A WORLD BANK COUNTRY STUDY

BULGARIA

ENERGY - ENVIRONMENT REVIEW

EXECUTIVE SUMMARY

NOVEMBER, 2001

ABSTRACT

The main purpose of the Energy and Environment Review (EER) was to develop and test a methodology to better integrate energy sector development and investment plans with the country's environmental objectives. It was undertaken at the request of Bulgaria's State Agency for Energy and Energy Resources (SAEER).

The EER highlights the intrinsic trade-offs between Bulgaria's objective to ensure least cost energy supply to the country and its concurrent objectives of being a dominant energy supplier in the region, minimizing its dependence on imported energy, and meeting its national and international environmental commitments. Achievement of these objectives is complicated by Bulgaria's heavy reliance on electricity to meet its own energy needs, the virtual absence of natural gas in the consumption mix of non-industrial consumers, and the fact that except for environmentally-polluting lignite, the country does not have economical energy resources. Since the bulk of Bulgaria's electricity (about 80%) is generated from nuclear fuel and indigenous lignite, disproportionate reliance on electricity will be costly, particularly as the country strives to meet the nuclear safety and environmental compliance requirements for accession to the European Union. On the other hand, growing electricity exports over he last few years have been good for Bulgaria, both from a financial point of view and in projecting Bulgaria as a stable and reliable source of electricity.

Under these circumstances, crafting an energy supply strategy which is cost-effective, provides adequate energy security, and reinforces the national goals of economic growth and poverty alleviation will indeed be challenging. Formulation of such a strategy could benefit from a wider debate among key stakeholders such as energy suppliers, industrial and other consumers, policy-makers, regulators and investors. The Energy and Environment Review provides a useful analytical framework for such a debate.

ACKNOWLEDGEMENTS

The report was prepared by a World Bank team consisting of Messrs. Salman Zaheer, Stratos Tavoulareas, Robin Bates and Nikolay Danev based on analytical input prepared by Energoproekt plc (Bulgaria), Mr. Ljulin Radulov and the Black Sea Regional Energy Center (Sofia), and Mr. Lyubomir Kaloferov.

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CURRENCY EQUIVALENTS

(as of June 1, 2001)

Currency Unit, Bulgarian Lev (BGN)
US$1 = 2.274 Leva

New Bulgarian Lev replaced the Old Leva (BGL) on July 5, 1999 @ 1 BGN = 1,000 BGL

WEIGHTS AND MEASURES

bcm	billion cubic meter
Btu	British thermal unit
boe	barrel oil equivalent
Gcal	Gigacalorie (10^9 cal)
GJ	Gigajoule (10^9 J)
GWh	Gigawatt hour (10^9 Wh)
kg	kilogram
km^2	square kilometer
kgoe	kilograms of oil equivalent
kWh	kilowatt hour
m^3	cubic meter
mt	million tons (metric)
MW	Megawatt (10^6 W)
PJ	Petajoule (10^{15} J)
T	ton (metric)
tce	tons of coal equivalent
tcm	thousand cubic meters
toe	ton of oil equivalent
Mtoe	million tons of oil equivalent
TWh	Terawatt hour (10^{12} Wh)

CONVERSION FACTORS

1 Gcal = 4.19 GJ = 3.97 million Btu = 1,163 kWh; 1 tce = 7 Gcal; 1 toe = 10 Gcal;
1 tcm natural gas = 8.1 Gcal; 1 ton crude oil = 7.3 barrels of oil, 1 boe = 1.59286 MWh

ABBREVIATIONS AND ACRONYMS

ACAA	Ambient Clean Air Act
BG	Bulgargaz
CCGT	Combined Cycle Gas-Turbine
CEEC	Central and Eastern European Countries
CHP	Combined Heat and Power
CH_4	Methane
CO_2	Carbon dioxide
COM	Council of Ministers
DH	District Heating
DSM	Demand Side Management
EC	European Commission
EER	Energy and Environment Review
EEEA	Energy and Energy Efficiency Act
ENPEP	Energy & Power Evaluation Program
EU	European Union
FGD	Flue-gas Desulfurization
GEF	Global Environmental Facility
GDP	Gross Domestic Product
GoB	Government of Bulgaria
GHG	Greenhouse gas
HPP	Hydroelectric power plant
IAEA	International Atomic Energy Agency
IMF	International Monetary Fund
IPPC	Integrated Pollution Prevention & Control
MOEW	Ministry of Environment and Waters
N_2O	Nitrous oxide
NEK	National Electricity Company
NG	Natural Gas
NOx	Nitrogen oxides
NPP	Nuclear Power Plant
NSI	National Statistical Institute
O&M	Operation and maintenance
OCGT	Open cycle gas turbine
OECD	Organization for Economic Cooperation & Development
PLF	Plant load factor
PPA	Power Purchase Agreements
PV	Present Value
REI	Regional Environmental Inspectorates
SAEER	State Agency for Energy & Energy Resources
SEEA	State Energy Efficiency Agency
SERC	State Energy Regulatory Commission
SO2	Sulfur dioxide
TPES	Total Primary Energy Supply
TPP	Thermal Power Plant
UNFCCC	United Nations Framework Convention on the Changes of the Climate
WASP	Wien Automatic System Planning model
WHO	World Health Organization

EXECUTIVE SUMMARY

A. OBJECTIVES AND OUTPUTS

1. **Objectives:** The main purpose of the Energy and Environment Review (EER) was to develop and test a methodology to better integrate energy sector development and investment plans with the country's environmental objectives. It was undertaken at the request of Bulgaria's State Agency for Energy and Energy Resources (SAEER) according to agreed Terms of Reference.

2. **Outputs**: Related outputs of the EER are:

(a) An update of the end-use energy demand forecasts which were used to prepare the 1998 "National Strategy for Development of the Energy Sector till 2010", and adoption of a "most-likely" demand scenario for the ***base case*** assessment of energy supply options;

(b) An evaluation of the economic and environmental impact of alternative energy supply strategies (see below) to meet projected demand until 2015 (including an estimate of associated capital and operating costs for power supply)[1]:

A. **The Base Case Scenario** assumed that nuclear Units 1 & 2 at Kozloduy will be retired in end-2002, Unit 3 in end-2007, and Unit 4 in end-2008. Other key assumptions included: annual electricity exports of 4,200 GWh from 2002, SAEER/National Electricity Company (NEK) forecasts for lignite and coal prices, and World Bank cost estimates for thermal power generation technologies and forecasts for natural gas prices ($130 per thousand cubic meters in 2000 dropping to $75/tcm by 2015, at constant 1999 prices, net of taxes); and

B. **An "Inter-fuel Substitution Scenario"** analyzed the consequences of varying the contribution of nuclear and natural gas-based power over the planning period through analysis of the following sub-scenarios:

B.1 **Early Retirement of Kozloduy Units 3 and 4 Scenario (or EU Preferred Scenario)** assessed the implications, relative to the base case, of advancing the retirement of Units 3 and 4 to end-2006;

B.2 **Late Retirement of Kozloduy Units 3 and 4 Scenario (NPP Economic Life Scenario)** assessed the implications, relative to the base case, of utilizing the full useful (economic) lives of Units 3 and 4, thereby retiring Unit 3 in end-2010 and Unit 4 in end-2012;

B.3 **High Natural Gas Price Scenario** considered the impact of substantially higher gas prices on least-cost power supply options, and associated environmental consequences. This alternative used the "high price projections" published in the US Department of Energy's "Annual Energy Outlook for 2001" ($147 per tcm in 2000 and $150/tcm in 2015, at constant 1999 prices, net of taxes).

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[1] Environmental impact analysis included an assessment of the impact of electricity exports on carbon emissions to illustrate the opportunity cost to Bulgaria of consuming its carbon emission allowances under the Kyoto Protocol should a global carbon trading system be put in place.

(c) Policy options for balancing least-cost energy supply with energy security (greater reliance on indigenous resources) and compliance with national and international environmental requirements.

3. **A collaborative approach**. To help mainstream the methodology, the analysis was carried out in cooperation with local experts, using existing data, information and local modeling capability to the extent possible. Several differences of opinion between Bulgarian energy authorities and the Bank team were accommodated through the alternative scenarios, some of which (like high gas price and high exports) were included in response to the SAEER's comments relevant to the Base Case Scenario.

4. General agreement was reached in key areas such as domestic electricity and energy demand projections, the rehabilitation program for existing power plants and district heating systems in high population density areas, and the need to develop the low pressure gas network to serve the market for space heating and cooking investments. It was also agreed to maintain capacity reserves at no less than 22% above projected peak demand (in part due to the old age of Bulgaria's power plants). While agreement was reached on electricity export projections for the Base Case, SAEER is optimistic that exports will be significantly higher.

5. **Some key differences remain**. While views of the Bank team and the Government have converged through the collaborative preparation of the EER, main differences are related to the finding of the EER that no new power generation capacity is needed before 2006 and that plants based on imported fuels may well provided cheaper and cleaner electricity than plants based on indigenous energy resources. The Government's strategy (articulated initially in the National Strategy for Development of the Energy Sector till 2010 adopted by Parliament in early 1999 and now being updated) envisages large-scale investment in new capacity earlier, in part to meet higher domestic demand projections made before the EER was initiated (pre-2000), and in part to position Bulgaria to capture an increasing share of regional demand[2], and minimize reliance on imported fuels (mainly natural gas) for power generation[3].

6. The Bank, in contrast, has recommended that lower-cost rehabilitation investments and priority reforms be implemented first (para. 15), and that costly investments in new capacity be made with private investors assuming the bulk of market risks, particularly those related with export markets. Regardless of the final course taken by the Government, the EER methodology has served to highlight the costs and benefits of different supply scenarios. Some investment projects the Government is considering are captured in the scenarios analyzed under the EER and are summarized below.

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2 SAEER expects to increase electricity exports from the level in 2000 (about 4,300 GWh or 11% of domestic demand) to about 8,000 GWh/year over the next 3-5 years.

3 SAEER also disagrees with the Bank's conclusion that the entire installed capacity at the Chaira Pumped Storage Plant (864 MW) is available to provide emergency backup reserve, arguing that only half could be available because of limited water resources. However, the Bank believes that investment in the Jadenitsa Dam (included for all scenarios and in NEK's plans) would expand the available capacity to its design level.

B. RESULTS: DEMAND, SUPPLY OPTIONS AND ENVIRONMENTAL IMPACT

Demand

7. **Energy Demand forecasts – Base Case**. The EER estimates an average annual growth rate of approximately 1.6% for ***total energy and electricity*** consumption over the 2000-2015 period within Bulgaria ***for all scenarios***. This demand estimate is consistent with that of the Bulgarian authorities (SAEER and National Electricity Company) and is based on an average GDP growth of about 3.8% per year and the energy consumption trends of each consumer group. The implied elasticity of 0.42 incorporates improvements in energy efficiency and adjustment of prices to cost-recovery levels (Fig. A4.8), and is broadly consistent with estimates from other European countries. As mentioned above, three export demand scenarios have been analyzed: Base Case with 4,200 GWh/year; no exports; and 8,000 GWh/year from 2004 (under the main Carbon Trading Scenario). Particular attention has been paid to electricity demand forecasts due to strong Government interest related to the power sector investment program and the closure of Kozloduy units 1-4. Primary and final energy consumption forecasts, and breakdown by sector and type of energy are presented in Tables A4.12-A4.18.

8. Consumption of primary energy is forecast to increase by 40% over 2000-15 period. The most rapid growth (56%) is in liquid fuels, mirroring the underlying expansion in the transport sector. Substantial increases are also experienced in solid fuels (40%) and natural gas (39%), even though the end-use of solid fuels drops (by 7%) due to a decline in household use of coal and lignite. The production of primary electricity falls by 39%, following the retirement of the Kozloduy units 1-4. One consequence of these changes is that Bulgaria's dependence on energy imports is higher in 2015 (66% of primary energy needs is imported) than in 2000 (when the figure is 59%). These estimates of primary energy consumption are for the Base Case scenario and would be different for other scenarios (e.g. lignite consumption would be higher under the higher gas price scenario).

9. **Energy Intensity**. Energy intensity, represented by the amount of primary energy resources consumed to produce one unit (US$) of GDP, is an important element of national competitiveness. The "Base Case Scenario" estimates Bulgaria's energy intensity to decline by 27% over the planning period (to about 1.2 kg of oil equivalent per US$ of GDP), with all productive and service sectors improving their energy efficiency (Fig. A4.1). However, even more aggressive energy efficiency measures will be needed to bring Bulgaria's energy intensity to the present (1998) levels of other more advanced transition economies, such as Hungary (0.54 kgoe/$), the Czech Republic (0.74 kgoe/$) and Poland (0.61 kgoe/$) with whom it will need to compete (Table A1.5). While market forces will ensure that productive sectors improve their energy efficiency (or go out of business), more deliberate policies and investments will be necessary to improve energy efficiency in the following areas:

(a) **Energy Conversion Processes and Losses** (e.g. in refining, electricity and heat production, briquetting, and energy transmission and distribution). For the Base Case, conversion and transportation losses increase from about 36% in 1998 to 39% by 2015 reflecting both an increase in liquid fuels for the growing transportation sector (demand for primary fuels for this sector increases by about

80%) and the continued high level of reliance on electricity for cooking and heating[4]; and

(b) **Household energy/electricity consumption.** While the total energy consumed by households is in line with other countries with similar climatic and economic conditions, Bulgaria stands out in the high level of household electricity consumption. NEK's electricity demand forecasts, used for the Base Case scenario, imply an increase in annual household electricity consumption (per capita) from 1,301 in 1998 (or 3,698 kWh per household) to 1,804 in 2015 (Table A1.6 and Chapter 6). This consumption can be compared with substantially lower household consumption (per capita) in Romania (352 kWh), Lithuania (471 kWh), Turkey (608 kWh), Estonia (923 kWh) and Slovakia (1,030 kWh). This high usage of electricity by Bulgarian households reflects the dependence on electricity for heating (a costly and inefficient use of energy resources) due to historical choices (opting for large nuclear and lignite-based power plants versus developing low pressure gas networks) and will be particularly challenging to overcome in the transition to a market economy. High electricity usage has been exacerbated by continued electricity price subsidies and delays in modernizing district heating systems or developing gas systems[5].

Least-Cost Power Supply Options

10. **Common for all scenarios**. Key assumptions which would affect supply options (timing and least-cost selection) and have been kept constant for all scenarios include:

(a) **Rehabilitation Program (4,295 MW) and Modernization of Kozloduy nuclear units 5 & 6 (2,000 MW):** It is assumed that NEK's rehabilitation program (Table A4.9) will be implemented as it is deemed to be the least-cost means for meeting projected electricity demand. It includes the rehabilitation of generation capacity at Maritsa East 2 (1,520 MW) and 3 (840 MW), Bobov Dol (645 MW) and Varna (1,290 MW);

(b) **Cogeneration/Combined Heat and Power (CHP) Units**: All scenarios include the addition of several small combined heat and power (CHP) units (50 MW total), capacity expansion of the Sofia CHP plants through their replacement (60 MW), and a new replacement CHP plant serving industrial steam demand in Devnja (230 MW).

(c) **Retirement of Kozloduy Nuclear power units 1 and 2**: It is assumed that Units 1 and 2 will be retired in end-2002 (as agreed with the EU);

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4 Net fuel conversion efficiency (after auxiliary uses) is about 25-30% for the bulk of Bulgaria's power plants, another 15-20% of this is "lost" in transmission/distribution to end-users resulting in a very inefficient (and fuel intensive) means of heating and cooking. District heating, particularly if produced by combined heat and power plants with over 80% conversion efficiency, and other fuels such as gas would be far more efficient and clean modes of cooking and space heating.

5 Much electrical heating in Bulgaria is derived from small 2 kW electric heaters which are switched on for short durations which coincide with the peak periods of electricity demand. One million households switching on a heater around the same time would drive up peak demand by 2,000 MW. Building new generation capacity to meet this demand would cost about $2 billion for lignite-based capacity or $1.0 billion for gas-based capacity. Efficient gas or district heating systems could be constructed (or rehabilitated in the case of DH) for a fraction of the cost.

(d) **Expansion of capacity available from the Chaira Pumped Storage Plant (PSP)**: Investments in the Jadenitsa Dam are made in all cases because it extends the duration for which the Chaira PSP (864 MW) can contribute to meeting peak demand and providing emergency reserves;

(e) **Capital and Operating Costs of Candidate Units**: Standard industry estimates were employed for the capital and operating costs for new power plants utilizing fossil fuels (imported coal, lignite and natural gas), while the costs of nuclear and hydroelectric options were provided by NEK since they are site-specific;

(f) **Fuel Costs**: With the exception of the price forecast for natural gas, other fuel prices were the same under all scenarios;

(g) **Electricity Imports**: As provided by NEK, electricity imports are priced at $0.05/kWh during off-peak periods and $0.07/kWh at peak hours.

11. **Timing for New Capacity Requirements**. The analysis shows that existing generation capacity, if appropriately rehabilitated in accordance with NEK's plans, would be sufficient to safely meet demand at least until 2005. This timeline can be extended by: (i) accelerating cost-effective investments in non-electrical heating systems, particularly modernization of existing district heating systems; (ii) implementing demand-side, energy efficiency measures; and (iii) allowing reserve capacity margins to drop, for example to a safe 22% in 2006, thus deferring the need for about 450 MW of new capacity. However, this flexibility would be reduced if Bulgaria decides to shut Kozloduy Units 3 and 4 (880 MW) by 2006, as desired by the EU, or exports expand beyond the levels assumed in the Base Case.

12. **Investment, Operating Costs and Emissions of Each Scenario**. The timing and least-cost selection of the candidate new plants is summarized in Table A. This table also compares Present Values of investment and operating costs each scenario. The emissions of particulates, SO_2, NO_x and CO_2 for each scenario are summarized in Table B.

13. The key conclusions regarding the investment program derived from the scenario analysis are:

(a) A substantial portion (55% or 925 MW over the planning period) of new capacity is needed to meet projected export demand. This proportion increases to 67% (1,496 MW) if export demand is 8,000 GWh/year compared with 4,200 MW/year in the Base Case;

(b) If exports double (over the Base Case), new capacity would be needed as soon as 2003 (assuming adequate transmission capacity is in place). In other cases new capacity is needed in 2006 or later (assuming that a number of planned small cogeneration plants with a total capacity of 305 MW are implemented in the 2003-05 period). With no exports, new capacity is not needed until 2009 (or later if nuclear Units 3 & 4 are operated until the end of their economic life);

(c) If high gas prices prevail throughout the planning period, the model selects lignite-based plants as being least-cost compared with gas-based plants. However, at least one gas-based plant is selected because of its greater flexibility to respond to changes in load (with lignite plants preferred for meeting base demand). As could be expected, the preference for lignite plants increases the present value (PV) of capital costs (highest PV with the exception of the High Exports scenario), but reduces the PV of operating costs;

(d) Late retirement of Units 3 & 4 at the Kozloduy nuclear power plant still justifies the need for about 450 MW of new capacity in 2006 (gas or lignite based, depending on the price of natural gas), but even this capacity could be postponed for about 2 years if the reserve margin is allowed to drop from 26% to 20%. The next capacity increment beyond that is not needed until 2011, when another 450 MW gas turbine is recommended for commissioning (again depending on the gas price and assuming exports at 4,200 GWh/year). As could be expected, this scenario also has the lowest investment cost (in present value terms);

(e) Imports of electricity, if they could be reliably secured, could play an important role in alleviating short-term demand-supply imbalances. It might be possible to postpone investment in new capacity from 2006 to 2008 if imported electricity of up to 2,700 GWh could be purchased at reasonable rates. Screening curve analysis suggests that imports could be more attractive than building new capacity if import prices were at or below US$0.035/kWh. Capacity additions could also be deferred through peak shaving (shifts in load profile) which may well occur as household electricity prices are adjusted to their cost-recovery levels[6].

14. With respect to environmental impact, the EER concluded that:

(a) Bulgaria generally remains in compliance with local environmental standards and international treaties over the 2000-10 period under all scenarios examined;

(b) The "High Gas Price" (with more lignite power plants) and "High Export" scenarios result in the highest level of emissions and are the most costly to Bulgaria (particularly if green house gas emissions become tradable and any reduction in carbon emissions has the potential to earn foreign exchange revenue). Assuming a value of US$10 per tonne of carbon (i.e. US$2.73 per tonne of CO_2 equivalent), the EER found that, compared with the Base Case, Bulgaria's potential sales of carbon in a carbon trading market would fall by approximately US$13 million per year with high exports of 8,000 GWH/yr and increase by US$19 million per year if exports were eliminated. This penalty attached to exports would be even higher if more lignite plants and fewer gas plants are built in anticipation of high gas prices or higher import dependence. Increased use of lignite would also exacerbate SO_2 emissions, which are projected to exceed the level of the Gothenburg Protocol after 2010 even under the Base Case.

(c) While total particulate emissions are expected to remain unchanged from 2000 to 2015, site/city specific analyses and measures will be needed to ascertain whether the air quality in a number of "hot spots" (such as Varna and Devnja) meets national and WHO standards. However, increased use of natural gas in industrial and urban areas is expected to result in improvements.

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6 Examination of existing typical daily load curves for winter and summer indicate that annual system peak is driven partly by the residential heating load.

C. KEY POLICY RECOMMENDATIONS

15. The scenario analysis approach followed by the EER offers some important conclusions which will serve policy-makers well in developing sector policies, strategies and investment plans. Some key issues and recommendations are summarized below:

(a) The Government's strategy of capturing export power markets while reducing dependence on energy imports is likely to face resistance from trading partners, particularly within the context of EU accession. Market design and regulatory restrictions favoring the use of indigenous lignite or nuclear fuel would also require higher capital cost investments (per MW) at a time when the risk-adjusted cost of capital is high and could make the electricity produced less competitive in foreign markets and unaffordable in the domestic market. While the increased used of indigenous fuels will improve energy security, it would adversely effect Bulgaria's environmental performance. The impact on the balance of payments would have to be compared weighing foreign exchange requirements for debt and equity service (as the bulk of investment capital is likely to be foreign for the next few years) against costs for imported energy;

(b) Bulgaria could boost its competitiveness and social welfare through the efficient use of its energy resources. There is an urgent need to promote energy efficiency in all areas – end-use consumption, production, transmission and distribution. While the EER has relied on reasonable estimates of demand growth (1.6% per year), the energy intensity at the end of the period remains uncompetitive with other transition economies. Part of this high energy intensity is explained by Bulgaria's legacy which has been heavily reliant on electricity[7]. While this may have been sustainable with the low costs of nuclear fuel and indigenous lignite (on which Bulgaria relies most), and the depreciated asset base, the high dependence on electricity is unlikely to be affordable if Bulgaria is to meet EU environmental requirements and include capital costs of new investment in electricity tariffs. The extraordinarily high amount of electricity used by households is likely to be a serious public policy challenge as electricity prices are adjusted to their full-cost recovery levels, particularly when capital costs of costly new investments are passed through to end-users. Particular attention will be needed to develop more efficient, alternate forms of energy services (modern district heating, gas supply, etc.) to alleviate the adverse impact on consumer welfare and on economic competitiveness[8];

(c) Cost-effective rehabilitation of existing assets must be accelerated, ideally through proper privatization of assets. While appropriate regulations are being put in place, it may be necessary to consider suitable contracts, with sovereign guarantees if necessary, to attract qualified investors to improve energy services. In areas such as the transmission/distribution of district heat, where major legal and regulatory reforms are still needed and contractual arrangements are more complex, investments could be initiated through the budget and sovereign loans;

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[7] Electricity in Bulgaria is produced largely by condensing-type thermal plants with poor conversion efficiencies (25-30%). Losses in transmission and distribution are presently around 20%, resulting in only 25-30% of the primary fuel actually being available for use by the end-user.

[8] Over the next few years, average electricity price for households is expected to rise to its economic cost of US$50-60/MWh. Compared with this, the economic cost of low pressure natural gas would be US$20-24/MWh (or $200/tcm), and district heating would be about US$25/MWh.

(d) Defer costly investments in new power and heat generation capacity until regulatory reforms are more advanced and investors can assume a larger share of the market risks (under a suitable regulatory framework). Given the high level of uncertainty associated with demand projections at this early stage of transition to a market economy, the available surplus capacity, the "lumpy" nature of investments in power plants, and the high risk premium which private capital is likely to demand at the present time, it would be more prudent to direct investment capital towards areas of highest return. These include rehabilitation of existing assets to improve their efficiency, reliability and safety, and measures to reduce the high dependence on electricity for heating and cooking;

(e) As a priority, ensure that private investments in new power capacity for export are made with investors taking all export market risks. This is particularly important because over 55% of new capacity is justified to meet export demand projections. Under the present market structure, only NEK can export (and import) electricity and therefore must assume all the market risks (and rewards) of the export markets. These risks and rewards are best assumed by the private sector;

(f) In order not to constrain the emergence of a competitive electricity market, NEK (the transmission/dispatch company) should consider long-term power purchase agreements (PPAs) only for essential investments to ensure reliable supply over the next 4-5 years. Already, with the signing of long-term PPAs for the Maritsa East 1 (670 MW) new plant and Maritsa East 3 (860 MW) rehabilitation, and the "must run" nature of nuclear and cogeneration plants, only about 40% of projected demand will be available to competitive suppliers (Table A4.20);

(g) The Government must ensure that environmental costs are internalized as fully as possible by monitoring and enforcing compliance with all relevant environmental regulations. The pricing of exports will also need to reflect any commitments that might eventually be assumed by the Government on the emissions of green house gases. Furthermore, all electricity prices should include (in a transparent manner), NEK's costs (as System Operator), of maintaining capacity reserves (20-25% over peak) needed to ensure reliable supply to domestic and foreign consumers;

(h) The Government should consider transparent policy measures, rather than site, fuel and plant selection by itself, to ensure strategic objectives of energy security. Such pre-determination goes against market principles, deters many reputable strategic investors, and places more responsibility (and contingent liabilities) on the Government. Specific objectives such as reducing import dependence and promoting exploitation of indigenous energy resources may be better achieved through the provision of explicit tax incentives (or disincentives)[9]. Similar mechanisms could be extended to the development of clean and renewable energy and the promotion of efficient energy technologies. This would give investors a clear framework within which to make investment decisions while also satisfying the Government's strategic and environmental objectives.

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9 The dependence on Russian gas is likely to be mitigated through the major expansion of Russian gas transit to Turkey (increased "inter-dependence") and the on-going development of gas pipelines from the Caucasus and Iran (through Turkey).

Table A: New Power Generation Capacity (MW) Additions and Present Values (million 2000 US$)

Year	A. Base Case		B.1 NPP 3&4 Early Closure		B.2 NPP 3&4 Late Closure		B.3 High Gas Price		C.1 Maximum Exports		C.2 No Exports	
	Fuel	Capacity	Fuel	Capacity	Fuel	Capacity	Fuel	Capacity	Fuel	Capacity	Fuel	Capacity
2000												
2001												
2002												
2003									NG	450		
2004									Lignite	300		
2005												
2006	NG	450	NG	450	NG	450	Lignite	300				
2007			Lignite	300			Lignite	300				
			Imp. Coal	300								
2008	Lignite	300							NG	450		
									Imp. Coal	300		
2009	Lignite	300	NG	450			Lignite	300	Lignite	300	NG	450
							NG	450				
2010	Imp. Coal	300							Lignite	300		
2011					NG	450						
2012	N	25			Imp. Coal	300	Imp. Coal	300				
2013	Lignite	300			NG	450			NG	146		
2014			Hydro	156								
2015											Lignite	300
Total		**1,675**		**1,656**		**1,650**		**1,650**		**2,246**		**750**

NG: Natural Gas NPP: Nuclear Power Plant (Kozloduy) (3 & 4 refers to Units 3 and 4)

Present Values[10] discounted @10% (in million US$ adjusted to 2000 prices)

	A. Base Case	B.1 NPP Early	B.2 NPP Late	B.3 High Gas Price	C.1 Max. Exports	C.2 No exports
Investment Cost	1,398.0	1,431.1	1,192.2	1,467.4	1,747.9	1,027.4
Operating Cost	7,625.7	7,601.0	7,588.8	7,609.2	7,974.5	7,056.6
Total Cost	**9,023.7**	**9,032.1**	**8,781.0**	**9,076.6**	**9,722.4**	**8,084.0**

[10] Present Values take into account residual value of assets at the end of the planning period. 1998 prices have been adjusted upwards to reflect their 2000 values. PV of the Rehabilitation and Nuclear Power Plant modernization program are common for each scenario. Costs for the cogeneration units have not been included but are common for each scenario.

Table B: Total Emissions from Energy Sector

(in kilo tons, except for CO2eq which is in million tons)

	Particulates (TSP)				SO2				NOx				CO2 eq (million tons)				Average
	1998	2005	2010	2015	1998	2005	2010	2015	1998	2005	2010	2015	1998	2005	2010	2015	2008-12
Base Case	23	22	21	21	1,095	796	801	806	155	182	209	228	57.4	63.2	73.4	77.9	72.9
Early NPP Closure	23	22	21	21	1,095	796	790	807	155	182	215	240	57.4	63,2	72.5	77.7	72.5
Late NPP Closure	23	22	19	20	1,095	796	776	797	155	182	206	242	57.4	63.2	68.5	76.9	68.9
High Gas Price	23	22	24	24	1,095	798	856	875	155	183	218	250	57.4	63.3	76.7	82.7	76.0
No Elect. Exports	23	19	21	21	1,095	702	779	802	155	159	203	227	57.4	57.1	67.0	73.4	66.6
High Elect. Exports	23	23	24	24	1,095	820	853	875	155	196	229	258	57.4	68.3	79.9	85.2	78.5
Second Sulfur Protocol						1,230	1,127										
Gothenburg Protocol/SO2							856	856									
Sofia Protocol										350	290						
Gothenburg Protocol/NOx											266	266					
Kyoto																	92.2

Early and Late NPP Closure relates to shut-down of Units 3 and 4 at the Kozloduy Nuclear Power Plant