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GreenNet-Incentives

Promoting grid-related incentives for large-scale RES-E integration into the different European electricity systems

Deliverable D6a

Report on RES-E potentials and costs for several major 35 European countries

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1 INTRODUCTION

The core objective of the project **Green*Net*-Incentives** is to promote grid-related incentives for large-scale RES-E integration into different European electricity systems, to identify existing non-technical barriers for RES-E grid integration, and to actively involve key European market actors in the discussion process towards "green" electricity grids. This is mainly done by organising expert platforms, stakeholder consultation, training/education workshops and summer schools. The major products of this project are tailor-made recommendations and actions plans for several key market actors to establish a common European vision on the implementation of grid-related policies favouring "green" electricity networks.

Within work package 2 the existing database on RES-E potentials and cost developed within the predecessor IEE-project **Green*Net*-EU27** has been updated and extended to cover several countries addressed in the present project:

- existing: EU-27 Member States, Norway, Switzerland, Croatia
- newly added: remaining Balkan countries Albania, Bosnia Herzegovina, FYR of Macedonia, Montenegro, Serbia and Turkey

The database on RES-E potentials and costs contains basic input data used for the software tool **Green*Net*-Europe**.

This report gives an overview on potentials and cost of RES-E for several mentioned countries. Besides this report a data base (Deliverable D5a) is available for download on the project website www.greennet-europe.org.

The report is organised as follows:

- In chapter 2 potentials and cost of RES-E for the EU-27+ countries are addressed. After the description of the analytical framework for the model implementation an overview on potentials and cost is given for the EU-27 Member States on country as well as technology level. The Balkan countries and Turkey are characterised separately including a brief description of the power system structure, implemented RES-E support schemes and achieved as well as future RES-E potentials.
- The references include selected data sources used in predecessor projects and most relevant sources describing RES-E resources in newly added countries.
- Annex I contains a description of the legislative background for RES-E support in newly added countries. Figures and tables are listed in annex II of the report.

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2 POTENTIALS AND COSTS FOR RES-E IN EU-27+ COUNTRIES

A broad set of different technologies in the field of electricity generation based on renewables (RES-E technologies) exists today. Obviously, for a comprehensive investigation of the future development of RES-E in EU-27+ countries it is of crucial importance to provide a detailed investigation of the country-specific situation, e.g. with respect to the potential of the certain RES-E in general as well as their regional distribution and the corresponding economic aspects. Therefore based on the existing database on potentials and cost of RES-E for the EU-27 Member States incl. Croatia, Norway and Switzerland developed under predecessor projects of the **Green*Net*** project-line an actualised and extended database has been developed under WP2 of the present project that covers additionally Turkey and the Balkan countries Serbia, Montenegro (considered as one country in the data base), Bosnia-Herzegovina, Macedonia and Albania. The result of the assessment is presented in the following addressing in particular: (i) the general framework for model implementation in software tool **Green*Net*-Europe**, (ii) an overview on the historical development, achieved and future potentials and cost of RES-E in the EU-27+ countries and (iii) a brief description of new countries that have been investigated in this project containing information on the power system structure, RES-E targets, implemented promotion schemes and achieved (until end of 2005) as well as future RES-E potentials (up to 2020).

General Remarks

Calculation of electricity costs

In the model **Green*Net*-Europe** the calculation of electricity generation costs for the various generation options is done by a rather complex mechanism as described later – internalized within the overall set of modelling procedures. Thereby, band-specific data (e.g. investment costs, efficiencies, full load-hours, etc.) is linked to general model parameters like interest rate and depreciation time. The later parameters depend on a set of user input data like policy instrument settings, etc. Nevertheless, for a better illustration of the band-specific set of data presented in the following, marginal electricity generation costs are exemplarily depicted. Thereby, for long-run marginal generation costs (as applied for new plants) a default capital recovery factor is used – based on the following settings:

- Interest rate z = 6.5%
- Pay-back time PT = 15 years

Cost-data with respect to CHP-plants

In case of CHP, investment costs, etc. refer to the power plant only – i.e. costs for district heating network are excluded. Hence, the assumed heat price in default size of 20 €/MWh must be seen as price according to the defined hand-over point. In this context, this price represents the additional revenue for the power producer due to selling of heat in case of combined heat production, but, of course, does not indicate the final consumer price for heat.

Classification of RES-E

Initially, in order to increase the legibility of this report and to avoid any misinterpretation, an overview on the investigated RES-E technologies and their classification used within the project **Green*Net*-Incentives** is given (see table below).

Table 2.1. Overview on classifications applied for the various RES-E

Detailed classification (in accordance with 'RES-E Directive' & sub-categories of **Green*Net*-Incentives**)	**Common classification**
Agricultural biogas[1]	**Biogas**
Landfill gas	
Sewage gas	
Forestry products (wood)	**Solid biomass**
Forestry residues (bark, sawmill by-products etc.)	
Agricultural products (energy crops)	
Agricultural residues (incl. vegetal and animal substances, e.g. straw)	
Biodegradable fraction of waste (MSW+ISW)	**Biowaste**
Geothermal electricity	**Geothermal electricity**
Small scale hydro power (<10 MW)	**Small hydro**
Large scale hydro power (>10 MW)	**Large hydro**
Photovoltaics	**Photovoltaics**
Solar thermal electricity	**Solar thermal electricity**
Tidal energy	**Tidal & wave**
Wave energy	
Wind on-shore	**Wind onshore**
Wind off-shore	**Wind offshore**

The resource definition, representing the most detailed classification (left), is done in accordance with the 'RES-E directive' (European Council and Parliament, 2001). A similar categorization is applied in the software tool **Green*Net*-Europe** and the accompanying database. For most graphical representations, e.g. of results, databases, etc. the common classification will be used in this document.

[1] Fuel sources are in this case farm slurries, usable agricultural residues (i.e. from sugar beet production), residues from pasture and the separated biodegradable fraction of municipal wastes.

2.1 Model implementation - Analytic framework

In the toolbox **GreenNet-Europe** generation costs and corresponding potentials of all RES-E (for each EU country) are described by 'dynamic cost-resource curves' being subject to this section. Firstly, the calculation of electricity generation costs from RES will be explained, followed by a description of the potentials. Finally, the methodology used for the specification of dynamic 'cost-resource curves' is outlined.

2.1.1 Calculation of electricity generation costs

When calculating the generation costs a distinction must be made between already installed and potentially new plants. For existing plants, the running costs (short-term marginal costs) are relevant only for the economic decision whether or not to use the plant for electricity generation. On contrary, for new capacities the long-term marginal costs are important.

2.1.1.1 Existing plants

The annual running costs are split into two parts: fuel costs and operation/maintenance (O&M) costs. The fuel costs are a function of the fuel price of the primary energy carrier and the efficiency. In the toolbox **GreenNet-Europe**, the O&M-costs must refer to the electricity output. Hence, the O&M costs, referring to the energy unit in the database, must be coupled with the full-load hours.[2] In general, one average operation time (full-load hour) is taken for each technology band. Analytically, the generation costs for existing plants are given by:

$$C = C_{VARIABLE} = C_{FUEL} + \tilde{C}_{O\&M} - R_{HEAT} = \frac{p_{FUEL}}{\eta_{el}} + \frac{C_{O\&M}}{H} * 1000 - p_{HEAT} \frac{\eta_{heat}}{\eta_{el}} \cdot \frac{H_{heat}}{H_{el}} \qquad (1)$$

where:

- C .... Generation costs per kWh [€/MWh]
- $C_{VARIABLE}$ .... Running costs per energy unit [€/MWh]
- C_{FUEL} .... Fuel costs per energy unit [€/MWh]
- $\tilde{C}_{O\&M}$ .... Operation and maintenance costs per energy unit [€/MWh]
- $C_{O\&M}$ .... Operation and maintenance costs per energy unit [€/(kW*a)]
- R_{HEAT} .... Revenues gained from purchase of heat [€/MWh]
- p_{FUEL} .... Fuel price primary energy carrier [€/$MWh_{primary}$]
- p_{HEAT} .... Heat price [€/MWh_{heat}]
- η_{el} .... Efficiency – electricity generation [1]
- η_{heat} .... Efficiency – heat generation [1]
- H_{el} .... Full-load hours – electricity generation [h/a]
- H_{heat} .... Full-load hours – heat generation [h/a]

[2] The full-load hours represent the equivalent time of full operation in a year. It is calculated for a certain power plant by dividing the amount of electricity generated per year by its nominal power capacity. For the theoretical cost-resource curves, this term reflects an important aspect, namely the suitability of sites (e.g. for wind energy). The full-load hours in the case of wind energy are determined by the wind speed distribution and the rated wind speed of the machines. Knowing the expected full-load hours, the quantity of electricity to be generated can be calculated. Hence, costs per unit are determined. 'Full-load hours' divided by the number of hours in a year (8765h on average) equals the dimensionless 'capacity factor'.

General remarks:

- Apart from all kinds of biomass (biogas, solid biomass, sewage and landfill gas), renewables have zero fuel costs, so running costs are determined by operation & maintenance costs only. Therefore the running costs for RES-E are normally low compared to fossil fuels.
- In the toolbox **Green*Net*-Europe**, primary fuel prices are given exogenously on a yearly basis. For the sensitivity analysis, however, these default values can be adapted.
- In the case of simultaneous electricity and heat generation (i.e. CHP), electricity generation costs are calculated by considering the revenues gained from the sale of the heat.

2.1.1.2 New plants

The calculation of the generation costs of electricity consists of two parts, variable costs and fixed costs. In more detail, the generation costs are given by:

$$C = C_{VARIABLE} + \frac{C_{FIX}}{q_{el}} = \left(C_{FUEL} + \frac{C_{O\&M}}{H_{EL}} * 1000 - R_{HEAT} \right) + \frac{1000 * I * CRF}{H_{EL}} \qquad (2)$$

where:

C .... Electricity generation costs per kWh [€/MWh]

q_{el} .... Quantity of electricity generation [MWh/a]

$C_{VARIABLE}$ .... Running costs per energy unit [€/MWh]

C_{FIX} .... Fixed costs [€]

C_{FIX} / q_{el} .... Fixed costs per energy unit [€/MWh]

C_{FUEL} .... Fuel costs per energy unit [€/MWh]

$C_{O\&M}$ .... Operation and maintenance costs per energy unit [€/(kW*a)]

R_{HEAT} .... Revenues gained from sales of heat[3] [€/MWh]

I .... Investment costs per kW [€/kW]

CRF.................... Capital recovery factor: $CRF = \frac{z*(1+z)^{PT}}{\left[(1+z)^{PT} - 1\right]}$

z .... Interest rate [1]

PT .... Payback time of the plant [a]

H_{EL} .... Full-load hours electricity generation [h/a]

A more detailed description of the running costs is given in the previous chapter. Fixed costs occur independently whether or not the plant generates electricity. These costs are determined by investment costs (I) and the capital recovery factor (CRF).

Investment Costs

The investment costs differ by technology and energy source. In general, investment costs per unit capacity for RES-E are higher than for conventional technologies based on fossil fuels. Also differences occur between RES-E technologies, e.g. investment costs per unit

[3] In case of CHP, the calculation of the revenues gained from sales of heat is described in equation (1).

capacity for small hydropower plants are generally at least twice those for wind turbines. Since most RES-E technologies (with the exception of (large-scale) hydropower) are still not mature, investment costs decrease over time. This evolution is taken into consideration in the toolbox **GreenNet-Europe**, i.e. investment costs are derived annually.[4]

Forecasting technology development is a crucial activity, especially for a long time horizon. Considerable efforts have been made recently to improve the modelling of technology development in energy models. A rather 'conventional' approach relies exclusively on exogenous forecasts based on expert judgements of technology development (e.g. efficiency improvements) and economic performance (i.e. described by investment and O&M-costs). Recently, within the scientific community, this has often been replaced by a description of technology-based cost dynamics which allow endogenous forecasts, at least to some extent, of technological change in energy models: This approach of so-called 'technological learning' or 'experience/learning curves' method takes into account the "learning by doing" effect.[5]

Within the model **GreenNet-Europe** the approach chosen differs by technology. In principle, the database is prepared to include two different approaches: Standard cost forecasts or endogenous technological learning. Default settings have been applied as follows:

- For conventional power generation technologies – as well as some renewable energy technologies - it was decided to adopt well-accepted expert judgements.
- For a set of renewable energy technologies like, e.g. wind power or PV, it was decided to adopt the approach of technological learning. Learning rates were assumed at least for each decade[6] separately.

The default approach chosen to determine future investment costs is summarised by technology in Table 2.2.

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[4] The 'yearly' determination of the investment costs represents an important input to the data-tables. In more detail, the following parameter must be derived for each country and technology according to the given situation for the year n-1 and the year n:

- quantitative values for investment costs over time.
- quantitative values for the development of efficiency over time.

[5] In principle the so-called 'learning effect' - being empirically observed in several fields of technological development – states that for each doubling of producing / installing a certain technology, a decline of the costs can be expected by a certain percentage, the learning rate. For a brief description of the learning / experience curve approach, see e.g. Wene et al., 2000.

[6] In many cases experience has shown that the rate of technological learning is often closely linked to the development stage of a certain technology – i.e. at an early stage of development, if a technology is 'brand new', high learning rates can be expected and later, as the technology matures, a slowdown occurs.

Table 2.2. Overview of the methodology to derive investment costs for different technologies

Dynamic cost development	Methodology to derive investment costs year n
Biogas	learning curve–approach or forecast
Biomass	Forecast
Geothermal electricity	Forecast
Small scale hydropower (<10 MW)	Forecast
Large scale hydropower (>10 MW)	Forecast
Landfill gas	learning curve–approach or forecast
Sewage gas	learning curve–approach or forecast
Photovoltaics	learning curve–approach
Solar thermal electricity	Forecast
Tidal energy	Forecast
Wave energy	Forecast
Wind on-shore	learning curve–approach
Wind off-shore	learning curve–approach
Nuclear power stations	Forecast
Steam	Forecast
Gas turbine	Forecast
Combined cycle power turbines	Forecast
Internal combustion engine plants	Forecast

Capital recovery factor CRF

The CRF allows investment costs incurred in the construction phase of a plant to be discounted. The amount depends on the interest rate and the payback time of the plant. For the standard calculation of the generation costs these factors are set for all technologies as follows:

- payback time (PT) of all plants: 15 years
- interest rate (z) equals 6.5%

Note, in the toolbox **Green*Net*-Europe**, different interest rates will be applied. The interest rate depends on stakeholder behaviour and is a function of

- guaranteed political planning horizon
- promotion scheme
- technology
- investor category

General remarks:

- As the generation costs are calculated per energy output, the fixed costs must also be related to electricity generation q_{el}, compare equation (2). Hence, the fixed costs per unit output are lower if the operation time of the plant - characterised by the full load-hours - is high.
- Deriving the generation costs for CHP plants is similar to the calculation for plants producing electricity only. Beside the short-term marginal costs, i.e. the variable costs, fixed costs must be considered for new plants. Of course, equivalent to the case of existing plants, variable costs differ between CHP and pure electricity plants, as the revenue from selling heat power must be considered in the first case.
- In general, no taxes are included in the various cost-components.

2.1.2 Determination of the (additional) mid-term potential

The starting point for deriving the dynamic potential is the determination of the additional mid-term potential for electricity generation for a specific technology in a specific country.[7] The additional mid-term potential is the maximal additional achievable potential assuming that all existing barriers can be overcome and all driving forces are active. The so-called 'dynamic potential' is the maximal achievable potential for the year n. This means advantage must have been taken of all existing promotion strategies both on the investor and the consumer side. To illustrate this more clearly, the connections between the different potential terms are depicted in Figure 2.1.

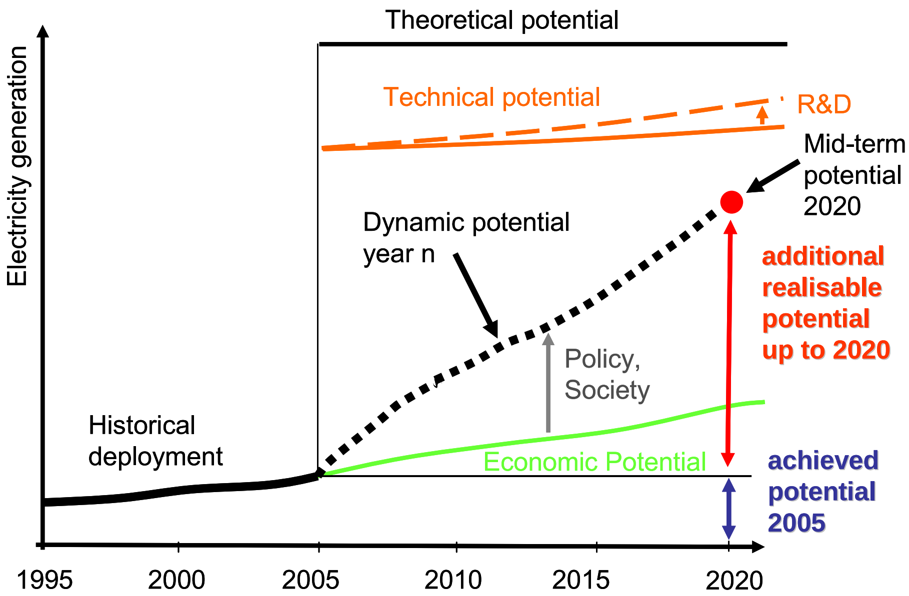

Figure 2.1. Methodology for the definition of different potentials

In the toolbox **GreenNet-Europe** the additional mid-term potential for electricity generation refers to the year 2020. The methodology for the analysis of the potential varies significantly from one technology to another.

In most cases a 'top-down' approach is used (e.g. for wind energy, photovoltaic). In a first step the technical potential for one technology in one country for 2020 has to be derived by determining the total useable energy flow of a technology. Secondly, based on step one, the mid-term potential for the year 2020 is determined by taking into consideration the technical feasibility, social acceptance, planning aspects, growth rate of industry and market distortions. The additional mid-term potential is given by the mid-term potential minus existing penetration plus decommissioning of existing plants.[8]

For a few technologies, a 'bottom-up' approach has been more successful (e.g. for geothermal electricity), i.e. by looking at every single site (or band) where energy production seems possible and by considering various barriers, the additional mid-

[7] Note: While the additional mid-term potential represents an important input parameter in the **GreenNet-Europe** database, the additional annual potential (dynamic potential) is one of the essential output parameters of the cost curve development.

[8] To use the potential in the database of the toolbox **GreenNet-Europe**, the additional mid-term potential obtained on technology level (in one country) must be broken down to band level.

term potential is derived. The accumulated value of the single band yields the additional potential for one technology in one country.[9]

In this context, one specific problem occurs with respect to biomass. The total primary energy potential for biomass is restricted. The actual distribution among the different options - pure electricity generation, CHP generation, heat generation or biofuel - depends on the net economic condition. As for the economic assessment, various support schemes must be considered, the allocation of the primary energy potential to these options is only feasible after including this step. To solve this problem, the values and the different options are linked in the database.

For a detailed description of the resource-specific approaches used within the project **Green*Net*-Incentives** for the assessment of future RES-E potentials see Resch (2005), p.80-93.

2.1.3 Assessment of the economic data for RES-E

The assessment of the economic parameters and accompanying technical specifications of the various RES-E technologies comprises a comprehensive literature survey and an expert consultation. With respect to existing plant, representing the already achieved potential at the end of 2004, also project specific information is taken into account. References of major relevance are discussed below.

A set of studies can be listed which provide a comprehensive survey on RES-E technologies, thereby including detailed economic and technical data with respect to most common technologies. Namely these are, listed in chronological order: (DTI/ETSU, 1999) (DLR/WI/ZSW/IWR/Forum, 1999), (Neubarth et al., 2002), (Haas et al., 2001), (Resch et al., 2001), (Nowak et al., 2002), (Kaltschmitt et al., 2003), (BMU, 2004).

References with a focus on selected technologies are listed in the following by RES-E category:

- Biogas and Biomass: (Enquete, 2002), (EUBIONET, 2003)
- Geothermal electricity: (BMU, 2002)
- Hydropower: (Lorenzoni, 2001)
- Photovoltaics: (Alsema, 2003), (Schäffer et al., 2004)
- Solar thermal electricity: (Quaschning, Ortmann , 2003)
- Wind energy: (Greenpeace, 2001), (Neij et al., 2003), (BTM, 1999-2003), (Beurskens, Noord, 2003)
- Tidal and wave energy: (Thorpe, 1999), (DTI/ETSU, 2001), (Michael, 2002)

2.1.4 Development of the 'static' cost-resource curve

A cost-resource curve shows the correlation between electricity generation costs per unit and the potential (in terms of capacity or electricity generation) for one specific technology in one country per annum. Hence, the development of a cost curve implies knowledge of the two items explained above:

- costs for electricity per unit;

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[9] For the toolbox **Green*Net*-EU27** the addition of the single band is not necessary as the information must be available on band level.

- total quantity of electricity that can be generated or capacity that can be installed, respectively, per annum at certain cost levels. The cumulated sum of these amounts is equal to the totally available potential of a certain technology.

Cost curves for one technology (and country) are divided into different bands, see Figure 2.2.

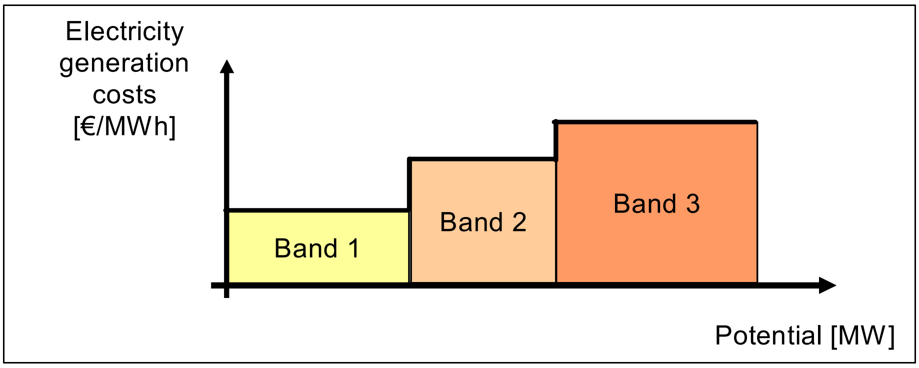

Figure 2.2. Relation between costs and potential for one technology

Bands are characterised by:

- same fuel input, e.g. biomass wood: forestry products (wood) – forestry residues (bark, sawmill by-products) – agricultural products (energy crops) – agricultural residues (straw etc.) – biogenic fraction of waste (MSW+ISW),
- same sub-technology and energy efficiency categories, e.g. photovoltaic systems: facade integrated systems – roof system,
- same range of full-load hours, e.g. wind energy onshore: 2600 h/a – 2500 h/a – 2400 h/a – 2100 h/a – …. – 1500 h/a.

Figure 2.3 depicts a characteristic run of a cost-resource curve. Thereby, all costs and potentials are threaded according to costs, i.e. the cheapest first and the most expensive last. It can be seen that it is helpful to show a separate development of the cost curve for already implemented capacities and for potential new plants.

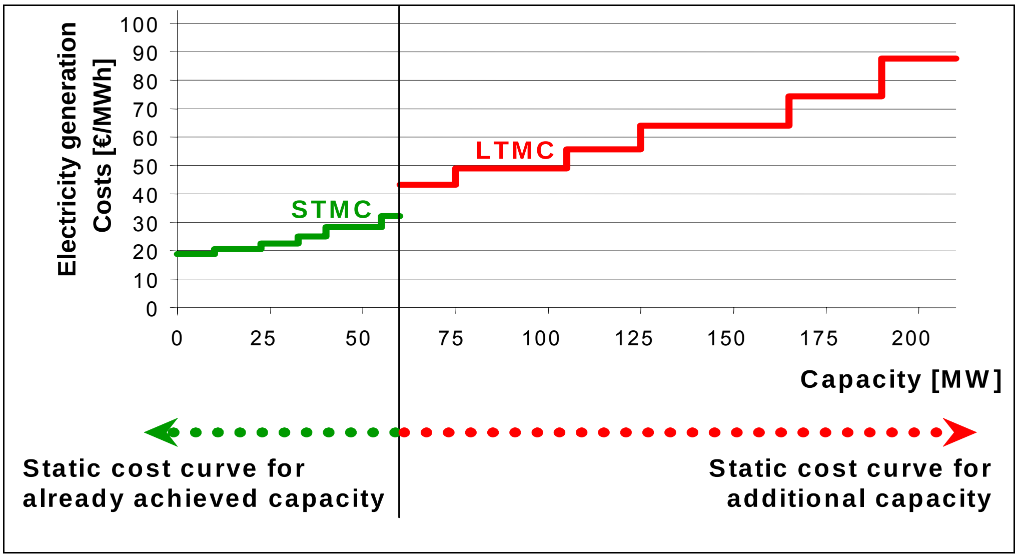

Figure 2.3. Cost curve for achieved and additional potential of technology x

2.1.4.1 Cost-resource curve – existing plants

A characteristic cost-resource curve for already achieved capacities is depicted in Figure 2.4. In this example the portfolio of existing plants of technology x consists of 4 different categories - bands B1 (efficient plant / good size) to B4 (inefficient plant / bad size). For each band the short-term marginal generation costs (STMC) and the long-term marginal generation costs (LTMC) are shown sorted by rising STMC.

The calculation of the STMC follows equation (1) explained above. The LTMC are derived according to equation (2), i.e. all cost parts, both investment and running costs, have to be taken into account. Note that the investment costs for existing plants refer to the year of installation and not to the year n.

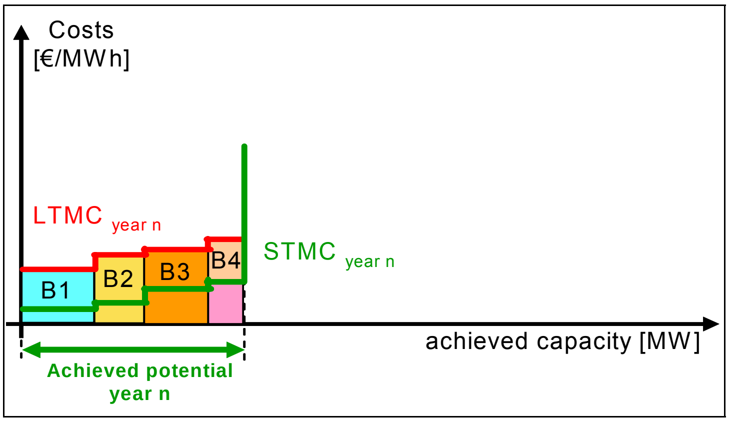

Figure 2.4. Cost curve for already achieved potential of technology x

As already mentioned, the short-term marginal generation costs (STMC) are relevant only for the economic decision whether or not to produce electricity with a certain capacity (represented in the model by the band). This is because for existing plants the investments in the capacity are already (irreversibly) sunk.[10]

Nevertheless the long-term marginal generation costs are still important for the calculation and evaluation of important results, e.g. the derivation of the producer's profit. More precisely, as long as the plant is not fully depreciated, the actual investment cost influences (significantly) the actual full generation costs and, hence, the producer's profit.

2.1.4.2 Cost-resource curve – new plants

As already mentioned, electricity generation costs for new installations are characterised by the long-term marginal costs. The costs are derived according to equation (1) and (2), respectively. In contrast to already existing plants, the investment costs decrease over time according to the derived learning curve of the technology for the year n. The stepped function depicted in Figure 2.5 indicates the different cost/potential levels (bands). For instance, in the case of wind energy, sites have a known average wind speed and wind availability, so the load factor (or full-load hours) and hence the costs can be predicted. In the example shown

[10] It is assumed that the capacity cannot be rebuilt and sold to a third party.

in Figure 2.5, seven different bands (characterised by different full-load hours) are defined starting with high wind speeds and hours (band B1) through to poor wind conditions (band B7).

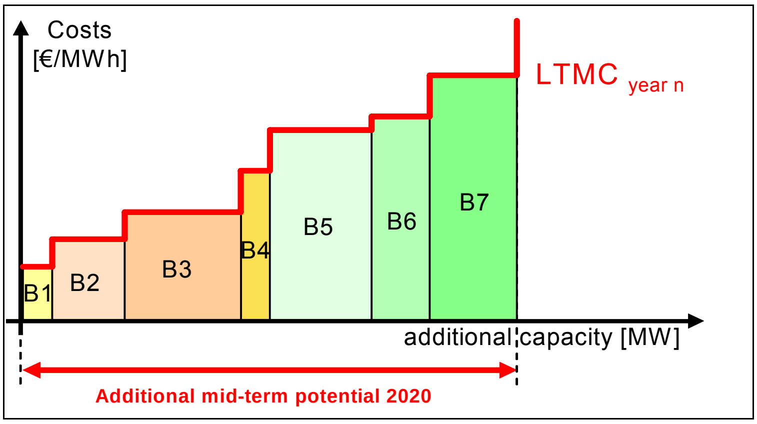

Figure 2.5. Cost curve for additional mid-term potential of technology x

Some technologies can be used either to produce electricity only or both electricity and heat. Therefore, information with respect to the mix of 'pure' electricity generation to combined heat and power production is of high relevance. In the toolbox **Green*Net*-Europe**, the ratio of CHP plants to pure electricity generation plants depends on the competitiveness of each technology. To keep the simulation time short, it is assumed that the power to heat generation ratio is constant within one band but differs among the bands of a certain CHP technology.[11]

[11] An alternative option would be the assumption that the ratio of pure electricity generation plant to CHP plant is constant. In this approach, the ratio must not be derived in the computer model itself. Therefore, the implementation in the computer model requires much less methodological effort. The advantage is a shorter running time of the simulation compared to the other method and, subsequently, resulting in improved user-friendliness of the toolbox. The disadvantage of this approach is: Firstly, some divergences occur between the estimated and the actual possible ratio of pure electricity and combined heat and power generation. Secondly, the grid connected heat demand (for CHP and heat plants) is given as an exogenous variable in the toolbox **Green*Net*-Europe**. Hence a restriction of CHP plants (by heat demand) leads to a restriction of pure electricity generation, too. The reason is that the power to heat ratio is also restricted. This means, it is economically inefficient to produce a substantial electricity output and a low heat output with a CHP plant.

2.1.5 Development of the dynamic cost-resource curve

In general, in the toolbox **GreenNet-Europe** dynamic effects will be considered covering the areas of:

- costs for new plants
- available / achievable potential for existing and new plants, respectively.

The dynamic adaptation of the costs (investment costs and operation/maintenance costs) will take place at the end of one simulated year, i.e. the investment costs for the year n will be determined at the end of the year n-1. The methodology used to derive the new investment costs has been already described before.

The dynamic assessment of the potential will take place at two different stages in the model. The evaluation of the available potential of existing plants for the year n will be made - similar to the cost evaluation – at the end of the simulation run in the previous year. For new plants, the assessment of the maximal achievable potential for the year n will be made after the creation of the static cost-resource curve in the year n. The reason this step cannot be carried out also at the end of the year n-1 – as for all other dynamic evaluation steps - is that information about assessment parameters is necessary which is only available at the beginning of the year n. In more detail the following inputs must be available:

- Input database supply
    - Input database – existing plants
    - Input database – new plants
- Stakeholder behaviour
    - Investor
    - Society
- Policy instruments
    - Supply-side strategies
    - Demand-side strategies

Based on the development of the static cost-resource curves for existing and new plants, dynamic cost curves will be derived by applying a dynamic parameter assessment.

2.1.5.1 Dynamic parameter assessment – new plant

As already mentioned, the starting point for deriving the dynamic potential is the additional mid-term potential for the year 2020. These data will be used directly from the 'input database – new plants'.

In a first step, the restricting factors of the dynamic potential for the year n must be analysed compared to the given additional mid-term potential, i.e. existing barriers must be determined. Secondly, the additional potential for the year n can be derived by applying a dynamic parameter assessment. More precisely, for each band, the available potential for the next year compared to the year 2020 will be evaluated taking various barriers into consideration.

In the toolbox **GreenNet-Europe** the following obstacles are considered:

<u>Social barriers (social acceptance of additional generation)</u>

In some cases the acceptance is a function of the policy strategy, e.g. the acceptance of big wind projects (e.g. in Ireland) is more restricted knowing that most of the electricity generated will be exported (e.g. due to an international TGC market) rather than be consumed locally or at least domestically.

<u>Industrial barriers</u>

The availability of the technology in one country depends on the total global demand. This means that the total demand for a certain technology depends on the level of the worldwide (EU–wide) promotion scheme for this technology. If there is (suddenly), e.g. a high quota for wind energy in Europe (or worldwide) then the production of this technology (supply) cannot follow the demand because the growth of the industry is restricted. Hence, less capacity can be built in one country.

<u>Technical barriers (technical feasibility)</u>

e.g. the need of additional grid extension measures.

<u>Market barriers (market and policy distortions)</u>

e.g. less transparency of subsidy scheme, no stable planning horizon.

<u>Administrative barriers (high bureaucracy)</u>

e.g. long commissioning time of a plant.

<u>Availability of the resources</u>

e.g. the available potential for biomass increases over time due to the time gap (delay) between cultivation (afforestation) and harvesting of the biomass. In the case of landfill gas, the potential decreases over time due to changes in waste management.

Table 2.3 gives an overview of the analysis of barriers and their consideration.

Table 2.3. Summary: characterisation of dynamic barriers

Dynamic parameter & their characterisation		**Techno-logy - specific**	**Country specific**	**Band-specific**	**Link to policy**	**Impact on costs**	**Impact on poten-tials**	**Methodology to implement**
Industrial constraints	Growth rate of industry	X					X	EU-wide limitation of annual installations…
	…							
Technical constraints	Grid constraints (i.e. extension necessary)	X	X	X		X	(X)	Band-specific limitation of annual installations
	…							
Market constraints	Market trans-parency	X	X				X	Increased interest rate
	Investors behaviour	X	X		X		X	Increased interest rate
	…							
Admini-strative constraints	Bureaucracy (	X	X		X		X	Country and technology specific limitation
Societal constraints	‘Willingness to accept‘	X	X	X	X		X	(Band-specific) limitation of annual realisable potential
	…							

$$P_{add\ n} = P_{add\ n\ 2020} * f_{barrier}(\text{Industry, Technique, Market, Society, Administration}) \quad (3)$$

where:

$P_{add\ n}$ .... Additional dynamic potential year n [GWh/a]

$P_{add\ n\ 2020}$ .... Additional remaining mid-term potential (2020) in year n [GWh/a]

$f_{barrier}$ .... Limitation factor [1]

Similar to the additional mid-term potential for the year 2020[12], the maximal actual achievable potential for the year n takes into consideration several described obstacles and drivers. The dynamic potential for the year n ($P_{add\ n}$) can be derived by multiplying the remaining additional mid-term potential in year n ($P_{add\_n\_2020}$) by a factor ($f_{barrier}$) indicating the maximum constraint of all considered obstacles, i.e. the residual potential is available for the year n.

This procedure is depicted in Figure 2.6; the red lines represent the additional mid-term potential, the blue lines the additional potential being available for the next year (year n) for each band. Of course, the actual availability can vary between the single bands.[13]

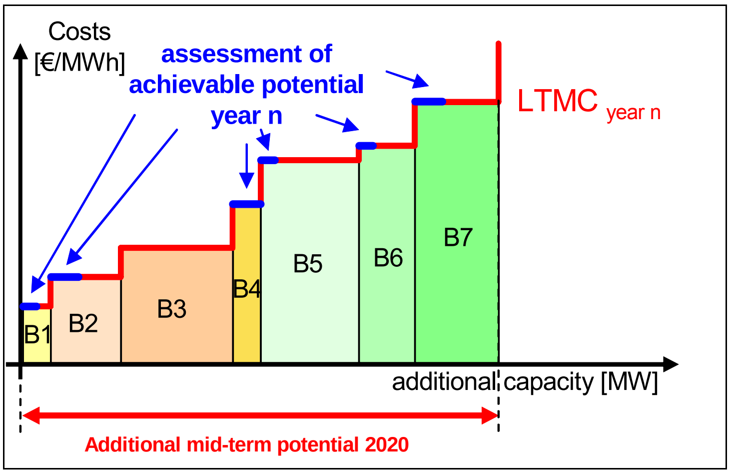

Figure 2.6. Cost curve assessment for additional potential year n of technology x

By adding the additional potential of each band for year n, the dynamic cost curve can be constructed. In the example, the blue lines in Figure 2.6 are put together with the available cost curve for the year n, see Figure 2.7.

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[12] Note, that the mid-term potential is equivalent to the dynamic potential for the year 2020 (since all barriers are already considered).

[13] E.g. in Figure 2.6 no additional potential for band 3 is available for the next year. Note, that the cost level of the individual bands remains not effected by the dynamic parameter assessment because the costs (referring to the mid-term as well as the dynamic potential) already refer to the year n for every cost curve.

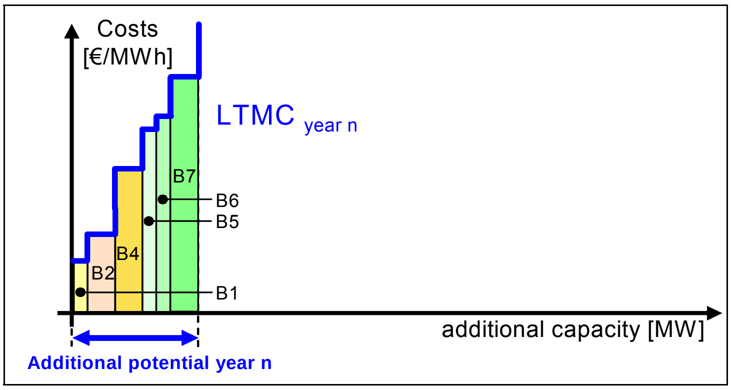

Figure 2.7. Cost curve for additional potential year n of technology x

2.1.5.2 Dynamic cost curves for the year n

The overall cost curve for the year n can be derived by horizontal addition of the already achieved potential (existing plants) and the available additional potential (new plants). This procedure is shown in Figure 2.8.

In general, it can be stated that generation costs of electricity from RES-E technologies are higher than those of conventional energy sources. Moreover, costs as well as achievable potentials differ widely among the specific RES-E technologies. The combination of the cost curves for potentially new and already achieved plants represents the output of the database ‘dynamic cost curve’.

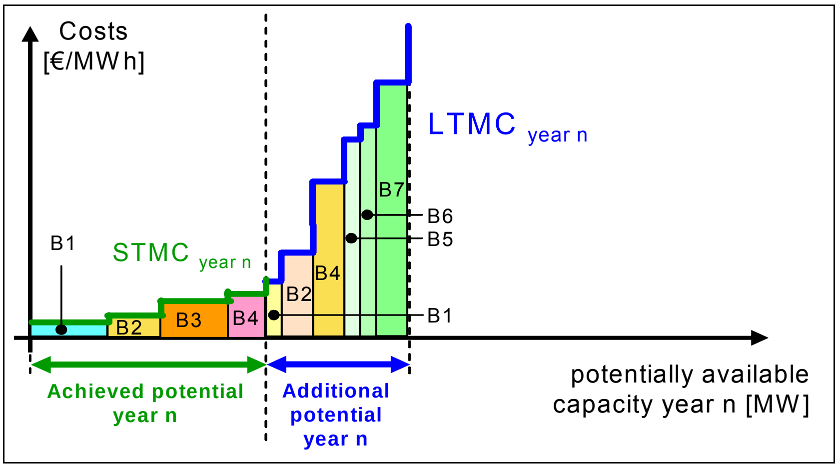

Figure 2.8. Combination of cost curve for already achieved and additional potential for the year n and technology x

Summing up, the future penetration of a certain technology depends on how it overcomes two categories of existing obstacles:

- economic barriers – they are reflected by the net generation costs, i.e. inclusive policy strategies.
- other barriers as described above – they restrict the available potential of electricity generation in year n.

Penetration of a technology will only take place if both categories of barriers can be overcome. So, on the one hand, it does not help to support a certain technology via a quota obligation, a guaranteed feed-in tariff or a tender scheme without preparing the framework conditions to overcome remaining existing barriers, e.g. increasing the social acceptance using information campaigns, or decreasing administrative burdens for commissioning new plants, etc.. In other words, low (net) generation costs, but a low existing potential, still results in less additional penetration.

On the other hand, providing a good environment at administrative, social, industrial and technical levels (i.e. admitting a huge potential) without economic incentives does not increase the future penetration rate of a certain technology. A high potential of electricity generation, but high generation costs, also results in a low market share.

Up to now, economic support schemes have not been considered in the toolbox **Green*Net*-Europe**, i.e. the influence of the support schemes and policy framework on the economic cost for an investor and an enterprise has not yet been analysed. This important step will be carried out in the economic assessment. The costs will be adapted in such a way that they agree with the promotion schemes for renewables, conventional power, CHP environment and climate change policy. Note, the costs correspond after the economic support assessment to the market conditions, i.e. they represent the offered prices / bids on the market. In other words, a transition from generation costs to offer prices takes place by applying the economic assessment.

For the description of the methodology used for the economic evaluation see Huber et al. (2004).

2.2 Overview on potentials and cost for RES-E in the EU-27 Member States

2.2.1 Achieved potentials

In 2005 the RES-E generation potential in EU-27 Member States amounts to 509 TWh which is a share of 15.5 % of gross electricity demand in 2005. Large-scale hydro power is still the dominating RES-E technology in the EU with a share of 62% on the total achieved potential. However, wind power in terms of onshore installations already contributes significantly to the overall RES-E generation portfolio with a share of 15.5%. Significant shares can further be observed for biomass (9.6%) and small-scale hydro (9.0 %). The remaining 5% are shared between biogas, biowaste and geothermal electricity. The contribution of technologies like PV, tidal and wave energy on EU-level is still inferior.

The distribution of the achieved RES-E potential on Member States is heterogeneous in absolute as well as relative terms and mainly determined by the utilisation of hydro power potentials. Austria, Sweden and Portugal are the Member States with the highest RES-E share on gross electricity demand.

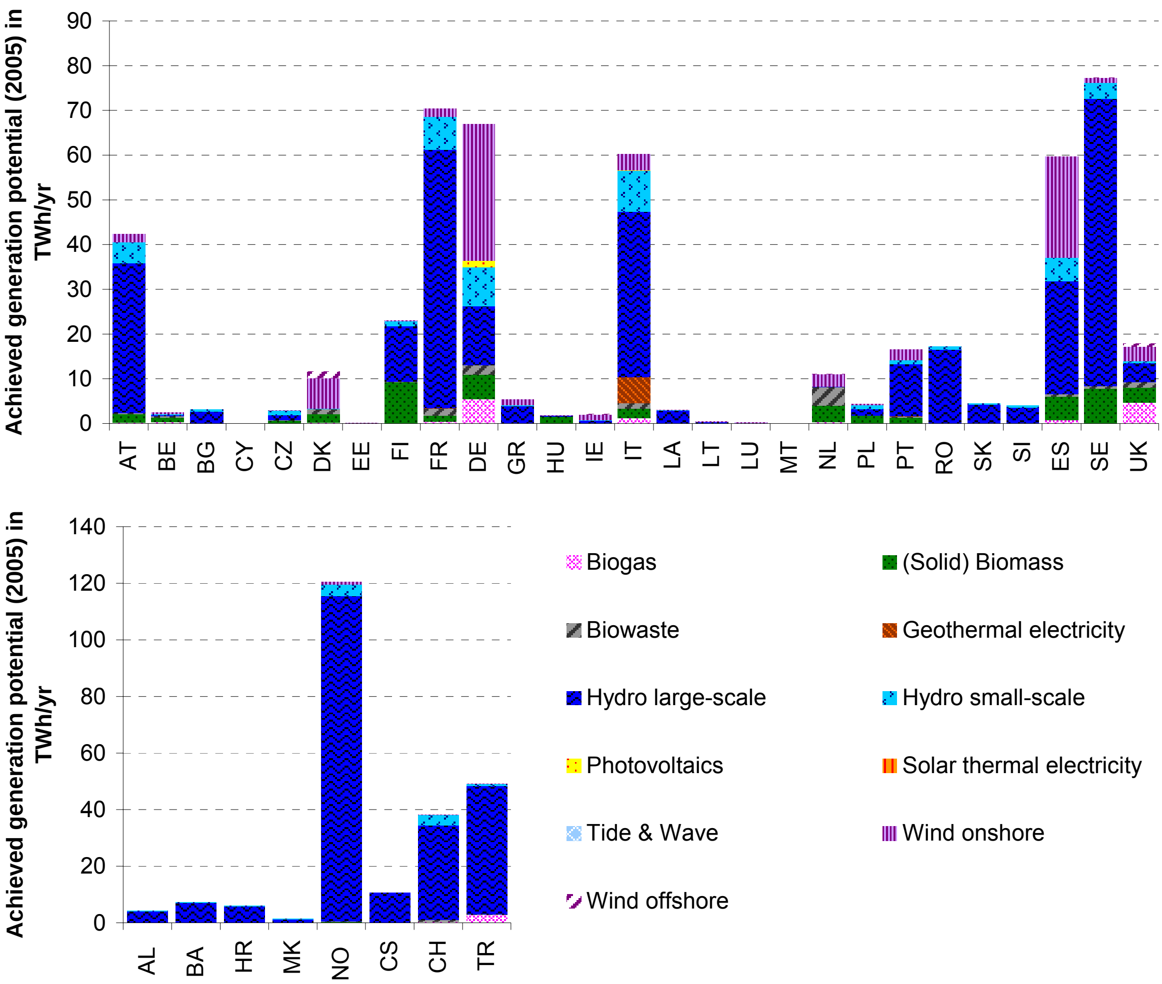

Figure 2.9. Breakdown of the achieved RES-E potential in EU-27 Member States (above) and remaining countries covered in the GreenNet-Europe model (below).

While in Eastern European countries so called “new” RES-E technologies play a minor role, their contribution to the RES-E portfolio in at least some of the former EU-15 Member States is already significant. Leading wind power countries are Germany, Spain and Denmark while Finland and Sweden show the highest contributions from biomass. Italy is the only country with a significant share of geothermal electricity. So far PV has a noticeable share on the achieved RES-E potential in Germany only (see Figure 2.9, above).

In non-EU countries the existing RES-E portfolio is highly dominated by hydro power. New RES-E technologies still play a minor role. Norway has the highest existing RES-E potential of all investigated countries with about 120 TWh/yr (see Figure 2.9, below).

2.2.2 Future potentials in EU27 Member States[14]

It should be mentioned that future RES-E potentials indicated in this chapter do not represent policy targets nor expected figures for the year 2020. The additional mid-term potential should instead be interpreted as the maximal additional potential that might be achieved when all existing barriers can be overcome and all driving forces are active (see also chapter 2.1.2 in this report). Depending on support policies and barrier settings chosen for the simulation the utilised additional RES-E potential for the year 2020 may be considerably lower.

As this report is intended to summarise the status quo of the updated and extended **Green*Net*-Europe** database it is not foreseen to give a detailed description of the methodology used for the assessment of diverse RES-E potentials. For more detailed information we therefore refer to WP1-report of the project **Green*Net*** (available on www.greennet-europe.org).

The main sources of data used for the assessment of RES-E potentials and cost are listed for "new" countries only (see corresponding country profiles in the following chapter). For a complete overview on data sources we again refer to WP1-report of the project **Green*Net***.

For RES-E technologies such as hydro power or wind energy, resources are characterised by natural variability. Therefore, in order to provide accurate forecasts of the future RES-E deployment, historical data have to be translated into electricity generation potentials. The so called achieved potential is related to the installed capacity in 2005 and an average availability of corresponding natural resources (e.g. average hydro inflow or average wind conditions). Future potentials are assessed taking additionally into account the country-specific situation as well as constraints for RES-E integration.

Figure 2.10 and Figure 2.11 depict the achieved and additional mid-term potential for RES-E technologies in the 35 covered countries on country and technology-level respectively. In EU-27 Member States the already achieved potential for RES-E generation equals 509 TWh[15], whereas the additional realisable potential up to 2020 is 1175 TWh. Also future RES-E potentials are distributed heterogeneously amongst EU-Member States. France, Germany, UK, Spain and Italy show the highest absolute numbers and represent together 2/3 of the additional potential within the EU.

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[14] In this report data for the Norway and Switzerland also covered within the GreenNet data base are not shown. You may find information for these countries in the corresponding report of the project GreenNet-EU27.

[15] The electricity generation potential represents the output potential of all plants installed up to the end of each year. The figures for actual generation and generation potential differ in most cases – due to the fact that, in contrast to the actual data, the potential figures represent normal conditions (e.g. in case of hydropower, the normal hydrological conditions), and furthermore, not all plants are installed at the beginning of each year.

While for established technologies like hydro power and geothermal electricity additional potentials are quite limited compared to the existing utilisation, considerable potentials are identified for new RES-E technologies. With 505 TWh wind power shows the highest additional potential in the EU which is shared equally between onshore and offshore utilisation. The additional electricity potential up to 2020 for biomass in terms of solid resources and biogas amounts to 306 TWh. Further promising RES-E options include tide and wave energy, PV and solar electricity. The composition of the additional mid-term potential in investigated countries is heterogeneous as indicated in Figure 2.12.

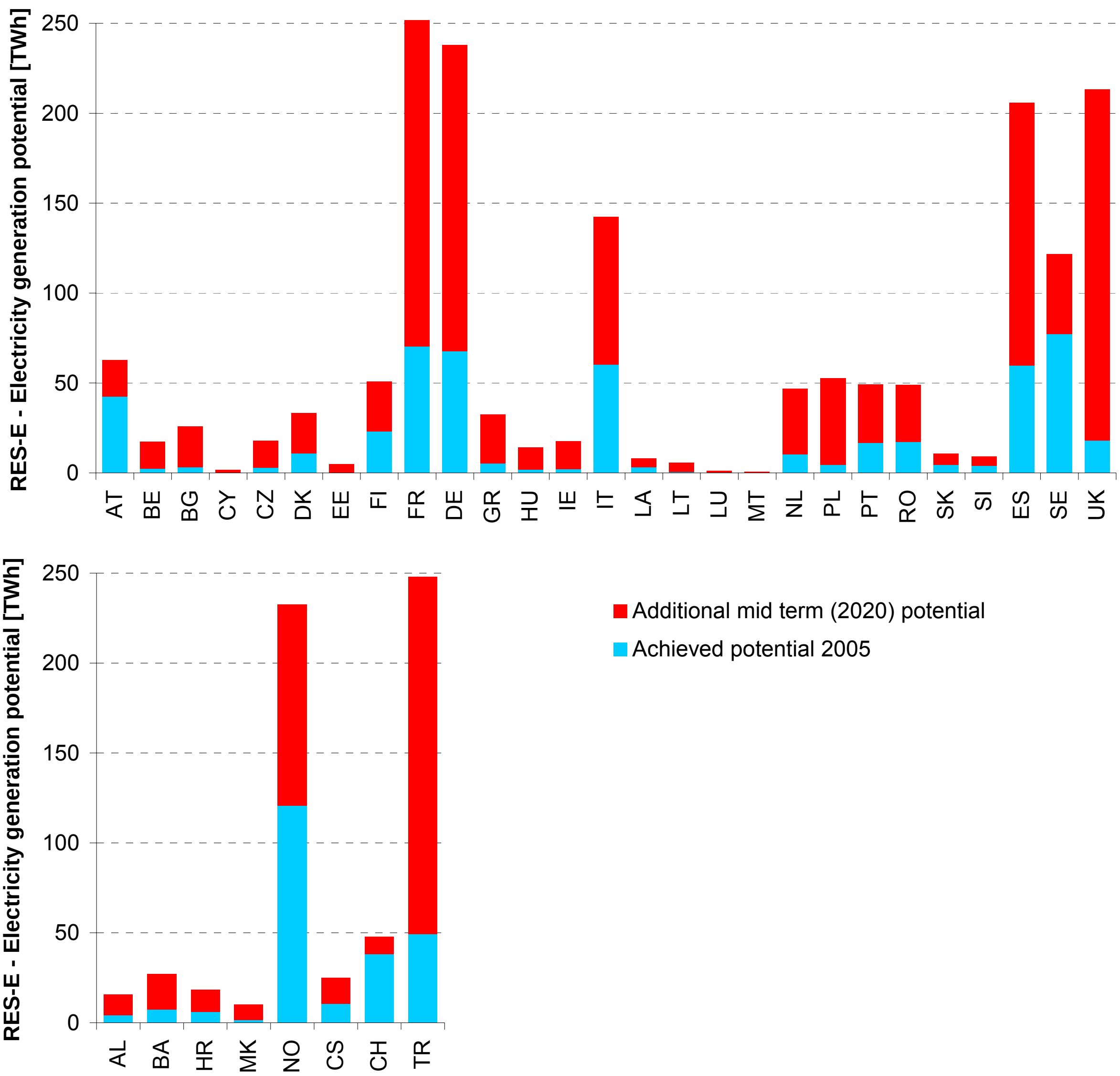

Figure 2.10. Achieved (2005) and additional mid-term potential (2020) for electricity from RES in EU-27 Member States (above) and remaining countries covered in the GreenNet-Europe model (below).

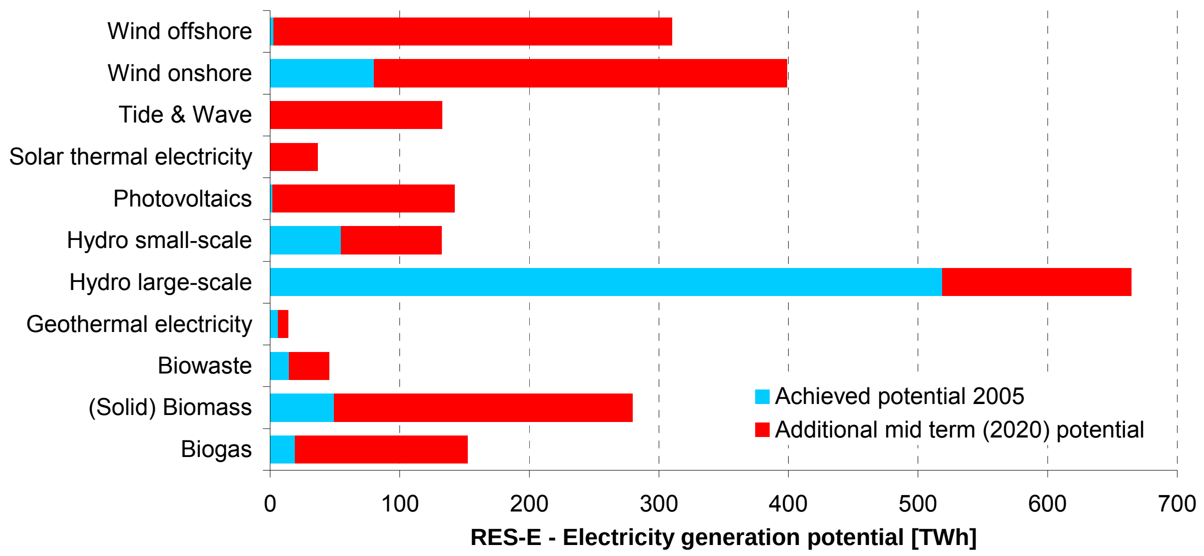

Figure 2.11. Achieved (2005) and additional mid-term potential (2020) for electricity from RES in all 35 implemented European countries

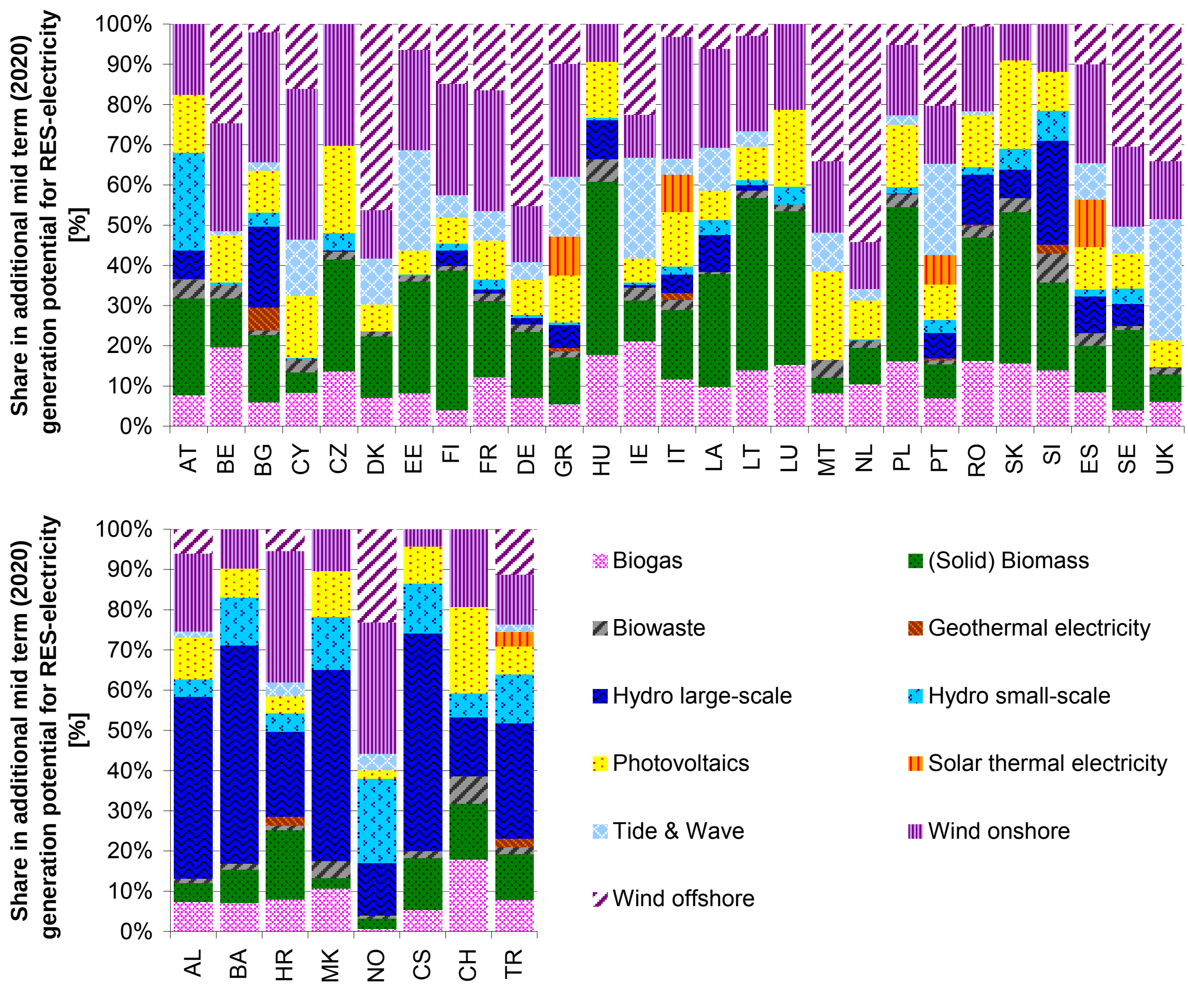

Figure 2.12. RES-E as a share of the total additional realisable potential in 2020 for all 35 implemented European countries

2.2.3 Economic data

High investment cost (and low fuel and O&M cost) of almost all RES-E technologies have been an impediment for broad market penetration. In recent years, investment cost decreased substantially for many RES-E technologies. Main drivers for cost reductions have been research and development as well as economies of scale. Also interest rates have been decreasing over the past two decades.

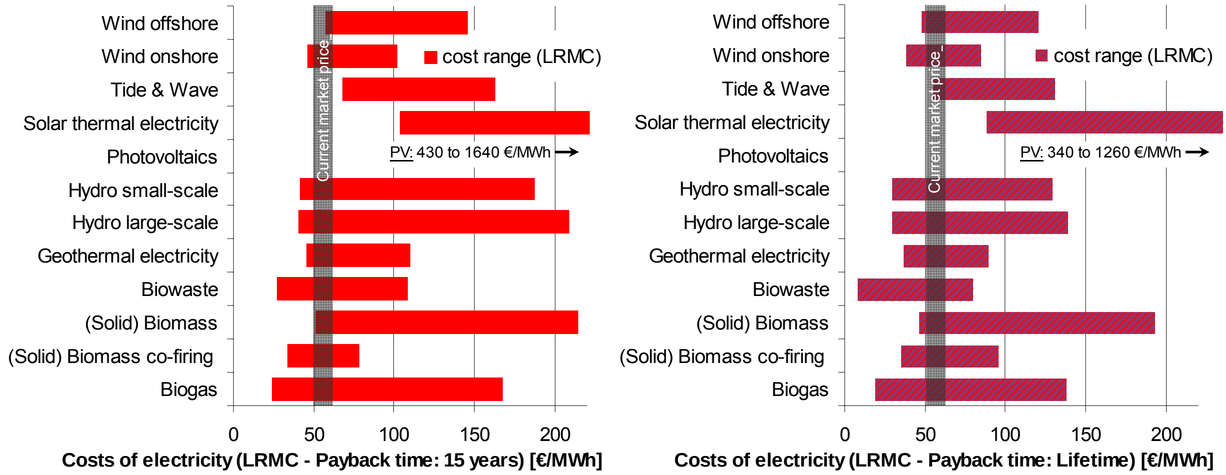

Figure 2.13. Bandwidth of long-run marginal generation cost (for the year 2005) of different RES-E technologies for several countries covered – based on a default payback time of 15 years (left) and payback time equal to lifetime (right).

Figure 2.13 depicts long-run marginal generation cost[16] by RES-E technology. Two different settings are applied describing the payback time:[17] On the one hand, a default setting of 15 years for all RES-E options (left)[18], on the other hand, the payback is set equal to the RES-E technology-specific life time (right). The broad range of cost for several RES-E technologies represents resource-specific conditions in different regions (countries). Costs also depend on technological options available (e.g. compare co-firing and small-scale CHP plants for biomass).

2.3 Achieved and future RES-E potentials on country-level

This chapter gives an overview of achieved (at the end of 2005) and additional mid-term potentials on country level for several Balkan countries including Turkey. Within a brief introduction the structure of power supply is characterised and RES-E support schemes and targets summarised. We also refer to major recent developments on the RES-E sector.

2.3.1 Albania

The Albanian power supply in 2005 was almost fully relying on hydro power with a share of total generation of 99 %. Most of thermal power capacity is currently not available. There are plans to rehabilitate an existing coal fired power plant to mobilise an additional thermal capacity of 60 MW.

[16] Long-run marginal generation cost is the indicator whether or not to build a new power plant.
[17] For both cases an interest rate of 6.5% is used.
[18] A payback time of 15 years aims to reflect the investor's point-of-view in competitive, liberalised markets.

RES-E support

In 2007 still no RES-E support scheme is in place. However, the development program for future production of electricity within the Albanian National Energy Strategy includes several targets for production of electricity from RES:

- Individual heating, central and co-generation plants (CHP) in services, industry and residential sector to be increased from 0.3 % in 2006 to 4.4 % in 2017;
- Wind energy usage for electricity generation to be increased from 0 % in 2006 to 1.5 % in 2017;
- Small hydropower production to be increased from 0.5 % in 2006 to 3.3 % in 2017.

The Albanian National Energy Strategy envisages the development of new hydropower capacities by 2015, approximately with the total installed capacity of 250 MW.

Achieved potentials

The use of renewable resources in Albania in 2005 was limited to hydro power. Total installed capacity amounted for 1445 MW of which 13.2 MW from small-scale installations.

Additional mid-term potentials

The highest additional mid-term potential is identified for large-scale hydro power with 5.2 TWh. Significant contributions to the future RES-E portfolio of Albania are also expected from wind power utilisation onshore. Recently hydro installations with more than 300 MW total capacity have gone online and projects of another 650 MW are in the planning phase. Furthermore there are plans to install Europe's so far biggest onshore wind farm with a total capacity of 500 MW which should be connected to Italy via a sea cable.

RES-E electricity generation potential [TWh/yr]	Achieved potential (2005)	Additional potential (up to 2020)
Biogas	0.06	0.84
(Solid) Biomass	0.00	0.55
Biowaste	0.00	0.12
Geothermal electricity	0.00	0.00
Hydro large-scale	4.13	5.15
Hydro small-scale	0.04	0.50
Photovoltaics	0.00	1.18
Solar thermal electricity	0.00	0.00
Tide & Wave	0.00	0.17
Wind onshore	0.00	2.22
Wind offshore	0.00	0.68
RES-E TOTAL	4.23	11.41

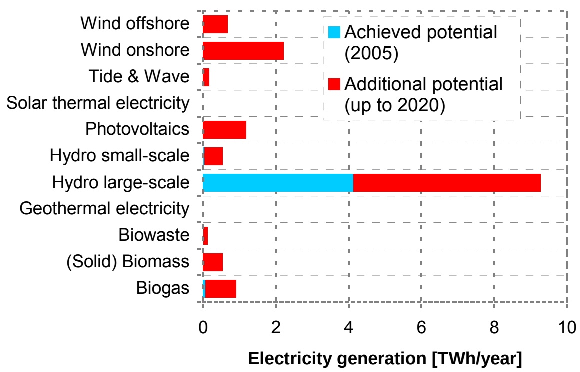

Figure 2.14. Albania – achieved (end of 2005) and additional mid-term (up to 2020) RES-E potentials.

2.3.2 Bosnia Herzegovina

In the hydro-thermal power system of Bosnia Herzegovina in 2005 coal and lignite fired power plants contributed to 52 % of total production and hydro power plants to 47 %. The remaining 1 % was generated by oil fired peaking units.

RES-E support

The two federal power utility companies, “Elektroprivreda BiH”, “Elektroprivreda HZ Herceg-Bosna” and “Elektroprivreda Republika Srpska” have the obligation to buy electricity from renewable sources.

The determination of the purchase price level of electric energy from renewable sources with installed power up to 5 MW is related to the tariff for the sale of electric energy on the territory of the Bosnia and Herzegovina. Feed-in price for electricity from small hydro is approx. 80% of the price for households. In 2007 the feed-in price was approx. 4.1 €ct/kWh. Wind and geothermal electricity receive 100%, biomass, biogas and biowaste 77% and PV installations 110 % of the household electricity price.

Currently several energy laws foresee the introduction of sub-laws which should define further incentive mechanisms for RES-E, but these have not yet been put in place.

Achieved potentials

In 2005 hydro power is the major source of green electricity in Bosnia Herzegovina. A total capacity of 2411 MW is installed of which 34 MW account for small-scale installations. The average generation potential is estimated with 7 TWh/yr.

Additional mid-term potentials

The highest additional mid-term potential is identified for large-scale hydro power with 10.8 TWh. Potentials for wind onshore and small-scale hydro are assumed to be 1.91 and 2.35 TWh respectively.

The realisation of both small and large-scale hydro power projects with a total of 250 MW is planned for the coming years.

RES-E electricity generation potential [TWh/yr]	Achieved potential (2005)	Additional potential (up to 2020)
Biogas	0.20	1.41
(Solid) Biomass	0.02	1.66
Biowaste	0.00	0.29
Geothermal electricity	0.00	0.00
Hydro large-scale	6.91	10.80
Hydro small-scale	0.17	2.35
Photovoltaics	0.00	1.45
Solar thermal electricity	0.00	0.00
Tide & Wave	0.00	0.00
Wind onshore	0.00	1.91
Wind offshore	0.00	0.00
RES-E TOTAL	7.29	19.88

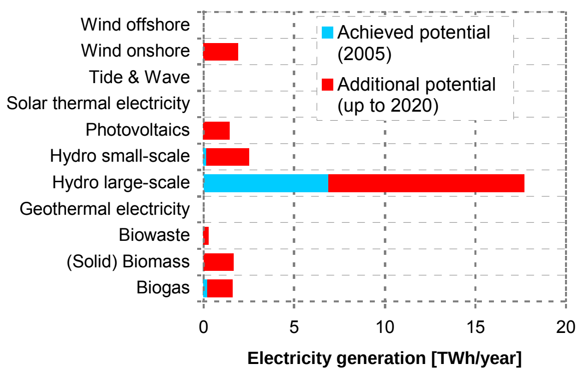

Figure 2.15 Bosnia Herzegovina – achieved (end of 2005) and additional mid-term (up to 2020) RES-E potentials.

2.3.3 Croatia

In 2005 the highest share of gross electricity demand was covered by hydro power with 38 % followed by thermal power, from gas, coal and oil with 31 %. The remaining 31 % of gross demand have been imported whereas the Krsko nuclear power plant located in Slovenia contributed to a share of 17 %. Within the *Croatian Energy Development and Organisation Programm (PROHES)* that aims on improving energy efficiency and raising the share of renewable energy sources subprograms for the following RES-E technologies were initiated: Biomass (BIOEN), solar (SUNEN), wind (ENWIND), geothermal energy (GEOEN) and small hydro (MAHE).

RES-E support

In July 2007 a new regulation for the support of RES-E went into force which defines the support scheme and also targets for future RES-E shares. The minimum share of RES-E (excl. large hydro power) on electricity gross demand to be reached in 2010 is set at 5.8 %. Feed-In Tariffs are set on technology level and depend on the installed capacity.

Achieved potentials

Current RES-E generation mainly comes from large-scale hydro power with an installed capacity of 2056 MW of which 26.7 MW is classified as small hydro. Further green electricity is produced by onshore wind installations (6 MW) and in biogas plants.

Additional mid-term potentials

Considerable additional mid-term potentials are identified for wind onshore (4.1 TWh), large hydro (2.6 TWh) and solid biomass (2.1 TWh). In 2006 the so far largest wind farm was commissioned with an installed capacity of 11.2 MW. Currently several hydro power (approx. 200 MW) and wind power projects (approx. 200 MW) are in the planning phase.

RES-E electricity generation potential [TWh/yr]	Achieved potential (2005)	Additional potential (up to 2020)
Biogas	0.09	1.50
(Solid) Biomass	0.00	2.14
Biowaste	0.00	0.15
Geothermal electricity	0.00	0.28
Hydro large-scale	5.84	2.61
Hydro small-scale	0.08	0.58
Photovoltaics	0.00	1.39
Solar thermal electricity	0.00	0.00
Tide & Wave	0.00	0.84
Wind onshore	0.01	4.06
Wind offshore	0.00	0.68
RES-E TOTAL	**6.03**	**14.23**

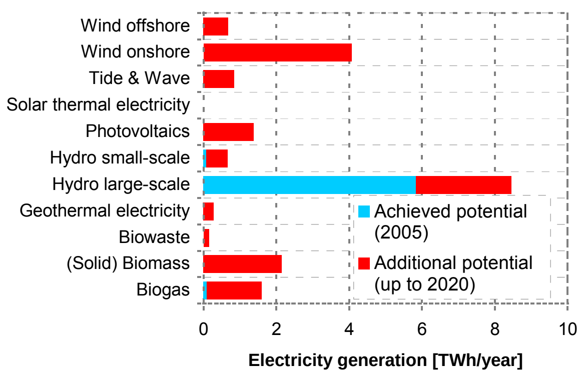

Figure 2.16 Croatia – achieved (end of 2005) and additional mid-term (up to 2020) RES-E potentials.

2.3.4 FYR of Macedonia

In 2006 58 % of electricity supply has been provided by lignite fired power plants, 19 % accounted for hydro power and remaining 23 % have been imported. Thermal power plants are so still supplied with lignite from local mines but reserves are estimated to last no longer than 2014.

RES-E support

In February 2007, in Decision of the Energy Regulatory Commission of Republic of Macedonia, feed-in tariffs for small-scale hydro power have been adopted. Tariffs range from 4.5 to 12 €ct/kWh depending on annual and monthly electricity production. In November 2007, rules on setting of feed-in tariffs for electricity from biomass were already adopted, but tariffs were not yet set.

Achieved potentials

In 2005 the only RES-E technology exploited so far is hydro power with an installed capacity of 516 MW of which about 40 MW account for small-scale installations. The corresponding generation potentials amount for 1.15 TWh. Most of the hydro power plants are equipped with reservoirs.

Additional mid-term potentials

The highest additional potential for green electricity production was identified for hydro power with 5.3 TWh. Significant potentials are also expected for Photovoltaics (1 TWh), biogas and wind onshore (both 0.9 TWh). Recently hydro power plants with a total capacity of more than 250 MW have been commissioned and projects of another 300 MW are in the planning phase.

RES-E electricity generation potential [TWh/yr]	Achieved potential (2005)	Additional potential (up to 2020)
Biogas	0.25	0.94
(Solid) Biomass	0.00	0.23
Biowaste	0.00	0.36
Geothermal electricity	0.00	0.00
Hydro large-scale	1.04	4.17
Hydro small-scale	0.14	1.16
Photovoltaics	0.00	0.99
Solar thermal electricity	0.00	0.00
Tide & Wave	0.00	0.00
Wind onshore	0.00	0.91
Wind offshore	0.00	0.00
RES-E TOTAL	**1.43**	**8.75**

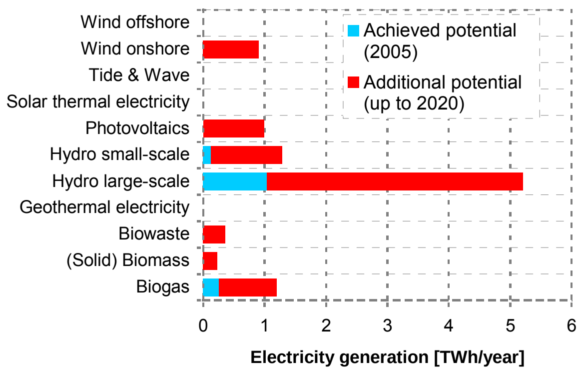

Figure 2.17. FYR Macedonia – achieved (end of 2005) and additional mid-term (up to 2020) RES-E potentials.

2.3.5 Serbia and Montenegro[19]

In the former State Union of Serbia and Montenegro the share of electricity produced by hydro power plants amounts to 31 % in 2005. The remaining electricity production comes from conventional thermal units whereas coal with a share of 66 % of total generation is the most important fuel. A minor part of the generation is provided by gas (2 %) and oil (1 %) fired power plants.

RES-E support

Serbia

In order to increase the usage of RES in Serbia, the Ministry of Mining and Energy (MoME) has initiated the development of the Study "*Analysis of Policies to Increase Renewable and Low Carbon Energy Use*". The Study will, among others, propose adequate incentive mechanisms and possible targets to be achieved.

The support schemes for RES electricity have not been implemented yet. There is single buyer - Elektroprivreda Srbije and feed-in price from RES-E source depends on negotiation.

Montenegro

Taking into account the development of entire energy sector in the Republic of Montenegro, according to long term National Energy Strategy, it is assessed that the share of all renewables (without large-scale hydro) in 2010/2015 can be achieved in the range of 3-5 % of the total energy consumption. It is expected that small-scale hydro generation can reach the share in the national electric power balance of approximately 2.5 % by 2015.

Support schemes for RES electricity have not been implemented yet. A feed-in tariff system is in preparation; the envisaged feed-in tariff for small hydro is estimated to approx. 7.6 €ct/kWh.

Achieved potentials

In 2005 the main source of RES-E is hydro power with an installed capacity of 2910 MW of which 22 MW account for small-scale installations. A total of 30 MW installed power plant capacity running on landfill and sewage gas have a generation potential of 140 GWh.

Additional mid-term potentials

The by far highest additional mid-term potential is identified for large-scale hydro power with 7.8 TWh. Significant future contributions to RES-E generation might origin from solid biomass (1.9 TWh), small-scale hydro power (1.8 TWh) and Photovoltaics (3.1 TWh). Currently hydro and wind power projects of with a total capacity of 600 and 25 MW respectively are in the planning phase.

[19] As statistical data and future projections are still mostly available for the area of the former State Union of Serbia and Montenegro it was not possible to assess RES-E potentials on country level. Therefore we present aggregated results for both countries in this report.

RES-E electricity generation potential [TWh/yr]	Achieved potential (2005)	Additional potential (up to 2020)
Biogas	0.14	0.78
(Solid) Biomass	0.00	1.86
Biowaste	0.00	0.26
Geothermal electricity	0.00	0.00
Hydro large-scale	10.50	7.82
Hydro small-scale	0.07	1.79
Photovoltaics	0.00	3.10
Solar thermal electricity	0.00	0.00
Tide & Wave	0.00	0.00
Wind onshore	0.00	0.60
Wind offshore	0.00	0.00
RES-E TOTAL	**10.71**	**16.21**

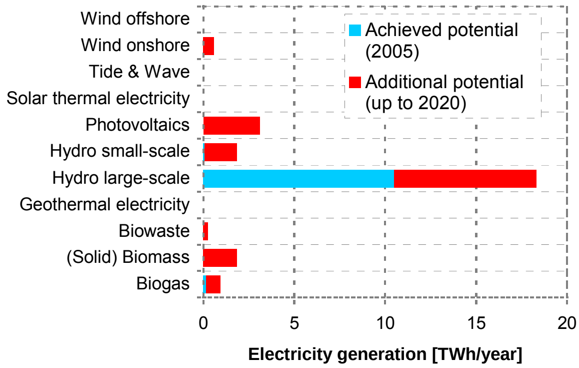

Figure 2.18. Former State Union of Serbia and Montenegro – achieved (end of 2005) and additional mid-term (up to 2020) RES-E potentials.

2.3.6 Turkey

The Turkish electricity production is dominated by thermal power whereas gas with a share of 45 % has been the most used fuel in 2005 followed by coal (27%) and oil (3%). Hydro power plants delivered 24 % of total electricity production.

RES-E support

In 2005, Turkey passed a new renewable energy law ("Law Concerning the Use of Renewable Energy Resources for Electricity Generation" No: 5346) to bring it into line with European Union legislation to support renewable sources, including wind power, by giving a government guarantee to purchase electricity at a set price for a period of 7 years. The tariff of about 5 eurocents per kWh of electricity is, however, much lower than in most other European countries, and rather discouraging investment in the renewable energy sector.

Until the end of 2011, the applicable price for the electrical energy to be purchased in accordance with Law Concerning the Use of Renewable Energy Resources for Electricity Generation within each calendar year is envisioned to be the Turkish average wholesale electricity price in the previous year determined by EMRA (Energy Market Regulatory Authority). This price is determined as 9.13 YKr/kWh for 2007. The price to be applied should not be lower than Turkish Liras equivalent of 5 Euro Cent/kWh and not higher than Turkish Liras equivalent of 5,5 Euro Cent/kWh. Besides those mentioned above, the Law No. 5346 brings some incentives about investment period applications and territory acquisition.

Achieved potentials

Large scale-hydro power is the dominant RES-E technology in Turkey so far with a share of more than 90 % of total RES-E generation potential. Minor contributions are observed from biogas (6 %) and small-scale-hydro (1 %). As from 2007 the development on the wind power sector has become more dynamic - installed capacity has increased from 50 to 146 MW at the end of the year.

Additional mid-term potentials

Even though hydro power in Turkey is already utilised to a remarkable content the additional mid-term potential for both small and large-scale hydro is expected to be considerable (57 and 24 TWh respectively). In the future also wind power might contribute to the overall RES-E generation with both on- and offshore installations. The additional potential is estimated to be 47 TWh which is 20 % of the total additional potential. Notable potentials are further indicated for solid biomass (23 TWh), biogas (20 TWh) and PV (41 TWh).

RES-E electricity generation potential [TWh/yr]	Achieved potential (2005)	Additional potential (up to 2020)
Biogas	2.93	20.23
(Solid) Biomass	0.00	22.86
Biowaste	0.11	3.37
Geothermal electricity	0.09	4.11
Hydro large-scale	45.32	57.11
Hydro small-scale	0.68	24.32
Photovoltaics	0.00	41.21
Solar thermal electricity	0.00	7.07
Tide & Wave	0.00	5.89
Wind onshore	0.06	24.66
Wind offshore	0.00	22.19
RES-E TOTAL	**49.19**	**233.01**

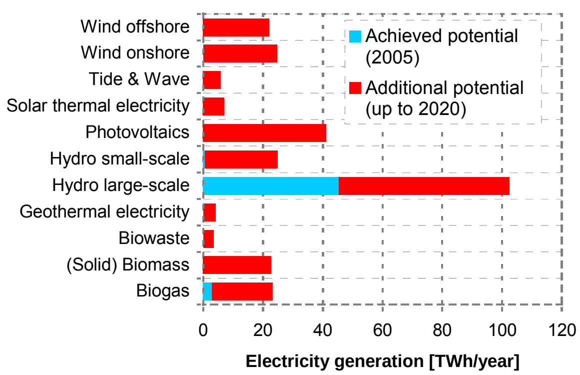

Figure 2.19. Turkey – achieved (end of 2005) and additional mid-term (up to 2020) RES-E potentials.

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ANNEX I RES-E SUPPORT IN NEWLY ADDED COUNTRIES

Albania

Framework policy documents and legislation

- Law No.9072 dated 22.05.2003 on power sector (http://www.ere.gov.al/en/Desktop/Power-2520Sector-2520Law-2520No9072.pdf)
- Albanian National Energy Strategy (http://www.seenergy.org/?/organizations&type=3&stat=1&col=2120)

RES-E support system

Not in place at the moment (2007).

Indicative targets

Albania has not yet set any national indicative targets for future consumption of electricity produced from RES.

Regarding international obligations, Albania is not included in Annex 1 of Kyoto Protocol due to most of its electricity being produced by HPPs. However, the development program for future production of electricity within the Albanian National Energy Strategy includes several targets for production of electricity from RES, as follows:

- Individual heating, central and co-generation plants (CHP) in services, industry and residential sector to be increased from 0.3 percent in 2006 to 4.4 percent in 2017;
- Wind energy usage for electricity generation to be increased from 0 percent in 2006 to 1.5 percent in 2017;
- Small hydropower production to be increased from 0.5 percent in 2006 to 3.3 percent in 2017.

The Albanian National Energy Strategy envisages the development of new hydropower capacities by 2015, approximately with the total installed capacity of 250 MW.

Currently, the Albanian National Energy Strategy is under review which includes also setting the RES national indicative targets.

Guarantees of Origin

Based on the Law No.9072 dated 22.05.2003 on power sector, ERE has approved the rules on procedures for issuing Guarantee of Origin and Green Certificate.

Based on Power Sector Law (art. 39), in February 2007 ERE has adopted a regulation on guarantees of origin and green certificates for power producers.

ERE has signed an agreement with Italian TSO for recognizing the system of guarantees of origin and green certificates. Similar agreements will be signed with other homologue institutions from other countries.

RES-E Quotas

The Power Sector Law (art. 39) stipulates that the new electricity producers with installed capacity higher than 100 MW are obliged to produce electricity from RES not less than 2 percent of their total generation from other sources.

This obligation can be considered fulfilled if they buy the same amount of electricity from other domestic producers or import. In the latter case the obligations is considered fulfilled when ERE and other homologue institutions of the countries the electricity is imported from have a reciprocal certification process of production from RES.

Licensing procedures

Licensing procedures are prepared by ERE and they are in force, but authorization procedures are not prepared. METE and ERE are reviewing existing regulatory framework regarding administrative procedures.

The new Concession Law was approved in December 2006 and the Government Decree No.19 on procedures for awarding the concession contracts stipulates that for small HPPs with installed capacity less than 10 MW a long term PPA will be signed with the public supplier and a uniform feed-in tariff for these plants will be approved by ERE. The Transitory Market Model states that the public supplier (KESH/DSO) will buy the output of small HPPs if they decide to sell it to public supplier.

ERE has approved a methodology for calculation of a uniform tariff for the existing small HPPs which are privatized or given through concessions. Based on this methodology a tariff has been approved by ERE in February 2007.

Article 38 of the Power Sector Law states that Privileged Power Producers are considered:

- producers generating electric power using renewable energy sources, whose installed capacity does not exceed 25 MW and in case of hydroelectric energy source up to 10 MW;
- producers generating electric power through cogeneration schemes, whose installed capacity does not exceed 100 MW;
- auto-producers for their electric power surplus provided that they use renewable energy sources and their installed capacity does not exceed 10 MW.

For the construction of a plant generating electricity from renewable energy sources it is necessary to obtain several documents as to water use, environment, and construction permissions.

Priority grid access and purchase of RES-E

Based on Concession Law No. 9663 Dt. 18.12.2006, TSO or DSO-KESH is obliged to buy electricity from RES producers. RES producers have the rights to sell electricity directly to eligible consumers or where they want. A regulation to ensure that TSO and DSO-KESH guarantee transmission and distribution of electricity produced by RES in case of network congestions is under preparation.

The Electricity Market Act provides for the status of eligible producer. The status of eligible producer secures the purchasing of the total electricity produced (Article 8 of the Electricity Market Act), i.e. the TSO or DSO is obliged to ensure purchasing of the total electricity produced from eligible producers as provided for in the prescribed conditions.

Together with the other Task Force members ERE has published Grid Code and Distribution Code, and Procedure for grid connection based on Power Sector Law No.9072 Dt.22.05. 2003, Article 37.

Tax exempts

The Law No. 8987 on creating facilities for new power generation plants (art.2) stipulates that the new plants using RES shall be exempted from custom duties for all equipments and machineries for generation purposes. Based on Albanian legislation (GoA Decree) small HPPs are not obliged to pay Water fee and Land property fee.

Bosnia and Herzegovina

Framework policy documents and legislation

The process of energy sector reform in Bosnia and Herzegovina has started, but is not completed yet, and the National Energy Strategy does not exist. Statistics and laws within energy sector are also only partly in existence. Within the EU EuropeAid/CARDS project for Bosnia and Herzegovina *Technical Assistance to Support the Energy Department of MoFTER in Bosnia and Herzegovina*, the main objective is to prepare the National Energy Strategy, within which the RES sector will be included. This project started 6 February 2006 and is expected to be finished 5 February 2008.

Several laws are in place which give positive treatment to RES for electricity production, but the relevant sub-laws which should define implementation aspects, including national indicative targets, are not yet in place. The following gives an overview of current legislation in existence relevant to RES electricity.

With the purpose, among other, of further increase of share of renewable sources, the state initiated development of the Study on Energy Sector as a basis for the development of a comprehensive Energy Strategy, which is financed from the World Bank loan. One of the reports to be made within the Study pertains to promotion of use of renewable electric energy sources.

RES-E support system

Not in place at the moment (2007). Currently several energy laws foresee the introduction of sub-laws which should define incentive mechanisms for RES electricity, but these have not yet been put in place.

Feed-in price for electricity from small hydro is approx. 80% of the price for households. In 2007 the feed-in price was approx. 4.1 eurocents/kWh.

Guarantees of Origin

Currently there are no guarantees of origin mechanisms for RES electricity in Bosnia and Herzegovina. It is planned to analyse and adjust models used in the countries of the region to the situation in Bosnia and Herzegovina.

Priority grid access and purchase of RES-E

The obligation to purchase electricity from RES is in place but only for small hydro below MW.

Licensing procedures

Competent entity ministries and electricity regulators have defined the procedures of authorisation for construction of small HPPs. The Law on Electricity of Republika Srpska prescribes issuance of licences for construction of power facilities for generation and distribution of electricity.

The Law on Electricity of Federacija BiH stipulates authorities of FERC.

Development of secondary legislations is planned (respective Books of Rules), which should define the required measures to guarantee transmission and distribution of electric power generated from RES.

Existing Books of Rules – Grid Code, General Conditions, Distribution Grid Rules (in process of adoption) and Book of Rules on Connection define minimum standard rules for connection. These Books of Rules need to be updated and the new BoRs need to be developed (BoRs on conditions and criteria for obtaining the eligible generator status, tariff pricing methodologies for connection to power grids) with special focus on use of renewable sources of electric power.

FYR of Macedonia

Framework policy documents and legislation

- The new Energy Law was published in the Official Gazette (Official Gazette of RM No. 63/2006) entered into force in May 2006. It replaces the Law on Energy of 1997 which had been amended several times, the last time in 2005.
- The Energy Regulatory Commission is established in 2002
- Energy Policy and Energy Efficiency Strategy until 2020 were adopted in 2004.
- Macedonia signed Energy Community Treaty in October 2005

RES-E support system

Under development at the moment (2007). Feed-in tariffs are being gradually adopted (according to Energy Law).

In February 2007, in Decision of the Energy Regulatory Commission of Republic of Macedonia No. 02-231/1, feed-in tariffs for small hydro were adopted.

Table A.1. Feed-in tariffs for small hydro in Macedonia

class	monthly production of electricity (kWh)	Annual production of electricity (kWh)	Feed-in tariff (€cents/kWh)
I	1 - 85.000	1 – 1.020.000	12,00
II	85.001 - 170.000	1 - 2.040.000	8,00
III	170.001 – 350.000	2.040.001 - 4.200.000	6,00
IV	350.001 - 700.000	4.200.001 - 8.400.000	5,00
V	over 700.001	over 8.400.001	4,50

In November 2007, rules on setting of feed-in tariffs for electricity from biomass were already adopted, but the feed-in tariffs were not yet set.

Guarantees of Origin

Rulebook for issuing guarantees of origin is to be adopted (according to Energy Law).

Indicative targets

The National targets have not been set yet.

Priority grid access and purchase of RES-E

The measures for utilisation of the renewable energy sources shall be in further details prescribed by the minister competent for the activities that fall within the energy sector.

In Article 141 from the Energy Law it is defined that the Market Operator is obliged to purchase the whole electricity generated from the eligible producers of electricity and from the generation of electricity from high-efficiency co-generator.

The cost for this kind of purchase the Market Operator will invoice this cost to the participant in the electricity market in accordance with the tariffs established by the Regulatory Commission.

A preferential producer of electricity and a high-efficiency co-generator shall be required to present to the Regulatory Commission a document from the EARM certifying that it uses renewable resources or that it uses high-efficiency cogeneration processes in order to receive preferential tariffs for its production.

The Regulatory Commission may require the electricity transmission system operator, when dispatching generation facilities, to give priority to generation facilities producing electricity from renewable resources and from high-efficiency co-generative installations.

Serbia

Framework policy documents and legislation

In order to increase the usage of RES in Serbia, the Ministry of Mining and Energy (MoME) has initiated the development of the Study "*Analysis of Policies to Increase Renewable and Low Carbon Energy Use*". The Study will, among others, propose adequate incentive mechanisms and possible targets to be achieved

The Law on Ratification of Kyoto Protocol is in the Serbian Parliament. Serbia will ratify the Protocol as non-Annex 1 Country, meaning that it will not have any emission reduction and will be eligible for CDM projects.

The Energy Law (OJ 84/04) already defines producers of RES-E as privileged power producers that shall be entitled to subsidies, tax relief, custom exemptions and other relief in line with laws and other regulations on taxes, customs and other duties. Amendments of the Energy Law, which are currently in the preparation, would set the clear responsibility and deadline for the introduction of these incentives.

RES-E support system

The support schemes for RES electricity have not been implemented yet.

There is single buyer - Elektroprivreda Srbije and feed-in price from RES-E source depends on negotiation.

Indicative targets

The national indicative targets for RES electricity have not been set yet.

Guarantees of Origin

No detailed analysis on the introduction of guarantee of origin has been conducted so far.

Priority grid access and purchase of RES-E

The Article 34 of the Energy Law (2004) sets obligations to TSO and DSO to allow access of third parties to the grid on the principles of transparency and non-discrimination in conformity with technical possibilities and depending on the load level of the transmission and distribution. Prices for transmission and distribution systems are regulated and publicly available.

For any priorities in transmission and dispatching the provisions must be made through changes of the Energy Law. The Market Rules, Transmission Grid Code and Distribution Grid Code, are being developed. Transmission and Distribution Grid Codes will be approved.

By the Decision of the Energy Agency from February 2007, the methodology for calculation of the costs for connection to distribution/transmission system is defined. For the power producers so called "shallow approach", which excludes costs for the grid reinforcement (except for the connection of the large installed capacities) is foreseen according to the methodology. Thus, methodologies facilitate RES-E producers implicitly.

For any further cost relieves for connection and access to the grid of RES-E producers provisions must be made through the Energy Law (amendments) and later reflected by methodologies set by Energy Agency.

Montenegro

Framework policy documents and legislation

- Energy Law was adopted in 2003 (Official Bulletin of Montenegro' 39/2003)
- Energy Regulatory Agency was established in January 2004.
- Energy Policy was adopted in February 2005.
- Electric Power Company of Montenegro (EPCG) has been functionally unbundled
- Energy Efficiency Strategy was adopted in October 2005.
- Montenegro signed Energy Community Treaty in October 2005
- The study on renewables (wind, sun and biomass) is in preparation
- Design of Energy Development Strategy until 2025 is underway

Implementation of the Energy Development Strategy of Montenegro until 2025 will contribute to higher utilization of substantial energy potentials of Montenegro, respectively hydro-potentials of big and small waterflows, coal deposits, wind energy, solar energy, biomass, etc.

Taking into account development of entire energy sector in the Republic of Montenegro, according to long term National Energy Strategy, it is assessed that the share of all renewables (without large HPPs) in 2010/2015 can be achieved in the range of 3-5 percent of the total energy needs. It is calculated that the small HPPs generation can reach the share in the national electric power balance of approximately 2.5 percent in 2015.

The Energy Law (Article 27) gives priority to generators using renewables energy sources. The Decree on the conditions regarding the grant concessions for research of water flows and technical-economic utilization of water energy potentials for production of electricity in small HPPs was adopted in November 2006.

The Strategy for small hydropower plants development in Montenegro was adopted in April 2006, as well as the Action Plan for its implementation.

RES-E support system

The support schemes for RES electricity have not been implemented yet. The feed-in tariff system is in preparation, envisaged feed-in tariff from small hydro is estimated to approx. 7.6 eurocents/kWh.

Indicative targets

The national indicative targets for RES electricity have not been set yet.

Guarantees of Origin

No detailed analysis on the introduction of guarantee of origin has been conducted so far.

Priority grid access and purchase of RES-E

The Energy Law (Article 32) states that the electricity produced in small HPPs or power plants on alternative sources shall be entitled to access to the transmission and distribution networks on non discriminatory basis. The simplified procedures for exercise for such entitlements will be defined, provided, that all such plants are required to adhere to the acquirements of applicable grid and distribution codes, market and other rules and legal requirements pursuant to this and other Law.

Regulations on technical conditions for small PP's connection onto electro-distribution network are currently in finalization phase.

Turkey

Framework policy documents and legislation

In 2005, Turkey passed a new renewable energy law ("Law Concerning the Use of Renewable Energy Resources for Electricity Generation" No: 5346) to bring it into line with European Union legislation to support renewable sources.

Within the framework of Electricity Market Law and the related secondary legislation, generation plants that generate electricity based on renewable energy sources are supported by the following mechanisms:

- The legal entities applying for licenses for the construction of facilities based on domestic natural resources and renewable energy resources pay only one percent of the total licensing fee.
- The generation facilities based on domestic natural resources and renewable energy resources do not pay annual license fees for the first eight years following the facility completion date inserted in their respective licenses.
- TEİAŞ (Turkish Electricity Transmission Company) and/or distribution licensees are obliged to assign priority for system connection of generation facilities based on domestic natural resources and renewable energy resources.
- Applicable for sales to non eligible consumers; if the price of electricity generated at generation facilities based on renewable energy resources is equal to or lower than the sales price of TETAŞ (Turkish Electricity Trading and Contracting Company) and if there is no cheaper alternative, the retail licensees are obliged to purchase such energy for the purposes of re-sale to the non-eligible consumers.
- The legal entities engaged in generation activity at facilities based on renewable energy resources may purchase electricity from private sector wholesale companies on the condition not to exceed the annual average generation amounts indicated in their licenses in a calendar year.
- Among generation facilities based on renewable energy resources which can be considered within the scope of Article 18 titled "Balancing Units and Registration Rules" of Electricity Market Balancing and Settlement Regulation are exempted from the responsibility of being balancing units.

RES-E support system

In 2005, Turkey passed a new renewable energy law ("Law Concerning the Use of Renewable Energy Resources for Electricity Generation" No: 5346) to bring it into line with European Union legislation to support renewable sources, including wind power, by giving a government guarantee to purchase electricity at a set price for a period of 7 years. The tariff of about 5 eurocents per kWh of electricity is, however, much lower than in most other European countries, and rather discouraging investment in the renewable energy sector.

Until the end of 2011, the applicable price for the electrical energy to be purchased in accordance with Law Concerning the Use of Renewable Energy Resources for Electricity Generation within each calendar year is envisioned to be the Turkish average wholesale electricity price in the previous year determined by EMRA (Energy Market Regulatory Authority). This price is determined as 9,13 YKr/kWh for 2007. The price to be applied should not be lower than Turkish Liras equivalent of 5 Euro Cent/kWh and not higher than Turkish Liras equivalent of 5,5 Euro Cent/kWh. Besides those mentioned above, the Law No. 5346 brings some incentives about investment period applications and territory acquisition.

Guarantees of Origin

Within the scope of the "Law Concerning the Use of Renewable Energy Resources for Electricity Generation" (Law No: 5346), electricity generation based on renewable energy resources is promoted and with this law EMRA is authorised to issue Renewable Energy Certificate (RES Certificate) and to determine the Turkish average electricity wholesale price. RES Certificate is granted by EMRA (Energy Market Regulatory Authority) to the legal entity holding generation license for the purpose of identification and monitoring of the resource type in purchasing and sale of the electricity generated from renewable energy resources in the domestic and international markets.

RES-E Quotas

The Law Concerning the Use of Renewable Energy Resources for Electricity Generation compels that, legal entities holding retail sale license are required to buy a certain ratio of available RES certificated energy. For every retail sale licensee, this ratio is obtained by dividing the total sale of retail sale licensee in the previous calendar year to the country total consumption.

ANNEX II FIGURES AND TABLES