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Development of Power Generation In the South East Europe

UPDATE OF GENERATION INVESTMENT STUDY

Volume 1: Summary Report

Final Report

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IMPORTANT NOTICE

This Report relates to the updating of the Generation Investment Study (GIS) for South East Europe. The report has been prepared by the South East Europe Consultants Ltd. (SEEC), under the World Bank contract No: 7138967.

This Generation Investment Study was performed as the CARDS Project No: 52276, contracted by Pricewaterhouse Coopers LLP as a consortium leader and Atkins International plc, with MWH as subcontractor and SEEC as subcontractor to MWH.

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ABBREVIATIONS AND UNITS CONVERSION

Abbreviations

- CCGT: Combined Cycle Gas Turbine plant
- CHP: Combined Heat and Power
- ESP: Electrostatic Precipitator
- ETS: European Trading System
- FGD: Flue Gas Desulfurization
- GIS: Generation Investment Study
- GIS–IIEP: Supplemental environmental study to GIS
- NPV: Net Present Value
- OPGT: Open Cycle Gas Turbine plant
- SEE: South-Eastern Europe
- SEEC: South Eastern Europe Consultants
- Ton: Metric ton

Conversion of Units

FIELD	FROM	EQUIVALENT TO
Exchange Rate	US$ 1	€ 0.8375
	US$ 1.194	€ 1
Heat	1 BTU	1,055.87 J
	1 MBTU	1.05587 GJ
	947,086.3 BTU	1 GJ
	1 kcal	4,186.8 J
	0.238846 Gcal	1 GJ
Volume of Oil	1 bbl	0.15899 m^3
	6.2897 bbl	1 m^3
Unit Costs	US$ 1/bbl	€ 5.2676/m^3
	US$ 1/MBTU	€ 0.79318/GJ
	US$ 1.2607/MBTU	€ 1/GJ
Natural Gas Costs	€ 1/GJ	€ 0.0333/m^3

FOREWORD

This report summarizes the key findings of an update to the Generation Investment Study (GIS) in South-Eastern Europe (SEE) and a supplemental environmental study (GIS – IIEP) which were completed in 2004. Significant increase in oil and natural gas prices, as well as emission credit prices in the European Trading System (ETS) was the primary motivations for this update. The GIS update provided an opportunity to assess the impacts of high fuel and emission credit prices, and during the course of the update identify the potential role strategic alternatives such as electricity imports, imported coal and nuclear energy could play in the region.

Both the original GIS and the update have a number of limitations, especially: 1. need for more detail assessment of the hydroelectric potential of the region;2. better assessment of the renewable potential and cost-effectiveness; and 3. assessment of the potential role of combined heat and power (CHP) associated with existing district heating systems. It also became clear that demand forecasts need to be revisited. Assessments to address these limitations are recommended for future follow-up activities. This is consistent with the realization that maintaining an up-to-date regional energy development program is essential for a well-functioning regional energy market. Also, recommendations are made regarding the need to have the institutional capacity to maintain up-to-date energy development plans in the region, as well as the role the World Bank may play in the interim.

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UPDATE OF THE POWER GENERATION INVESTMENT STUDY IN THE SOUTH-EASTERN EUROPE

This report (Volume 1) summarizes the key findings of an update to the Generation Investment Study (GIS)[1] in South-Eastern Europe (SEE) and a supplemental environmental study (GIS – IIEP)[2] which were completed in 2004[3]. The detailed results of this study (Terms of Reference are provided in Annex 1) are documented in Volume 2, which is available through the World Bank upon request. The main purpose for the update is to assess the effect of recent changes in fuel and CO2 markets on the power generation expansion plan of the SEE region and compare it to the earlier results of the GIS. Since 2004, oil prices increased from approximately $30/bbl to $60-75/bbl. Natural gas prices followed similar trends. Also, CO2 allowances (credits) reached €35/ton in the European Trading System (ETS), compared to €6-10/ton during 2004. Finally, the GIS Update provided an opportunity to examine further some strategic power generation alternatives, such as increased electricity imports, imported coal, hydroelectric and nuclear generation, which were not explored adequately in the Original GIS.

The Original GIS

The Original GIS (2004) included development of a long-term investment plan for the SEE Region[4] covering both power generation and transmission for the period 2005-2020. Key objectives of the GIS were to:

- Develop least-cost investment plans under different scenarios
- Assess the value of integrating the region into one electric power system; and
- Identify the high priority investments in transmission which are required to optimize investments and for the regional system to function efficiently.

The key definitions and assumptions used in the GIS analysis are provided in Box 1.

The GIS confirmed that operation of the SEE power system as one fully interconnected network reduces the investment requirements and saves approximately €3 billion (Net Present Value, NPV) during the planning period 2005-2020 mainly due to reduction of the need for new power generating capacity (11GWs vs 15.5GWs[5] of new power plants). System integration reduces the need for natural gas/oil (up to 6.8 GWs) and hydro plants (1.3 GWs), while the capacity of lignite and nuclear increased (2.0 GWs and 1.2 GWs, respectively).

[1] "Regional Balkans Infrastructure Study-Electricity (REBIS) and Generation Investment Study (GIS)", prepared for European Commission, Contract No CARDS 52276
[2] World Bank, "Development of Power Generation in South East Europe – Implications for Investments in Environmental Protection", Contract No 7128286
[3] The studies were actually completed in 2005, but reflect 2004 assumptions
[4] Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Montenegro, Kosovo (pursuant to UN resolution 1244), Romania, Serbia and the former Yugoslav Republic of Macedonia
[5] All reference to capacity requirements in this report are always MWnet. However, when the specific plants are mentioned, the nameplate (usually MWgross) is used

Box 1. Definitions and assumptions regarding GIS Analyses

The WASP (Wien Automatic System Planning) model was used in all scenarios to develop the power generation expansion plans.

The main groups of scenarios in the GIS were:

- *Scenario A:* Modeling of each country as a separate power system;
- *Scenario B:* Modeling of the region as a fully interconnected power system without any transmission constraints; and
- *Scenario C:* Modeling of the region as a fully interconnected power system, but with new transmission investments which were identified in Scenario B as regional priorities, in addition to the planned transmission projects.

Another variant which was considered in GIS was the compliance of thermal power plants with environmental regulations and EU Directives. All new power plants in the region comply with EU Directives. However for existing plants, two alternatives were evaluated:

- *Full Compliance:* All countries comply with the EU Environmental Directives.
- *Partial Compliance:* Bulgaria and Romania (EU members as of Jan 1 2007) were assumed to comply with EU Directives; the compliance of each power plant was specified according to the schedule agreed upon between these two countries and the European Commission. The remaining countries for which EU accession schedule is uncertain were assumed that they will not comply with all EU Directives within the planning period (2005-2020). Thermal power plants requiring rehabilitation would include upgrading of the particulate collection equipment and installation of low NOx burners; so they would comply with EU Directives with regard to particulates and NOx. However, they would not comply with the sulfur control requirements.

Under the GIS, partial compliance was viewed as a more realistic scenario for the region, and the GIS Update was based on this same assumption (Partial Compliance).

"Official Rehabilitation" and "Justified Rehabilitation": The term *"official rehabilitation program"* is used to indicate that the rehabilitation projects were implemented as provided by the Ministries of Energy and/or the power companies of each jurisdiction.

"Justified Rehabilitation" includes only the rehabilitation projects which proved cost-effective against competing options (new power plants which were selected as part of the least-cost plan,; more specifically, Kosovo lignite and natural gas-fired CCGTs).

This distinction between "official" and "justified" is made in both the Original GIS and the Updated GIS.

Additional assumptions of both the Original and Updated GIS:

- All costs were set to a January 2005 base price level and excluded inflation;
- The analysis was undertaken in Euros at an exchange rate of $1 to €0.8375;
- A basic real discount rate of 10% was assumed, discounted to January 2005. A sensitivity run was performed (only under the GIS) with a reduced discount rate of 7%;
- A range of reserve margins was used for the initial WASP selection of potential expansion plans. The final selection was based on a Loss of Load Probability (LOLP) criteria of one day per annum; and
- The average economic value of electric energy not served was set at: 0.42€/kWh.

The ***key options selected*** by WASP as part of the least-cost regional power generation plan (Scenario B) were:

- Kosovo lignite: 4,200MWs (4X300MW + 6X500MWs)
- Combined Cycle Gas Turbines[6]: 3,000MWs (5X300MW + 3X500MWs)
- Complete on-going and committed plants such as:
  - Nuclear: Cernavoda 2 (680MW) in Romania; and
  - District Heating Combined Heat and Power (CHP): 4X100MWs.
- The following plants were selected by the model based on the costs provided by the local authorities:
  - Lignite: Kolubara B (2X350 MWs) in Serbia and Maritsa East 1 (2X335 MWs) in Bulgaria; and
  - Nuclear: Cernavoda 3 (680MW) in Romania and Belene 1 (960 MWs) in Bulgaria.

The specific plants selected, as well as the existing plants rehabilitated, are shown in Annex 2.

The least-cost plan reflects, in addition to economics, certain constraints which take into account practical limitations (e.g., ability to build a large multi-unit plant in Kosovo with the associated transmission lines; or limited amount of natural gas available in the region); finally, limitations were imposed due to lack of data, especially with regard to hydro and renewables. The most relevant limitations are:

- For the planning period 2005[7]-2020, the maximum capacity was set at:
  - 5,500 MW for Kosovo; and
  - 6,300 MW for natural gas combined cycle.
- No new imported coal and nuclear plants were allowed, except for the nuclear plants already being planned (Cernavoda 2 and 3; and Belene).
- Renewables and hydro plants were not analyzed in detail, mainly due to lack of information. Approximately 2,100 MW of hydro plants were evaluated, representing not necessarily an exhaustive list of all the potentially attractive hydro sites in the region. While these plants proved marginally non-competitive under baseline scenario assumptions, increased fuel and CO_2 prices are expected to improve their cost-effectiveness. Also, these plants have benefits which are not usually accounted for by power system planning models, such as: hydro plants are good options for stand-by and spinning reserve capacity; also, they utilize a domestic energy resource which reduces foreign exchange requirements and enhances energy security.

In addition to the new plants, significant investments are needed for power plant rehabilitation. Official plans call for rehabilitation of 11,574 MWs of existing capacity to extend their operating life and restore their efficiency and reliability; the required investment is estimated at €4.8 billion. Compliance with EU Environmental Directives would require an additional €2.3 billion.

However, not all the planned rehabilitation projects are cost-effective compared to the available power generation expansion alternatives. Under the Original GIS basecase assumptions, screening curve analysis suggests that 9,916 MWs (or 86% out of the 11,574 MWs) are cost-effective when only rehabilitation (with ESP upgrading and low NOx burners)

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[6] Combined Cycle Gas Turbine (CCGT) plants are generic and no location is identified
[7] While the GIS update was done in 2006, the planning period was maintained to 2005-2020 for consistency with the Original GIS

is considered. When Flue Gas Desulfurization (FGD) is added for SO2 control, the percentage drops to 80% (9,223 MWs). Hence, FGD does not impact significantly the competitiveness of lignite plants.

Elimination of the non-competitive rehabilitation projects increases the investment requirements for new power generation capacity, which needs to replace the retiring plants. For the assumptions in the basecase scenario, the retiring capacity is replaced mainly by local lignite and natural gas (CCGT) plants.

The screening curve analysis involved comparison of each rehabilitation project to the least cost options for new power plants. ***While this analysis is adequate for power system planning purposes to estimate the order of magnitude of non-competitive rehabilitation projects, it is not a replacement for site-specific analysis which is required before a decision is made whether a power plant should be rehabilitated or retired***.

GIS Update/Basecase Scenario with Official Rehabilitation Program

All scenarios were for the region operating as a fully interconnected system. The specific scenario of the Original GIS which was used as a reference in the GIS Update was Scenario B/Case 2A2, fully interconnected power system without any transmission constraints and partial environmental compliance[8].

The GIS Update evaluated a number of scenarios including higher fuel prices, higher CO2 prices, the hydro option and high electricity imports. First, the basecase scenario of the GIS was updated to reflect recent fuel price forecasts; key changes included:

- Oil prices of $52.70/bbl in 2005 declining to $38.40/bbl by 2020; this compares to prices in the $23.20-26.02/bbl range used in the Original GIS.
- Natural gas prices[9] in the €4.4-6.2/GJ (€146-206/1000m^3) range over the planning period (2005-2020); this compares to €2.9-3.2/GJ (€97-107/1000m^3) used in the Original GIS.

Prices of other fuels (e.g., imported coal and local lignites) were adjusted, too. More details on the assumptions of the GIS Update, including the basis for the fuel price forecasts and the assumptions associated with the power generation technologies which were evaluated, are provided in Annex 3.

Assuming that the rehabilitation program is implemented as planned by each jurisdiction, the results of the GIS Update are shown in the following table. The specific plants selected, as well as the existing plants rehabilitated, are shown in Annex 2, which also compares them to the Original GIS.

Again, local lignite plays the most important role in new generating capacity. The main changes in the generation expansion are the reduction of combined cycle plants burning natural gas (CCGT) from 3,000MWs to 1,300MWs and the corresponding increase of imported coal from zero to 1,500MWs. Imported coal is assumed to be mainly in Bulgaria and Romania. The reduction of CCGTs is explained partly by the increase in the natural gas

[8] Scenario C was not used because revision of the least-cost power plants implies revision of the regional transmission system. Partial environmental compliance was determined to be more suitable; this means full compliance with EU Directives by all new power plants and all plants in Bulgaria and Romania, but in the rest of the region (for which EU accession timing is very uncertain and unlikely to be before 2015) existing plants comply only with particulates and NOx emission requirements.

[9] Natural gas prices are mentioned more often than other fuels, because natural gas is a key fuel for new power plants and its price experienced much higher increase than coal or lignite.

prices, but also because no imported coal was considered in the original GIS. In general, the least-cost plan under the basecase assumptions suggests that ***the least cost power generation options for the region are: Kosovo lignite, imported coal and natural gas.***

Scenario	Rehabs (MW)	New Plants (MW)	Key Selections of New Plants
Original GIS Base (with Official rehabilitation)	11,574	11,000	Kosovo: 4,200MW (4x300, 6x500) CCGTs: 3,000MW (5x300, 3x500) OCGTs: None (constrained) Imported Coal: None (constrained) Nuclear: None (except Cernavoda 2/3 & Belene)
Updated GIS Base (with Official rehabilitation)	11,574	11,022	Kosovo: 4,300MW (6x300, 5x500) CCGTs: 1,300MW (1x300, 2x500) OCGTs: 100MW Imported Coal: 1500MW (3x500 MW) Nuclear: None (except Cernavoda 2/3 & Belene)

Also, it is worth mentioning that natural gas can be used in open cycle gas turbines too, which are more suitable and potentially cost-effective for cycling duty (utilization for a short period of time during peak demand). While the capacity being selected in the least cost plan (Updated GIS) is not substantial (only 100MWs), it is a clear indication that it is an option to be included, especially if other peaking options (e.g., pumped storage hydro) are not available or they are too expensive.

GIS Update/Basecase Scenario with "Justified" Rehabilitation Program

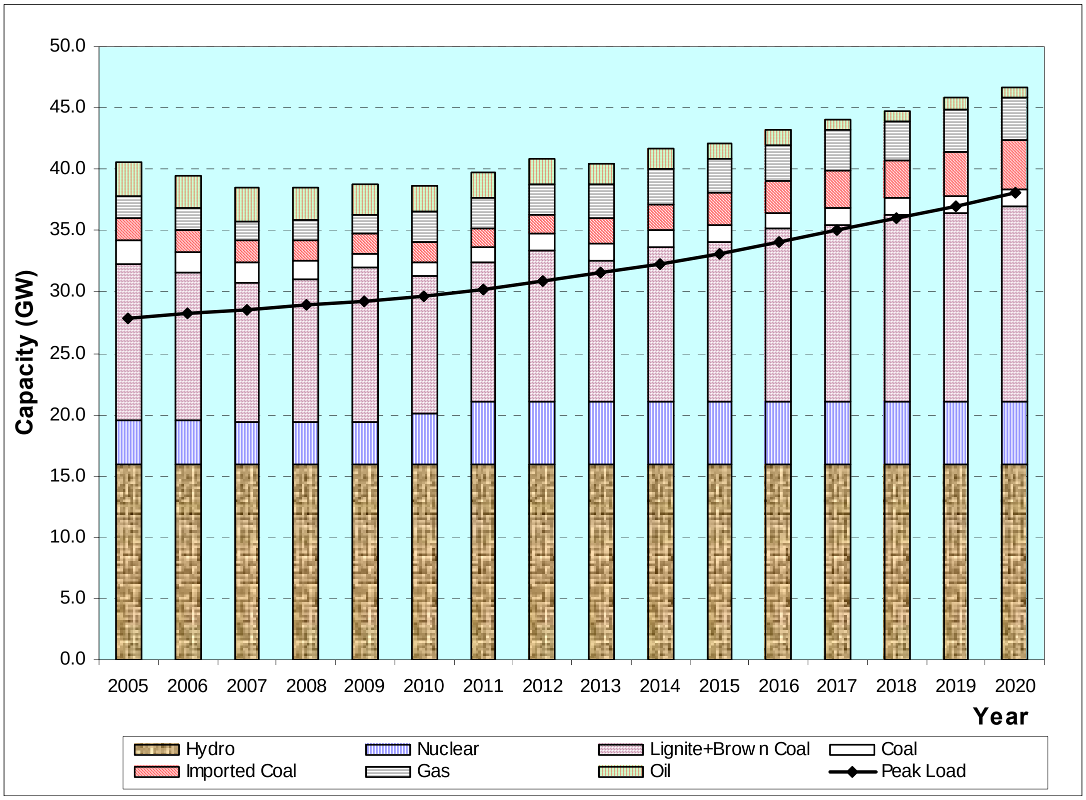
As it was the case with the Original GIS analysis, the basecase scenario was adjusted to include only the rehabilitation plants which are cost-effective against alternatives. This was done through a screening curve analysis, which compared all the alternatives for power generation (including new power plants); rehabilitation projects which resulted in cost of electricity above the least-cost plants were eliminated. This analysis concluded the 9,361 MWs out of the 11,574 MWs planned for rehabilitation are cost-effective under the assumptions of the GIS Update.

Reduced capacity of existing plants which are rehabilitated means that more new plants need to be built to replace them, in addition to meeting the rising electricity demand in future years. As the previous table shows, the total capacity of ***new plants*** in the planning period increased from 11,000 MWs to 12,696 MWs. This difference was made up by all three least-cost options: ***Kosovo increased from 4,300 MWs to 4,800 MW, CCGT increased from 1,300 MWs to 2,100 MWs and imported coal increased from 1,500 MWs to 2,500 MW.***

Scenario	Rehabs (MW)	New Plants (MW)	Key Selections of New Plants
Updated GIS Base (with Official rehabilitation)	11,574	11,022	Kosovo: 4,300MW (6x300, 5x500) CCGTs: 1,300MW (1x300, 2x500) OCGTs: 100MW Imported Coal: 1500MW (3x500 MW) Nuclear: None (except Cernavoda 2/3 & Belene)
Updated GIS Base w/ justified rehabilitation	9,361	12,696	Kosovo: 4,800MW(6x300+6x500) [max] CCGTs: 2,100MW (2X300+3X500) OCGTs: None Imported Coal: 2,500MW (5x500) Nuclear: None (except Cernavoda 2/3 & Belene)

The following figure shows how each power generation option contributes to satisfying peak electricity demand over the planning period.

Peak electricity demand and generating capacity (2005-2020)



The Net Present Value (NPV[10]) of the Updated GIS (with the official rehabilitation) is €35,725.3 million compared to €35,195.2 million for the Justified GIS Basecase scenario; in other words, elimination of the non-competitive rehabilitations saves approximately €530 million over the planning period.

High Fuel Price Scenario

In the high fuel price scenario, the natural gas prices were in the € 8.28-11.77/GJ (€276-392/1000m^3) range. This compares to €4.4-6.2/GJ (€146-206/1000m^3) for the GIS Update baseline. More information on fuel prices is provided in Annex 3.

A summary of the results are shown in the following table.

The high fuel price scenario had the following changes relative to the GIS Update baseline:

- More existing power plants are cost-effective to be rehabilitated (10,061 MWs vs. 9,361 MWs); this is because the competing alternatives (mainly CCGT burning natural gas) became more expensive;
- Kosovo lignite plants and imported coal increased to the maximum capacity (near 5,000 MWs and 3,000 MWs, respectively); these maximums were set to reflect what it may be feasible to be developed within the planning period; and

[10] The net present value (NPV) of the power generation system includes both investment and O&M costs and assumes 10% discount rate

- CCGT capacity declined from 2,100 MWs to 1,300 MWs.

Scenario	Rehabs (MW)	New Plants (MW)	Key Selections of New Plants
Updated GIS Base w/ justified rehabilitation	9,361	12,696	Kosovo: 4,800MW(6x300+6x500)[max] CCGTs: 2,100MW (2X300+3X500) OCGTs: None Imported Coal: 2,500MW (5x500) Nuclear: None (except Cernavoda 2/3 & Belene)
High Fuel Prices	10,061	12,494	Kosovo: 4,800MW (6x300+6x500)[max] CCGTs: 1,300MW (1X300+2X500) OCGTs: 1x100 MW Imported Coal: 3,000MW (6X500)[max] Nuclear: None (except Cernavoda 2/3 & Belene)

Low Fuel Price Scenario

The low fuel price scenario evaluated natural gas prices in the € 2.70-5.65/GJ (€90-188/1000m^3) range over the planning period. This compares to €4.4-6.2/GJ (€146-206/1000m^3) for the GIS Update baseline. More information on fuel prices is provided in Annex 3. A summary of the results is shown in the following table.

The opposite trends were experienced compared with the high fuel price scenario:

- Less existing power plants are cost-effective to be rehabilitated (6,814 MWs vs. 9,361 MWs); this is because CCGT burning natural gas became less expensive;
- As a result, the need for new capacity increased significantly from 12,696 MWs to 14,712 MWs;
- CCGT capacity increased from 2,100 MWs to 4,000 MWs;
- Kosovo lignite plants remained at near maximum (4,800 MWs); and
- Imported coal was similar to the basecase (2,500 MWs).

Scenario	Rehabs (MW)	New Plants (MW)	Key Selections of New Plants
Updated GIS Base w/ justified rehabilitation	9,361	12,696	Kosovo: 4,800MW(6x300+6x500)[max] CCGTs: 2,100MW (2X300+3X500) OCGTs: None Imported Coal: 2,500MW (5x500) Nuclear: None (except Cernavoda 2/3 & Belene)
Low Fuel Prices	6,814	14,712	Kosovo: 4,800MW(6x300+6x500)[max] CCGTs: 4,000MW (5X300+ 5X500) OCGTs: 2X100 MW Imported Coal: 2,500MW (5X500) Nuclear: None (except Cernavoda 2/3 & Belene)

Increased prices for CO2 allowances (emission credits)

Two CO2 price scenarios were evaluated: €20/ton and €30/ton of CO2[11]; this was to supplement the Original GIS which evaluated €5/ton and €10/ton. Hence, the two analyses

[11] In the scenarios evaluated, all the parameters stay the same as in the justified basecase except for the one parameter which is evaluated in each scenario. Hence, the parameters which

together (Original GIS and GIS Update) cover the range from zero to €30/ton of CO2. The results of the GIS Update scenarios are summarized in the following table.

Scenario	Rehab (MW)	New Plants (MW)	Key Selections of New Plants
Update GIS Base w/ Justified Rehabilitation	9,361	12,696	Kosovo: 4,800MW (6x300+6x500) [max] CCGTs: 2,100MW (2X300+3X500) OCGTs: None Imported Coal: 2,500MW (5x500) Nuclear: None (except Cernavoda 2/3 & Belene)
€20/ton CO2	4,573	16,634	Kosovo: 2,500MW (5x500) CCGTs: 7,900MW (14x500 + 3x300) [max] OCGTs: None Imported Coal: 3,000MW (6X500) Nuclear: None (except Cernavoda 2/3 & Belene)
€30/ton CO2	None	21,259	Kosovo: 2,500MW (5x500) CCGTs: 7,900MW (14x500 + 3x300) [max] OCGTs: None Imported Coal: 3,000MW (6X500)[max] Nuclear: 5x1000 MW (plus Cernavoda 2/3 & Belene)

The most important conclusions for high CO2 prices are:

- Utilization of natural gas increases to its maximum (near 8,000 MWs); if more gas is available at the basecase prices, it is possible that natural gas capacity may increase further replacing other power generation options.
- But imported coal and Kosovo lignite remain competitive even at €30/ton CO2. The Kosovo plants are reduced from 4,800 MWs to 2,500 MWs for both scenarios, but their contribution remains substantial.
- New nuclear power plants become competitive at the €30/ton CO2 level.
- Similarly to the high fuel price scenario, the cost-effective rehabilitations are reduced significantly throughout the region; for €20/ton CO2 only 4,573 MWs are competitive and for €30/ton CO2 none of the existing power plants are competitive to be rehabilitated and continue operating.

These changes in rehabilitation competitiveness have a significant impact on the new for new power plants which increase to 16,634 MWs for €20/ton CO2 and 21,259 MWs for €30/ton CO2 scenarios.

changed in each scenario are treated as independent variables. This may not be true for the fuel and CO2 prices, which are related. However, the relationship between them is not well established. For example, during 2005 fuel prices increased significantly; during the same period, CO2 in the ETS increased from less than €10/ton to €35/ton, but then it declined back to €10-15/ton, while fuel prices were maintained at high levels. So, fuel price is not the only factor affecting the price of CO2. The scenarios analyzed cover a wide range of potential outcomes which provide a good indication of how each factor affects the key outcomes (least-cost power development plan and power generation mix).

The following table summarizes the impact of CO_2 prices on the competitiveness of the rehabilitation of the existing power plants and the need for new plants for both the Original GIS and the Updated GIS analyses[12].

Project	Scenario	Rehabilitation Capacity MW	New Capacity Addition MW
Original GIS – IIEP	GIS Base Case with Justified Rehabilitation	9,916	11,884
	Scenario with €5/t CO2 Taxes	7,555	14,948
	Scenario with €10/t CO2 Taxes	6,046	16,449
Updated GIS	Base Case with Justified Rehabilitation	9,361	12,696
	Scenario with €20/t CO2 Taxes	4,573	16,634
	Scenario with €30/t CO2 Taxes	0	21,259

Even though some of the assumptions of these two analyses are different (mainly fuel prices), the trend is consistent.

The total CO_2 emissions decline from approximately 2.15 billion tons for the basecase scenarios to 1.6 billion for the €30/ton CO_2 scenario. The decline is linear with the CO_2 price.

Hydroelectric Power and Renewables

The Original GIS identified 2,112 MWs of hydroelectric projects (above 100 MWs) for which data was available and evaluated them; it concluded that they are not competitive under the assumptions of the basecase scenario. More specifically, these plants increased the power system NPV of costs[13] by €1.1 billion.

These plants were re-evaluated under the Updated GIS analysis especially under the high fuel price and high CO_2 price scenarios. The evaluation approach involved the following steps.

First the hydro projects for which information was available were screened to identify the most cost-effective; as a result, the following projects representing 5,877 MWs of installed capacity were identified.

Then, the top ranked hydro power plants with a priority index Benefit/Costs (B/C) greater than 1.0 were included in the analysis. These plants, totaling 2,112 MWs gross, have been "forced" into the regional expansion plan between year 2012 and 2015, according to the following schedule:

- 2012: Zhur 293 MW + Komarnica 168 MW;
- 2013: Buk Bijela 456 MW + Srbinje 55.5 MW + Kostanica 552 MW;
- 2014: Glavaticevo 172 MW + Dabar 160 MW;
- 2015: Andrijevo 200 MW + Zlatica 55.5 MW.

[12] The Original GIS analysis of CO2 scenarios was performed assuming Full Environmental Compliance while the Updated GIS assuming Partial Compliance; however, there is no much difference between the two withy regard to capacity requirements

[13] Net Present Value (NPV) of costs of the power system reflects all the costs, including investments, O&M costs and fuel-related costs

Ranking of the Hydro Power Plants for Medium Gas Price Forecast

Plant Name	Installed Capacity	Average Annual Energy	Total Investment	Construction Cost	Range
	(MW)	(GWh)	Euro x million	Euro/kW	B/C
Kostanica (Montenegro)	552	1,120	266.1	482	2.039
Zhur (UNMIK)	293	398	172.9	590	1.987
Komarnica (Montenegro)	168	232	95.6	569	1.641
Andrijevica[1)] (Montenegro)	255.5	717	227.9	892	1.275
Glavaticevo (BiH)	172	313	188.3	1,094	1.156
Dabar (BiH)	160	303	171.7	1,073	1.137
Buk Bijela[2)] (BiH&Mon)	511.5	1119	482.2	943	1.020
Glavaticevo (BiH)	194	257	200.7	1,035	0.958
Cebren (Macedonia)	157	164	159.5	1,016	0.878
Konjic (BiH)	122	292	134.9	1,106	0.850
Galiste (Macedonia)	170	434	196.1	1,153	0.783
Ljutica (Montenegro)	250	528	231.2	925	0.640

Notes:
1) - with HPP Zlatica
2) - with HPP Srbinje

3) - These projects are not necessarily the only hydro projects which may be viable in the region. Also, it was not been determined if these projects meet safeguard requirements. However, for consistency with the Original GIS and because comprehensive assessment of the hydro option was outside the scope of this project, the analysis was limited to these projects. At the end of this report, it is recommended that a more comprehensive assessment of hydro plants be carried out.

Finally, comparison of the NPV of the power system costs[14] with and without hydro was used to determine whether the hydro projects are competitive.

Are the hydro plants competitive? The analysis carried out under the GIS Update concluded that the hydro options are competitive under high fuel prices or high CO2 prices. This is shown in the following table which compares the NPV of costs for the three scenarios which were evaluated with and without the 2,112 MW hydro projects (high fuel prices; €20/ton and €30/ton). Comparison of the NPVs for each pair of scenarios suggests that the NPVs are about the same, certainly within the level of uncertainty of the analysis (for the CO2 scenarios less than 0.003% and 0.05% difference). Also, the NPVs undervalue the hydro projects because they are built in the second half of the planning period and their operating life is much longer than other plants[15].

It should be noted that the new plant capacity is not the same in each pair of scenarios (with and without hydro), because hydros serve as peaking plants (operating on the average 2,000 hrs/yr and producing 4,080 GWh/yr); hence, scenarios with high hydro capacity need more baseloaded capacity too to satisfy the demand forecast.

[14] Power System NPV includes capital costs for new power plants and O&M for all the plants, but does not include the investment required for rehabilitation of the existing thermal power plants
[15] No residual value was taken into account at the end of the planning period (2020)

NPV of Power System Costs for Alternative Scenarios Involving Hydro Plants

Scenario	Capacity, MW		NPV, Million €		
	Rehabilitation	New Plants	Rehabilitation	Power System	Total
High Fuel Price w/o HPP	10,061	12,494	3,592.0	34,675.0	38,267.0
High Fuel Price with HPP	10,061	13,926	3,592.0	34,853.8	38,445.8
€20/t CO_2 w/o HPP	4,573	16,634	872.7	52,147.6	53,020.3
€20/t CO_2 with HPP	4,573	18,172	827.7	52,174.3	53,047.0
€30/t CO_2 w/o HPP	0	21,259	0	61.537.8	61,537.8
€30/t CO_2 with HPP	0	22,817	0	61,555.7	61,555.7

What plants does hydro replace? The following table presents the key power plant selections in the least cost plan for the three scenarios which were evaluated.

Key Results of Hydroelectric Scenarios

Scenario	Rehab (MW)	New Plants (MW)	Key Selections of New Plants
High Fuel Price with HPP	10,061	13,926	Kosovo: 4,800MW(6x300+6x500) CCGTs: 800 MW (1x300+1x500) OCGTs: None Imported Coal: 3000 MW (6x500) Nuclear: None (except Cernavoda 2/3 & Belene) HPP: 2,112 MW
€20/ton CO2 with HPP	4,573	18,172	Kosovo: 2500 MW (5x500) CCGTs: 7900 MW (3x300+14x500) OCGTs: None Imported Coal: 2500 MW (5x500) Nuclear: None (except Cernavoda 2/3 & Belene) HPP: 2,112 MW
€30/ton CO2 with HPP	None	22,817	Kosovo: 2000 MW (5x500) CCGTs: 7900 OCGTs: None Imported Coal: 3000 Nuclear: 5x1000 (in addition to Cernavoda 2/3 & Belene) HPP: 2,112 MW

Comparison of these selections to the corresponding selections without hydro (see earlier tables for the high fuel price and CO2 scenarios) reveals that the 2,112 MW hydros replace:

- 500 MWs of CCGT capacity under the high fuel price scenario;
- 500 MWs of imported coal in the €20/ton of CO2 scenario; and
- 500 MWs of Kosovo lignite in the €30/ton of CO2 scenario.

This is consistent with the characteristics of these options, as each of them is the marginal power generation option in the corresponding scenario; all three are included in the basecase least-cost plan, but:

- High natural gas prices in the High Fuel Price Scenario make CCGT the most expensive of the three options;
- €20/ton of CO2 make imported coal the most expensive of the three; and
- €30/ton of CO2 make lignite most expensive because it has been assumed that the lignite plants are subcritical with lower plant efficiency than imported coal supercritical plants.

Does this assessment reflect the full potential of the region? The short answer is no, mainly because of lack of data. Certainly, the hydros evaluated do not reflect the total hydro potential of the region. More large and small hydros exist for which no information was available. Considering the site-specific nature of hydro, lack of data is more detrimental than for any other option which can be generalized and evaluated easier. A detailed assessment of hydro, including run-of-river and large hydro, is recommended.

Also, the potential for rehabilitation and life extension of the existing hydro plants should be assessed. The established practice in the region is to invest relatively small amounts for life extension activities on an on-going basis. However, it would be helpful to assess what is the realistic impact of a comprehensive rehabilitation/life extension program for the hydro plants.

Finally, such study should extend to all renewables. While there are claims of significant renewable resources in the region[16], the competitivess of the renewable projects is not clear and most of them are not economic without subsidies. However, their competitiveness under increased fossil fuel prices and high CO2 prices needs to be re-evaluated.

High Electricity Imports

The Original GIS evaluated electricity imports of 1,500 MWs base loaded capacity (24 hrs/day) in the period 2010-2020. Imports of electricity are feasible (surplus available especially in Ukraine) and potentially cost-effective depending on price.

The GIS Update assumed imports of 3,000 MWs in the period 2010-2014 and 5,000 MWs in 2015-2020. As it was the case with the Original GIS, this is simplified analysis which assumes that electricity is imported on a 24 hrs/day basis and adequacy of transmission capacity is not evaluated. The results of this scenario are shown in the table below.

Key Results of Electricity Import Scenario

	Rehabs (MW)	New Plants (MW)	Key Selections of New Plants
Updated GIS Base w/ justified rehab	9,361	12,696	Kosovo: 4,800MW(6x300+6x500) [max] CCGTs: 2,100MW (2X300+3X500) OCGTs: None Imported Coal: 2,500MW (5x500) Nuclear: None (except Cernavoda 2/3 & Belene)
High Electricity Imports	9,361	6,936	Kosovo: 2,100MW (2x300+3x500) CCGTs: 1,000MW (2X500) OCGTs: 1X100 MW Imported Coal: None Nuclear: None (except Cernavoda 2/3 & Belene)

As expected, electricity imports reduce the need for new power plants; Kosovo lignite is reduced from 4,800 MWs to 2,100 MWs; CCGTs are reduced from 2,100 MWs to 1,000 MWs; and the need for imported coal is eliminated. In conclusion, ***electricity imports replace mostly imported natural gas and imported coal, but reduce also the need for Kosovo lignite plants.***

Finally, it is noteworthy that the break-even price of imported electricity is €32.6/MWh. This is the price at which the NPV of power generation system costs for the electricity import

[16] For example, Bulgaria and Romania are estimated to have 3.4 and 3 GW of wind potential, respectively according to the World Bank, “Study of Electricity Trade Potential in the Black Sea Region Black Sea”, February, 2006

scenario and the basecase scenario (with justified rehabilitation) are equal. This break even price is an indicative number for baseloaded capacity (available on a 24 hr/day basis) and should not be used as a benchmark ceiling for imports to be competitive. Imports satisfying intermediate and peak demand could afford a higher price. Also, the above break-even price does not reflect transmission costs.

Summary of Key Findings[17]

The strategic implication of the analysis is that ***diversification of energy supplies is essential for the region and should include local lignite, imported energy (in the form of natural gas, coal and electricity), renewables, hydro and potentially nuclear power (under high CO2 price scenario).*** This conclusion is derived from the observation that all scenarios evaluated are feasible and plausible. Even scenarios (forecasts) which were considered extreme a few months ago (e.g., oil price in the $70-100/bbl range) have proven to be close to or at least a reasonable extrapolation of present market conditions. Hence, all options identified from the various scenarios of this study should be considered as viable options of the generation expansion plan.

More specific conclusions drawn from the study:

- ***Fuel and CO2 prices have a significant impact on the viability of existing coal and lignite power plants, which require rehabilitation and environmental controls.*** Compared to 11,574 MWs intended to be rehabilitated, 9,361 MWs are cost-effective under the basecase scenario, 4,573 MWs under €20/ton CO2 and none of them under €30/ton CO2 scenario; if these non-cost-effective plants retire, they need to be replaced by new power plants; hence increasing further the required investment for new capacity.
- ***From the solid fuel new plants, Kosovo continues to be the least-cost option.*** Most scenarios indicate desirable Kosovo capacity in the 4,200 - 4,800 MWs range***.*** This is close to the maximum capacity (5,000 MWs) assumed to be practical within the planning period. Even under high CO2 prices and significant electricity imports, there is a need for Kosovo plants (2,000-2,500 MW). Moderate CO2 prices (€5-10/ton CO2) resulted in an increase of Kosovo plants to the maximum (5,000 MWs); this was because as the value of carbon credit increases, existing power plants become less cost-effective and there is need for more efficient plants burning Kosovo lignite. A more comprehensive assessment is needed regarding the feasible capacity which could be developed in Kosovo considering all relevant constraints (e.g., ability to transmit the power to the region and beyond, capacity to finance future plants, environmental impacts, energy security considerations, etc.). Also, ***there are other lignite mines in the region which potentially could play a role in the future***. In this study, other mines did not play an important role mainly because the cost of production of Kosovo lignite is the lowest. However, lignite production costs in other countries could be reduced and become competitive.
- ***Natural gas is one of the key power generation options under all scenarios, but its optimum generating capacity is highly dependent on gas price and maximum available supply;*** capacities range from 800MW (for the cases of high gas price with hydro plants and the high electricity import scenarios, respectively) to 7,900 MW (for the case of high CO2 price). The amount of gas varies significantly from scenario to scenario (see following table). An uncertainty is the amount of

[17] The capacity and power generation mix in year 2020 for all the scenarios evaluated is shown in Annex 4

available gas in the region over time; this analysis assumes that a maximum of 8,000MWs could be supplied, in addition to the existing gas-fired plants. Natural gas should be considered not only for CCGT plants which are suitable for intermediate or baseloaded operation (utilization factor above 50%), but also for peaking plants (in an open cycle gas turbine configuration).

Total Fuel Consumption per Scenarios

Scenario	Lignite	Domestic Coal	Imported Coal	Fuel oil	Natural Gas
	Million tons	Million tons	Million tons	Million tons	BCM (Billion m^3)
Base with official Rehabilitation	2013	146	84	7	31
Base with justified Rehabilitation	1970	111	98	6	32
Low Fuel Price	1762	100	94	6	67
High Fuel Price	1961	108	114	8	24
€20/t CO_2 Tax	1461	87	93	5	115
€30/t CO_2 Tax	1220	83	86	6	125
High Electric. Import	1741	98	69	4	19
High Fuel Price with HPP	1948	105	109	8	23
€20/t CO_2 with HPP	1457	87	85	5	114
€30/t CO_2 with HPP	1215	82	83	6	121

- ***Imported coal could play an important role with capacities in the 1,500-3,000MW range.*** Less price variability relative to oil and natural gas, and available supplies from multiple sources make it an attractive energy source. Furthermore, advances in power plant design and environmental control technologies have contributed to significant increase in plant efficiencies (hence, lower CO2 emissions) and very low rates of local and regional pollutants (particulates, SO2 and NOx). Presently, Bulgaria and Romania are the key countries importing coal. If coal is to be imported in the region, the infrastructure (especially ports and railroads) needs strengthening. This was the main reason the maximum capacity for this fuel was set at 3,000 MWs during the planning period.
- ***Approximately 2,100MWs of hydro plants are cost-effective under high gas prices or high CO2 prices.*** However, subsequently, it is revealed that there are more hydro resources (including large storage, pumped storage and small, run-of-river hydros), which were not included in this analysis. ***More detailed assessment is needed urgently*** regarding hydro and renewables (including small hydro, rehabilitation of existing hydros plants, biomass and wind power).
- ***New nuclear power plants are cost-effective under high CO2 prices*** (€30/ton scenario). This analysis is based strictly on economic considerations and does not address issues such as potential sitting and permitting, financing without Power Purchase Agreements and/or Guarantees, and waste disposal management.
- Approximately 400 MWs of Combined Heat and Power (CHP) plants associated with district heating have been included in the least-cost expansion plan. This dual purpose option is difficult to evaluate with conventional power generation expansion models such as WASP and deserves more comprehensive analysis. The SEE region has significant potential to rehabilitate or replace the many district heating generation facilities with efficient and cost-effective CHPs, which could increase their contribution to power generation, too. ***A comprehensive assessment of the CHP potential in the region is recommended.***

- ***Large amounts of excess power generating capacity exists (especially in Ukraine) which could be imported in the SEE region.*** This study evaluated the scenario of importing 3 GWs in 2010-2014 and 5 GWs in 2015-2020 compared to 1.5GWs in 2010-2020 in the Original GIS. ***Imports reduce the need for all types of new power plants (especially imported gas and imported coal, but also Kosovo).*** However, ***a more detailed assessment is needed to assess***, in addition to price, the adequacy of the transmission system to accommodate the increased electricity flows and the implications on greenhouse gas balances among the importing and exporting countries. With regard to the latter, Ukraine and Russia have significant amounts of excess emission allowances ("hot air"), which could be used to counterbalance the increased emissions generated due to the potential electricity exports to the SEE region.
- ***The investment requirements*** associated with the scenarios evaluated are shown in the following table. The fluctuations of investments reflect the type of prevailing option in each scenario. For example, the €20/t CO_2 scenarios have relatively low investment because they utilize the most CCGTs which have low capital costs but high fuel costs. The opposite is true for the €30/t CO_2 scenario which utilizes nuclear plants, a high capital cost and low fuel cost option.

Investment Requirements for the Scenarios of Power System Development

Scenario	Capacity, MW		Investment Costs, Million €		
	Rehabilitations	New Plants	Rehabilitations	New Plants	Total
Base with official rehab	11,574	11,000	5,860	11,003	16,863
Base with justified rehab	9,361	12,696	4,906	11,842	16,748
Low Fuel Price	6,814	14,712	3,326	12,906	16,232
High Fuel Price	10,061	12,494	5,182	11,911	17,093
€20/t CO_2	4,573	16,634	1,999	12,798	14,797
€30/t CO_2	0	21,259	0	20,618	20,618
High Electricity Imports	9,361	6,936	4,906	6,300	11,206[18]
High Fuel Price with HPP	10,061	13,926	5,182	13,061	18,243
€20/t CO_2 with HPP	4,573	18,172	1,999	13,765	15,764
€30/t CO_2 with HPP	0	22,817	0	21,540	21,540

Recommendations regarding future assessments

As mentioned earlier in this report, it is clear that certain gaps exists requiring immediate attention:

- Assessment of hydro potential of the region and identification of the most cost-effective projects to pursue; this should include large and small (run-of-river) hydros, but also rehabilitation of existing facilities.
- Assessment of renewable potential in the region.
- Assessment of CHP potential.

All these could be done as an update to the GIS (following the same methodology) preferably with an updated energy demand forecast. The latter requires special attention because the countries of the region are economies in transition, each at different stage of economic

[18] Note: Electricity import reduces significantly the need for investments but increases the expenditures to buy electricity.

development making it difficult to forecast energy demand. Forecasts should be based on consistent methodologies which combine bottom-up and top-down analyses reflecting lessons learned from similar economies in transition. Inter-fuel substitution, especially with the introduction of natural gas in the region, is another important consideration.

In general, updating the regional energy plan (maybe every 2-3 years) is essential, not as a central planning instrument, but as an indicative plan against which key projects could be evaluated and public sector initiatives could be planned. The next update, in addition to the obvious deliverables (updated energy plan for the region), should have as an objective to engage a key local institution, which should develop the capability to carry out or supervise such analyses on a permanent basis. The role of this institute should be to:

- Maintain up-to-date data on energy demand, planned projects and status of key energy projects in the region.
- Have the capacity to carry out or supervise updates of regional energy analyses similar to the GIS. The analytical capacity exists in the region (many private and public organizations can run the relevant models), but an organization is needed to guide the analyses and ensure quality and consistency of these analyses.

The World Bank has contributed significantly, both financially and intellectually, to the GIS analyses, and should take a leading role until a regional institution is able to assume this responsibility.

Annex 1 Terms of Reference

Updating Generation Investment Study for South Eastern Europe

A Generation Investment Study (GIS) in South Eastern Europe was carried out under the auspices of the European Commission and the World Bank[19]. Also, a related study (*Environment Study*), which was funded by the World Bank, assessed the environmental impacts from Power Development in South Eastern Europe including compliance with European Community Directives related to local and regional pollution, and climate change-related considerations. These studies, which were completed in June 2005, included the following jurisdictions: Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Macedonia, Montenegro, Romania, Serbia and UNMIK (UN Interim Administration Mission in Kosovo, pursuant to UN Resolution 1244). Considering the substantial changes in international fuel prices, as well as prices of CO2 allowances in recent months, it is necessary to update these studies.

2. Objective

The objective of this contract is to update the GIS analysis to reflect recent fuel price forecasts and CO2 allowances.

3. Scope of Work

Task 1. Update Baseline Scenarios

The Consultant will update the following two regional baseline Scenarios for medium electricity demand forecast and for the partial application of EU environmental protection standards:

- Scenario B/Case 1A which reflects the rehabilitation program the way it is planned by the governments and power companies (WASP runs only)
- Scenario B/Case 2B or Case 2A2[20] (screening curves plus WASP runs)

The main changes which would be made to these scenarios from the previous GIS study are:

- Prices of oil, natural gas and imported coal
- Capital and O&M costs of new lignite-fired power plants in Kosovo

All data for the updating will be specified by the Consultant who will supervise the project on behalf of the World Bank.

The implementation schedules of the planned projects and all other information will be kept the same, for consistency purposes, even though some changes may have actually occurred in the actual project schedules, costs, design etc.

Use of WASP - IV model is envisioned, as well as screening curves approach and spreadsheet analysis to eliminate the non-cost-effective rehabilitation projects for Scenario B/Case 2B or 2A2, as well as CO2 allowance sensitivity analyses.

Task 2. Sensitivity Analyses

The Consultant will develop the following scenarios which will be sensitivities to Scenario B/Case 2B or 2A2 selected in Task 1:

[19] "Regional Balkans Infrastructure Study-Electricity (REBIS) and Generation Investment Study (GIS)", prepared for European Commission, Contract No CARDS 52276

[20] Which of the two cases will be modeled is to be decided upon consultation with the World Bank Task Manager

- High fuel[21] price scenario (screening curves plus WASP runs)
- Low fuel price scenario (screening curves plus WASP runs)
- Price A[22] for CO_2 allowances (screening curves plus WASP runs)
- Price B[23] for CO_2 allowances (screening curves plus WASP runs)
- Higher electricity import scenario. The amount of electricity to be decided jointly with the World Bank Task Manager (screening curves plus WASP runs).

On the electricity import scenario: the WASP expansion planning analysis will be based on ˝one node˝ approach, i.e. without any transmission network system constraints, which is the same as the previous GIS project analysis. In the latter, it was assumed that there is an import of 1500MW (as base load, i.e. 24h/day) into the SEE power system in the 2010 – 2020 planning period. Similar approach, but a different level of imports will be assumed under the Higher Electricity Imports Scenario of this study.

The discounted cost of imported electricity will be calculated in separate spread sheet and added to all other system costs.

Reports

The key inputs and results of the analyses will be provided to the World Bank as an informal report.

Schedule

- Task 1: completed within 2 weeks from project commencement
- Task 2:
  - Fuel scenarios: 5 weeks from project commencement
  - CO_2 scenarios: 6 weeks from project commencement
  - Electricity import scenario: 8 weeks from project commencement

[21] Fuel Prices and forecasts to be decided after consultation with the World Bank Task Manager
[22] Prices A and B to be decided after consultation with the World Bank Task Manager
[23] Prices A and B to be decided after consultation with the World Bank Task Manager

Annex 2 Base Case Capacity Expansion Plan GIS and Updated GIS Comparison

Year	Peak Demand (MW)	Official Rehabilitation Plan	New Power Plant Additions	
			Original GIS	Updated GIS
2005	27,882			
2006	28,202	Maritza E3 U2 (189 MW) Maritza E3 U3 (189 MW) Maritza E2 (148 MW) Ruse 3 (100 MW) Novi Sad1 (100 MW) Zrenjanin (100 MW)	Bucuresti Sud (100MW), Ro	Bucuresti Sud (100MW), Ro
2007	28,553	Fierza (58MW) Balsh (11MW) Tuzla 5 (182 MW) Maritza E3 U1 (189 MW) Maritza E2 U2(148 MW) Turceni 5 (272 MW) Deva 1 (167 MW) N Tesla A4 (280 MW) Kostolac A1 (90 MW) Novi Sad2 (108MW)	Bucuresti Sud (100MW), Ro	Bucuresti Sud (100MW), Ro Cernavoda 2 (664 MW), Ro
2008	28,927	Tuzla 6 (198 MW) Kakanj 6 (100 MW) Maritsa E3 U4(189 MW) Maritza E2 U3(148 MW) Rovinari 3 (278 MW) Galati 3 (92MW) Deva 2 (167 MW) N Tesla A6 (280 MW)	Bucuresti West (100MW), Ro	Bucuresti West (100MW), Ro

2009	29,234	Gacko (276 MW) Maritsa E2 U4(148 MW) Maritsa E2 U6(185 MW) Ruse 4 (100 MW) Turceni 6 (272 MW) Isalnita 7 (266 MW) Paroseni 4 (120 MW)	Vlora (132 MW), Al Maritsa East 1 (275 MW)x2, Bg	Vlora (132 MW), Al
2010	29,649	Bobov Dol 1 (198 MW) Varna 1 (200 MW) Ruse 1 (25 MW) Turceni 3 (272 MW) Galati 4 (50 MW) N Tesla A1 (191 MW) Deva 4 (167 MW)	Bucuresti West (100MW), Ro Cernavoda 2 (664 MW), Ro Lignite Subcritical (450 MW), UNMIK Kolubara B (320 MW, Srb	Bucuresti West (100MW), Ro Maritsa East 1 (275 MW)x2, Bg Combined cycle (288 MW) Combined cycle (480 MW)
2011	30,242	Ugljevik (279 MW) Bobov Dol 2 (198 MW) Varna 2 (200 MW) Ruse 2 (25 MW) Pljevlja (191 MW) Negotino (197 MW) Rovinari 5 (278 MW) N Tesla A2 (191 MW)	Kolubara B (320 MW), Srb	Kolubara B (320 MW), Srb
2012	30,864	Bobov Dol 3 (198 MW) Varna 3 (200 MW) Ruse 5 (25 MW) N Tesla B1 (580 MW)	Combined cycle (288 MW)	Kolubara B (320 MW), Srb Kosovo B3 (275 MW), UNMIK
2013	31,535	Varna 4 (200 MW) Ruse 6 (25 MW) Oslomej (109 MW) Galati 5 (92 MW)	Cernavoda 3 (664 MW), Ro CCHP (86 MW) Kosovo B3 (274 MW), UNMIK Lignite Subcritical (450 MW), UNMIK	Belene (930MW), Bg Cernavoda 3 (664 MW), Ro
2014	32,282	Varna 5 (200 MW)	CCHP (86 MW)	Kosovo B4 (275 MW), UNMIK

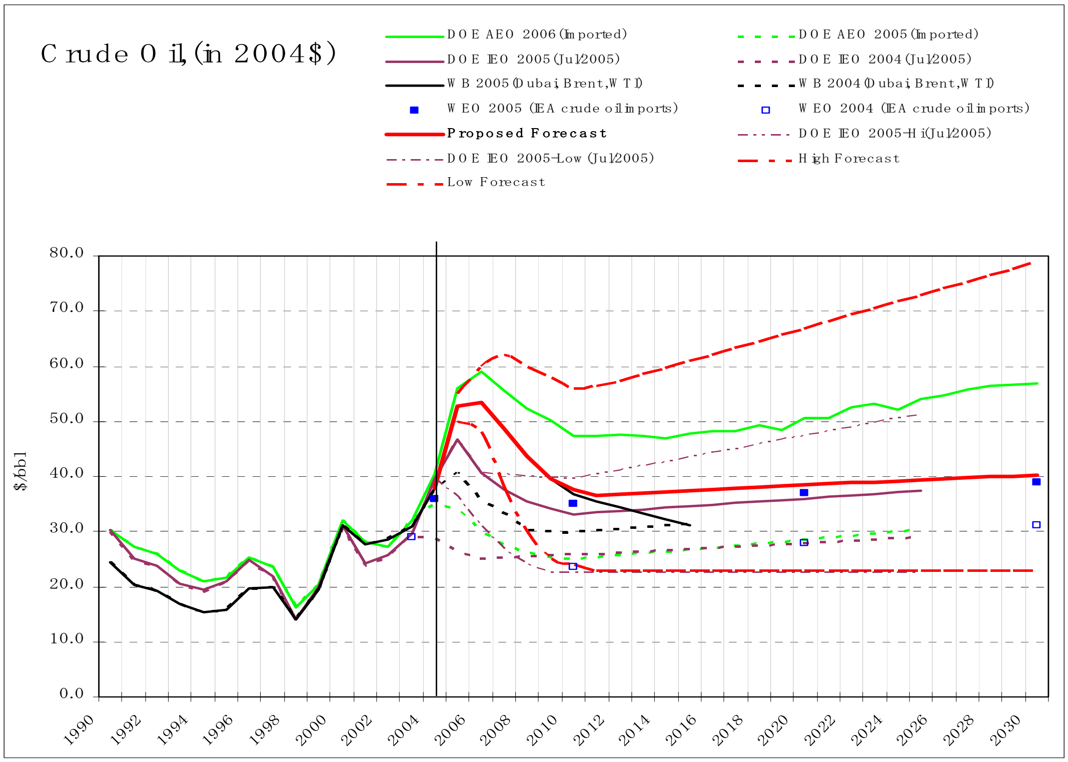
		Galati 6 (92 MW) N Tesla B2 (580 MW)		
2015	33,151	Varna 6 (200 MW) Bitola 1 (207 MW)	Combined cycle (288 MW) Combined cycle (480 MW) Lignite Subcritical (450 MW), UNMIK	Kosovo B5 (275 MW), UNMIK Lignite Subcritical (450 MW), UNMIK
2016	34,072	Kostolac B1 (320 MW)	CCHP (86 MW) Combined cycle (480 MW)	Kosovo B6 (275 MW), UNMIK Lignite Subcritical (450 MW), UNMIK
2017	35,026	Bitola 2 (207 MW)	Belene (930MW), Bg Combined cycle (480 MW)	Combined cycle (480 MW) Kosovo B7 (275 MW), UNMIK Lignite Subcritical (450 MW), UNMIK
2018	36,002	Kostolac B2 (320 MW)	Combined cycle (288 MW) Kosovo B4 (274 MW), UNMIK Lignite Subcritical (450 MW)	Lignite Subcritical (450 MW), UNMIK Imported Coal (470MW)
2019	37,024		CCHP (86 MW) Combined cycle (288 MW) Kosovo B5 (274 MW), UNMIK Lignite Subcritical (450 MW), UNMIK	Open Cycle (96MW) Lignite Subcritical (450 MW), UNMIK Imported Coal (470MW)
2020	38,049	Bitola 3 (207 MW)	Combined cycle (288 MW) Kosovo B6 (274 MW), UNMIK Lignite Subcritical (450 MW), UNMIK	Kosovo B8 (275 MW), UNMIK Lignite Subcritical (450 MW), UNMIK Imported Coal (470MW)
Total		**11,574 MW**	**11,000 MW**	**11,022 MW**

Annex 3 Key Assumptions of the Updated GIS

Oil prices

The project team reviewed numerous fuel price forecasts from organizations, such as the World Bank Commodities Department, the International Energy Agency (IEA), the Energy Information Administration (EIA) of the US Department of Energy and the NYMEX forward prices. The forecast used in this study[24] (see thick line in the graph below) is based mainly on World Bank Commodity Forecasts up to 2015; after 2015, the trend is based on the IEA World Energy Outlook 2005.

Crude Oil Prices Forecasts



The following table compares the baseline oil[25] forecasts used in the Original GIS and the GIS Update.

	2005	2010	2015	2020
Original GIS ($2002/bbl)	23.30	24.17	25.07	26.02
Proposed Update ($2004/bbl)	52.70	37.60	37.40	38.40

In addition to the baseline, a low price and a high price scenario were developed, as shown in the following table.

In addition to the baseline, a low price and a high price scenario were developed, as shown in the following table.

[24] This forecast has also been used in another World Bank Study (“Technical and Economic Assessment: Off Grid, Mini-Grid and Grid Electrification Technologies”).
[25] “Oil price” refers to an average of Dubai, Brent and West Texas Intermediate (WTI) oil

Crude Oil Prices **FOB, $\$_{2004}$/bbl ($/GJ)**

Crude Oil	Scenario	2005	2010	2015	2020
Dubai, Brent, WTI	Base	52.7 (9.2)	37.6 (6.6)	37.4 (6.5)	38.4 (6.7)
	High	70.0	100	100	100
	Low	48.0	24.0	23.0	23.0

Gas Prices

As in the original GIS analysis, the natural gas prices are:

- 100% indexed to oil prices; this is derived from the contracts signed already by Gazprom of Russia and most of the SEE countries including Bulgaria, Greece, Romania and Turkey; most contracts are based on a basket of three grades of oil (crude + two distillates) cif Italy and gas prices are adjusted quarterly to follow the prices of these oil products;
- Base price (for the SEE region) refers to the Romania-Ukraine border; and
- Prices for each country reflect the approximate investment in pipelines required to bring the gas from the Romania-Ukraine border.

Following this approach, natural gas prices for each country were adjusted for the GIS Update as shown in the following table, which also included the Original GIS prices for comparison purposes.

As this table shows, the natural gas prices for the basecase scenario (relative to the GIS) experienced significant increase (roughly 100%) in 2005 and about 50% for remaining years (up to 2020). The increase for the high fuel price scenario was even higher.

Natural Gas Prices in the Balkans for Original and Updated GIS (€/GJ)

	Scenario	2005	2010	2015	2020
Original GIS	Low Fuel Prices	2.11	2.11	2.11	2.11
	Base	2.90	3.00	3.12	3.23
	High Fuel Prices	3.87	4.14	4.26	4.31
Updated GIS	**Low Fuel Prices**	**5.65**	**2.82**	**2.71**	**2.70**
	Base	**6.20**	**4.41**	**4.40**	**4.51**
	High Fuel Prices	**8.28**	**11.73**	**11.77**	**11.74**

Imported Coal Prices

Imported coal prices are taken from the International Energy Agency's World Energy Outlooks 2004 and 2005 and are shown in the following table:

	2005	2010	2020
IEA WEO 2004 ($/ton)	**41**	**43**	**45**
IEA WEO 2005 ($/ton)	**55**	**49**	**50**
Change (%)	**34**	**14**	**11**

These prices reflect a significant short-term increase, but long-term forecasts are following historical trends.

The imported coal prices used in the original GIS analysis are adjusted by the above percentage changes (34% for 2005; 14% for 2010; and 11% for 2020).

Lignite Prices

Local lignite production costs (and hence prices) do not change significantly. Also, lignite is not traded internationally and is not affected significantly by short-term fluctuations in the global energy markets. Finally, lignite is supplied to the power plants based on long-term contracts or agreements. So, no major changes could be identified with lignite prices since the Original GIS was completed, except for the two most competitive mines in the region, Kosovo and Maritsa East in Bulgaria; prices for these mines were adjusted as follows:

- Kosovo lignite was adjusted to Eu7.50/ton (Eu0.92/GJ) based on World Bank study; this compares to Eu0.62/GJ which was used in the GIS.
- Maritsa East 1 lignite was adjusted to Eu1.09/GJ; GIS used Eu0.88/GJ.

All the other lignite prices are the same with GIS. In general, Kosovo lignite continues to be the lowest cost fuel in the region, followed by Maritsa East.

Other changes relative to the Original GIS

Other important changes in the GIS Update were the relaxation of certain constraints; most importantly:

- New imported coal power plants were allowed up to 3000MW; this option was not allowed in the GIS.
- The nuclear plants of Cernavoda 3 in Romania and Belene 1 in Bulgaria were evaluated based on the data provided by the power companies; final decision whether these plants are competitive was left to the WASP model. Additional nuclear power plants were allowed to be built (if competitive) up to 3,000 MW in the region; an exception was made for the high price CO2 scenarios for which the limit of new nuclear plants was raised to 5,000MW. No new nuclear plants had been allowed in the Original GIS.
- The Kosovo lignite plants were limited to a maximum of 5,500 MW.
- Maximum capacity for natural gas plants was set at 8,000 MWs[26], compared to 5,000 MW in the GIS. This limitation is mainly due to the availability of gas. While there are announcements about a number of gas pipelines (the most noteworthy being the Nabucco pipeline bringing gas from the Caspian Sea to the Balkans and Central Europe through Turkey), it is not clear whether these projects will materialize and when.

Open cycle gas turbines were allowed to compete, considering that most of the available power plants in the region are suitable for baseloaded capacity and the open cycle gas turbine may be competitive for cycling operation (use during peak demand). The GIS did not evaluate this option.

The assumptions with regard to the power generation option were the same with the Original GIS (see following table).

[26] This corresponds to about 10 bcm/yr assuming 50-55% plant efficiency and 6500 hrs/yr of operation.

Generic Plant Characteristics

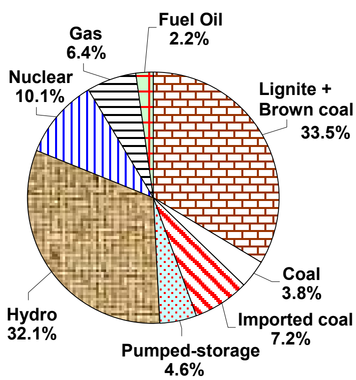
lant Type	Fuel Type	Gross Output	Aux Power	Net Output	Min Output	Heat Rate**) at		Constructio n	FOR	MOR	Plant Efficiency**)	Investments		O&M Costs	
						Min	Max					Total	Unit	Fixed	Variable
		MW	%	MW	MW	Kcal/kWh		Years	%	%	%	€ Million	€/kW	€M/yr	€/MWh
Coal Super-Critical	Imported Coal	500	8	470	250	2462	2230	4	6	13	38.5	454	908	9.4	1.1
		600	8	564	300	2450	2190	4	6	13	38.5	544	907	11.2	1.1
Lignite Sub-Critical	Local Lignite	300	10	275	150	2819	2530	4	5	11	33.5	304	1013	10.2	1.3
		500	8.5	450	250	2707	2430	4	6	13	35.0	499	998	12.6	1.3
Lignite Super-Critical*)	Local Lignite	300	10	270	150	2600	2350	4	5	11	37.5	354	1180	10.8	1.7
		500	9	450	250	2462	2210	4	6	13	39	536	1072	14.8	1.7
		600	8.5	550	275	2304	2140	4	6	13	39.5	612	1020	16.7	1.7
Lignite CFBC Sub-critical	Local Lignite	150	10	135	75	2562	2300	4	9	4	36	179	1195	5.5	1.3
		300	10	270	150	2543	2283	4	10	5	36	324	1080	10.3	1.0
CCGT Single Shaft	Natural Gas	150	4	144	88	1917	1617	2	5	5.8	51	96	642	3.6	2.2
		300	4	288	150	1680	1560	2.5	5	5.8	53	174	579	4.0	1.3
		500	4	480	250	1888	1753	3	5	4	52	241	483	5.7	1.3
OCGT Single Shaft	Natural Gas	50	4	48	29	2715	2219	1.5	5	4	33	17	341	0.5	7.2
		100	4	96	57	2747	2248	1.5	5	5	34	30	297	0.7	4.4
Nucl.	Nuclear	600	10	540	300	N/A	2700	8	8	16.4	32.0	1024	1707	37.6	4.9
		1000	8	925	700	N/A	2672	6	10	16.4	32.2	1564	1564	56.1	4.9

*) From 2010;
**) All heat rate and plant efficiency are based on the net plant output;
FOR Forced Outage Rate;
MOR Maintenance Outage Rate.

Annex 4 Capacity and Generation Mix in 2020

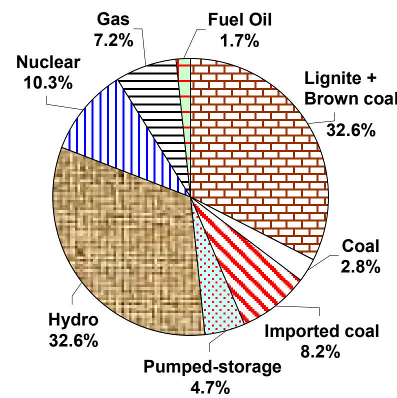
Figure B.1 Capacity Mix in 2020

Scenario with Official Rehabilitation



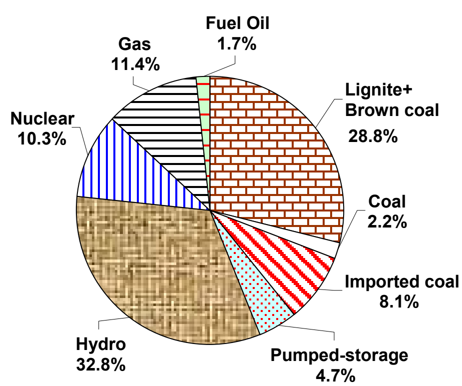
Total net capacity 49,682 MW

Scenario with Justified Rehabilitation



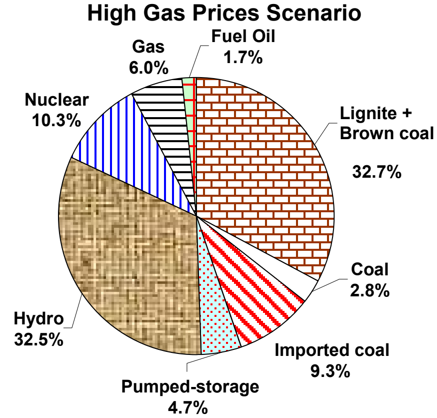
Total net capacity 48,995 MW

Low Gas Prices Scenario



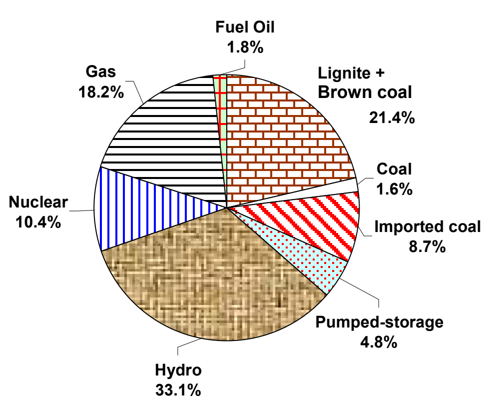
Total net capacity 48,690 MW

High Gas Prices Scenario

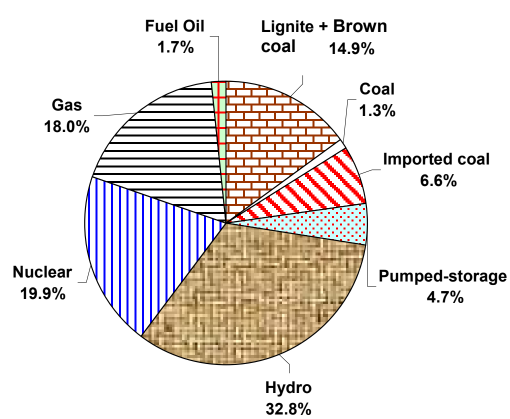


Total net capacity 49,051 MW

€20/t CO_2 Scenario



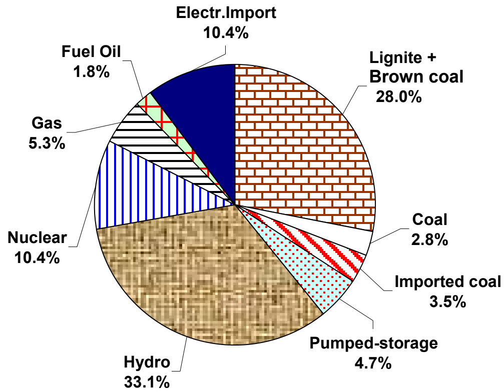
€30/t CO_2 Scenario



Total net capacity 48,162 MW

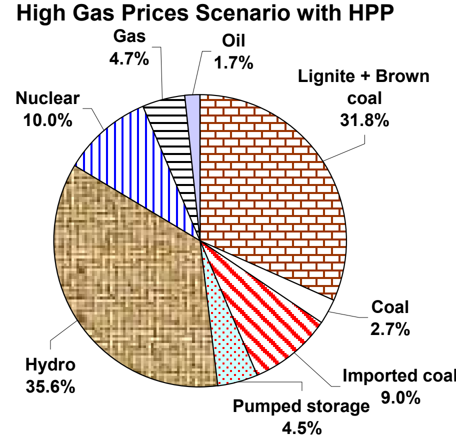
Total net capacity 48,626 MW

High Electricity Import Scenario



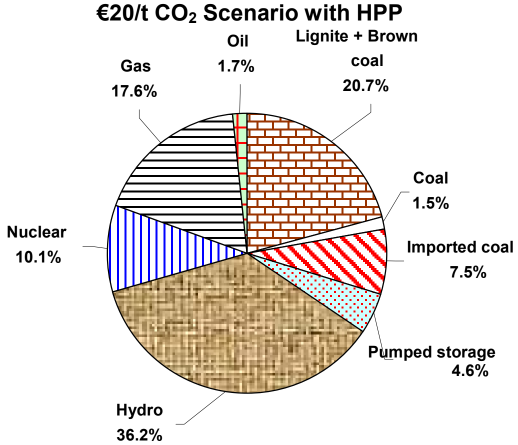
Total net capacity 48,235 MW

High Gas Prices Scenario with HPP



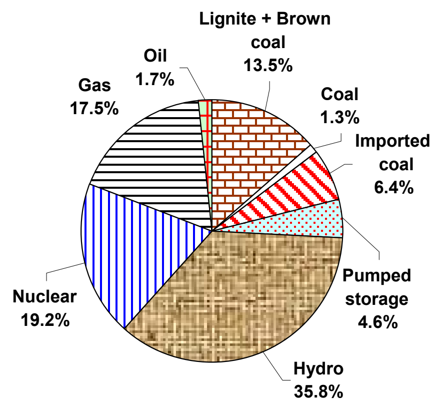
Total net capacity 50,482 MW

€20/t CO_2 Scenario with HPP



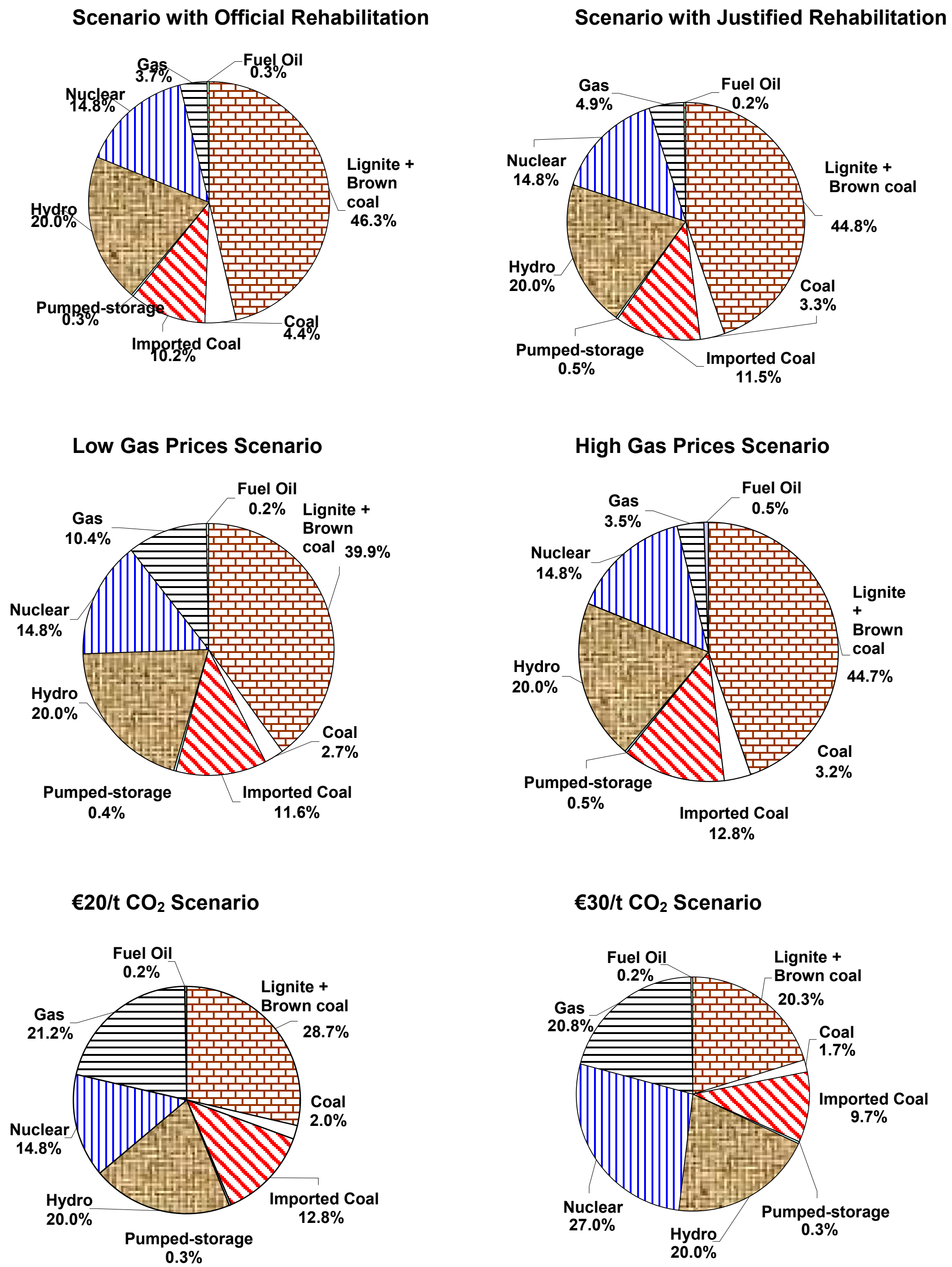
Total net capacity 49,699 MW

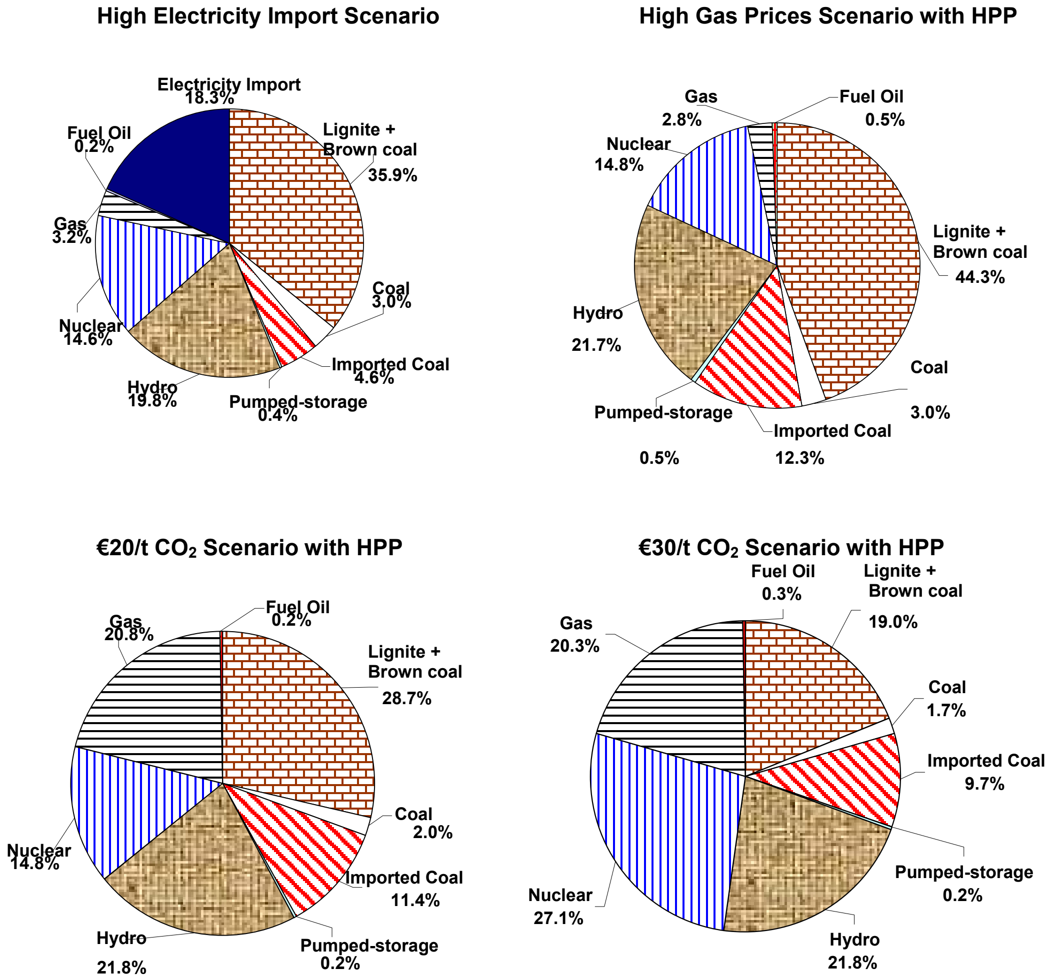
€30/t CO_2 Scenario with HPP



Total net capacity 50,179 MW

Figure B.2 Generation Mix in 2020





Total power output 237 TWh