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REGIONAL ENERGY SECURITY AND MARKET DEVELOPMENT - STRATEGIC PLANNING COMPONENT

INVESTMENT REQUIREMENTS AND BENEFITS ARISING FROM ENERGY EFFICIENCY AND RENEWABLE ENERGY POLICIES IN SELECTED ENERGY COMMUNITY COUNTRIES:

SERBIA POLICY BRIEF

July 2012
This report was produced for review by the United States Agency for International Development (USAID). It was prepared by Electric Power Industry of Serbia and International Resources Group (IRG).

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ACRONYMS

AEO	Annual Energy Outlook
BAU	Business as Usual
CC	Combined cycle
CRES	Centre for Renewable Energy Sources
EC	Energy Community
ECES	EPS Capacity Expansion Strategy (ECES)
ECS	Energy Community Secretariat
EE	Energy Efficiency
EIA	Energy Information Association (US)
EPS	Electric Power Institute of Serbia
ESD	Energy Services Directive
ESDS	Energy Sector Development Strategy of the Republic of Serbia until 2015
ESEC	Energy Strategy of the Energy Community
EU	European Union
GDP	Gross Domestic Product
GFEC	Gross Final Energy Consumption
HGVs	Heavy Goods Vehicles
ICE	Internal combustion engine
IEA	International Energy Agency
IPA	International Policy Analysis
IRG	International Resources Group
IVA	Industrial Value Added
LCVs	Light Commercial Vehicles
LDVs	Light Duty Vehicles
LPG	Liquid Petroleum Gas
LWR	Light Water Reactor
MARKAL	MARKet ALlocation
MOME	Ministry of Mining and Energy
NEEAPs	National Energy Efficiency Action Plans
NPV	Net Present Value

NREAPs	National Renewable Energy Action Plans
OECD	Organisation for Economic Co-operation and Development
O&M	Operation and Maintenance
PC	Pulverized coal
PED	Prosperous Economic Development
PET	Pan-European TIMES model
RE	Renewable Energy
REDP	Regional Energy Demand Planning
RESMD	Regional Energy Security and Market Development
RPS	Renewable Portfolio Standards
SED	Slow Economic Development
SF	Steam Fossil
SSP	SYNENERGY Strategic Planning
UK	United Kingdom
US	United States
UNFCCC	United Nation Framework Convention on Climate Changes
USAID	US Agency for International Development

A. INTRODUCTION

Under the US Agency for International Development (USAID) Regional Energy Security and Market Development (RESMD) project and in conjunction with the joint SYNENERGY Strategic Planning (SSP) effort undertaken with Greece Hellenic Aid, a strategic planning activity was undertaken to develop a comprehensive national energy planning framework to support policy making and analysis of future energy investment options.

This initiative builds on the earlier groundbreaking USAID Regional Energy Demand Planning (REDP) project that laid the foundation for integrated supply/demand energy systems analysis in Southeast Europe.

This Policy Brief provides an overview of the analysis undertaken by the Serbian Planning Team using their national MARKAL (MARKet ALlocation)/TIMES integrated energy system model, MARKAL-Serbia, to examine the role of energy efficiency (EE) and renewable energy (RE) in meeting future requirements out through 2030 to support sustained economic growth and while considering Energy Community (EC) commitments and European Union (EU) accession directives.

This is a revised version of a previous Policy Brief drafted during the summer of 2011. This revision has been undertaken based on a range of model improvements including the inclusion in the model of transport/refining sectors, a review of key electricity sector assumptions, updated fuel prices, and improved emissions accounting, along with a more advanced approach to the energy efficiency analysis.

The analysis reflects several years of model development and use, jointly undertaken by the Ministry of Mining and Energy (MOME) and the Electric Power Industry of Serbia (EPS), supported by International Resources Group (IRG) and the Centre for Renewable Energy Sources (CRES). The MARKAL-Serbia analysis undertaken uses a cross-sectoral, cost optimization approach to identify the most economic efficient set of measures.

This Policy Brief focuses on assessing the energy sector costs and benefits for the entire energy system of meeting energy efficiency and renewable targets in Serbia, as a Contracting Party under the Athens Treaty establishing the Energy Community. It also considers how meeting the targets impact on key issues facing energy sector decision-makers – namely, how to foster energy security and diversification, and ensure competitiveness and affordability, while taking into consideration climate mitigation and other environmental issues, as part of promoting cost-effectiveness in energy planning. Furthermore, what is important for decision-makers is that there is now a strategic planning platform available for Serbia, where model assumptions and policy scenarios may be readily changed and explored, that can provide analytic rigor and insights to underpin future national strategic planning and policy formulation.

The following supply and demand analyses have therefore been undertaken.

- Reference (Business-as-Usual or BAU) Development: The likely supply and investment requirements to support the evolution of the national energy system in the absence of policies and programs aimed at altering current trends. The Reference scenario is fully discussed in Section C.

- Energy Efficiency Promotion: This demand-side policy explores the range of energy efficiency measures (e.g., conservation measures, improved appliances, building shell improvements across all sectors) that are the most cost-effective means to meet national targets aimed at reducing final energy consumption (in line with National Energy Efficiency Action Plans or NEEAPs). The EE scenario is fully discussed in Section D.

- Renewable Energy Target: This supply side policy examines the requirements to successfully achieve a renewable energy target by 2020 (in line with that proposed by the Energy Community) aimed at enhancing energy security (by reducing imports). The RE scenario is fully discussed in Section E.

- Combined EE and RE Policies: This combination of supply-side and demand-side approaches examines the resulting synergies of these policy goals. The combined RE/EE scenario is fully discussed in Section F.

In addition, country-specific issue, in this case, the development on energy system in case of higher economic growth, is examined in Section G.

B. KEY INSIGHTS FOR POLICY MAKERS

The analysis undertaken provides some important insights on how improving energy efficiency and promoting renewable energy impacts three key policy areas: energy security and diversification, economic competitiveness, and climate mitigation. These insights are summarized in Table 1.

Table 1. Summary Overview of the Impact of RE / EE Objectives on Key Energy Policy Issues

Policy issue / Scenario	Reference Scenario Trends	Renewables	Energy Efficiency	EE+RE
Energy security and diversification	• Increasing hydro and thermal generation • decreasing energy intensity	• Increased use of domestic RE resources	• Reduction of imports by 5060 Ktoe • Direct energy and electricity consumption reduced by 14847 Ktoe (5.8%)	• Increased use of domestic RE • Final energy further reduced compared to Reference, by 6.4%
Enhanced competitive-ness[1]	• Electricity system expansion • Increased electricity and oil products exports	• Stimulates investment in renewable market • Increases in electricity price for consumers • Cuts payments for imported fuels, dropping by over 3.6% (2383€M)	• Lower fuel costs, saving 4.6% in fuel expenditure (4132€M) • Increase in exports by 1171 ktoe (21%) compared to Reference scenario	• Lower fuel costs, saving 7.6% in fuel expenditure (6931€M)
CO_2 mitigation	• Emissions increase by 26% by 2030 due to increased use of fossil fuels	• Cumulative reduction of 9.5% due to use of less fossil energy and lower total energy consumption	• Cumulative reduction of 3.9% due to lower total energy consumption	• Cumulative reduction of 13.3% due to more renewable energy and lower energy consumption

[1] The analysis does not provide full insights into the real macroeconomic impacts of changes to the energy system, as it does not account for allocation of resources across other economic sectors, as a general equilibrium model does. However, by looking to minimize the costs of a sustainable energy system it is inherently fostering competiveness.

ENERGY SECURITY AND DIVERSIFICATION

Currently only 38% of Serbia's primary energy requirements are imported, going up to 41% by 2030 in the Reference case. Under the RE scenario, import levels will be reduced cumulatively by around 4.4%, by 3% under the EE scenario, and by 5.8% under the combined scenario. This is due to the increased use of indigenous renewable energy under an RE target, and lower energy consumption resulting from increased energy efficiency in scenarios with an EE target.

However, overall, the energy supply becomes less diversified under the RE case, with an increased reliance on hydro generation, and relatively constant gas supply. Large increases in investment in hydro capacity need to be balanced against issues of supply diversity, particularly if hydrological patterns change in future years (due to climate change) and leave the system exposed to shortfall.

ENHANCED COMPETITIVENESS

An energy efficiency target, in combination with the right policies and programs, has strong benefits for competitiveness by reducing payments for imports, increasing profits from energy exports, cutting industry production costs, and lowering fuel bills for households, despite the higher overall cost to the energy system. If policies that promote an increased uptake in energy efficiency are pursued without setting an explicit reduction target, there is actually an overall savings seen of total cumulative fuel expenditure savings (compared to the Reference case), amounting to a reduction of 4.6%, or cumulative saving of 4.1€ billion, nearly offsetting the cost of the more expensive efficient technologies. Once transformed, the energy system savings continue into the future, making the Serbia energy system more competitive over time.

In RE target case, energy system costs are 2.4% higher (3.14€ billion Net Present Value (NPV) [2]). If the RE target is implemented in parallel with policies to promote energy efficient technologies, the combined cost of meeting renewable targets and energy efficiency targets is less, with additional costs of just 1.5%.

In addition, as already mentioned, a combined EE+RE policy can substantially reduce imports by 9,750 ktoe, saving valuable foreign exchange funds, amounting to 2.87€ billion cumulatively. Electricity and oil products exports bring additional cumulative revenue of 0.5€ billion compared with the Reference scenario. These together offset much of the more expensive generation and efficient device upfront costs.

It should be mentioned that under the Reference scenario, assumptions of relatively low GDP growth rates and forced firm power plant builds of 6,200MW by 2030, there is a significant increase in electricity exports. This should be treated with caution, especially considering the uncertainty relating to the regional electricity market.

It must also be noted that the ancillary direct economic benefits arising from these domestic-centered polices, such as increased jobs to undertake a large number building retrofits and deploying renewable power generation alternatives, are not captured by this analysis.

CO_2 MITIGATION

Within the scope of its international activities, Serbia signed and ratified the Kyoto Protocol as a non-Annex I country. Therefore, Serbia did not take on any obligations beyond general obligations under the United Nation Framework Convention on Climate Changes (UNFCCC).

[2] All references to total system costs over the entire planning horizon are discounted at 7.5% and reported according to a 2006 base year as Net Present Values.

However, as an accession candidate, the EU requirements for emission reductions need to be considered.

The policies examined show strong synergies with a goal of moving to a lower carbon footprint for the Serbian energy economy. The combined EE and RE policy leads to cumulative reductions of 13.3% in CO_2 emissions, getting Serbia part of the way there. This is accomplished by increasing renewable generation from hydro and wind power of the order of 1,700 MW, compared to the Reference scenario, coupled with the overall reduction in demand for energy, due to the more efficient energy system. Assessment of what it will take for Serbia to achieve the EU target can be undertaken using MARKAL-Serbia, in particular to look at the resulting technology roadmap and costs of energy under various attainment timing scenarios.

POLICY IMPLICATIONS

The Energy Community region faces daunting investment challenges to replace aging infrastructure and keep pace with energy demand growth. As the Energy Strategy of the Energy Community[3] (ECES) notes, the Western Balkans region will require an additional 13 GW of investment in new power plants just through 2020, at a cost of nearly 30 € billion, a figure that dwarfs actual investment in new capacity over the past two decades. The MARKAL-Serbia model shows that rapid electricity demand growth requires an over 70% increase in electricity generation capacity by 2030 to over 12 GW at a cost of nearly 14.4 € billion, driven by moderate Gross Domestic Product (GDP) growth (average rate of 3.2%), decreasing population, and increasing per capita consumption, with annual energy system costs reaching 1,8749 € million by 2030. At the same time, policy priorities to ensure secure, diverse supplies and mitigate carbon dioxide emissions increase the challenges.

Investment in energy efficiency is a key strategy to meet all of these policy priorities. The MARKAL-Serbia analysis shows that a 3.5% reduction in final energy consumption can be achieved at a net savings of 862 € million NPV (or 0.7%), while achieving the more ambitious NEEAP target of 9% savings of 367 € million (0.3%) are still seen, with reduced fuel expenditures of 4.6% (4,100 € million NPV), lower imports by 3% (1,650 € million) and a drop in carbon emissions by 3.9%. Achieving these goals requires a 6.4% (5,300 € million NPV) increased investment in more efficient demand devices, resulting in a nearly 83 € million reduction in new power plant expenditures. The most cost-effective areas for energy efficiency investment identified in this analysis include residential and commercial space heating, lighting and industrial process heat. The MARKAL-Serbia model can be used, along with market analysis, to identify key technology and building opportunities and develop targeted measures to achieve this potential.

Meeting RE targets, on the other hand, increases energy system costs by 2.4% (3,137 € million NPV) and requires the 2,075 MW additional power sector capacity, with associated investment increasing by 70%, or by 10.12 € billion over that in the Reference scenario. Achieving the target yields the following benefits: a more than 4.4% (2,400 € million NPV) decrease in imports, an 5.8% (5,242 € million NPV) decrease in fuel expenditures and 9.5% decrease in carbon emissions. An additional reliance on hydropower may increase the risks from a poor hydrological year, and these risks should be balanced against those arising from dependence on imported gas supplies. Further analysis using the stochastic formulation of MARKAL can explore uncertainty associated with future water availability and help formulate more robust hedging strategies.

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[3] Energy Community, 2012. 10thMC/18/10/2012 - Annex 19/27.07.2012

Although the investment challenges are significant, pursuing the EE and RE strategies simultaneously leads to important synergies. The increase in system cost is limited to 1.5%, (1,918 €million NPV) or 0.9% less than the renewable energy strategy alone. The savings are significant: a 7.6% (6,931 € million NPV) decrease in fuel costs, 13.3% decrease in carbon emissions, and 5.8% (9,750 € million NPV) decrease in imports. The benefits of these investments extend beyond 2030, creating a lasting shift of the economy onto a lower energy intensity, more sustainable and secure trajectory.

The analyses described herein also make it clear that Serbia now has an integrated energy system planning model that can be used to examine in more detail the best policies to achieve these and other policy goals. Key areas for future analysis include assessing tradeoffs regarding hydro versus other RE capacity investments, designing feed-in tariffs to encourage RE development, and developing targeted EE policies, including standards and appliance and retrofit subsidies.

C. SERBIA BUSINESS-AS-USUAL ENERGY PATHWAY

To assess the impact of different policies and programs on the evolution of the energy system in Serbia, a Reference scenario was developed, taking into account specific characteristics of the national energy system, such as existing technology stock, domestic resource availability and import options, and near-term policy interventions. It also "forces" new power plant builds according to the EPS Capacity Expansion Strategy (ECES).[4] The influence of this forcing is discussed later in this chapter. The Reference scenario utilizes all available national data sources (State Statistical Office, National energy balances, etc.) as well as some international databases (e.g., International Energy Agency or IEA). The full list of information sources is provided in Appendix I. Once established, the Reference scenario can also produce baseline estimates of energy consumption and carbon emissions to measure trends with respect to achieving NEEAP and low emission development goals.

Under the Reference scenario, energy consumption is projected to grow 32.5% in terms of final energy by 2030, driven by moderate Gross Domestic Product (GDP) growth (average rate of 3.2%), decreasing population, and increasing per capita consumption. In accordance with the current national plan, the installed electricity generation capacity will almost double from 6,961 to 12,031 MW. Total imports will grow by 35.8% and CO_2 emissions by 40.7%. Key indicators from the Reference scenario are shown in Table 2 and summarized subsequently.

Table 2. Key Indicators for the Reference Scenario

Indicator	2006	2030	Annual Growth Rate (%)	Overall Growth (%)
Primary Energy (ktoe)	14,230	17,814	0.9%	25.2%
Final Energy (ktoe)	8,568	11,355	1.2%	32.5%
Power plant capacity (MW)	6,961	12,031	2.3%	72.8%
Imports (ktoe)	5,335	7,244	1.3%	35.8%
CO_2 emissions (kt)	41,285	52,294	1.0%	26.7%
GDP (€ Mill.)	23,520	50,586	3.2%	115.1%
Population (000s)	7,515	7,077	-0.3%	-5.8%
Final Energy intensity (toe/€000 GDP)	0.36	0.22	-2.0%	-38.4%
Final Energy intensity (toe/Capita)	1.14	1.60	1.4%	40.7%

Primary energy consumption in 2030 will be 17,814 ktoe, increasing from 2006 levels by 25.2%. Whilst growing GDP and increasing household energy intensity are driving up energy demand, it is also important to note that energy intensity per unit of economic output is significantly lower than observed in 2006 – estimated to be 0.22 toe/1000€, a reduction of around 38%, mainly due to assumption improvement in technology performance over the next 20 years.

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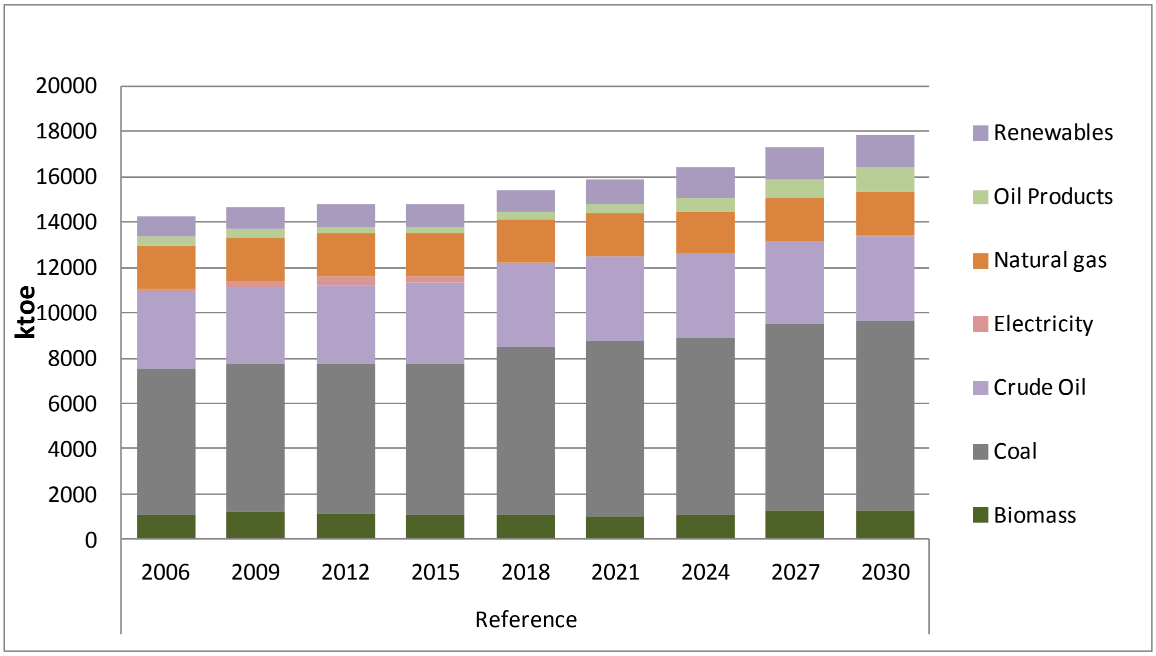
[4] According to EPS "Srednjoročni plan razvoja 2008-2015 sa osvrtom do 2025".

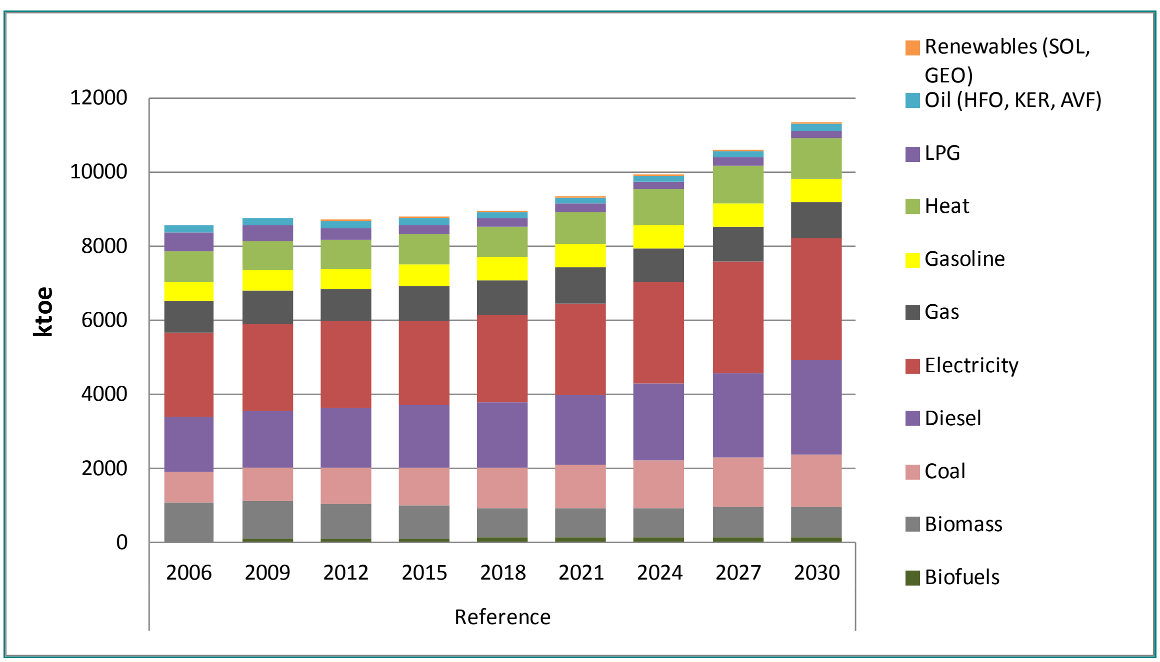
The observed growth in primary energy supply does not lead to significant changes in the supply mix over the planning horizon. As shown in Figure 1, primary energy supply increases by about 25% with coal supply growth around 30%, oil products around 161% (due to large rapid growth in the transport sector), and renewables by 60%.

Figure 1. Primary Energy Supply – 2006 - 2030



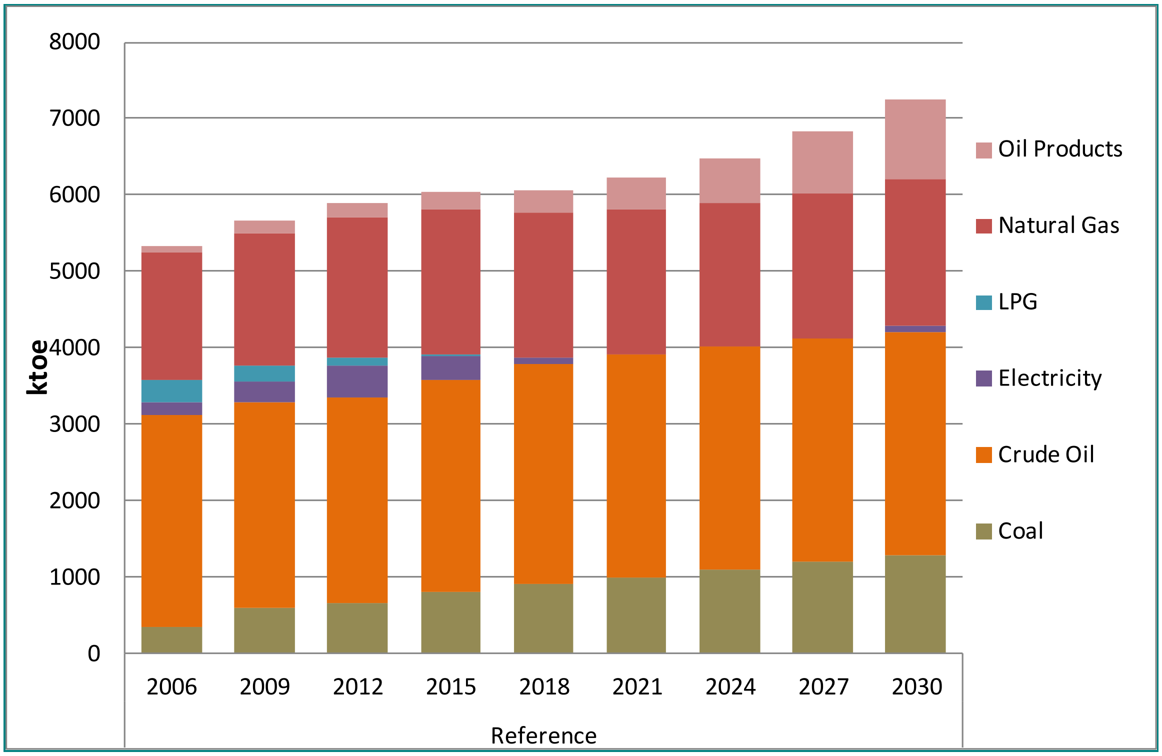
Total final energy consumption grows by 32.5% over the planning horizon, in accordance with the relatively moderate GDP growth rates and decreasing population. The most significant increases are observed in the consumption of coal (68%), diesel (73%), electricity (44%), and heat (37%).

Figure 2. Final Energy Consumption by Energy Type



The majority of fossil fuels consumed are produced domestically – mainly lignite, together with some crude oil, hard coal, and brown coal. As a result, only about 43% of Serbia's fossil energy requirements are imported. With the growth in energy demand, this share is projected to grow to 48%. The major imported fossil fuels are natural gas and crude oil, used for the refining of oil products. Near the end of the planning horizon, imports of oil products begin to rise due to available existing capacity and limits on future investments in refineries.

Figure 3. Imports by Type



New power generation capacity additions until 2030 are shown in Table 3 (for each three-year period). The majority of this new capacity represents currently planned projects (including a large amount of capacity post-2020), which are forced into the model. This means the power generation capacity built in the Reference case is not based on cost-optimization in the main but rather the perspective on sector development put forth in ECES.

New capacity includes 1,840 MW of new coal plants (mainly using domestic resources), and 3,900 MW of new hydro plants (including 3,080 MW pumped storage). This accounts for over 90% of all new capacity, most of which comes into the system during the 2018/2024 periods, as illustrated in Figure 4. Non-hydro renewables also make a contribution of 117 MW biomass cogeneration and 30 MW of wind.

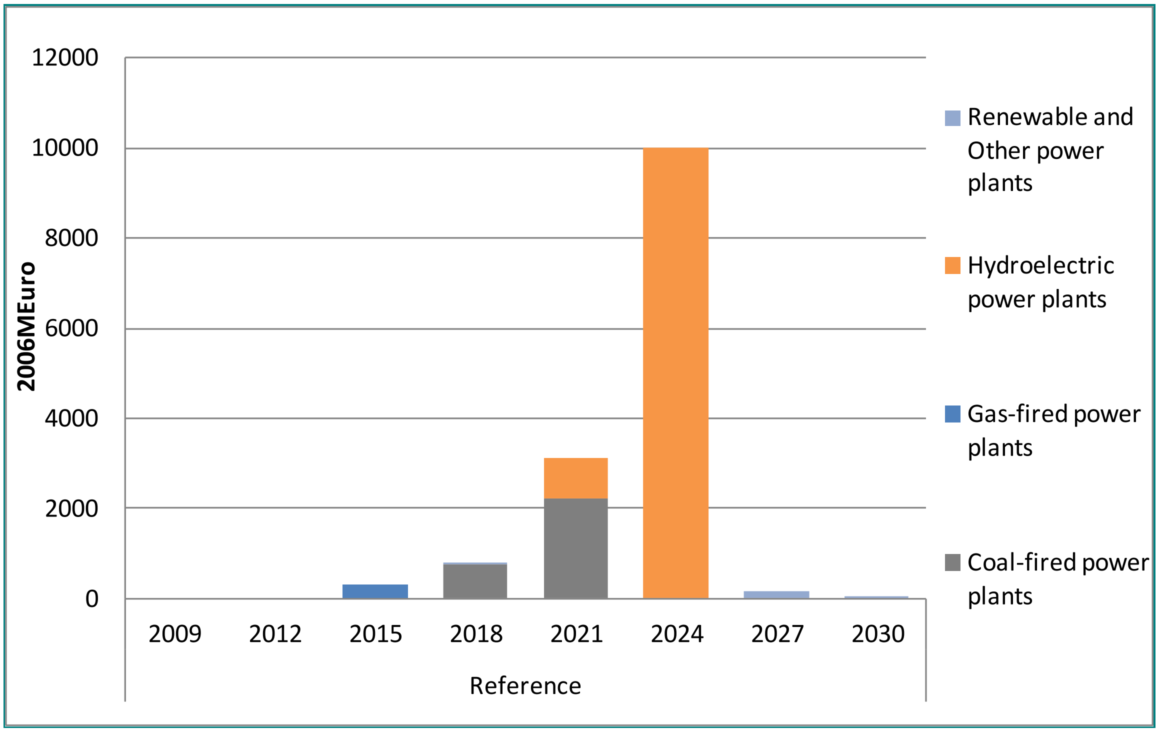
Table 3. Additional Power Plant Capacity by Fuel Type (MW)

Plant Type	2009	2012	2015	2018	2021	2024	2027	2030	Total
Coal	0	0	0	750	1,090	0	0	0	1,840
Gas	0	0	450	0	0	0	0	0	450
Hydro[1]	0	0	0	0	830	3,087	0	0	3,917
Renewables	0	0	0	30	0	0	99	18	147

Plant Type	2009	2012	2015	2018	2021	2024	2027	2030	Total
Total New Capacity	0	0	450	780	1,920	3,087	99	18	6,354
% of Installed Capacity	0.0%	0.0%	6.3%	10.1%	20.3%	25.9%	0.8%	0.1%	

[1] Including pump storage

Figure 4. Total Investment Cost of New Power Plants*



* Investment levels are not annual but cumulative for a three-year period. Note that in the model the payments for this new capacity will be spread over the lifetime of the technology built.

Growth in the energy system will require significant levels of new investment (as illustrated in the previous graph) as well as increased payments for fuel. However, energy system expenditures are generally expected to absorb a smaller percentage of GDP in 2030 due to the reduced energy intensity per unit of economic output, shown in Table 2.

A breakdown of the energy system cost components is presented in Table 4, showing the growth in expenditure for fuel (extraction, import, and sector-based charges), operating and maintenance costs (fixed and variable), investments in new power plants, and the purchase of new end-use devices. The investment expenditures for new power plants and devices are incurred as demand rises and existing power plants and devices reach the end of their operational lifetimes.

Table 4. Annual Energy System Expenditure (€ Million)[5]

Expenditure Type	2009	2012	2015	2018	2021	2024	2027	2030
Fuel Costs	2,296	2,673	2,986	3,253	3,593	3,894	4,350	4,927
Operation and Maintenance (O&M) Costs	3,560	3,938	4,458	4,854	5,338	5,943	6,528	7,203
Annualized Investment (Demand)	835	1,604	2,447	3,374	4,107	4,542	5,010	5,479
Annualized Investment (Power)	0	0	26	88	334	1,123	1,137	1,140
Total	**6,691**	**8,215**	**9,917**	**11,569**	**13,373**	**15,502**	**17,025**	**18,749**

Under the Reference scenario assumptions, to add the 5,070 MW of new generation capacity called for by 2030 a total investment of 14.4€ billion is required, which corresponds to average payments (over the model time horizon) of 430€ million per year. At the same time, by 2030 over 5.5€ billion annually will be required to cover the cost of new demand devices, with the majority of this investment made by the private sector, including households (and vehicles). Fuel supply costs will also increase significantly, driven by growing demand and increasing prices, from 2.3€ billion per year to 4.9€ billion.

To illustrate how the forced power plant builds affect the overall system behavior, a sensitivity case was examined where the power plants were not forced but rather given as options. Listed in Table 14. Key Assumptions in the Reference Scenario: Power Sector New PlantsTable 14 are those plants where either size or timing of new build decisions changed when a least-cost expansion was permitted. The resulting scenario showed 1.3% (1.7€ billion, 9.7€ billion in the power sector investments) decrease in overall system cost and only 27% increase in electricity consumption over the planning horizon compared to Reference's 44% (supplemented by liquid petroleum gas or LPG). The table below illustrates the major power plants builds in reference scenario (forced builds) and sensitivity scenario (builds by least cost optimization)

Table 5. Power Plant Build Differences between Reference and Sensitivity Scenarios

Power Plant	Reference Scenario MW(year)	Sensitivity Scenario MW(year)
TPP TENT B3	740 (2021)	250 (2030)
Kostolac B3	350 (2021)	260 (2024), 350 (2027)
HPP Velika Morava	150 (2021)	150 (2024)
HPP Middle Drina	320 (2024)	320 (2027)
PSHPP Bistrica	680 (2021)	240 (2021), 440 (2024)
PSHPP Djerdap III	2,400 (2024)	0 (2024)

[5] For power plants and end-use devices, the upfront capital cost is amortized over the lifetime of the unit with annualized payments calculated according to the lifetime and cost of capital. These annualized payments, along with associated operating and maintenance costs and fuel expenditures constitute the overall energy system cost. The annualized investment costs associated with existing power plants and demand devices are not included.

Other than some small changes in timing of some of new plants, the main difference is in TTP TENT B3, only built to 250MW instead of 750MW and delayed until 2030 instead of 2021. There are also differences in builds of pumped storage plants, with PSHPP Bistrica only 440MW instead of 680MW and PSHPP Djerdap III not built at all.

It must also be noted that choices of building the capacity in the sensitivity scenario is based on the assumption of zero electricity imports after 2018, because electricity imports are competitive to those new plants when not forced.

D. EXAMINATION OF THE PROMOTION OF ENERGY EFFICIENCY IN SERBIA

Energy efficiency is a priority for Serbia, as reflected in the Energy Sector Development Strategy (ESDS) of the Republic of Serbia until 2015, adopted in May 2005. The ESDS attempts to address current and future problems in the energy sector identifying priority programs which are needed for the energy sector and broader economic development. In the ESDS, energy efficiency is recognized as a key priority.[6]

A key policy initiative to promote energy efficiency goals is the National Energy Efficiency Action Plan. Such plans have been prepared under the requirements of Directive 2006/32/EC of the European Parliament and of the Council on energy end-use efficiency and energy services. The primary aim is that all Member States achieve an energy savings target of 9% of the average final inland energy consumption for the period 2001-2005 for the ninth year of application of this Directive.[7] The Energy Community has similar goals for the Contracting Parties

In the case of Serbia, this first Action Plan covers the period 2010-2018 and sets an intermediate indicative target for the first three-year period (up to the end of 2012) of 2%(0.16722Mtoe) of final energy consumption in 2008, and a target of at least 9% in 2018.

The implementation of measures needed to achieve the indicative target requires significant financial resources to be mobilized, energy efficiency improvement measures expanded, and the energy market to be further liberalized, especially on the supply side, as well as energy services and development of public-private partnerships in the field of energy efficiency.

This analysis provides insights into the cost-effective technologies that would be required to meet the NEEAP target. It is difficult to compare the outputs of this analysis with the measures listed in the NEEAP, as those measures tend to be related to policies and programs rather than technologies per se. It is also difficult to compare costs, as the NEEAP only cites implementation costs required in the public budget, not the costs of the actual technologies net of fuel savings (which MARKAL provides).

Also, it is well known that the costs of overcoming barriers to take-up of different technologies can be significant, and require strong policies and programs. Such barriers are highlighted in the World Bank (2010) report *Status of Energy Efficiency in the Western Balkans*.[8] The costs attributed to such barriers (e.g., long payback period, lack of familiarity, inconvenience, high transaction costs)

6 Energy efficiency has been also recognized as a priority in both Sustainable Development Strategy of the Republic of Serbia and National Economy Development Strategy from 2006 to 2012.

7 The above mentioned target does not apply to energy consumers covered by Directive 2003/87/EC of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community or to aviation and inland navigation sectors.

8 Report can be found at ECS website - http://www.energy-community.org/pls/portal/docs/664179.PDF

and extra hidden costs (e.g., appliance and building standards, information campaigns, low interest (subsidized) loans, "giveaway" programs for the poor) are accounted for in this analysis by the inclusion of so-called hurdle rates,[9] as discussed in Appendix II. As a result, such options are not invested in under the Reference case, but it is assumed that when energy efficiency policies (e.g., setting a NEEAP target) are pursued, programs aimed at reducing these impediments (or "hurdles") are also put in place, reducing those inherent added costs.

The basis for the energy efficiency target is the Serbian NEEAP, which has a percentage reduction calculated from the 2006-2009 average final energy consumption levels, which results in total reduction requirements from the Reference scenario levels as shown below in Table 6. As the NEEAP only extends out to 2018, it is assumed that the reductions under NEEAP continue over the later years in the planning horizon, reflecting Government ambition to maintain improvements in energy efficiency over time.

Table 6. Energy Efficiency Targets (from average 2006-2009 FEC)

Approach	2012	2015	2018	2021	2024	2027	2030
NEEAP target	1.5%	5.1%	8.7%	9%	9%	9%	9%
Reduction totals* (ktoes)	125.5	438.9	752.4	778.9	778.9	778.9	778.9

* Reduction totals are relative to average across 2006/2009 consumption levels

Introducing the NEEAP target to promote increased energy efficiency has significant benefits, as described below. Key insights include these.

- A decrease in the total discounted energy system costs of 0.3% (367€ million NPV) is observed under the NEEAP target. Without programs and policies to reduce barriers to uptake of energy efficient technologies, the cost to meet the same target is estimated to increase by 1% compared to Reference case.
- Over 3% cumulative reductions (5,060 ktoe) in imports are observed under the NEEAP target, enhancing energy security goals.
- Significant cumulative reductions in final energy of 5.8% are observed (14,847 ktoes). However, CO_2 emissions are only reduced by 3.9% (or 47,887 Kt). An equivalent reduction in CO_2 is not observed due to electricity savings (from efficiency measures) being exported, to generate additional cumulative revenues of 0.5€ billion.

Table 7 shows the key results as change between the EE and Reference scenarios. The *Energy Efficiency Promotion* illustrates the benefits of EE policies and measures that lower the barriers associated with the uptake of more efficient devices and the *Energy Efficiency + Target* represents the former but also requires that the NEEAP consumption reduction target be met. The first case illustrates that cost savings can be seen by EE promotion, when socio-economic barriers to uptake of more efficient technologies are reduced. In the second case, a target "forces" the model to go beyond this economically efficient level, and deploy additional higher cost technologies to meet the target level.

Under the *Energy Efficiency Promotion* case (no EE target but reduced barriers to uptake), there is only a 3.5% reduction in final energy consumption in 2018 (not the required 9% under NEEAP),

[9] For example, UK studies include *The hidden costs and benefits of domestic energy efficiency and carbon saving measures* (Ecofys 2009) and *Review and development of carbon dioxide abatement curves for available technologies as part of the Energy Efficiency Innovation Review* (Enviros Consulting 2006).

with an overall energy system savings of 862€ million (or 0.7%, as shown in Table 7) over the planning horizon. However, simply removing some of these barriers is not enough to meet the reduction levels required by the target in the NEEAP. So finding the balance between policies, programs, and targets is important to ensure that goals are achieved without undue burden on the economy or individuals.

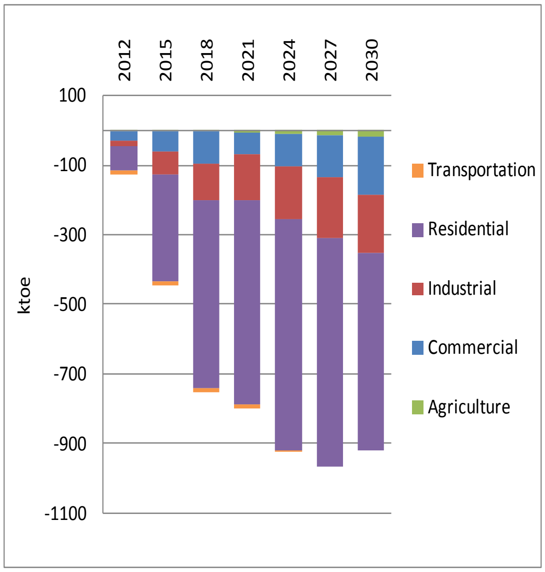
Thus, the focus here is on the *Energy Efficiency + Target* case, as the NEEAP is the main ongoing policy action in this area. As shown in Table 7, all of the key cumulative metrics (other than investment in new demand technologies) are reduced due to efficiency savings while meeting the NEEAP target. Total system costs decrease by 0.3% (367€ million), imports drop by 3%, and fuel expenditure goes down by 4.6%; saving 1.65€ billion/5,060Ktoe and 4.1€ billion respectively. Such savings enhance economic competitiveness and energy security, and can serve to offset the higher cost of the more efficient devices to households. No major decrease in new power plant capacity additions is observed, due to the majority of new power plants being forced onto the model. It is worth noting that electricity exports increase by 20%, generating the additional cumulative revenue of 0.5€ billion. This increase is due to the forced new power plants and electricity savings in demand sectors. These exports should be treated with caution, especially considering the uncertainty relating to the regional electricity market.

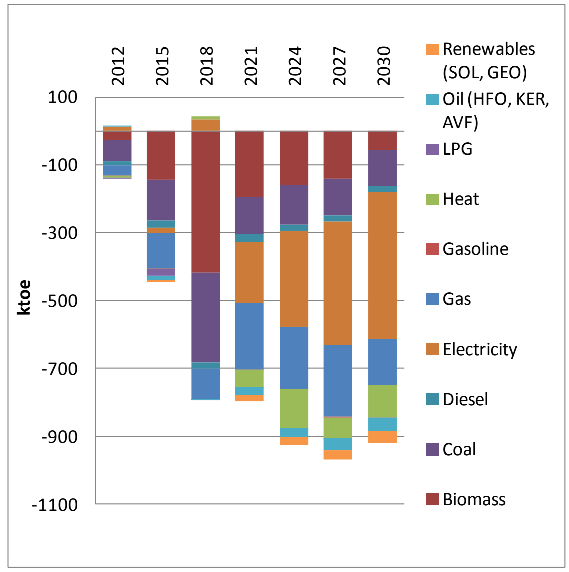
Table 7. Cumulative Impacts of the EE Target on the Energy System (Change Compared to Reference Scenario)

Indicator	Units	Reference	Energy Efficiency Promotion		Energy Efficiency + Target	
Total Discounted Energy System Cost	2006M€	131,149	-862	-0.7%	-367	-0.3%
Primary Energy Supply	Ktoe	423,624	-14,240	-3.4%	-16,960	-4.0%
Imports	Ktoe	167,393	-2,965	-1.8%	-5,060	-3.0%
Fuel Expenditure	2006M€	90,797	-3,429	-3.8%	-4,132	-4.6%
Power Plant New Capacity	MW	6,348	-46	-0.7%	-52	-0.8%
Power Plant Investment Cost	2006M€	14,403	-73	-0.5%	-83	-0.6%
Demand Technology Investments	2006M€	82,195	3,178	3.9%	5,300	6.4%
Final Energy	Ktoe	254,744	-9,811	-3.9%	-14,847	-5.8%
CO_2 Emissions	Kt	1,231,297	-52,109	-4.2%	-47,873	-3.9%

The contribution of different sectors to the targets is shown in Figure 5 indicating the major role of the residential sector in achieving savings, accounting for 69% of total savings. This is followed next (based on level of contribution) by the industry (16%) and commercial sectors (13%). In terms of fuels, the largest reductions come from biomass, coal, gas, and electricity (post-2020).

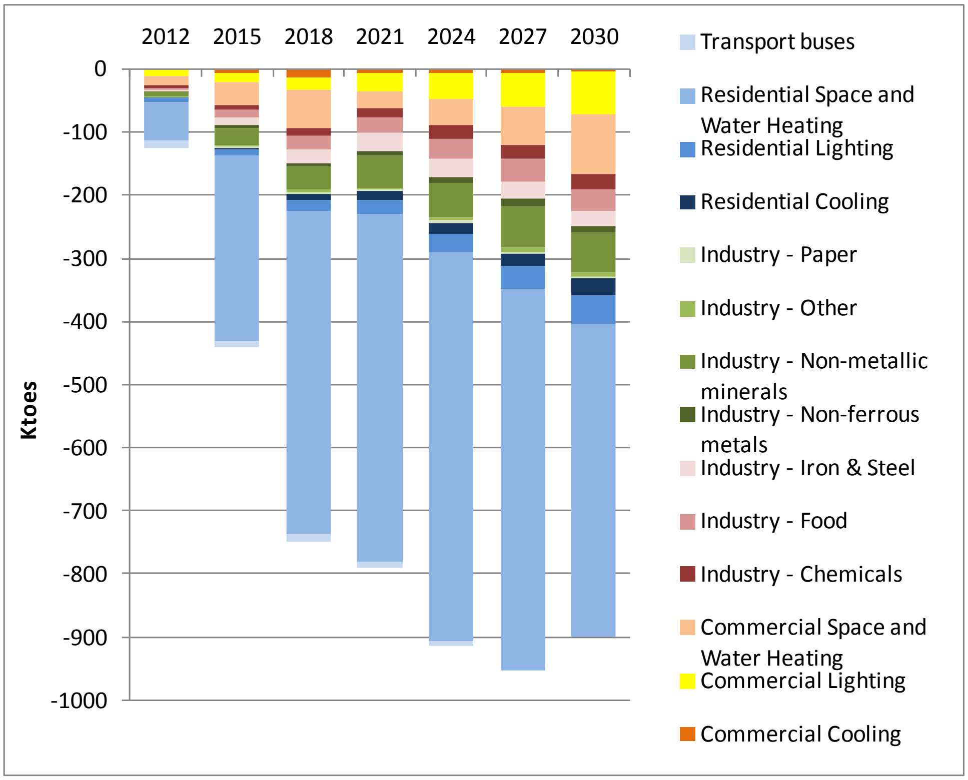
Figure 5. Final Energy Reduction by Sector and Fuel under Energy Efficiency Target





A more detailed overview of savings by energy service demands is shown in Figure 6. The most cost-effective reductions occur through more efficient provision of space and water heating in residential and commercial sectors, with a strong uptake of more efficient energy using technologies. In terms of fuels, savings are observed in gas, electricity, and biomass (wood) consumption in residential sector and coal in commercial. Significant savings of electricity are observed for lighting in both of these sectors. In industry, savings are most prevalent in the food, chemical and non-metallic mineral industries, where efficiency savings from process heat and mechanical energy are realized, with savings in coal, low temperature heat, and electricity.

Figure 6. Final Energy Reduction by Energy Service Type under Energy Efficiency Target



It is important to highlight that there are significant uncertainties concerning the potential of opportunities for energy efficiency. This is highlighted in the World Bank (2010) report *Status of Energy Efficiency in the Western Balkans*. Therefore, it is important to continually review the model assumptions, assessing new data available in Serbia to further encourage confidence in the analysis.

Under the EE target, costs are shown to decrease as a result of significant reductions in fuel expenditures saving over 4€ billion over the planning horizon. While the cost of demand technologies increases (due to the use of more advanced types), this additional cost is nearly offset by the savings in fuel costs. Economic benefits may in fact be greater if the wider economic benefits that come from energy efficiency, in terms of export competitiveness or stimulating new industries are captured; however, these macro effects are not accounted for in this analysis.

Note also that a more aggressive NEEAP target post-2018 can be achieved at only modest additional cost. A 15% reduction by 2024 results in additional costs of only 0.1% compared to current EE target case, highlighting scope for additional efficiency opportunities which are still relatively low cost.

Such insights are useful in the context of the EU ambition to reduce primary energy by 20% by 2020 (relative to projected primary energy consumption). In fact, the EU is proposing a new Directive (*Proposal for a Directive of the European Parliament and of the Council on energy efficiency and repealing Directives 2004/8/EC and 2006/32/EC. EC draft 12046/2011, COM(2011)370, Issued 22 June 2011*) that is seeking to ensure that the 20% energy efficiency target can be met by 2020 – as current legislation (including the ESD) will not achieve this goal.

E. ASSESSMENT OF A RENEWABLE ENERGY STRATEGY FOR SERBIA

A Renewable Energy Directive for the EU sets targets for Member States in order to achieve the objective of getting 20% of its energy from renewable sources by 2020. This Directive is part of the set of measures that will enable the EU to cut greenhouse emissions and make it less dependent on imported energy. In addition, this will help develop the clean energy industry, further encouraging technological innovation and employment.

The Energy Community Secretariat (ECS) commissioned a study in 2009 examining illustrative RE targets for the contracting parties,[10] adopting the RE Directive methodology for allocating targets, with biofuels assumed to contribute 10% of transportation sector energy requirements. This study has subsequently been updated with revised targets estimated.[11] A 2020 renewables target of 29% of Gross Final Energy Consumption for Serbia has been proposed by the ECS and was used in the analysis presented here.

Key insights to achieve the RE target are summarized in Table 8 and elaborated upon in the rest of this section.

- Cumulative energy system costs (to 2030) are 2.4% higher. This is largely due to the 2,075 MW additional power sector additions needed, with associated investment increasing by 70%, or by 10.12€ billion over that in the Reference scenario.
- Energy security is enhanced owing to a 4.4% cumulative decrease in imports, saving cumulatively about 2.4€billion.
- Cumulative exports, increase by 20%, based on exports of electricity, resulting in additional revenue of 0.55€billion.
- Demand for final energy decreases by 2.8% as a result of more efficient use of energy. More efficient technologies are introduced to lower the final energy consumption owing to somewhat higher electricity prices, which in turn makes achieving the Renewable target easier. This reduction is modest because the EE technologies are introduced without accounting for promoting of energy efficiency measures (in contrast with combined EE+RE case discussed below, where measures to increase uptake of advanced technologies are implemented together with both targets).

[10] Study on the Implementation of the New EU Renewable Directive in the Energy Community to Energy Community Secretariat, International Policy Analysis (IPA) Energy + Water Economics, United Kingdom, February 2010.

[11] Updated Calculation of the 2020 RES Targets for the Contracting Parties of the Energy Community, Presentation by ECS to 8th Renewable Energy Task Force meeting, 06 March 2012.

Table 8. Cumulative Impacts of the RE Target on the Energy System (Compared to Reference Scenario)

Indicator	Units	Reference	RE target change	
Total Discounted Energy System Cost	2006M€	131,149	3,137	2.4%
Primary Energy Supply	Ktoe	423,624	-14,594	-3.4%
Imports	Ktoe	167,393	-7,355	-4.4%
Fuel Expenditure	2006M€	90,797	-5,242	-5.8%
Power Plant New Capacity	MW	6,348	2,075	32.7%
Power Plant Investment Cost	2006M€	14,403	10,116	70.2%
Final Energy	Ktoe	254,744	-7,038	-2.8%
CO_2 Emissions	Kt	1,231,297	-117,544	-9.5%

Serbia already has a relatively high projected use of renewable energy. In 2021, it is estimated that there will be a 20% share of renewable energy in the Reference scenario. In other words, renewable electricity generation is playing a crucial role in meeting future demand without a renewable energy target. Pursuing the proposed EC renewable target has energy security and carbon reduction merit, though at a cost.

Adapting the energy system to meet the RE target increases total energy system costs by 2.4%, or 3,137€ million relative to the Reference scenario over the entire planning horizon. Most notably, under the RE target, cumulative additions in renewable power generation capacity (between 2009-2030) total 3,059 MW out of total new capacity of 8,430 MW (including 3,080 MW pump storage hydro plants). This is an additional 2,075 MW of RE capacity (compared to the Reference case), the majority of which is new hydro capacity. This suggests that meeting the target and, critically, sustaining it beyond 2020, will require strong policies to stimulate investment and attract high levels of capital in the power generation sector. The additional capital required under the RE target in the power generation sector is estimated at 10.12€ billion.

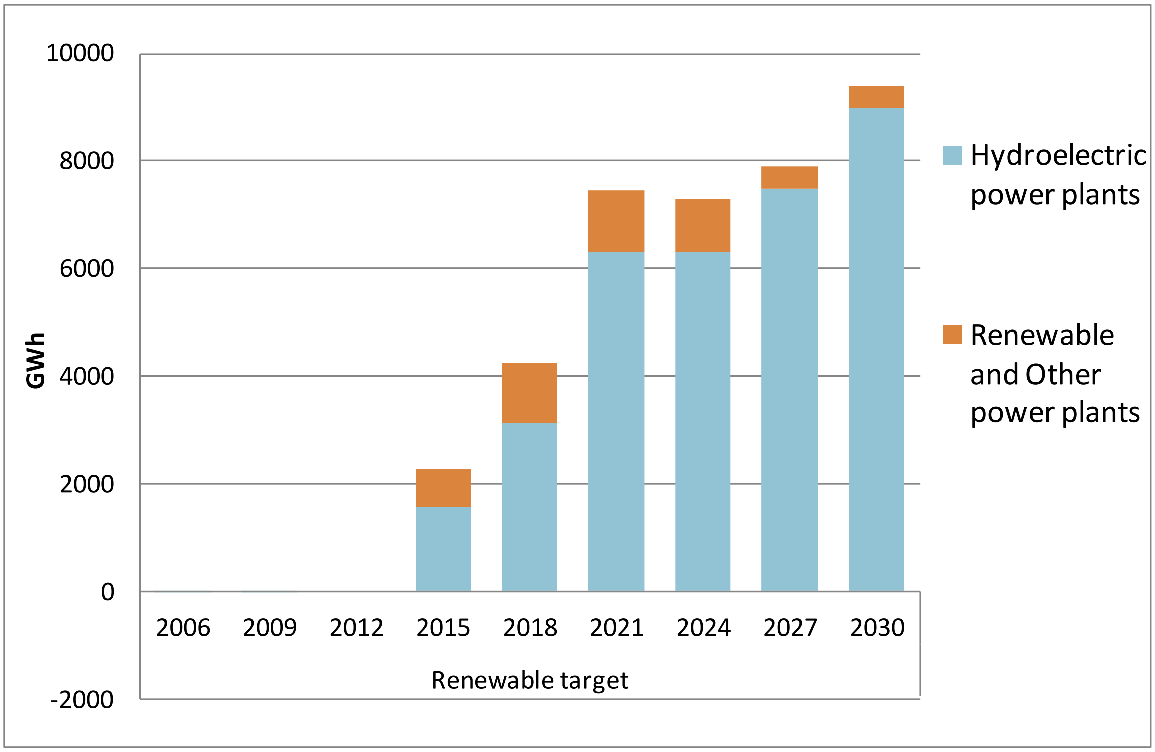
A consequence of this substantial increase in more expensive renewable generation is a doubling of the electricity price by 2030 (based on the marginal cost of generation calculated in the model). While overall electricity consumption increases, the higher price does incentivize the uptake of more efficient devices, which is why combining the EE and RE policies has merit, as discussed in the next section.

It is worth noting that even if new power plants are not forced to be built, the same amount of additional renewable capacity is necessary to meet the target as in the RE scenario with forced builds. However, about 1,000 MW less coal is built in this case, due to lower electricity consumption and the fact that in the RE scenario with forced builds much of the coal capacity remained idle (utilization of only 20% verse 65% in the Reference scenario in 2021) in order to achieve the RE target.

The other contributor to the renewable energy target is biofuels, which are required to contribute a minimum of 10% of transport fuels by 2020. In 2021, the percent contribution of biofuels to additional renewable energy required is around 11%; decreasing down to 7% in 2030 (though remaining 10% of transportation). Sustaining the target after 2020 becomes significantly more difficult due to the overall growth of the energy system (making the same percentage share much higher in absolute terms). Additional hydro capacity is required to sustain the target, highlighting a critical need for decision-makers to take into consideration the post-2020 regime and plan for even higher investment levels if the RE target share is to be maintained.

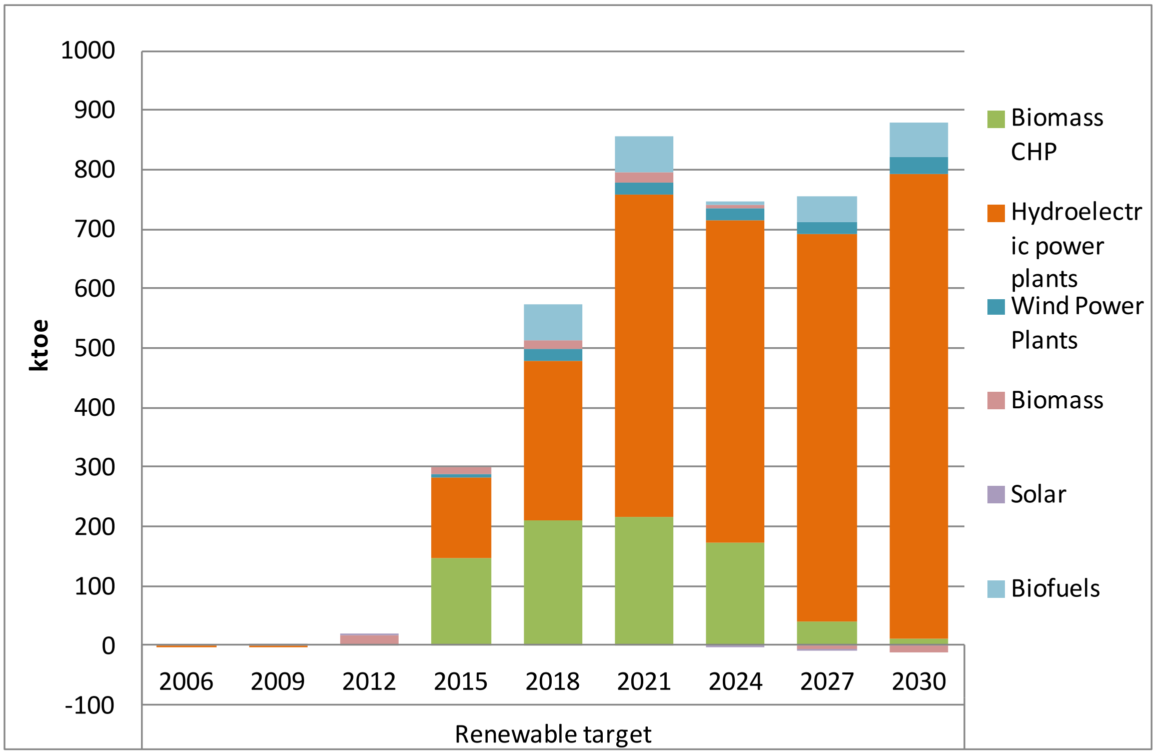
A summary of the change in renewable electricity generation (compared with the Reference scenario) is provided in Figure 7.

Figure 7. Additional Renewable Electricity under RE Target, Compared to the Reference Scenario



Total renewable energy under the Reference and RE target cases are compared below, in Figure 8.

Figure 8. Change in Total Renewable Energy from Reference



While the challenges of ramping up investment to meet the target are clear, a significant shift to renewables has two important co-benefits. Energy imports drop by over 4.4% and CO_2 emissions are reduced (cumulatively) by almost 9.5% relative to the Reference scenario. This suggests strong synergies between an ambitious renewable policy and other policies relating to energy security, competiveness, low emission strategies. Furthermore, as discussed in Section F, coordinating policies that encourage energy efficiency can dramatically enhance the benefits and lower the cost of meeting a renewables target.

F. COORDINATED RENEWABLES AND ENERGY EFFICIENCY POLICIES FOR SERBIA

Promoting both energy efficiency and renewable energy goals in parallel has strong policy synergies, and is more cost-effective when pursued jointly. Key insights are summarized here.

- Energy system costs increase by 1,918€ million or 1.5%, as compared with 2.4% seen to reach the RE target without a coordinated EE promotion policy.
- The measures to reduce final energy through energy efficiency (which is reduced by 6.4%) means a lower level of renewable energy required, resulting in lower overall costs.
- Imports and CO_2 emissions are reduced by 5.8% and 13.3% respectively, illustrating important synergies and co-benefits arising from the implementing efficiency and renewable energy policies together.

Table 9 shows the key differences in results metrics between the combined RE & EE scenario and the Reference scenario.

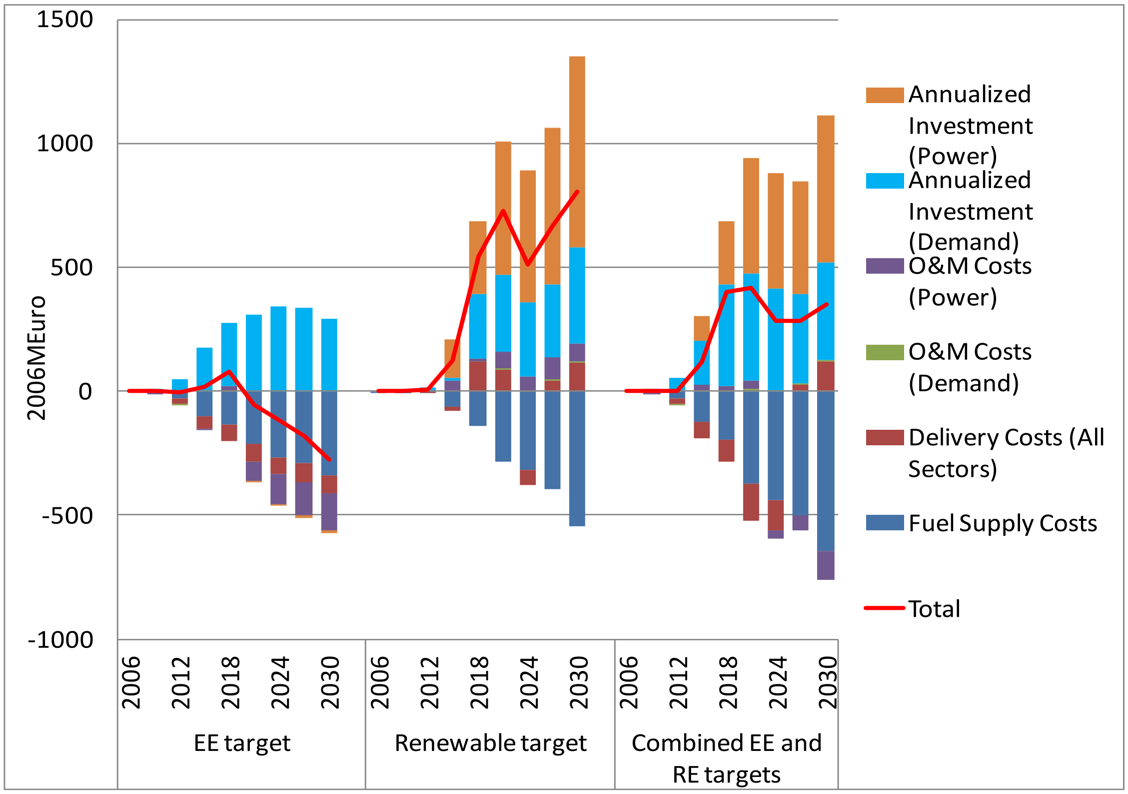
Table 9. Cumulative Impacts of Combined RE/EE Targets on the Energy System (Compared to Reference Scenario)

Indicator	Units	Reference	Energy Efficiency + Renewable Target	
Total Discounted Energy System Cost	2006M€	131,149	1,918	1.5%
Primary Energy Supply	Ktoe	423,624	-28,120	-6.6%
Imports	Ktoe	167,393	-9,750	-5.8%
Power Plant New Capacity	MW	6,348	1,684	26.5%
Power Plant Investment Cost	2006M€	14,403	7,751	53.8%
Demand Technology Investments	2006M€	82,195	6,715	8.2%
Final Energy	Ktoe	254,744	-16,240	-6.4%
CO_2 Emissions	Kt	1,231,297	-164365	-13.3%

Figure 9 shows the change in annual energy system costs for the three policy scenarios relative to the Reference scenario. The bars show the increases (positive) and decreases (negative) in annual system cost components, and the change in net costs over time is shown as the red line.

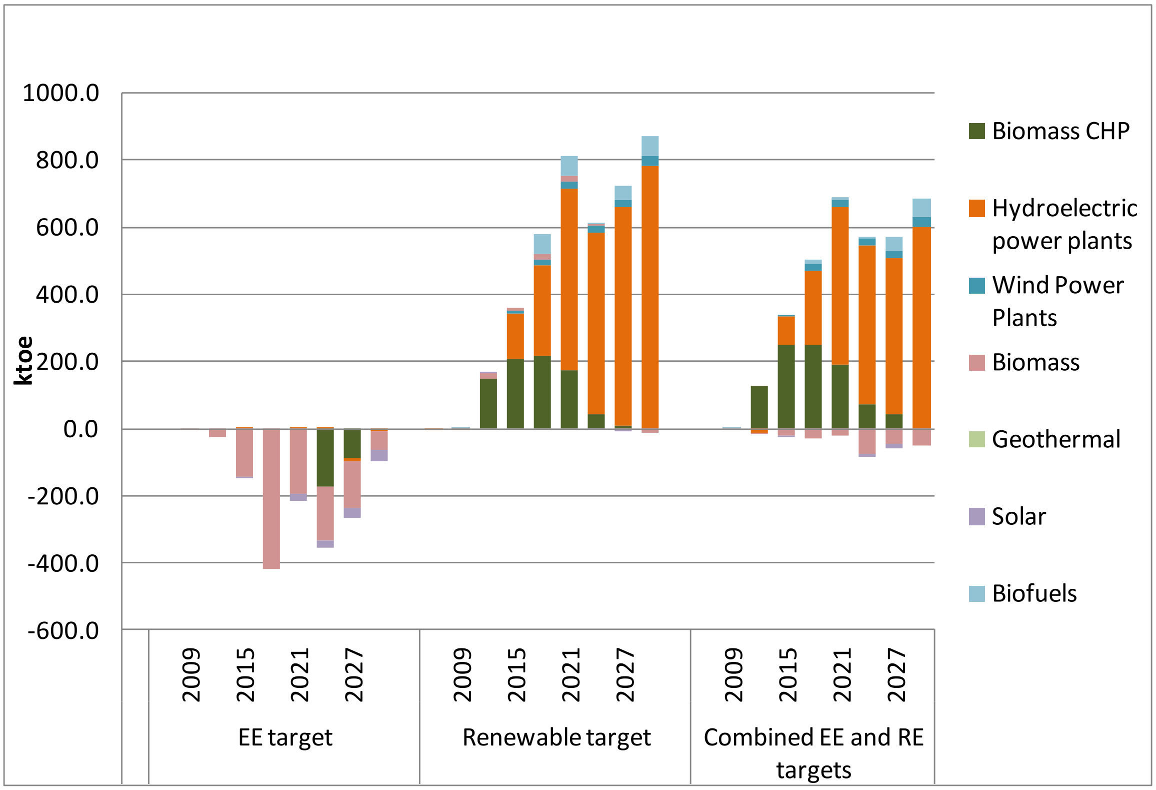
Overall, costs increase when an RE target is in place due to the additional investment needs for renewable generation capacity, and the additional costs of energy efficient demand devices when an EE target is imposed. Fuel savings (in dark blue) can be seen in all scenarios, reaching over 650€ million per annum in the combined scenario by 2030 dampen the effects of the higher investment requirements.

Figure 9. Costs and Savings from Renewable and Energy Efficiency Policies



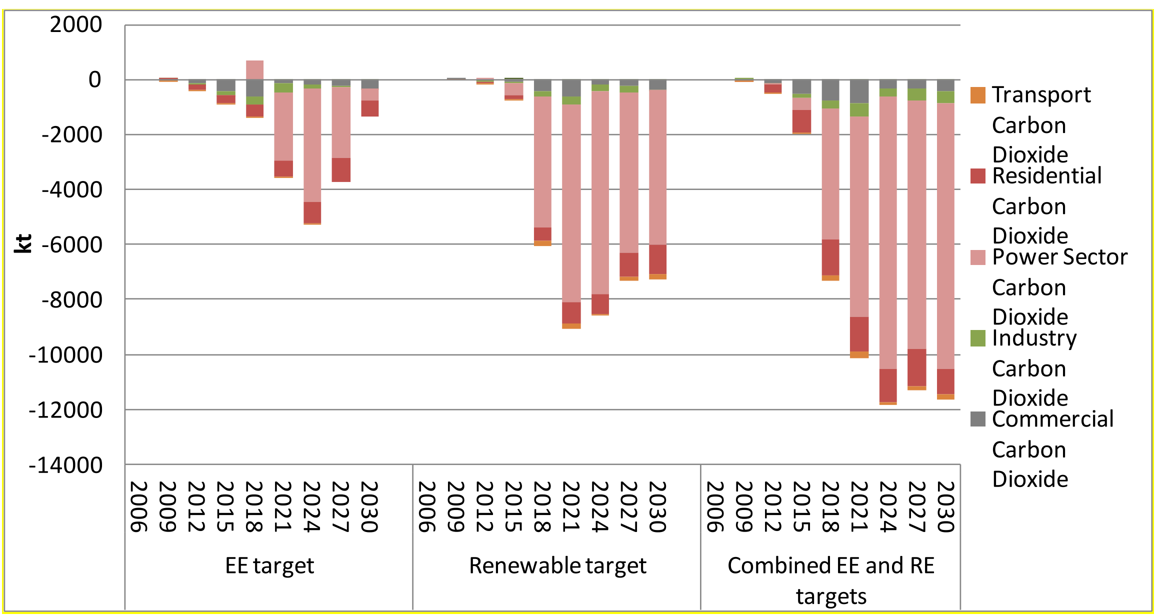
The synergies of meeting both targets at an overall lower cost are illustrated in Figure 10 below. Energy efficiency results in lower levels of renewable energy being required, as the renewable target is relative to (gross) final energy consumption.

Figure 10. Renewable Energy Consumption under RE and RE+EE Combined Cases



CO_2 emission reductions are shown in Figure 11, illustrating the significant savings associated with energy efficiency and renewable policy, in particular when pursued in tandem.

Figure 11. Sectoral CO_2 Emission Reductions under RE, EE and RE+EE Combined Cases



G. EXPLORING ADDITIONAL NATIONAL PRIORITIES – DEMAND FOR ENERGY UNDER HIGHER ECONOMIC GROWTH

There is significant uncertainty around the assumptions of economic growth for the Republic of Serbia. When the ESDS was being developed, there were no official projections of GDP growth, so macroeconomic and demographic parameters and energy indicators of relevance were established on the basis of expert consultations, out to 2015.

The following two scenarios of economic and industrial development of the Republic of Serbia until 2015 were included in ESDS:

1. Prosperous economic development (the PED scenario), based on a gradual increase in the already moderately high gross domestic product (GDP) growth rate and industrial value added (IVA) rate, and
2. Slow economic development (the SED scenario), based on a slower GDP growth and IVA rate.

The growth rates assumed are shown in Table 10 below.

Table 10. Predicted GDP growth rates for the period 2006-2015 from ESDS

GDP Growth Rate	2006-2009	2009-2012	2012-2015
PED Scenario (%)	4.4	4.9	5.2
SED Scenario (%)	2.9	3.2	3.4

Source: ESDS

The Reference case actually uses a lower growth rate than the SED projection to 2015, due to slower than predicted growth in the economy in recent years. However, significant uncertainties remain how growth might change in future years, particularly given current economic uncertainty. This suggests this is an important factor to assess through sensitivity analysis. Therefore, a high growth scenario has been run, similar to the growth rate predicted under the

PED scenario. The assumed growth rates for this high growth case are compared the Reference case in Table 11 below.

Table 11. Assumed GDP growth rates in Reference and High Growth scenarios

GDP Growth Rate	2009	2012	2015	2018	2021	2024	2027	2030
Reference Scenario (%)	2.50	1.00	2.00	3.00	4.00	4.50	4.50	4.50
High Growth Scenario (%)	2.50	3.00	5.20	5.20	5.20	5.20	5.20	5.20

The key findings are summarized below, and reflected in Table 12 and figures that follow.

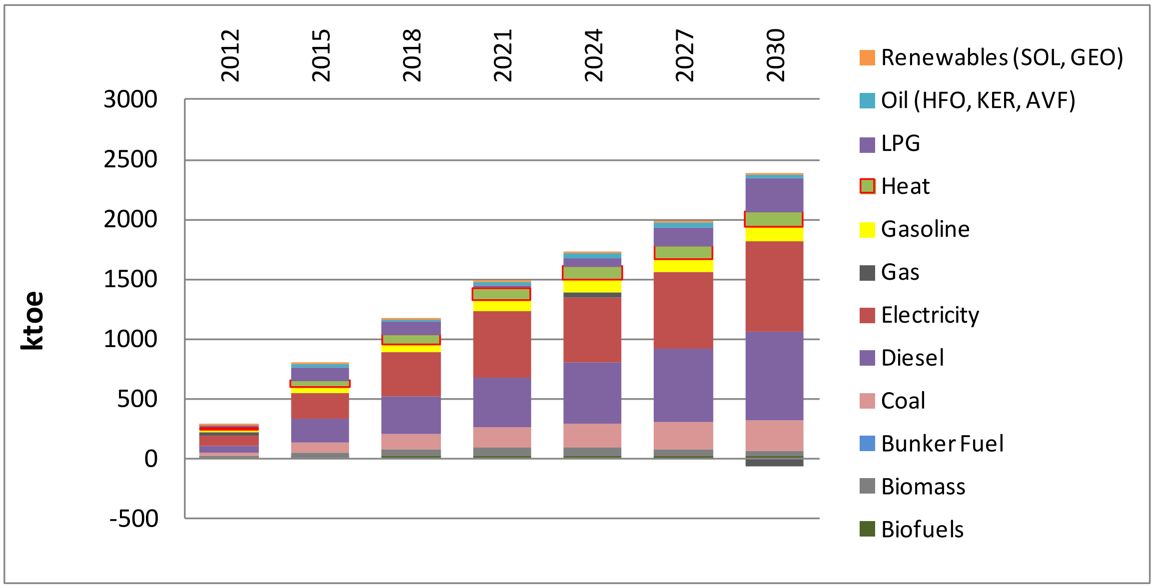
- A higher growth rate inevitably leads to an increase in the cost of the energy system. An additional cost of 14€ billion is estimated, or a 10.7% increase compared to the Reference scenario. The increased cost is primarily driven by increased fuel expenditures and demand technology investments.
- A cumulative 33,395 ktoe (7.9% increase) of more primary energy and 29,113 ktoe (11.4% increase) of more final energy will be required to satisfy a larger economy.
- Despite the growth in electricity consumption, the electricity generation system doesn't require any significant additional capacity to satisfy increased demand until 2030. This is primarily because in the Reference scenario there was excess power plant capacity (that were forced to align with the ECES) which was underutilized, as well as the fact that some exports are now shifted to meet domestic demands.

Table 12. Key Results: Higher Economic Growth sensitivity (Cumulative) Difference from Reference Scenario

Indicator	Units	Reference	High Growth Change	
Total Discounted Energy System Cost	2006M€	131,149	14,029	10.7%
Primary Energy Supply	Ktoe	423,624	33,395	7.9%
Imports	Ktoe	167,393	20,934	12.5%
Fuel Expenditure	2006M€	90,797	14,706	16.2%
Power Plant New Capacity	MW	6,348	-19	-0.3%
Power Plant Investment Cost	2006M€	14,403	-30	-0.2%
Demand Technology Investments	2006M€	82,195	16,113	19.6%
Final Energy	Ktoe	254,744	29,113	11.4%
CO_2 Emissions	Kt	1,231,297	95,561	7.8%

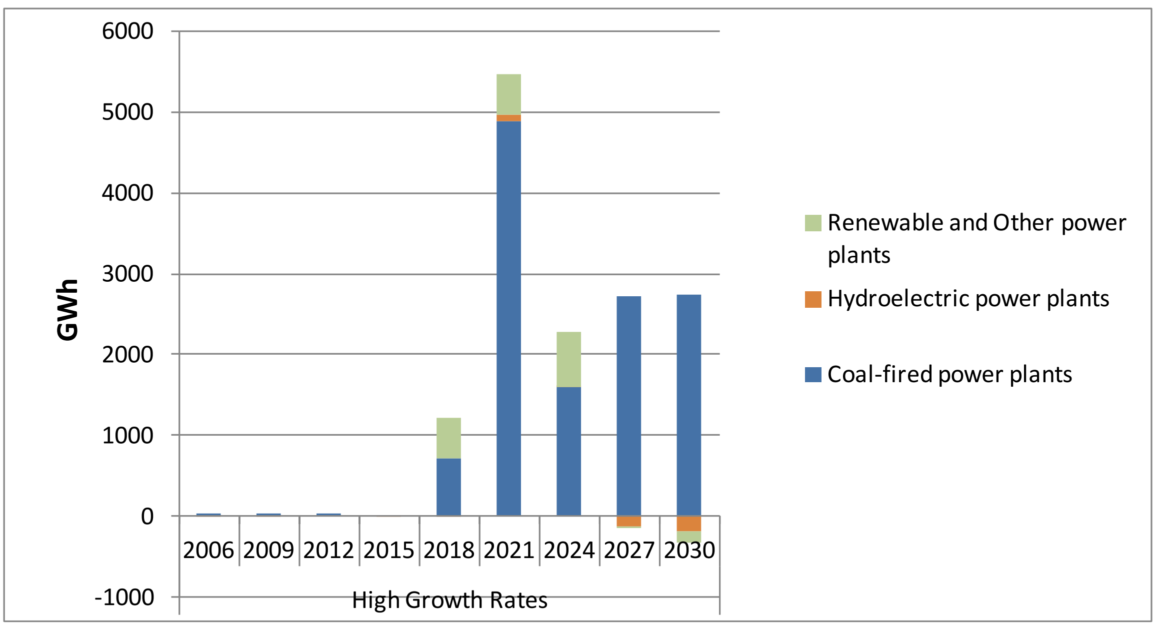
Final energy consumption grows by 11.4% compared to the Reference case, a growth of 60% in 2030 compared to 2006 (versus the Reference 32% increase). The largest increases are observed across coal, diesel, and electricity, as illustrated in Figure 12.

Figure 12. Change in Final Energy Consumption in High Growth Scenario



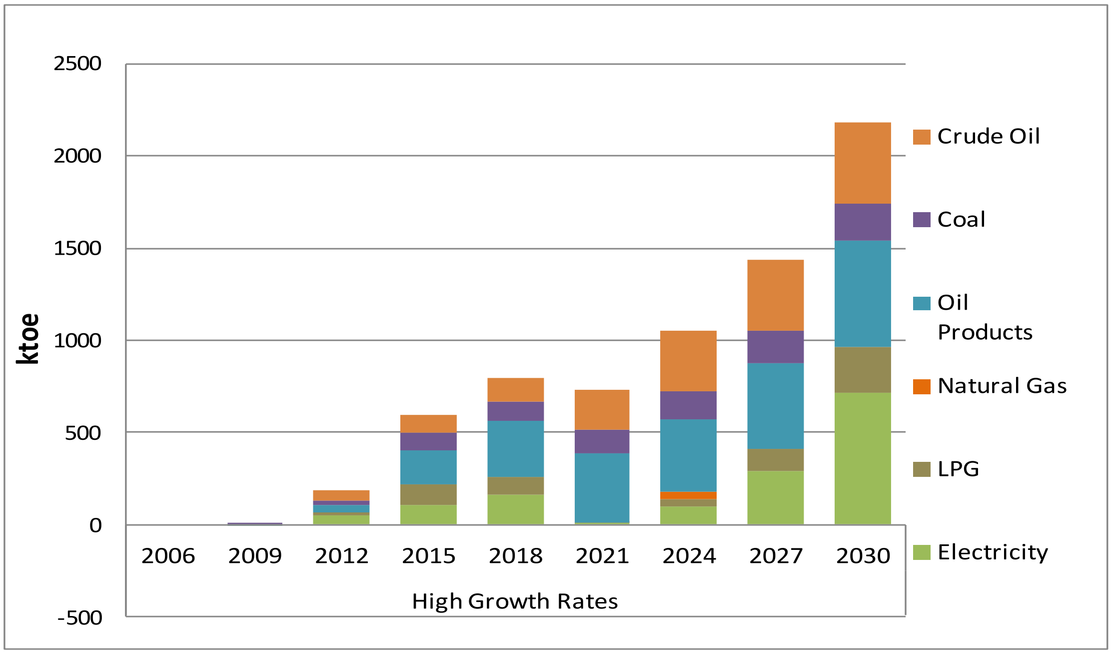
Electricity consumption across end-use sectors grows by about 14% under the high growth scenario, which can be satisfied by almost the same level of generation capacity, based on higher load factors and lower exports of electricity (48% less than under the Reference case). The increase in generation output is shown in Figure 13.

Figure 13. Change in Electricity Generation under High Growth Scenario



Imports grow by 12.5%, increasing Serbia's reliance on imported fuels. Major contributors to the increase are crude oil (4995ktoe) and oil products (6992ktoe). Electricity imports appear in different amounts, but are compensated for by exports. Figure 14 shows the change in imports in a High Growth scenario compared to the Reference case.

Figure 14.Change in Imports under High Growth Scenario



Due to economic growth CO_2 emissions also increase by 7.8% cumulatively compared to Reference scenario.

In summary, the results show that higher economic growth will increase the overall costs of a country's energy system and its dependence on imported fuels. Nevertheless, the current plan for construction of new power plants for electricity generation is enough to cover higher growth of electricity demand until 2030.

APPENDIX I: DATA SOURCES AND KEY ASSUMPTIONS

The Serbia analysis is based on numerous data inputs and assumptions, and therefore requires a set of key national data sources. The sources of this information are listed by data requirement in Table 13 below.

Table 13. Key Data Sources

Data Requirement	Source
2006 Energy Balance	Annual Energy Report for year 2006 by Statistical Office Annual Energy Report for year 2009 by Statistical Office Energy balance for year 2006. by , Ministry of Mining and Energy Energy balance for year 2009. by , Ministry of Mining and Energy
Domestic Energy Prices	Annual Energy Report for year 2006 by Statistical Office, Actual energy prices for 2009.
Resource Potential, including imports/exports	Ministry of Mining and Energy Statistical office of Republic of Serbia Electric Power Industry of Serbia
Installed capacity and characterization of existing electricity, heating and CHP plants	Electric Power Industry of Serbia
New Power Plant Builds by plant (type)	Electric Power Industry of Serbia, "Srednjoročni plan razvoja 2008-2015 sa osvrtom do 2025" (ECES)
Electricity generation by plant (type)	Electric Power Industry of Serbia
Timing of demands for energy services	Assumptions are consistent with analysis of the overall electricity load duration curve for 2008
Fuel consumption patterns by energy service	Statistical office of Republic of Serbia
Demand Drivers	Expert team assumptions Base year GDP: Official 2006 data Projected GDP growth: Planning team assumptions
Known energy policies	Energy Strategy of Republic of Serbia until 2015 National Plan for Energy Efficiency

Drawing on these data sources the underlying assumptions and thereby resulting model is reasonably strong. However, there are some specific areas where data availability and quality could be further improved – in particular, household and commercial appliance breakdown and industrial processes, either through better coordination with statistical agencies or based on further research.

The Planning Team has ensured (to the extent possible) that current or planned policy is reflected in the Reference scenario (e.g. Feed-in tariffs for renewable energy, natural gas import policy, power plant new builds are in line with the ECES. They have also consulted with different sector experts to ensure that the Reference scenario in the model is reasonable, and does not diverge significantly from other analyses undertaken e.g. for the Energy Strategy, Energy Efficiency Strategy.

A set of key assumptions comprising the Reference case, which properly reflects the situation in Serbia, are presented in Tables 14 and 15.

Table 14. Key Assumptions in the Reference Scenario: Power Sector New Plants
New Electricity Plant Performance and Cost Data

Conversion Technologies	Life-time	Start	Fuel	Efficiency (based on LHV of fuel)	Heat/ Elc ratio	Investment Cost (EUR/Kw)	Availability Factor AF(T)[12,13]	Capacity (MW)	Forced/ Optional[14]
Cogen.Biomass.Elec+Heat .Decen.06	25	2009	Biomass	0.31	1.742	1,600	0.85	150	optional from 2012
CCGHTP Novi Sad	35	2015	Natural gas	0.45	0.67	710	0.85	450	forced in 2015
TPP Kolubara B1&B2	40	2018	Lignite/Elc	0.39		1,000	0.80	750	forced in 2018
TPP TENT B3	40	2021	Lignite/Elc	0.41		2,162	0.80	740	forced in2021
Kostolac B3	40	2021	Lignite/Elc	0.40		1,710	0.80	350	forced in 2021
Lignite Coal plant centralized general	40	2027	Lignite/Elc	0.45		1,000	0.80		optional from 2027
HPP Velika Morava - Run of River (RoR)	80	2021	Hydro	1.00		2,400	Summer 0.5, winter 0.66, intermediate 0.61	150	forced in 2021
HPP IBAR - RoR	80	2024	Hydro	1.00		2,580	Summer 0.5, winter 0.66, intermediate 0.62	1,170	forced in 2024
HPP Upper Drina - RoR	80	2024	Hydro	1.00		1,740	Summer 0.5, winter 0.66, intermediate 0.63	0.25	forced in 2024

[12] In the model, 'winter' season is 15 Nov - 15 Mar, 'summer' season is 1 Jun -15 Sep; the rest of the year is 'intermediate'

13 The seasonal availability factors are based on availability factors of existing plants, calculated using 2008-2010 average generation

[14] According to the EPS Capacity Expansion Strategy (ECES) till 2025.

Conversion Technologies	Life-time	Start	Fuel	Efficiency (based on LHV of fuel)	Heat/ Elc ratio	Investment Cost (EUR/Kw)	Availability Factor AF(T)[12,13]	Capacity (MW)	Forced/ Optional[14]
HPP Middle Drina - RoR	80	2024	Hydro	1.00		2,720	Summer 0.5, winter 0.66, intermediate 0.64	0.32	forced in 2024
Large Hydro plant general	80	2027	Hydro	1.00		3,500	Summer 0.5, winter 0.66, intermediate 0.65		optional from 2027
Small hydro new	60	2009	Hydro	1.00		5,850	Summer 0.42, winter 0.51, intermediate 0.4	0.02	optional from 2012
PSHPP Bistrica	40	2021	Hydro	0.75		810	0.200	0.68	forced in 2021
PSHPP Djerdap III	40	2024	Hydro	0.75		3,500	0.200	2.4	forced in 2024
Power plant, wind medium farms.06.decentralised	20	2027	wind	1.00		950	0.250		optional from 2027
Power plant, solar PV, centralised.06.	30	2012	solar	1.00		2,000	0.100	0.03	optional from 2012
Power plant, wind large farms.06.centralised	30	2015	wind	1.00		950	0.150	0.03	forced in 2018

Table 15. Key Assumptions in the Reference Scenario: Import Commodity Price Assumptions[15]

Energy Type	Units	2006	2009	2012	2015	2018	2021	2024	2027	2030
Oil	($/boe)	61.72	60.40	75.35	94.00	103.30	111.93	117.93	123.90	130.00
Gas	($/MBTU)	7.31	7.40	8.90	10.70	11.52	12.26	12.74	13.29	13.90
Coal	($/ton)	62.87	97.30	97.55	97.80	102.52	106.53	108.75	110.69	112.50
Electricity	EUR/kwh	0.037	0.037	0.039	0.040	0.041	0.043	0.044	0.045	0.047

15 For fossil commodities, these are 'beach' prices based on IEA projections (WEO 2010) and therefore do not take account of additional taxes or delivery costs specific to Serbia (although these are captured in the model);

The primary data for technologies used in the non-transport end-use sectors draws on the technology characterizations employed in the EU NEEDS model. This is a pan-European MARKAL/TIMES model that has evolved into a standard planning framework for numerous EU countries, as well as the EU Joint Research Centre, and used for key EU policy analysis (such as RES2020 examining the RES directive http://www.res2020.eu/).

Technology characterizations depict the current typical technology available in 2009, and then assumptions are made that reflect the cost and performance improvement of more efficient alternatives. There are more than 300 instances of these core technologies, and then up to three levels of improved devices available to the analyst to include in their model. The cost (M€/PJa) and performance characteristics for a subset of the key base devices are shown in Table 16.

Table 16. Characterization of Key Base Demand Devices

Energy Service Demand	Demand Device	Investment Cost (€/GJ)	Efficiency (Fraction)
Commercial cooling	Central air conditioning	2.74	3.00
	Air heat pump	6.26	3.40
	Split air conditioner	2.74	3.00
Commercial lighting	Incandescent bulbs	5.00	1.00
	Halogen lamps	30.00	2.00
	Fluorescent lamps	20.00	4.00
Commercial space heating	Electric furnace	3.90	0.85
	Gas furnace	4.88	0.76
	Oil furnace	5.37	0.70
	Solar thermal (with oil)	23.42	0.68
	Solar thermal (with gas)	15.75	0.70
Commercial water heating	Electric water heater	10.00	0.90
	Gas water heater	20.00	0.70
	LPG water heater	20.00	0.70
	Oil water heater	12.00	0.65
Iron & Steel High temperature heat	High temperature heat (Gas)	20.00	0.75
Iron & Steel Mechanical drive	Motor drive (Electricity)	5.00	0.88
Iron & Steel Low temperature heat	Low temperature heat	10.00	0.72
Residential space heating	Electric Furnace	4.49	0.86
	Gas Furnace	4.39	0.67
	Oil Furnace	6.17	0.62
	Solar thermal (with oil)	15.85	0.68
	Solar thermal (with gas)	8.96	0.70
	Ground source heat pump	20.13	3.33
	Solar heat pump	16.78	4.00

Energy Service Demand	Demand Device	Investment Cost (€/GJ)	Efficiency (Fraction)
	Biomass furnace	5.72	0.55
	Coal furnace	5.72	0.57
	LPG furnace	6.45	0.67
	Heat pumps	13.42	1.90
Residential cooling	Ground source heat pump	1.54	2.55
	Solar heat pump	3.09	0.64
	Air source heat pump	0.99	2.00
Residential lighting	Incandescents	15.28	1.00
	Halogen	19.10	2.80
	CFL	16.55	4.60
Residential hot water	Electric water heater	10.00	0.90
	Gas / LPG water heater	20.00	0.70
	Oil water heater	12.00	0.65
	Biomass water heater	14.00	0.60
	Solar (with electric) water heater	60.00	0.90
	Solar (with gas) water heater	70.00	0.70

The characterization of the improved devices varies by end-use, but in general, for a series of efficiency improvements by, for example 20/30/50 %, the base purchase price may increase a corresponding 0.74/1.34/2 times. All these assumptions may be adjusted for national circumstances, although this standard approach is usually used as described.

Note that due to lack of data on the process details of Serbian industry an approach that calibrates to the current energy intensity of each industrial demand, with then up to three generic options with similar price/performance improvements in the future, rather than representing specific processes/devices, is employed.

The transport sector is a key new sector added to the model in the last six months. It uses data from a range of sources, summarized below.

- Default values for new vehicle efficiencies and activity data are taken from a study funded by the European Commission called *EU Transport GHG: Routes to 2050 project*, which can be found at http://www.eutransportghg2050.eu. The data values are taken from the project's Sultan Tool (see Table 17) but adjusted to take account of country-specific data/ assumptions

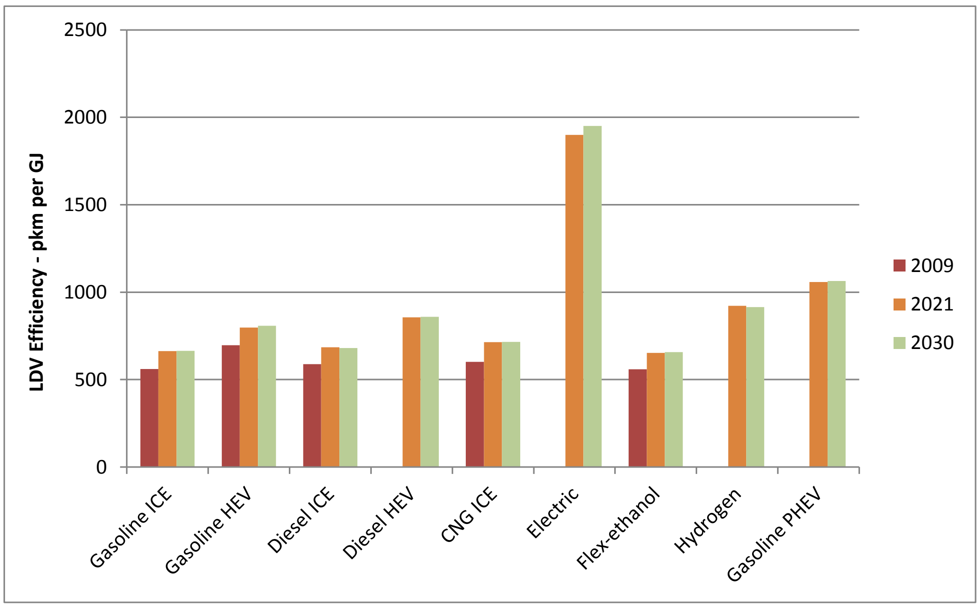
- Information on the relative efficiencies across different types of light duty vehicles (LDVs) and the difference in costs (now and in future years) is based on information from Annual Energy Outlook (AEO) 2011. Only the relative efficiency numbers are used and applied to information from the Sultan Tool mentioned earlier. Relative cost values are applied to user-provided information on standard gasoline/diesel vehicles. LDV costs and efficiencies are shown in Table 17.

- Marine and aviation estimates are from the best available data from the US/UK National MARKAL models. This approach is satisfactory as the subsectors in the model are not subject to technology choice.

Table 17. Sultan Tool Values on Vehicle Efficiencies, Payloads, and Annual Activity

Vehicle type	Fuel	Efficiency		Payload	Activity	
		mvkm/PJ	mpkm OR mtkm/PJ	Persons / tonnes	km per yr	pkm / tkm per yr
Buses	DST	110	1659	15.05	43,817	659,331
	ELC	330	4968	15.05	43,817	659,331
Cars	GSL	428	700	1.64	13,189	21,573
	DST	449	735	1.64	13,189	21,573
	LPG	427	698	1.64	13,189	21,573
Motorcycles	GSL	984	1078	1.10	5,664	6,209
Heavy trucks	DSL	91	781	8.54	49,201	420,233
	CNG	69	588	8.54	49,201	420,233
Medium trucks	DSL	204	328	1.61	15,992	25,674
Rail Pass.	DSL	20	2453	124.6		
	ELC	32	3949	124.6		
Rail Freight	DSL	14	5431	393.0		
	ELC	22	8721	393.0		

Figure 15. LDV Efficiency by Type in Serbian MARKAL Model



For year 2006, the transport sector is calibrated to the national energy balance. The transport sector energy totals have been disaggregated using available statistics, and other information sources, such as those provided by Organisation for Economic Co-operation and Development (OECD).

Transport demands use the same core drivers that are used in other sectors, namely annual GDP growth rates and population growth. Different transport subsectors are subject to different projections approaches. LDVs and two-wheelers use a vehicle ownership – GDP per capita relationships, with elasticity factors (from the IEA) that capture the strength of the relationship based on different income bands. Other freight-based subsectors use a more simple approach based on GDP growth rates. All derived drivers are based on information from the IEA.

APPENDIX II: A Closer Look at Modeling Energy Efficiency Policies and Measures.

As MARKAL/TIMES is a least-cost optimization modeling framework, it evaluates competing alternatives within an energy system based strictly on lifecycle costs, within other constraints imposed on the model. The lifecycle costs are the purchase price + operating costs + payments for fuel spread over the entire operational lifetime of the device. This approach tends to favor energy efficient devices because the fuel savings accrued over the lifetime will be greater than the costs associated with the investment and operation of the device. However, in reality, consumers do not necessarily evaluate purchasing on this basis. Decisions may be impacted by a range of factors which act as barriers to investment in EE devices including:

- Risks and uncertainty around new technologies (perhaps due to lack of information)
- High transaction costs (affecting the ease of choice)
- Problems accessing capital (as EE devices often have higher purchase prices)
- Other costs not included or missed in typical economic analysis (known in the literature as hidden and missing costs)
- Consumer inertia (perhaps due to non-economic factors, e.g. stick with what you own (even if past performance lifetime), buy only what you know, style)
- Longer pay-back periods undermining the attractiveness of making the alternative investment with higher upfront cost

These factors often lead to energy efficient appliances being overlooked even though under strict economic principles, they should be selected. Such barriers to uptake are widely acknowledged in the field of energy efficiency research.

To deal with this "behavior" within a MARKAL/TIMES model, there are basically two main options: 1) impose firm upper limits on the rate of uptake of new devices or 2) use sector/technology-specific discount rates (so-called "hurdle" rates) to take account of barriers that prevent these investments from happening. This second approach enables some aspects of consumer behavior that typically may be characterized as economically irrational (in a perfectly competitive market) to be reflected in the model. The additional costs associated with overcoming the above barriers could be seen as representing the cost of policies and programs that might be associated with overcoming such barriers (e.g. labeling, information campaigns, appliance/building standards).

The first approach (*firm constraints)*, used previously for the RESMD EE analysis, has the disadvantage of underestimating the costs of EE (which was a criticism of the earlier work) and tends to be an all-or-nothing choice by the model. In addition, it is difficult to use in association with an EE target.

The second approach (*flexible constraints)* is considered a less rigid, more flexible approach as the model is free to find the cost-effective penetration level for the EE devices, taking into consideration these extra costs (but with no firm limits as per the first approach). The difficulty with it is that there is only limited empirical evidence on what the "hurdle" rates should be for each technology, though research in the United States (US) and United Kingdom (UK) point to a 15-25% premium.

The set-up of these different approaches for the baseline run and energy efficiency policy run are summarized in the table below.

Scenario / Approach	Previous approach – "firm constraints"	Revised approach – "flexible constraints"
Baseline	In general, energy efficiency devices are restricted to 10% uptake as a share of a given technology category.	Energy efficiency uptake is calibrated to the levels seen under the "firm constraints" approach – but using hurdle rates not firm constraints.
Energy efficiency	The constraints were relaxed to 50% (or whatever a country thought was appropriate) of new devices purchased in 2030 to determine the economically efficient uptake. The approach was used to demonstrate the impact of energy efficient devices but was not policy driven targets. It did not capture the additional costs associated with energy efficiency devices (as reflected in the hurdle rates).	Two mechanisms are applied to the baseline – an energy efficiency target was introduced and hurdle rates were reduced to a level based on an empirical basis. The big advantage of this approach is that it is target-based (so policy relevant) and reflects much of the costs associated with implementing energy efficiency measures.

The sections below describe in greater detail how to implement the revised approach, where "hurdle" rates are used to keep the EE devices out of the Reference scenario (for the most part), based upon the assumption that without policies and programs people will tend to buy what they know and what has the lowest upfront cost.

CALIBRATING NEW DEMAND DEVICE UPTAKE IN THE REFERENCE SCENARIO

As summarized in the table above, an approach has been established that uses hurdle rates (technology specific discount rates) to control new technology uptake. The benefit of such an approach is that alternative scenarios (e.g., consumption reduction targets) can be explored without the requirement to adjust constraints that impose hard bounds (limits) on the rate of penetration of advanced technologies, because now their uptake is limited on the basis of cost rather than using fixed limits.

The calibration process for various RESMD models uses hurdle rates of 20-40% range to achieve the dampening of the new device updates to the original Reference scenario level. This reflects the fact that in the absence of policy it is highly unlikely that (most) people will recognize the cost savings over the lifetime of an advanced improved device and overcome the higher upfront cost. Then, as EE policies and programs incentivize uptake, these hurdle rates are reduced. Under the EE target case, hurdle rates are reduced to the range of 10-20%, reflecting the impact of policies (e.g., appliance standard – that eliminates inefficient options from the market place) and programs (e.g., low interest loans for building shell improvements and the purchase of efficient appliances).

CONDUCTING EE ANALYSIS

Empirical evidence in the UK/US literature indicates that there is a required rate of return perceived by consumers for EE measures of between 15-25%. These hurdle rates can be reduced by incentives, programs, and campaigns (such as those called for in NEEAPs) to reduce the barriers seen by consumers. Thus, rates in the range of 10-20%, reflecting low interest loans or simply the cost of credit card purchase for the high efficiency devices are reflective of the environment under such policies.

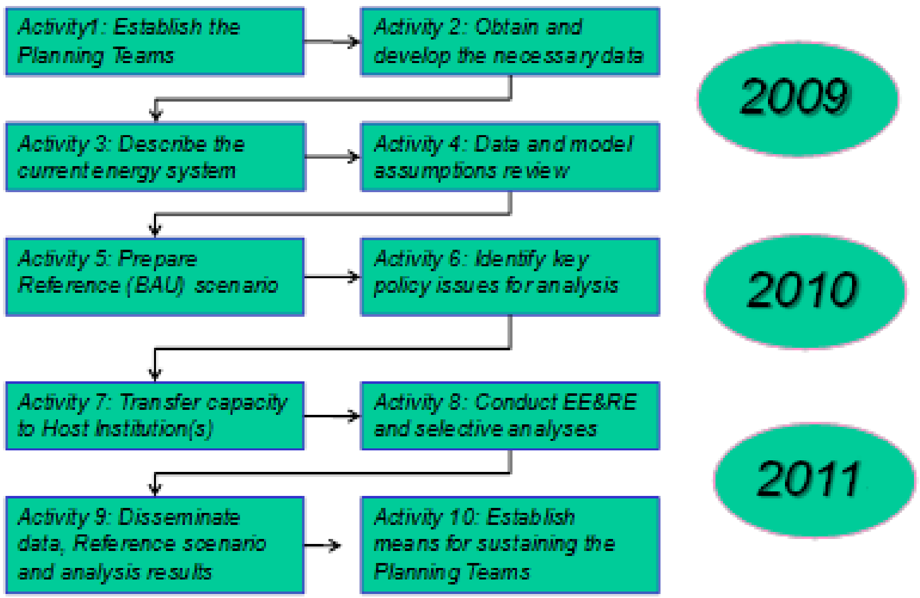
APPENDIX III: PROJECT ACTIVITIES AND METHODOLOGY EMPLOYED

MAJOR PROJECT ACTIVITIES

The consultant teams for International Resource Group (IRG) and the Centre for Renewable Energy Sources (CRES) worked with key personnel from Ministry of Mining and Energy (MOME) and the Electric Power Industry of Serbia (EPS) to establish a credible MARKAL-Serbia model, and guide this Planning Team's use of the model to assess and analyze several policy alternatives aimed at improving energy efficiency and increasing the use of renewable energy resources.

Over the course of two years, the joint SYNENERGY Strategic Planning (SSP) effort undertaken by the US Agency for International Development (USAID) and Greece Hellenic Aid was able to introduce new methods, implement these methods, and transfer the capabilities to the national counterparts in a sustainable manner (see Figure 16). The figure shows that data development and team building came first, taking much of Year One to arrive at an accurate quantitative description of the country's current energy system, and identify the options available for consideration over the next 20 years. For the Planning Teams that were involved in the precursor to SYNENERGY Activities, the USAID-sponsored Regional Energy Demand Planning (REDP) undertaking, Activities 1 - 5 were replaced by improvements to their initial models built and updating of their Reference Scenario, along with supplemental training for new members of those Planning Teams.

Figure 16. Sequence of Project Activities



Once the data and information systems were established it was possible to reproduce a valid energy balance for each of the countries. These energy balances, relying on best available information and a consistent management framework, provide the foundation for useful policy analysis and assessment.

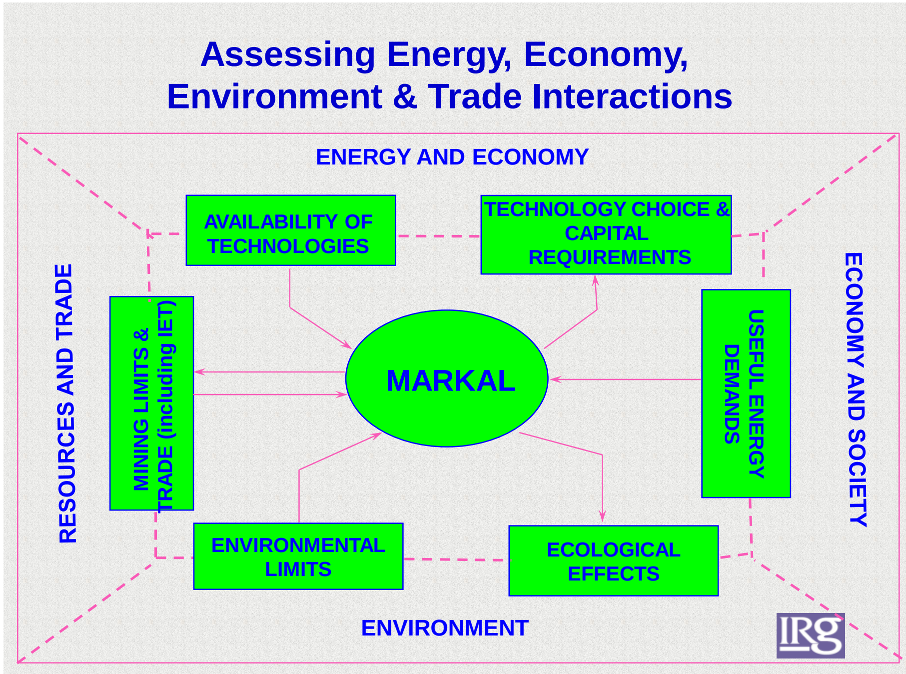
At least as important as the energy balances themselves, and the accompanying information systems, is the process of building a team of professionals in each country who can work with the data, maintain the information systems, and support higher level analytical approaches. This team building should be considered a major benefit of the project for the region. However, to date, only a couple of the countries have moved actively on Activity 10 and looked to established means for sustaining the Planning Teams, so this will be more actively pursued in the next phase of the project.

METHODOLOGY EMPLOYED

Patterned after successful efforts in other countries, this project has transferred significant energy system modeling and analytical capabilities, along with a practical approach to decision support. Such capabilities are focused on the use of a consistent framework for analysis and assessment, the MARKAL/TIMES model, making collaborative efforts among the participating countries simpler and more transparent.

The MARKAL/TIMES model produces robust, scenario-based projections of a country's energy balance, fuel mix, and expenditures required for the energy system over time. The model relates economic growth to the necessary resources, trade and investments, incorporating a nation's environmental standards (or goals), depicting the least-cost energy future (see Figure 17).

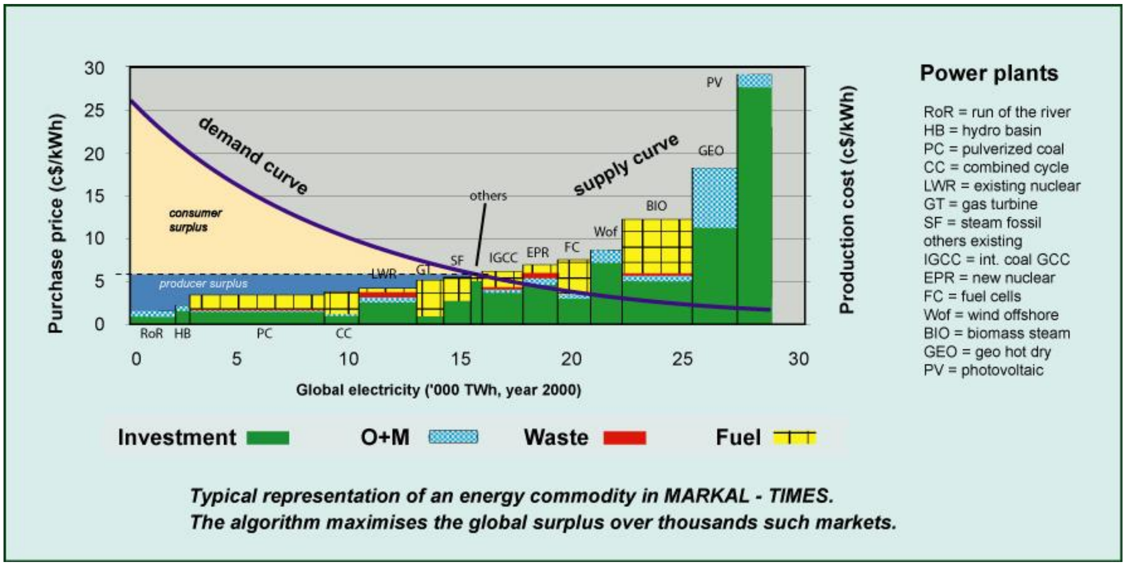
Figure 17. Interactions in the MARKAL/TIMES Model



The MARKAL/TIMES model simulates energy consumption and investment/supply decisions on the basis of a simple calculus of costs and benefits. Producers will supply the market as long as consumers will pay a price equal to or greater than the cost of supply. The model performs this calculation simultaneously for each energy form and all the energy service demands, solving for the least cost solution for the energy required to support economic growth.

In the example below (Figure 18) the model meets electricity demand by first dispatching run-of-river (RoR) hydro plants, then pumped hydro (HB), next pulverized coal (PC), then combined cycle (CC), nuclear (LWR), gas turbines (GT), and finally steam fossil (SF) up to a price of $.06/kWh. If more electricity needs to be delivered the model will turn to more expensive types of power plants, but at some point the consumer will switch to some other fuel (e.g., gas for space heating) rather than pay more for electricity. This basic principle is applied across the board to ensure that the least-cost deployment of technologies and consumption of fuels is realized, within the constraints imposed on the model. A fuller description of MARKAL/TIMES and its use internationally may be found at www.etsap.org.

Figure 18. Power Plant Dispatch in the MARKAL/TIMES Model



One of the most relevant suite of studies conducted recently using are those sponsored by the European Union that employ MARKAL/TIMES to represent the pan-European energy picture as a closely tied integration of the national energy systems. The initial incarnation of this was realized as part of the New Energy Externalities Developments for Sustainability (NEEDS)[16] undertaking. The Pan-European TIMES model (PET)[17] evolved from the original NEEDS model and has been employed for series of high profile EU projects, including RES2020[18] examining the EU renewables directive,[19] REALISEGRID[20] looking to promote the optimal development of the European national transmission grid infrastructure, and the Risk of Energy Availability: Common Corridors for Europe Supply Security (REACCESS).[21] Another pair of high-profile uses of MARKAL/TIMES is the IEA Energy Technology Perspectives[22] and UK Climate Change Policy "White Paper."[23]

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16 http://www.isis-it.net/needs/

17 http://www.res2020.eu/files/fs_inferior01_h_files/pdf/deliver/The_PET_model_For_RES2020-110209.pdf

18 http://www.res20202.eu

19 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:140:0016:0062:EN:PDF

20 http://realisegrid.rse-web.it/

21 http://reaccess.epu.ntua.gr/TheProject/ProjectObjectives.aspx

22 http://www.iea.org/techno/etp/index.asp.

23 http://www.ukerc.ac.uk/ResearchProgrammes/EnergySystemsandModelling/ESM.aspx.

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