claus Huber, Thomas Faber, Gustav Resch
Energy Economics Group (EEG)



Overview

- Introduction
- Available versions of the simulation tool
- Overview of the computer-model **Green-X**
(Methodology)
- Illustration of the computer-model **Green-X**



Introduction

- The dynamic toolbox *Green-X* represents the main product of the project *Green-X*
 - A database, allowing dynamic changes and calculating potentials and costs of RES-E, CHP and conventional power
 - A dynamic computer model *Green-X* integrating RES-E, CHP generation, conventional electricity production and the most relevant demand-side activities
- The computer model allows a comparative and quantitative analysis of interactions between RES-E, CHP, DSM activities and GHG-reduction within the liberalised electricity sector both for the EU as a whole and individual Member States over time by simulating different scenarios



Scenarios Output

- ***Advice on policy proposals*** at both EU and on national level e.g. to reach targets indicated by the EU RES-E Directive
- Demonstrate the consequences of a ***non-harmonised*** approach ***versus a harmonised RES-E policy***
- Show the effects of ***linked policies*** for RES-E, CHP, important DSM activities and GHG-reduction versus separated and ***individually adjusted strategies*** for these areas, (demonstrating especially the impact on TGCs and GHG permits).
- ***Estimation of costs and benefits*** for the EU as a whole as for all 15 member states, producers and consumers.
- ***Recommendation*** for practical implementation of efficient strategies over time for each step



Available Versions

Internal Version

Aim:

- + Analysis of RES-E policy
- + Interactions of RES-E with the conventional electricity market and other policies (TEA, CHP, DSM)

Know-how:

Internal full version is an expert tool; detailed knowledge of the database and the applied methodology necessary

Interactive work during simulation runs necessary

Public Version (CD)

Aim:

- + Analysis of RES-E policy on country and EU-15 level (conventional power price exogenously given)

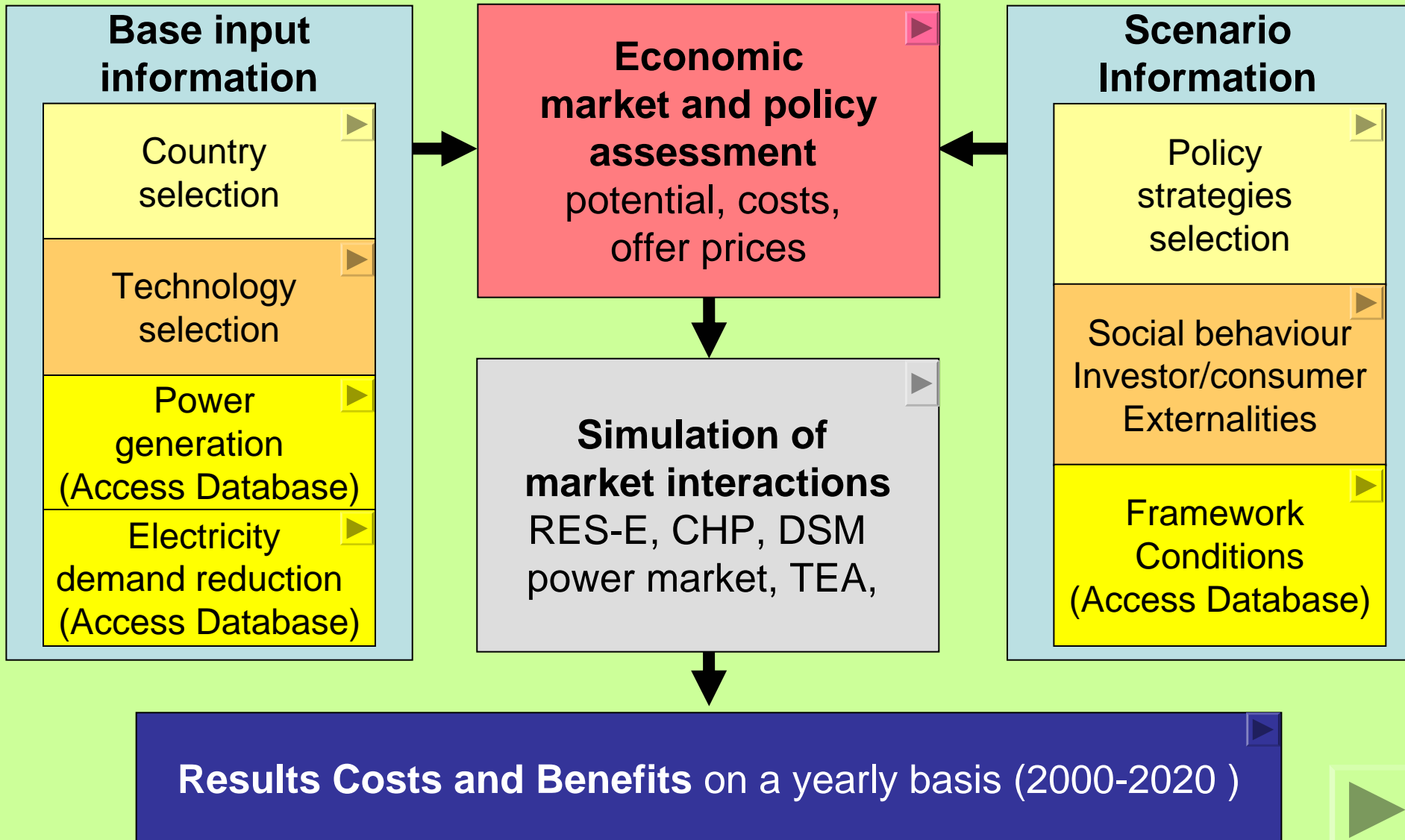
Know-how:

Public version is robust simulation tool – (rudimentary) knowledge of the RES-E system and promotion instruments necessary;

No comprehensive interactive work during simulation runs necessary, lower run-time



Overview computer-tool *Green-X*





Country Selection

Individual countries or whole group of countries

EU-15 Member States

EU 10+ Accession Countries -- extended version

EU Candidate Countries (BU, RO, TR) -- extended version

Other European countries (CH, NO) -- extended version





Technology Selection

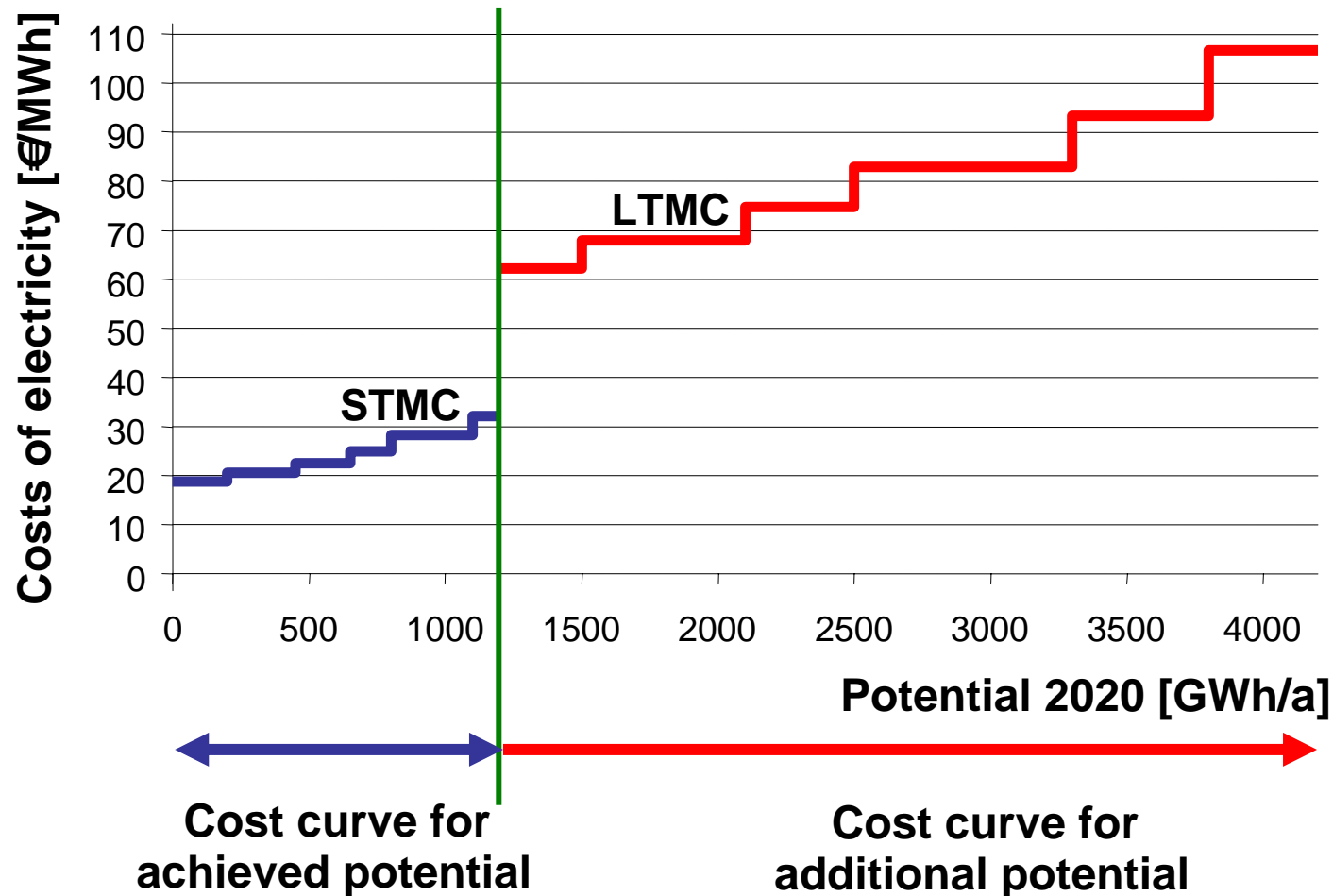
Considered Technologies
Electricity generation
<i>10 (17) RES-E technologies</i>
<i>4 (5) Thermal and nuclear power plants</i>
Combined heat and power generation - extended version
<i>4 (8) RES-E technologies</i>
<i>3 (4) Thermal power plants</i>





Power generation (Database)

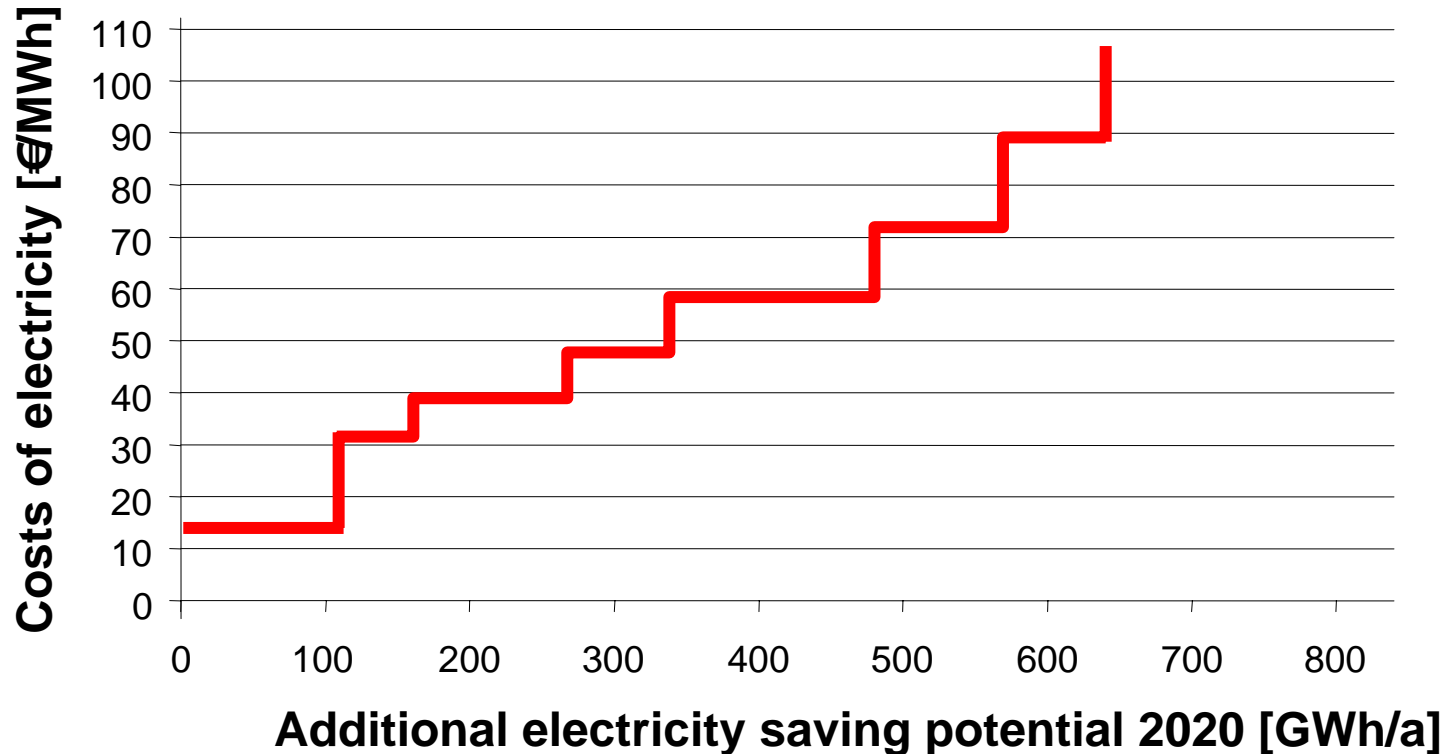
Cost-resource curve for each technology in each country





Electricity demand reduction (Database)

Electricity saving potential for each sector in each country





Policy strategy selection

Considered promotion strategy
General tax
<i>Energy tax</i>
<i>Environmental tax - extended version</i>
Electricity generation
<i>Price-driven strategies</i>
<i>Capacity-driven strategies</i>
Combined heat and power
<i>Price-driven strategies</i>
<i>Capacity-driven strategies</i>
DSM instruments
Climate Policy - extended version





Social Behaviour

Individual behaviour can be selected per technology country and year

Investment decisions of investors (interest rate) - extended version

Technology

Policy instrument

Planning horizon / policy design

Strategic behaviour investors (tendering, bidding)





Framework Conditions / Database

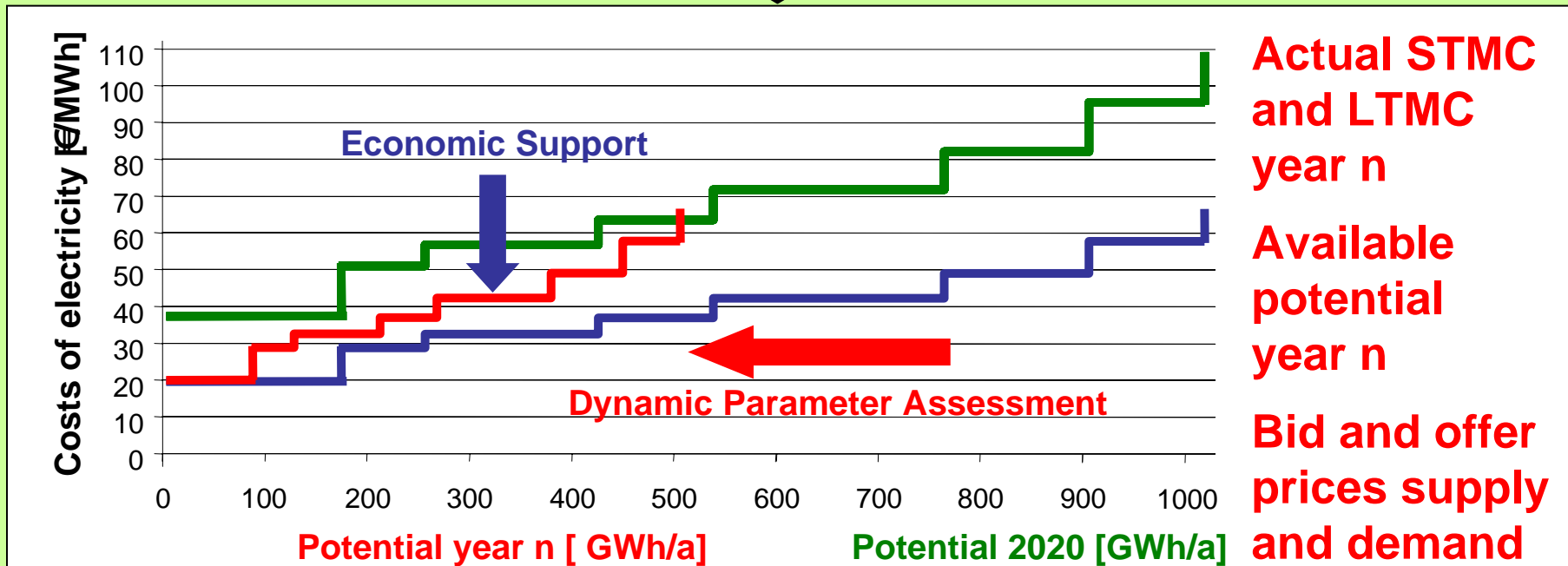
Different Scenarios available per country and year
Demand forecast
<i>yearly electricity demand</i>
<i>yearly heat from CHP</i>
<i>peak demand electricity</i>
<i>reserve capacity</i>
Price elasticity - extended version
Availability factor of each technology (yearly volatility)
Import / export restrictions electricity trade -- extended version
Dynamic parameter restrictions
Technology cost forecast / learning factors
Prices
<i>Primary energy price</i>
<i>Heat price CHP</i>





Economic market and policy assessment

Cost-resource curves
for each technology in each country

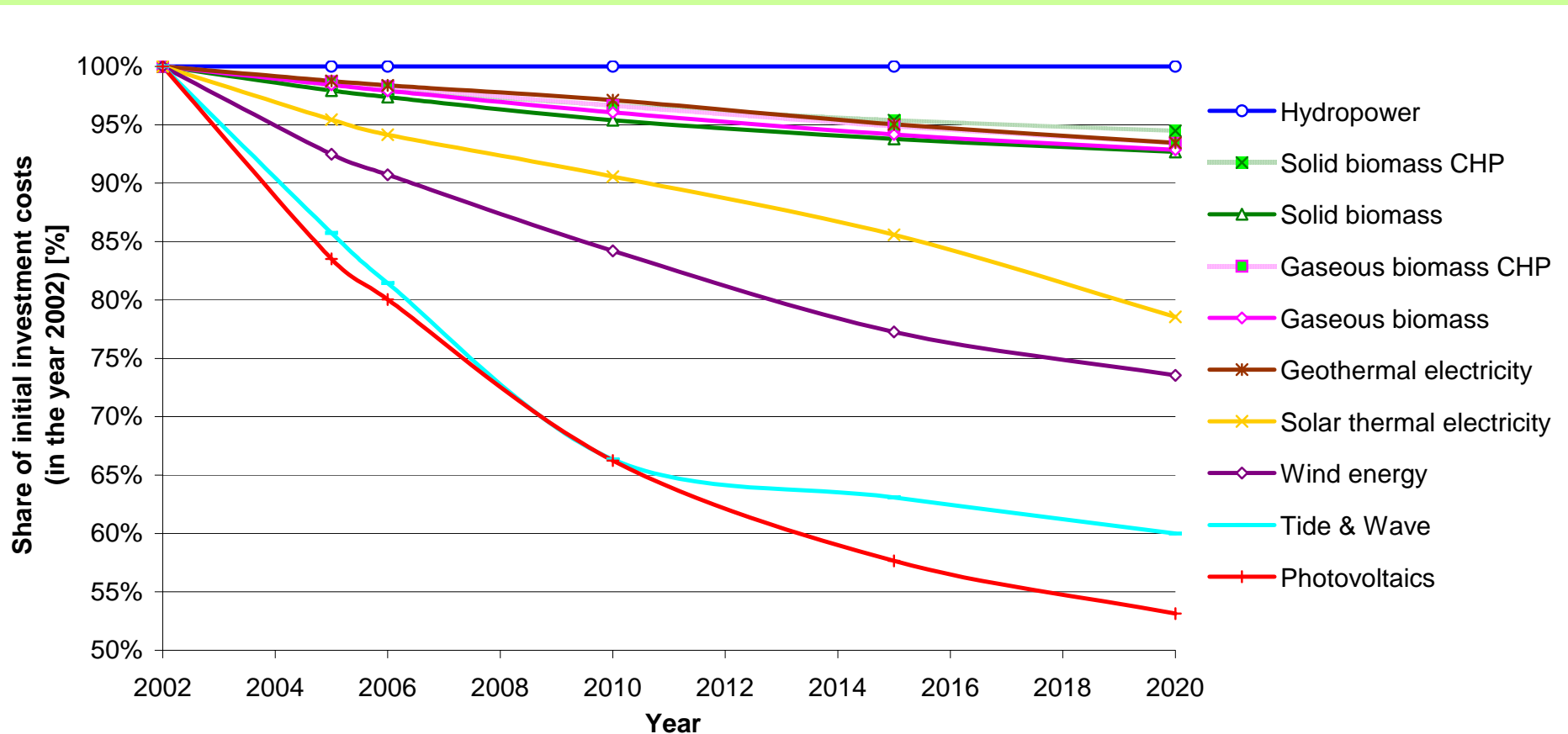


Technology / country specific support schemes
Incentives / Barriers Investor / consumer behaviour Externalities



Dynamic aspect: Investment costs

Illustration: Reduction of investment cost reduction BAU-scenario due to technological learning





Dynamic aspect: Potential

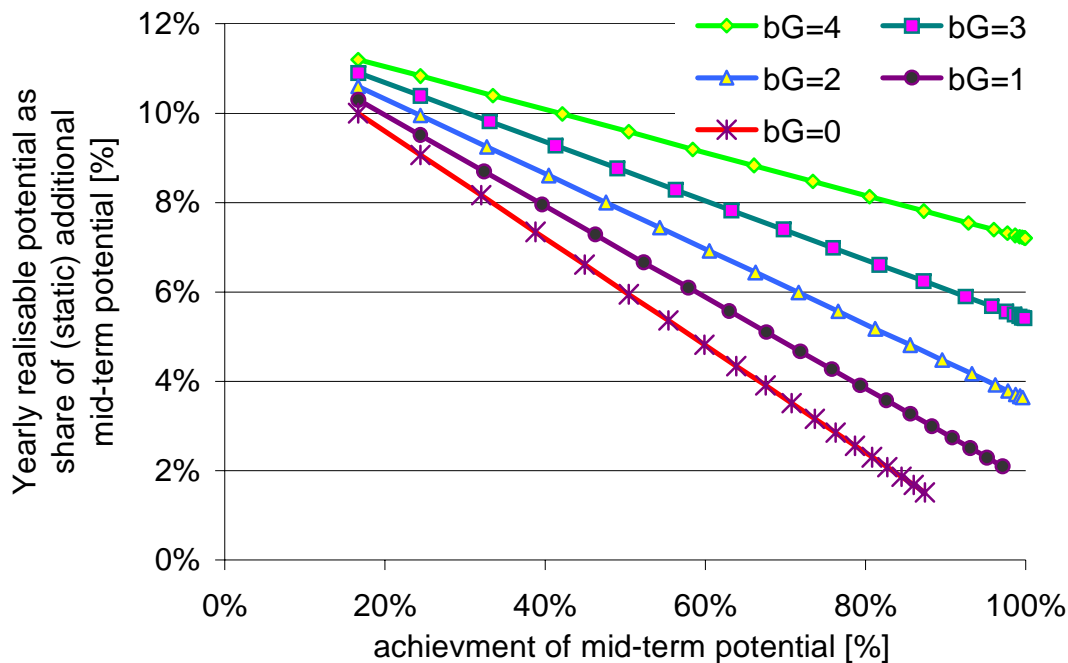
- Mid-term potential is to be broken down to yearly available potentials. In the model the following barriers will be considered:
 - Market barriers (e.g. no matured market)
 - Social barriers (e.g. social acceptance)
 - Industrial barriers (e.g. maximum of global growth rate of a certain technology)
 - Dynamic availability of resources (e.g. biomass, landfill gas)
- Determination of dynamic parameters is based on econometric analysis and stakeholder and expert interviews



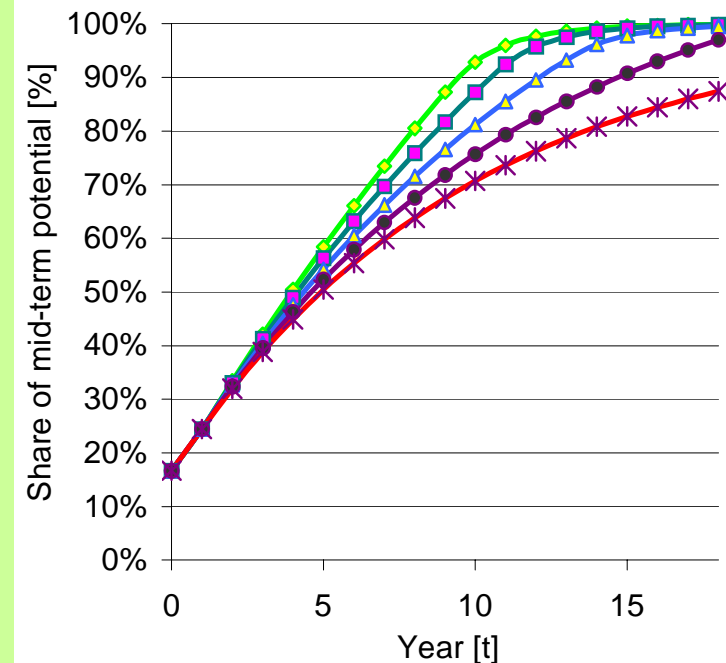
Dynamic aspect: Potential

Modelling approach for grid restriction

Realisable potential due to grid restriction



Deployment

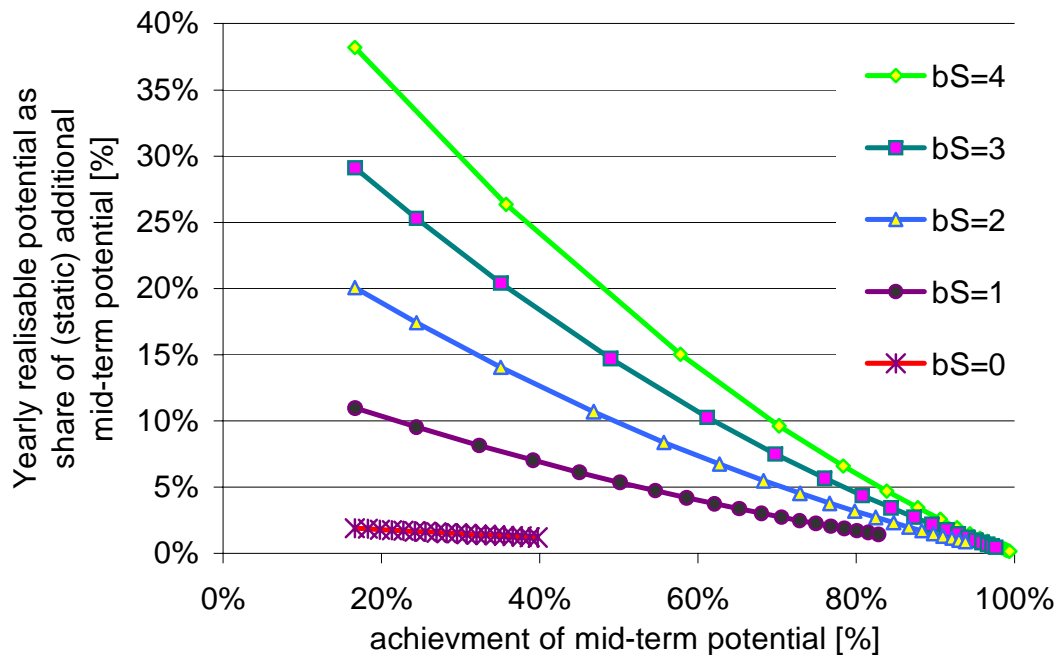




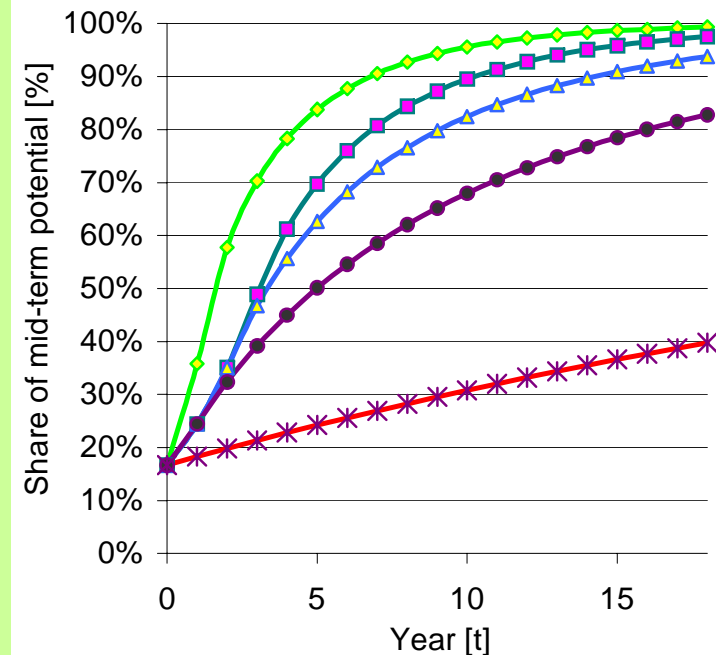
Dynamic aspect: Potential

Modelling approach for social constraints

Realisable potential due to social restriction



Deployment

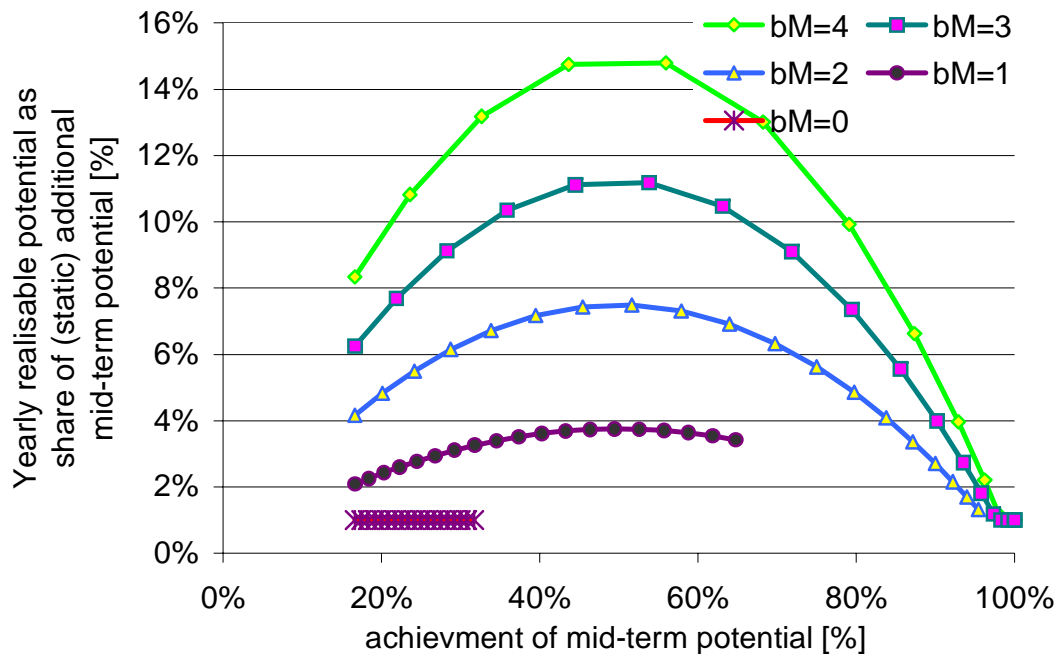




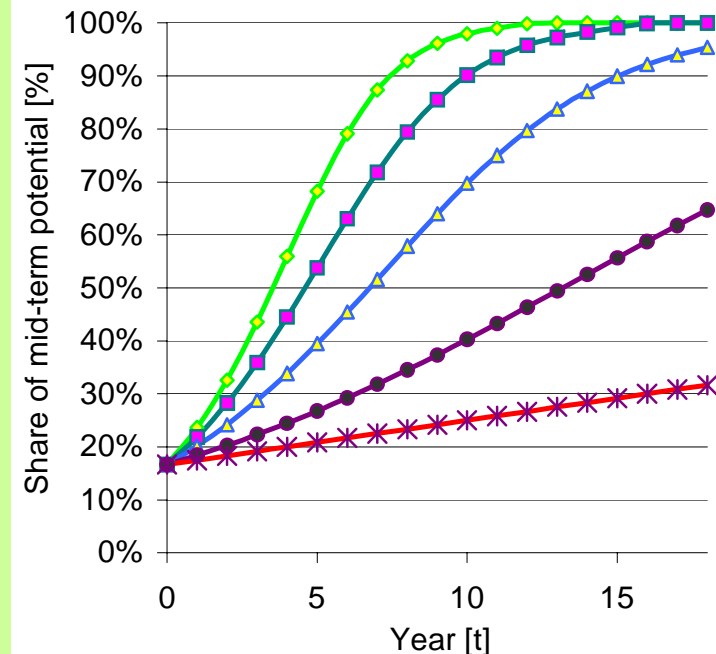
Dynamic aspect: Potential

Modelling approach for market constraints

Realisable potential due to market restriction



Deployment

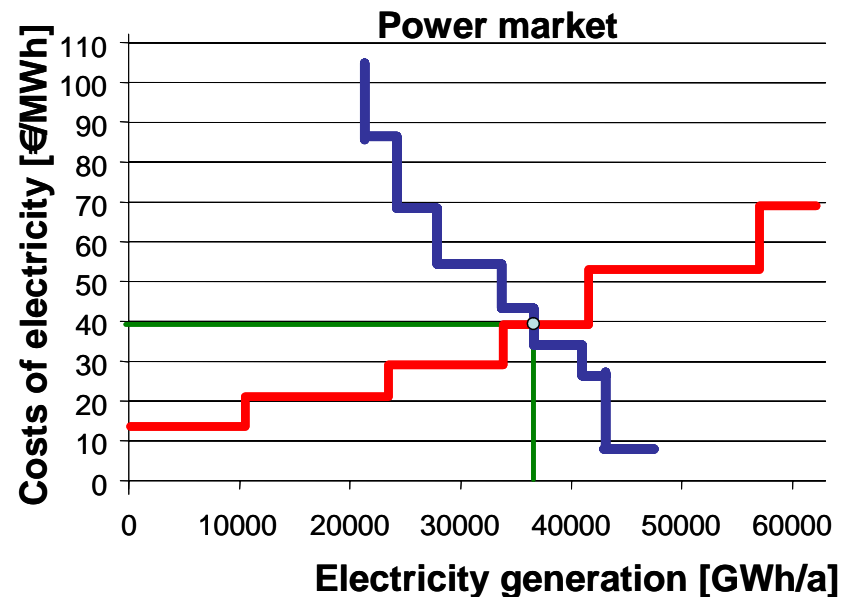
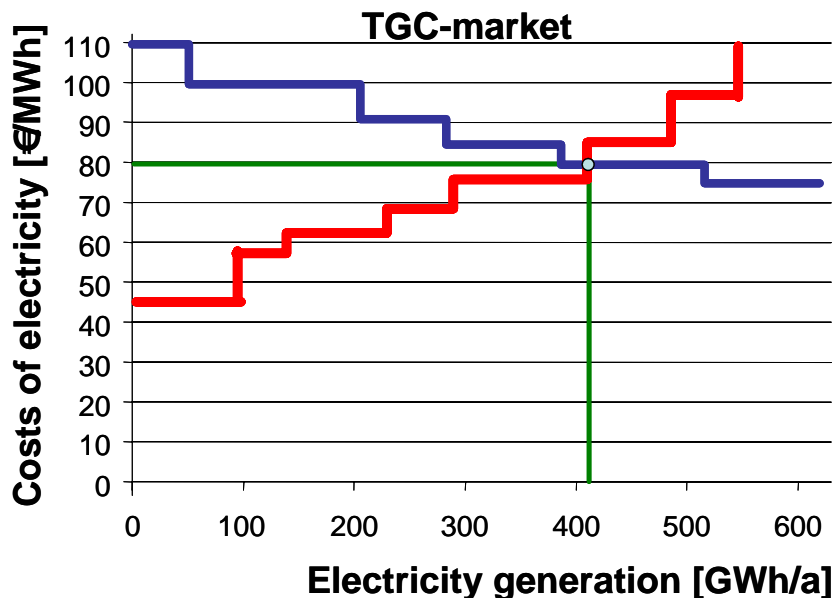




Simulation of market interactions

Analysis of various interactions between RES-E, power market, CHP support, GHG goals, and DSM activities

= > Possible market separations, clearing prices





Results computer model Green-X

- The following results can be derived on country and technology level on a yearly basis till 2020:
 - Total electricity generation (RES-E and conventional)
 - Electricity production by each technology
 - CO₂-emissions
 - Average costs of electricity generation on technology level
 - Import / export balances RES-E and conventional power
 - Influence of energy policy setting on
 - total generation costs and benefits for investors / utilities
 - costs and benefit for consumer / society



Expected Results (1/3)

Results per country and year
General Results
Installed capacity per technology [MW]
Total Fuel input [TJ]
Total energy generation [GWh]
<i>Total electricity generation [GWh]</i>
<i>Electricity generation per technology [GWh]</i>
National electricity consumption [GWh]
Import / export electricity balance [GWh, % of gen.] -- extended version
Total CO₂-emissions [Mt-CO₂] -- extended version



Expected Results (2/3)

Results per country and year
Impact Producer
Total generation costs [M€, €/MWh]
<i>Gen. costs electricity generation [M€, €/MWh]</i>
<i>Gen. costs electricity per techn. [M€, €/MWh]</i>
Total producer surplus (PS) [M€, €/MWh]
<i>PS electricity generation [M€, €/MWh]</i>
<i>PS electricity per techn. [M€, €/MWh]</i>
Marginal generation costs per technology electricity gen. [€/MWh]



Expected Results (3/3)

Results per country and year
Impact Consumer
Additional costs due to RES-E strategy [M€, €/MWh]
Additional costs due to CHP strategy [M€, €/MWh]
Additional costs due to DSM strategy [M€, €/MWh]
Additional costs due to CO ₂ -strategy total [M€, €/MWh, €/t-CO ₂] -- extended version
Prices
Market price electricity [€/MWh] -- extended version
Market price Tradable Green Certificates [€/MWh]
Market price Tradable Emission Allowances [€/t-CO ₂] -- extended version





System requirements Green-X

- Intel Pentium IV or AMD Processor with 2500 MHz frequency or more, respectively Centrino Mobile Processor with 1700 MHz frequency
- Minimum of 512 Mbyte RAM
- Minimum Screen Resolution 1024x768 (optimised for 1280x1024)
- 16 Bit Colours
- Operating system: Windows 2000, Windows XP



*Illustration of the computer-model **Green-X***



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Platform Win2000 SP2
Version 1.0



Thomas Faber, Claus Huber
Energy Economics Group
Institut of Power Systems and Energy Economics
Vienna University of Technology





Contact Details

Project co-ordination:

Prof. Dr. Reinhard Haas

Project co-ordinator

Energy Economics Group (EEG)
Institute of Power Systems and
Energy Economics,
Vienna University of Technology
Gusshausstrasse 25-29
A-1040 Vienna
Austria

email: Haas@eeg.tuwien.ac.at

phone: ++43-(0)1-58801-37352

fax: ++43-(0)1-58801-37397

Dr. Claus Huber

Scientific co-ordinator

Energy Economics Group (EEG)
Institute of Power Systems and
Energy Economics,
Vienna University of Technology
Gusshausstrasse 25-29
A-1040 Vienna
Austria

email: Huber@eeg.tuwien.ac.at

phone: ++43-(0)1-58801-37360

fax: ++43-(0)1-58801-37397

Project web-site:

www.green-x.at