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

The Dynamic Computer-model
Green-X

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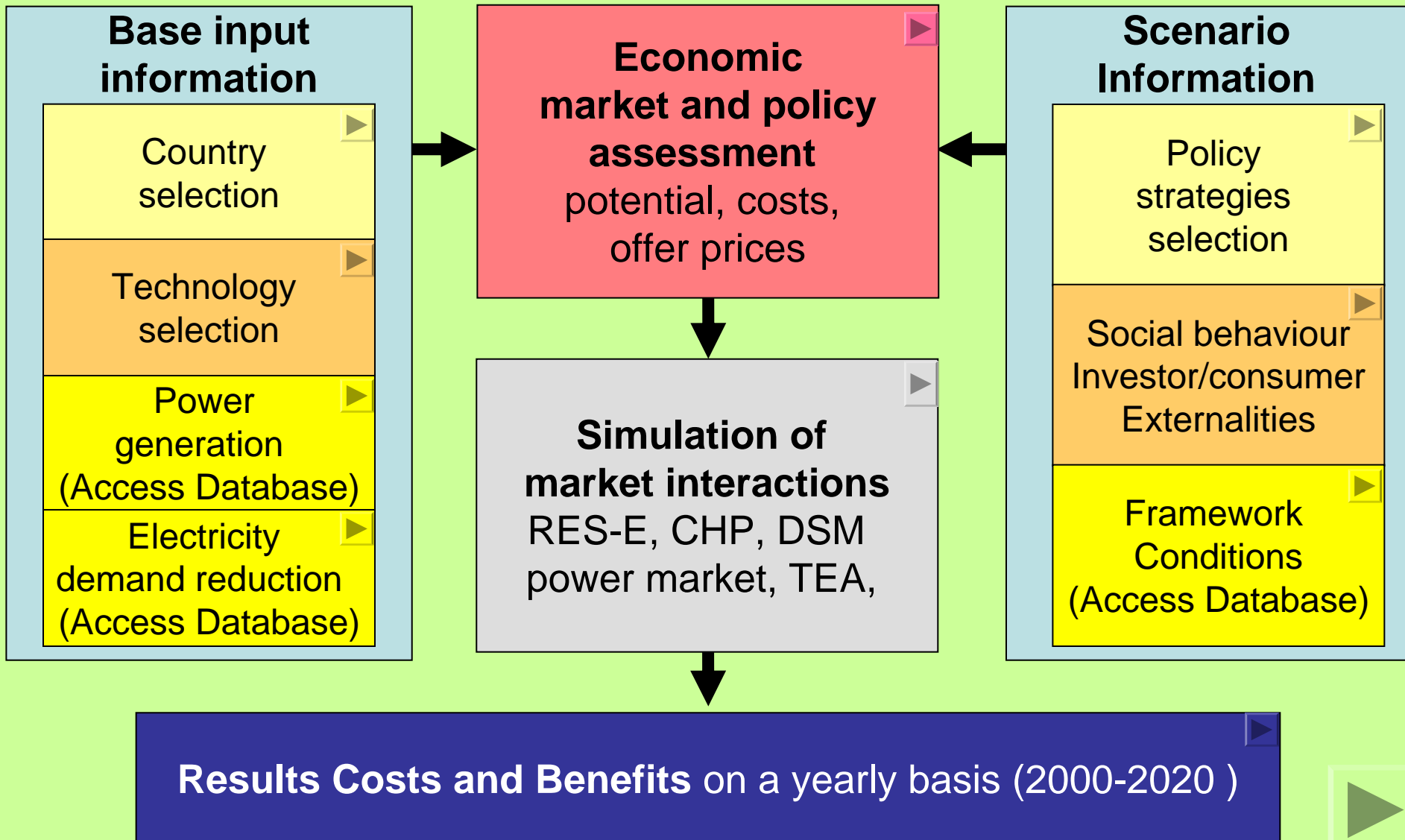+ Analysis of RES-E policy on country and EU-15 level (conventional power price exogenously given)

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

Base input information

Country selection

Technology selection

Power generation (Access Database)

Electricity demand reduction (Access Database)

Economic market and policy assessment
potential, costs, offer prices

Simulation of market interactions
RES-E, CHP, DSM power market, TEA,

Scenario Information

Policy strategies selection

Social behaviour Investor/consumer Externalities

Framework Conditions (Access Database)

Results Costs and Benefits on a yearly basis (2000-2020)

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
10 (17) RES-E technologies
4 (5) Thermal and nuclear power plants
Combined heat and power generation - extended version
4 (8) RES-E technologies
3 (4) Thermal power plants
Technological learning
Learning curves
Expert forecast

Power generation (Database)

Cost-resource curve for each technology in each country
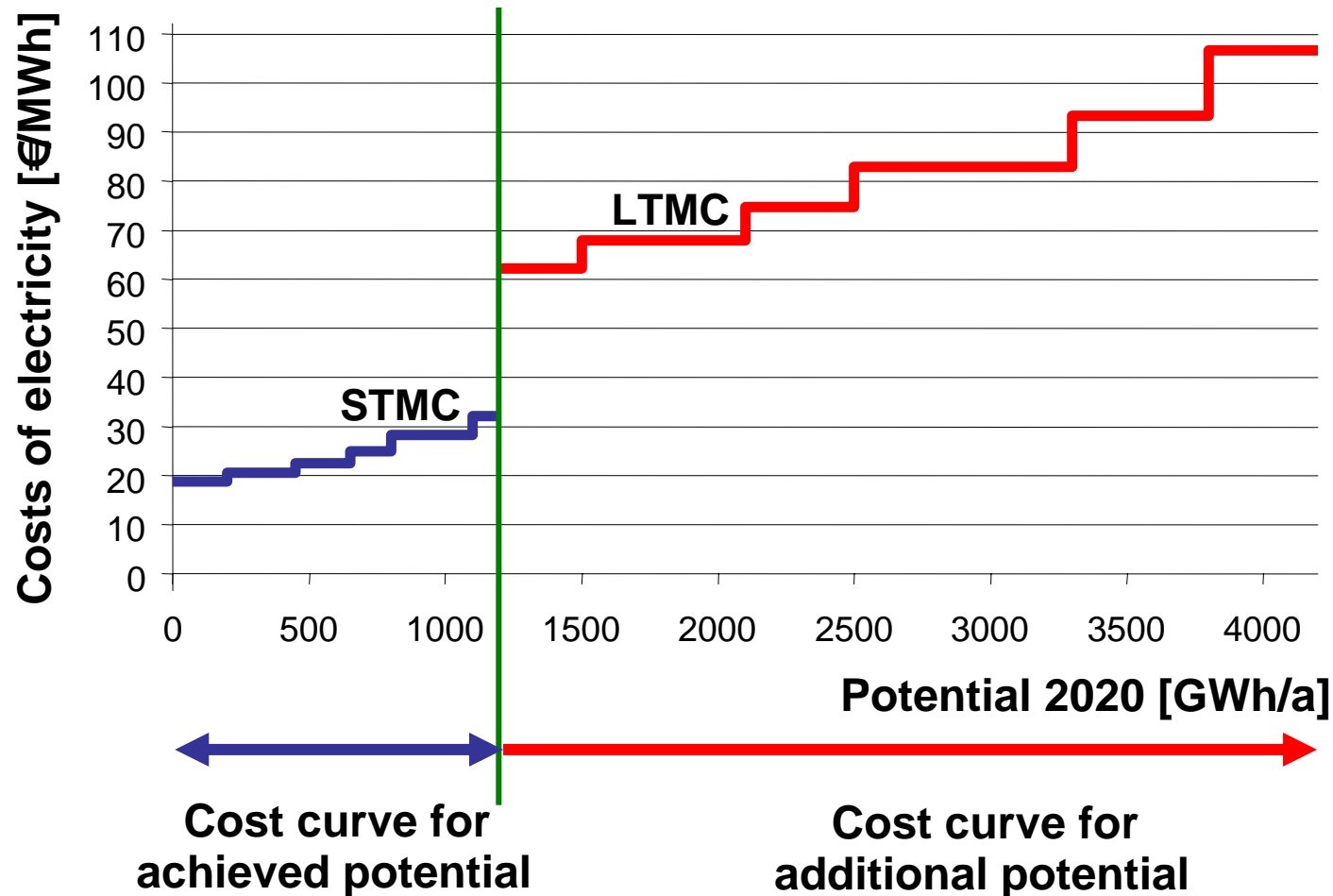
Electricity demand reduction (Database)

Electricity saving potential for each sector in each country
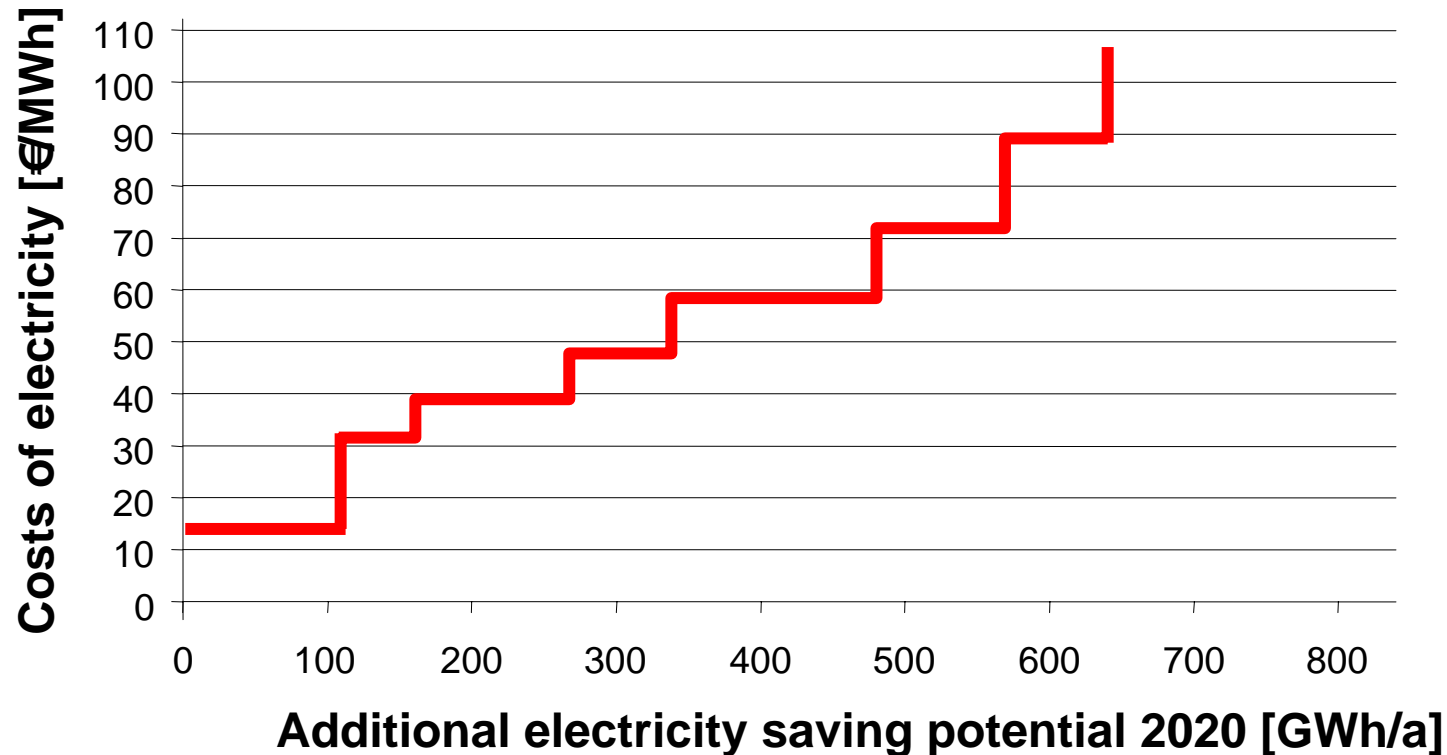
Policy strategy selection

Considered promotion strategy
General tax
Energy tax
Environmental tax **- extended version**
Electricity generation
Price-driven strategies
Capacity-driven strategies
Combined heat and power
Price-driven strategies
Capacity-driven strategies
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)
Dynamic non-economic barriers
Technical (Grid)
Social
Market / administration

Framework Conditions / Database

Different Scenarios available per country and year
Demand forecast
yearly electricity demand
yearly heat from CHP
peak demand electricity
reserve capacity
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
Primary energy price
Heat price CHP

Economic market and policy assessment

Cost-resource curves

for each technology in each country

Actual STMC and LTMC year n

Available potential year n

Bid and offer prices supply and demand
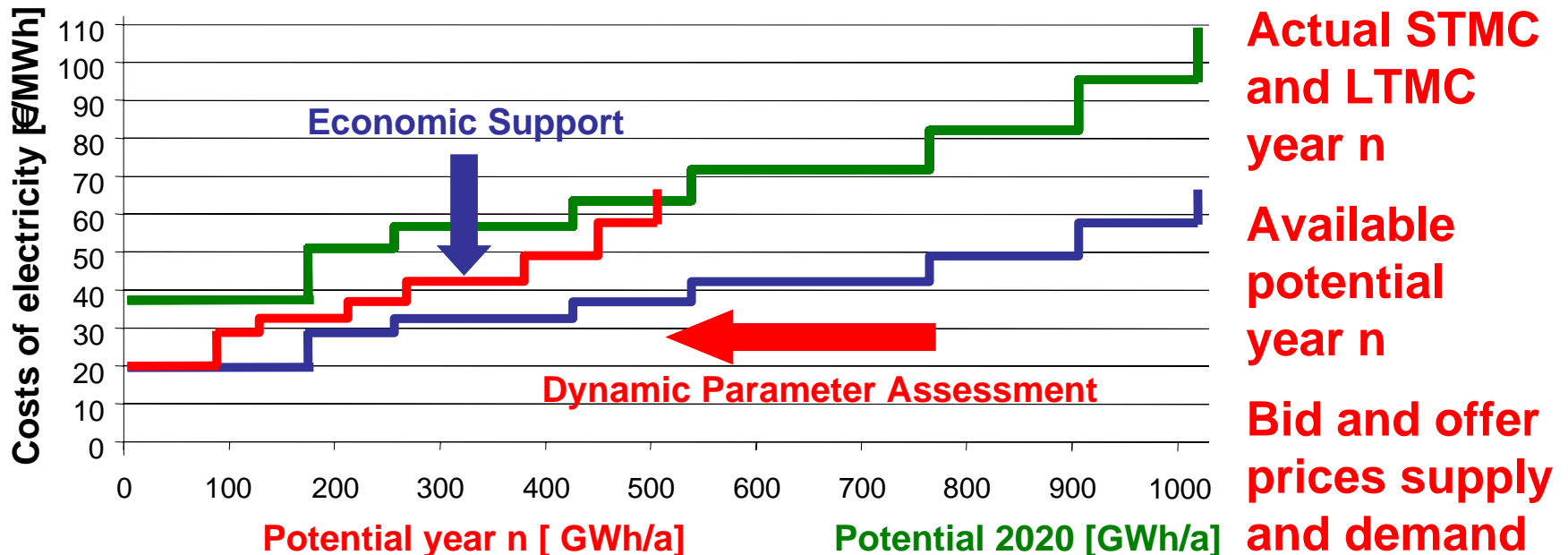
Technology / country specific support schemes

Incentives / Barriers   Investor / consumer behaviour   Externalities

Dynamic aspect: Investment costs

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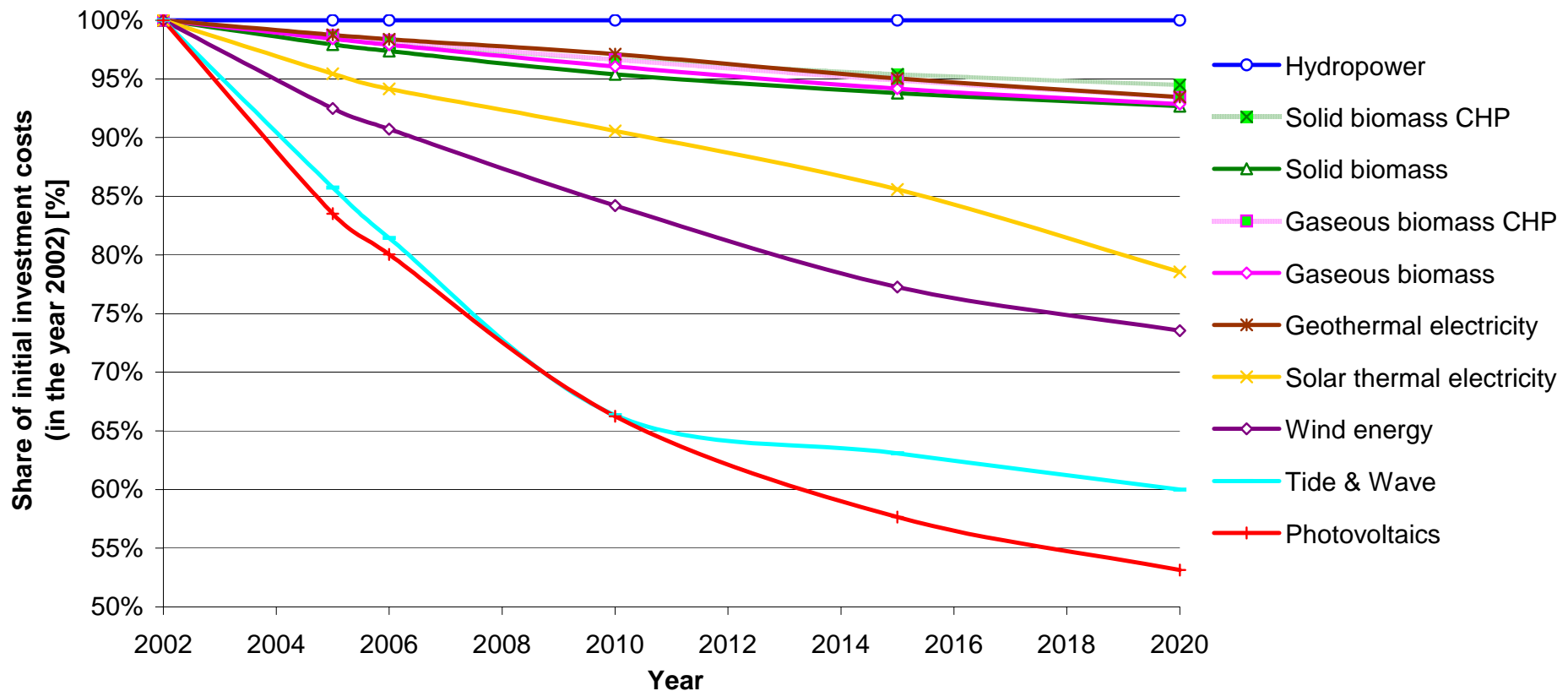
Dynamic aspect: Potential

- Mid-term potential is 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

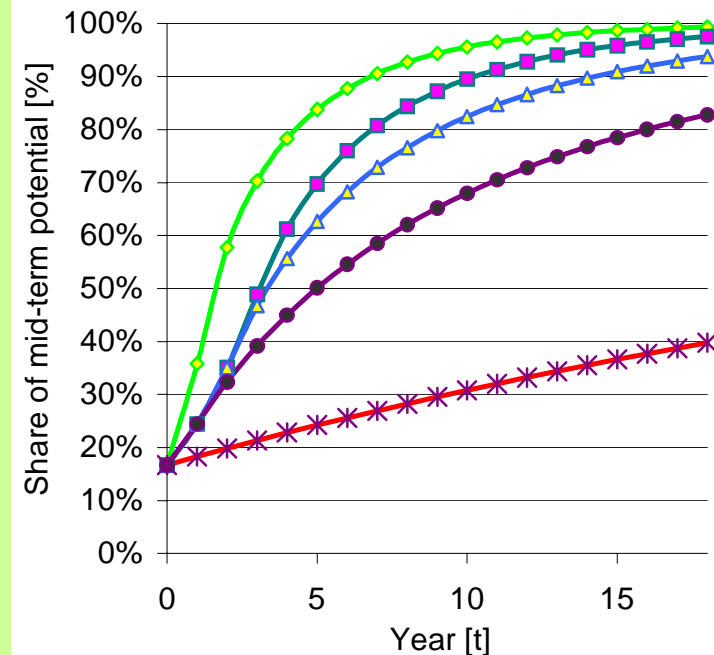**Realisable potential due to <u>grid restriction</u>**
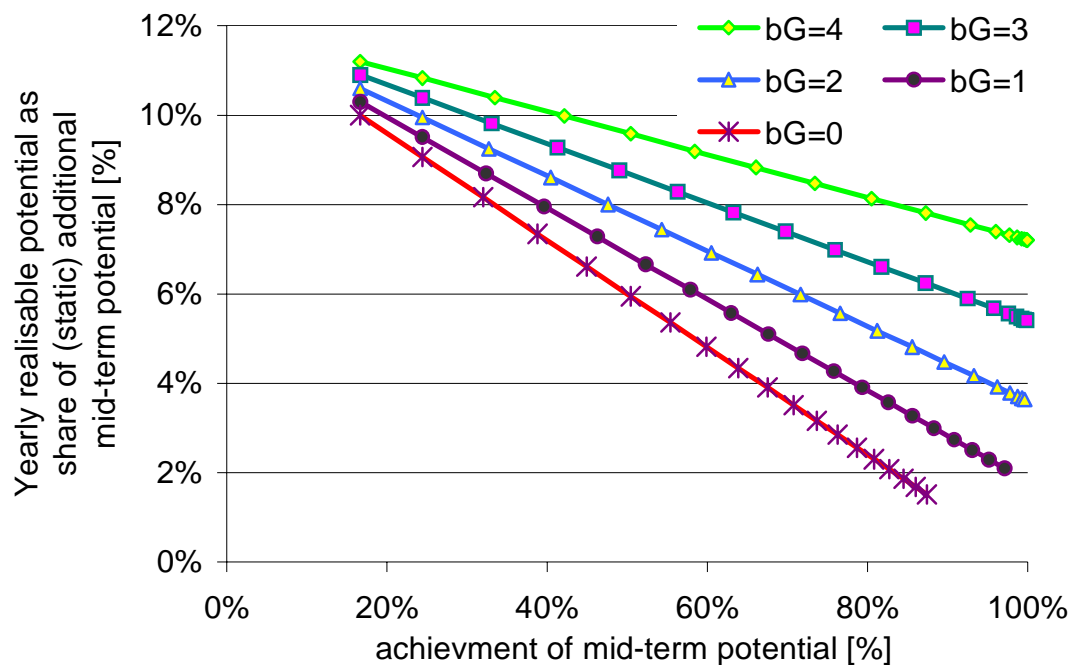
Deployment
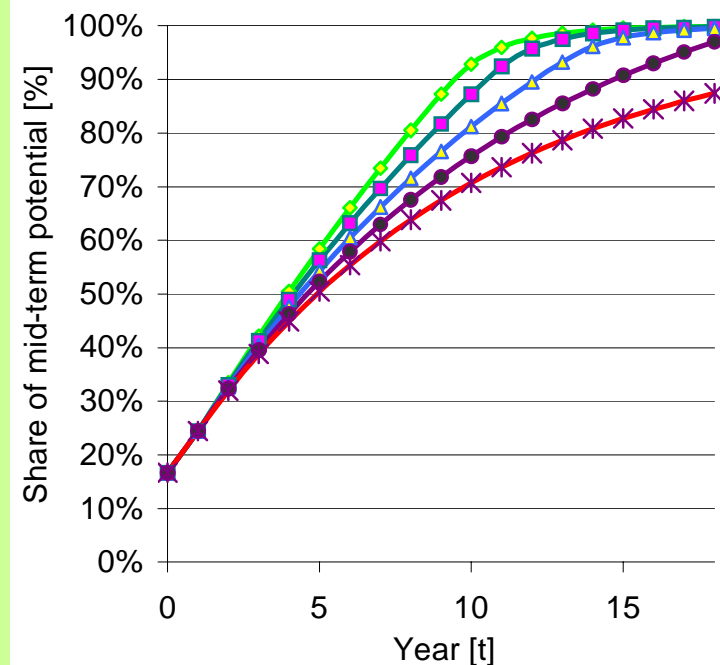
Dynamic aspect: Potential

Modelling approach for social constraints

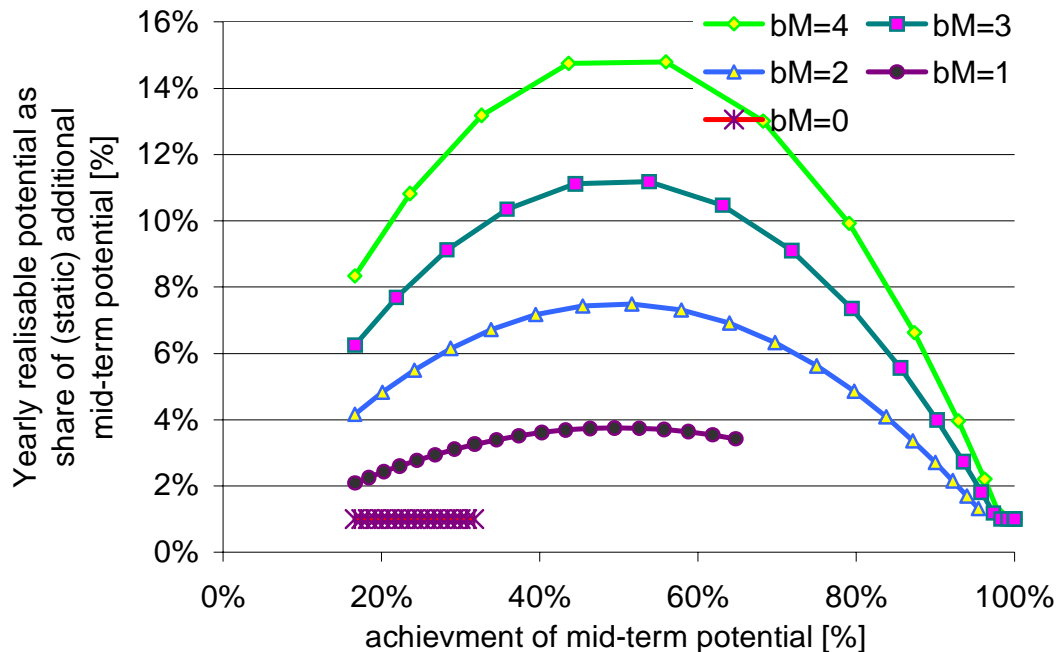**Realisable potential due to <u>social restriction</u>**
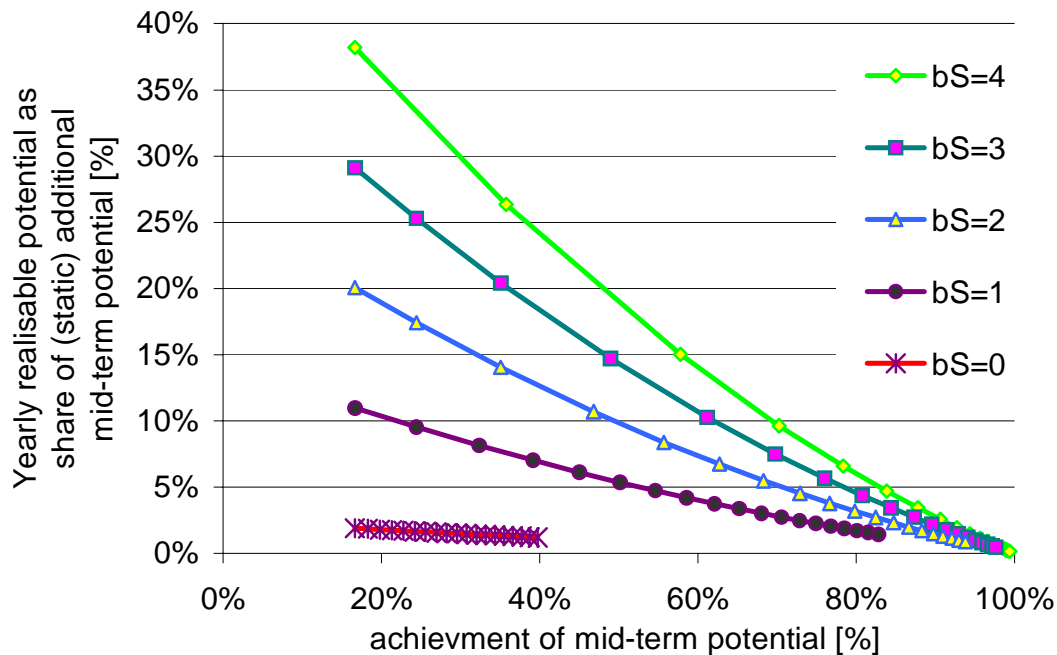
Deployment

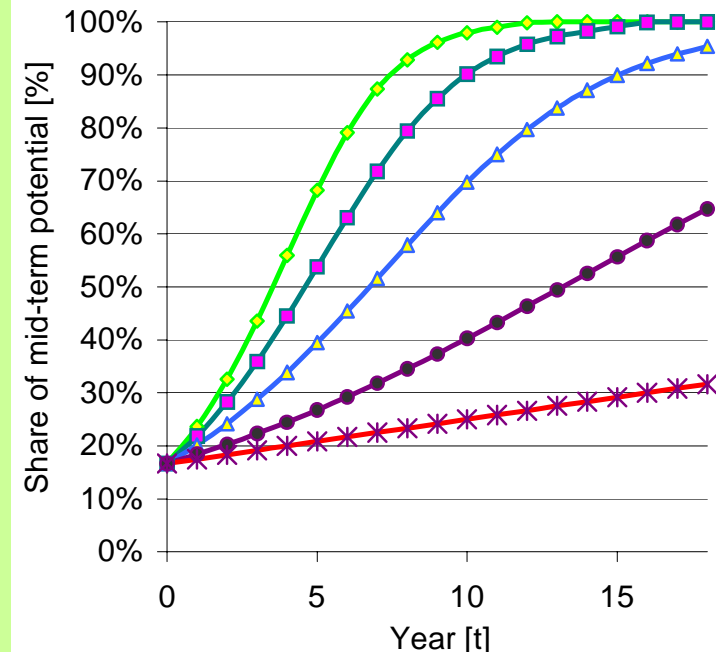# *Dynamic aspect: Potential*

Modelling approach for market constraints



Realisable potential due to <u>market restriction</u>

Yearly realisable potential as share of (static) additional mid-term potential [%]

achievment of mid-term potential [%]

bM=4 bM=3 bM=2 bM=1 bM=0

Deployment

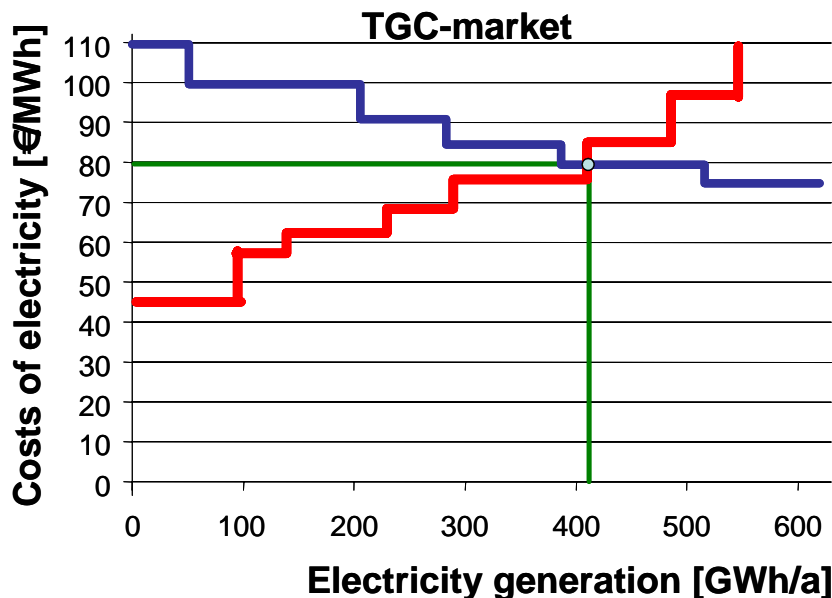Share of mid-term potential [%]

Year [t]

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
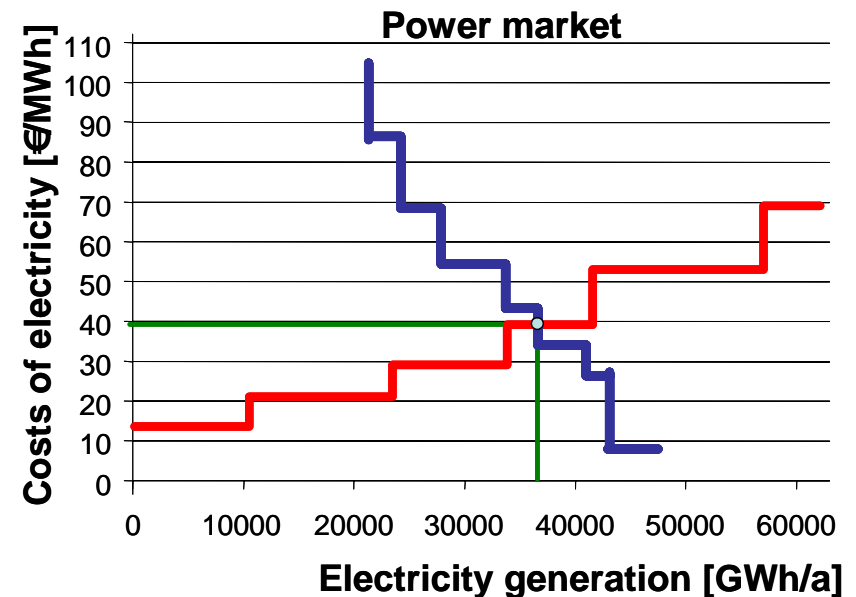
Expected Results (1/3)

Results per country and year
General Results
Installed capacity per technology [MW]
Total Fuel input [TJ]
Total energy generation [GWh]
Total electricity generation [GWh]
Electricity generation per technology [GWh]
National electricity consumption [GWh]
Import / export electricity balance [GWh, % of gen.] -- extended version
Total CO_2-emissions [Mt-CO_2] -- extended version

Expected Results (2/3)

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