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:

BOSNIA & HEZEGOVINA POLICY BRIEF

July 2012
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ACRONYMS

AEO	Annual Energy Outlook
BAU	Business as Usual
BHAS	Bosnia and Herzegovina Agency for Statistics
BiH	Bosnia and Herzegovina
CC	Combined cycle
CRES	Centre for Renewable Energy Sources
EC	Energy Community
ECS	Energy Community Secretariat
EE	Energy Efficiency
EIA	Energy Information Association (US)
EIHP	Energy Institute Hrvoje Požar
ESD	Energy Services Directive
ESEC	Energy Strategy of the Energy Community
EU	European Union
GDP	Gross Domestic Product
GFEC	Gross Final Energy Consumption
GT	Gas Turbines
HGVs	Heavy Goods Vehicles
ICE	Internal Combustion Engine
IEA	International Energy Agency
IPA	International Policy Analysis
IRG	International Resources Group
ISOBiH	Independent System Operator in Bosnia and Herzegovina
LCVs	Light Commercial Vehicles
LDVs	Light Duty Vehicles
LPG	Liquid Petroleum Gas
LWR	Light Water Reactor
MARKAL	MARKet ALlocation
MOFTER	Bosnia and Herzegovina Ministry of Foreign Trade and Economic Relations
NEEAPs	National Energy Efficiency Action Plans
NEEDS	New Energy Externalities Developments for Sustainability
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
PET	Pan-European TIMES model
RE	Renewable Energy
REDP	Regional Energy Demand Planning
RESMD	Regional Energy Security and Market Development
RPS	Renewable Portfolio Standards
SF	Steam Fossil
SSP	SYNENERGY Strategic Planning
TAP	Trans Adriatic Pipeline
UK	United Kingdom
US	United States
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 Bosnia and Herzegovina (BiH) Planning Team using their national MARKAL (MARKet ALlocation) integrated energy system model, MARKAL-Bosnia & Herzegovina, 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 Bosnia and Herzegovina's Ministry of Foreign Trade and Economic Relations (MOFTER), supported by International Resources Group (IRG) and the Centre for Renewable Energy Sources (CRES).The MARKAL-Bosnia & Herzegovina analysis undertaken uses a cross-sectoral, cost optimization approach to identify the most economic efficient set of measures, and produces a broadly similar mix to that being proposed in the Energy Institute Hrvoje Požar (EIHP) Study.

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 Bosnia and Herzegovina, as a Contracting Party under the Athens Treaty establishing the Energy Community. It also considers how meeting the targets impacts 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 Bosnia and Herzegovina, 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 (or Business-as-Usual (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 (NEEAPs)). The scenario both assumes policies that reduce impediments to the uptake of energy efficiency are in place as well as a target aimed at reducing consumption that is in line with the Energy Community goals for Contracting Parties. 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.

RESMD Policy Briefs have been prepared for eight other participating Contracting Parties and Observer Countries, as well as a Regional Overview that compiles the results from all nine countries to provide an aggregate perspective of the analyses undertaking by each.

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	Renewables	Energy Efficiency	EE+RE
Energy security and diversification	• Increasing gas imports • Coal-dominated generation system	• Increased use of domestic RE resources • Increased exports by 15% • Reduces gas imports by 345Ktoe (11%)	• Reduces gas imports and reduced coal consumption due to reduced electricity consumption (5.2%)	• Increased use of domestic RE (although at lower level than under RE case) • Electricity imports increased by 7.9%
Enhanced competitive-ness[1]	• Electricity system expansion at a total cost of 968 €M • Greater access to gas	• Stimulates investment in renewable market • Cuts payments for imported fuels (6.3%)	• Power sector investment reduced and freeing up for other capital investments	• Lower fuel costs, saving 2.3 €B in fuel expenditure
CO_2 mitigation	• Emissions increase by 50% by 2030 due more carbon-intensive energy system	• Cumulative reduction of CO_2 due to use of less fossil energy (especially gas) and lower total energy consumption (4.33%)	• Reduction of CO_2 due to lower total energy consumption (0.7%)	• Cumulative reduction of CO_2 due to more RE and lower energy consumption (4.89%)

ENERGY SECURITY AND DIVERSIFICATION

A renewable target results in increased use of indigenous energy resources, particularly hydro, while increased energy efficiency lowers overall demand for energy, thereby reducing imports of gas. Overall, the combined effect of both policies results in a reduction of 2.48% in imports, the majority of which is gas.

Despite the reductions in gas imports, there is a limited impact on the diversity of the energy mix. The key changes in addition to the reduction in the demand for gas are a reduction in coal use

[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.

for electricity; in the RE case, renewable generation displaces nearly 20% of coal generation, while a similar amount is displaced under the EE case due to the uptake of more efficient electric appliances.

Under both RE and EE scenarios, import levels will be reduced by around 2.14% and 0.7% respectively, or a 2.48% reduction under the combined scenario case. This is due to increased use of indigenous renewable energy under an RE target, and lower energy demand resulting from increased energy efficiency. Gas imports are particularly affected. Under the RE scenario, imported gas is reduced by over 10.9% cumulatively, while in the EE scenario, the reduction is 5.2%. (In the combined scenario, gas imports are reduced by 19.6%.)

If anything, the energy supply becomes less diversified under the RE case, with an increased reliance on hydro generation, and a significant reduction in 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. The additional costs of lower hydro generation levels are highlighted in this policy brief.

ENHANCED COMPETITIVENESS

An energy efficiency target with the right policies and programs has strong benefits for competitiveness by reducing payments for imports, decreasing power sector capacity needs, 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 an overall savings seen of 934€ million; however, only around a 2.44% reduction is achieved rather than the 9% called for by the Energy Community directive. With the target in place, total fuel expenditure savings (compared to the Reference case) amount to a reduction of more than 8.52% (in the combined scenario case), or cumulative saving of 3.36€ billion on fuel, nearly offsetting the cost of the more expensive efficient technologies. Once transformed, the energy system savings continue into the future.

The proposed 2020 RE target increases the cost of the energy system due to the additional renewable generation investment required, particularly towards 2030, under the assumption that the RE share is to be sustained over time. To meet the target an additional 1,500 MW of RE capacity will be required by 2020, and over 600 MW by 2030. Energy system costs are 1.35% higher (0.98€ 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 and energy efficiency targets are reduced, with additional costs of 2.6% (both policy scenarios undertaken individually) compared to an overall increase of 1.7% when undertaken together. It is important to note that electricity prices increase, so understanding the distribution of impacts and, where necessary, reducing competitiveness or social impacts will be important.

In addition, as already mentioned, a combined EE+RE policy can substantially reduce imports, saving valuable foreign exchange funds, amounting to 1.28€ billion cumulatively that can offset some of the more expensive generation and efficient device upfront costs and be rechanneled for other domestic priorities.

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[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.

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

The policies examined show strong synergies with a goal of moving to a lower carbon footprint for BiH energy economy. The combined EE and RE policy leads to cumulative reductions of 4.89% in CO_2 emissions. This is accomplished by increasing renewable generation from hydro and wind power of the order of 1,300 MW, compared to the Reference scenario, coupled with the overall reduction in demand for energy owing to the more efficient energy system.

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-BiH Reference scenario shows that rapid electricity demand growth requires a large increase in generation capacity by 2030 of 1.3 GW at a cost of nearly 968€ million. 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 goals.

The MARKAL-BiH analysis shows that a 3% reduction in final energy consumption can be achieved at a net savings of 934€ million (or 1.3%), while achieving the more ambitious NEEAP target of 9% requires only a modest cost increment of 0.36% (261€ million) over the baseline, while saving 1.5€ billion in fuel expenditures and reducing both imports and carbon emissions by 0.7% (586€ million/3.4Mton). Achieving these goals requires a 5.9% (1,055€ million) increased investment in more efficient demand devices. The most cost-effective areas for energy efficiency investment identified in this analysis include residential and commercial space heating, industrial process heat, and vehicle efficiency. The MARKAL-BiH 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 1.35% (978€ million) and requires more than a doubling of the required power sector capacity additions, and over 1.8€ billion in increased investment costs. Achieving the target yields substantial benefits: a more than 2% (1.8€ billion) decrease in imports, a 5.15% (2€ billion) decrease in fuel expenditures and a 4.3% reduction in carbon emissions. The cumulative capacity addition needed, relative to the reference, to reach the target by 2020 is approximately 1,350 MW (2.4€ billion), a very ambitious goal. As noted above, 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.

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 1.26%, (915€ million) or 0.45% (324€ million) less than the sum of the two strategies separately. The

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

savings are dramatic: an 8.5% (3.4€ billion) decrease in fuel costs, 2.5% (2.0€ billion) decrease in imports, and nearly 5% decrease in carbon emissions. 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 BiH 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. BOSNIA AND HERZEGOVINA BUSINESS-AS-USUAL ENERGY PATHWAY

To assess the impact of different policies and programs on the evolution of the energy system in Bosnia and Herzegovina, 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. The Reference scenario is aligned with the Energy Sector Study done by Energy Institute Hrvoje Požar. In addition, all other available national data sources (State Statistical Office, National energy balances, etc.) as well as some international databases (e.g., International Energy Agency or IEA) were utilized. 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 by 26.3% in terms of final energy by 2030, driven by strong Gross Domestic Product (GDP) growth and increasing per capita consumption. This will require nearly doubling electricity generation capacity from 3,507 to 4,772 MW and results in higher import levels, as well as growth in CO_2 emissions. Key indicators from the Reference scenario are shown in Table 2 and summarized subsequently.

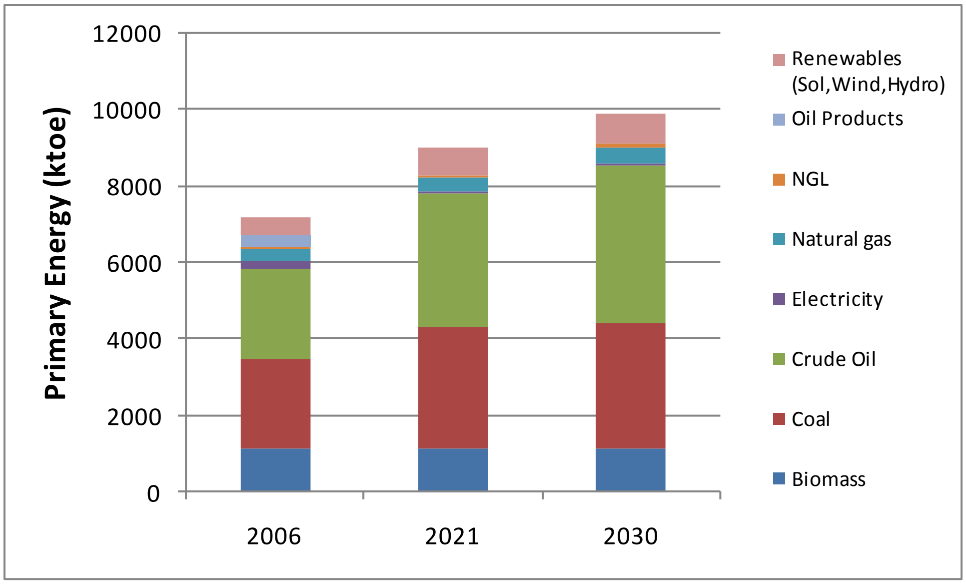
Table 2.Key Indicators for the Reference Scenario

Indicator	2006	2030	Annual Growth Rate (%)	Overall Growth (%)
Primary Energy (Ktoe)	7219	9934	2.2%	37.6%
Final Energy (Ktoe)	4,214	5,321	3.5%	26.3%
Power plant capacity (MW)	3,504	4,772	3.3%	36.2%
Imports (Ktoe)	3,208	3,543	2.1%	10.4%
CO_2 emissions (Kt)	14,659	21,466	3.7%	46.44%
GDP (€ Mill.)	8,619	25,622	4.45%	197.28%
Population (000s)	3557	3958	0.43%	11.3%
Final Energy intensity (toe/€000 GDP)	0.489	0.208	-0.95%	-57.5%
Final Energy intensity (toe/Capita)	1.185	1.344	3.1%	13.4%

Primary energy consumption in 2030 is projected to be 9,934ktoe, increasing from 2006 levels by 37.6%. 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 0.208 toe/1000€, a reduction of around 57.5%. This is a result of the continuation of current structural changes in the BiH economy and natural technological progress underway throughout the world.

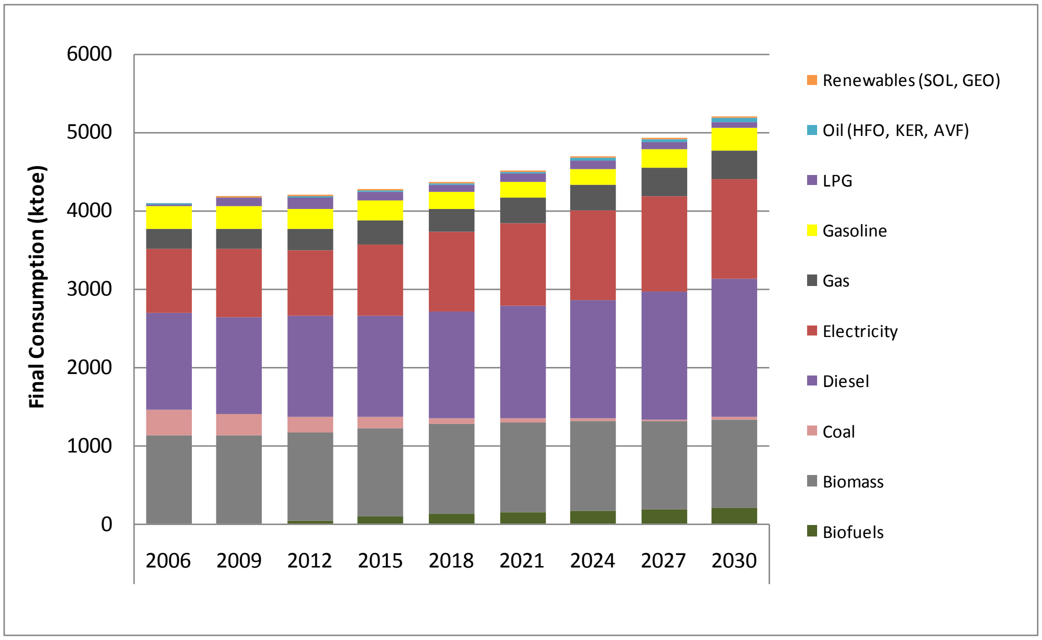
As shown in Figure 1, primary energy supply increases with imported crude oil accounting for 42% of total supply in 2030. The main reason for that is the growth in transport demand, which is reflected in the decrease in imported oil products (due to the increase in refinery production).The contribution of renewable energy sources (excluding biomass) to total primary energy during this period increases from 6.6% to 8%. The biomass contribution drops from 15% to 11%, as households switch to more modern forms of energy. Electricity imports decreases in the 2006-2030 horizon because of enough domestic resources.

Figure 1.Primary Energy Supply – 2006 / 2021 / 2030



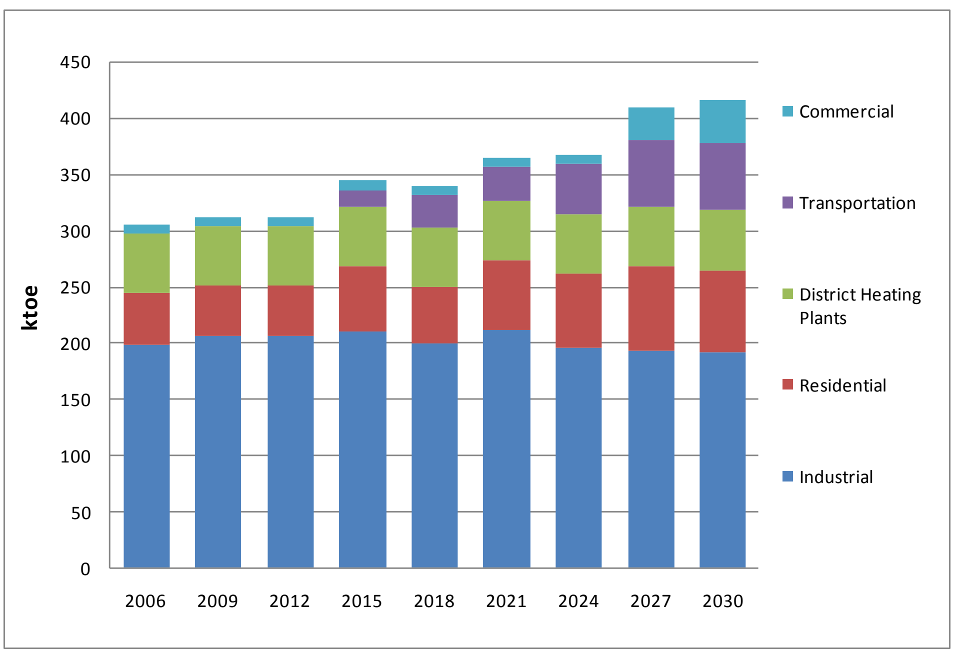
Total final energy consumption grows by over 26% over the planning horizon, with the most significant change being the 12% decrease of biomass and coal (as households switch to more modern forms of energy and more efficient devices). Figure 2 shows a more detailed final energy consumption graph.

Figure 2. Final Energy Consumption by Energy Type



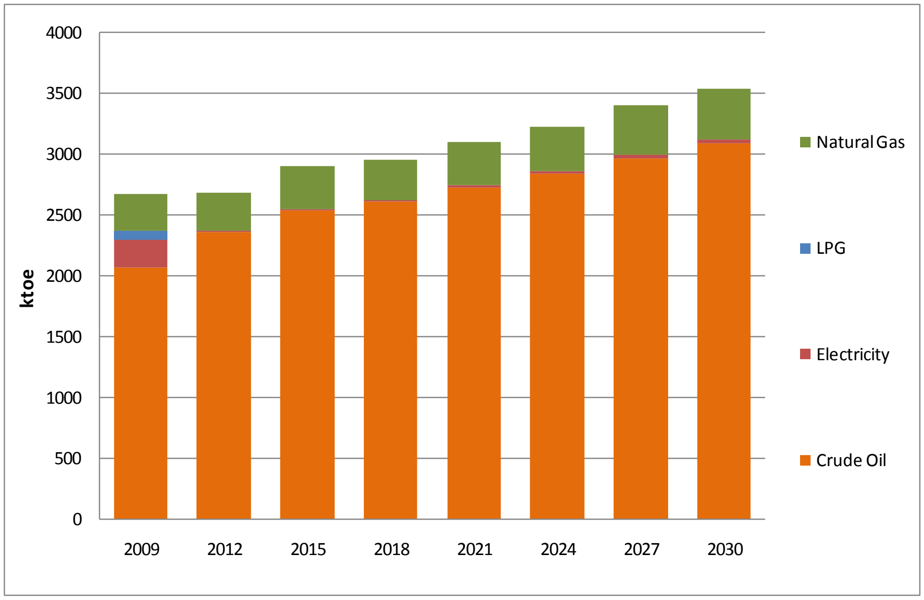
A more detailed view of gas consumption by sector is shown in Figure 3. It shows that the majority of gas is used in the industry, residential, commercial, and transport sectors. In the residential sector, gas is used primarily for cooking and space/water heating, while in the commercial sector the main uses are for cooking and space heating. Gas is used across most industry sectors for the production of high temperature heat for a number of different processes. Increase in gas consumption in the transport sector is important issue from the point of view of increasing number of vehicles that use this resource.

Figure 3. Gas Consumption by Sector and Power Plant Type



Except coal, all of Bosnia & Herzegovina's fossil energy requirements are imported. The demand for crude oil increases import dependency, resulting in an increase of 30.1% imports by 2030 (relative to current levels).

Figure 4. Imports by Type

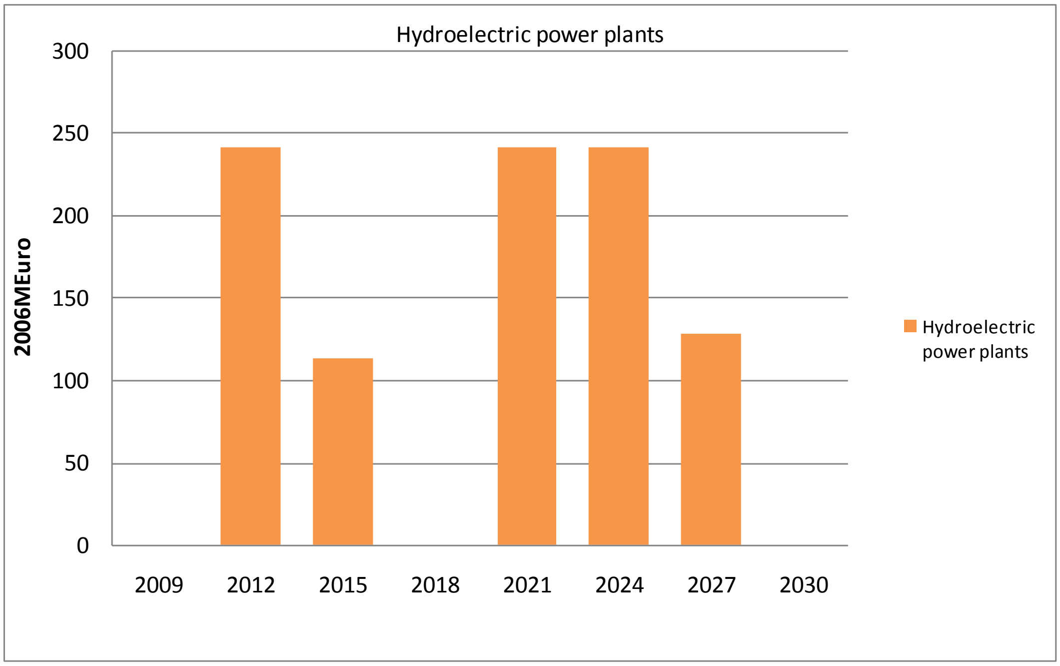


New power generation capacity additions needed in each three-year period are shown in Table 3. Continued expansion of hydropower is the most prevalent with cumulative additional capacity of 600 MW by 2030. Capacity additions and the retirement of old power plants results in 3,920 MW of total installed generation capacity in place in 2030.

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

Plant Type	Total Installed 2009	2012	2015	2018	2021	2024	2027	2030	Total
Dual-fired		0	0	0	0	0	0	0	0
Gas		0	0	0	0	0	0	0	0
Hydro		150	70	0	150	150	80	0	600
Wind		0	0	0	0	0	0	0	0
Total New Capacity		150	70	0	150	150	80	0	600
% of Installed Capacity		3.8%	1.9%	0%	3.8	3.8%	1.9%	0%	

Figure 5. Total Investment Cost of New Power Plants



* Investment levels are not annual but cumulative for a three-year period

Growth in the energy system will require significant levels of new investment and 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 differential 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)[4]

Expenditure Type	2009	2012	2015	2018	2021	2024	2027	2030
Fuel Costs	971	1078	1243	1396	1563	1723	1937	2176
Operation and maintenance (O&M) Costs	898	1068	972	1050	1135	1263	1410	1520
Annualized Investment (Demand)	552	1063	1633	2212	2652	2847	3266	3647
Annualized Investment (Power)	0	18	27	27	45	64	74	74
Total	**2422**	**3227**	**3876**	**4684**	**5395**	**5897**	**6686**	**7416**

4 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.

Under the Reference scenario assumptions, to add the 600 MW of new generation capacity required by 2030, a total investment of 968€ million is required, which translates to average annual payments of the order of 80€ million. At the same time, by 2030 over 7.6€ 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. Fuel supply costs will also increase significantly, driven by growing demand and increasing prices, from 4.9€ billion per year to 10.0€ billion per year.

D. EXAMINATION OF THE PROMOTION OF ENERGY EFFICIENCY IN BOSNIA AND HERZEGOVINA

The Ministerial Council of the Energy Community adopted Decision D/2009/05/MC-EnC in December 2009 concerning the implementation of certain Directives on Energy Efficiency, including Directive 2006/32/EC on energy end-use efficiency and energy services (ESD). This required Contracting Parties (under Article 14(2)) to submit their first National Energy Efficiency Action Plan by June 2010.

The background to this EU Directive was highlighted in the *Green Paper on the Security of Energy Supply* (2000) which noted increasing dependence on external energy sources, and an increase from 50% to 70% by 2030. At the same time, the role of the energy sector as an emission source needed to be addressed, as it was responsible for no less than 78% of EU greenhouse gas emissions. Therefore, efforts were required to focus on improving end-use energy efficiency and controlling energy demand.[5] The Directive notes that *Improved energy end-use efficiency will make it possible to exploit potential cost-effective energy savings in an economically efficient way.*

Bosnia and Herzegovina has not yet adopted a NEEAP and as a Energy Community Contracting Party there is a need to do so in the coming period. In a draft version of a NEEAP, EE targets are set at 6%. This analysis provides insights into the cost-effective technologies that would be required to meet a NEEAP target.

It is clear 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*.[6]

The costs attributed to such barriers (e.g. long payback period, lack of familiarity, inconvenience, high transaction costs) 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,[7] as discussed in Appendix II. As a result, such options are not invested in under the Reference case. However, 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.

Under such a scenario (no EE target but reduced barriers to uptake), there is a 3% reduction in final energy consumption in 2018 (not the required 6% under proposed NEEAP), with an overall savings to the energy system of 934€ million (or 1.29%, as shown in Table 6). However, simply removing some of these barriers is not enough to meet the reduction levels required by

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5 See European Commission website – http://europa.eu/legislation_summaries/energy/energy_efficiency/l27057_en.htm

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

7 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).

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.

Policies that promote increased energy efficiency have significant benefits, as described below.

- A modest increase in discounted energy system costs of 0.36% (261€ million) is observed under the NEEAP target.
- Over 0.7% cumulative reductions (586 ktoes) in imports are observed under the NEEAP target, enhancing energy security goals and saving 8.3€ million in foreign payments.
- Significant cumulative reductions in final energy of 8.28% are observed (10718 ktoes), as are strong synergies with low emission development, reducing CO_2 emissions by 0.7% (or 3,433kt).

The basis for the energy efficiency target is the BiH NEEAP, in line with that of other Energy Community Contracting Parties, which is a 9% reduction calculated from the 2006-2009 average final energy consumption levels, resulting in total reduction requirements from the Reference scenario levels as shown below in Table 5. 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 commitment to maintaining improvements in energy efficiency over time.

Table 5.Energy Efficiency Targets

Approach	2012	2015	2018	2021	2024	2027	2030
NEEAP target	3.0%	4.5%	6.0%	7.5%	9.0%	9.0%	9.0%
Reduction totals* (ktoes)	127.7	191.5	255.3	319.2	383.0	383.0	383.0

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

Table 6 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. In the first case, this represents a situation where only the most cost-effective technologies are purchased, incentivised by policies and programs that have been put in place. It illustrates that cost savings can be made by EE promotion, to reduce the socio-economic barriers to uptake of more efficient technologies. 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.

The focus of this section is on the *Energy Efficiency + Target* case, as the NEEAP is the main ongoing policy action in this area. As shown in the table, all of the key cumulative metrics (other than overall system cost and investment in new demand technologies) are reduced due to efficiency savings, through impact on power sector capacity addition requirements. For example, imports drop by 0.7% and fuel expenditure by 3.84%. Such savings, amounting to 1.5€ billion, enhance energy security and economic competitiveness.

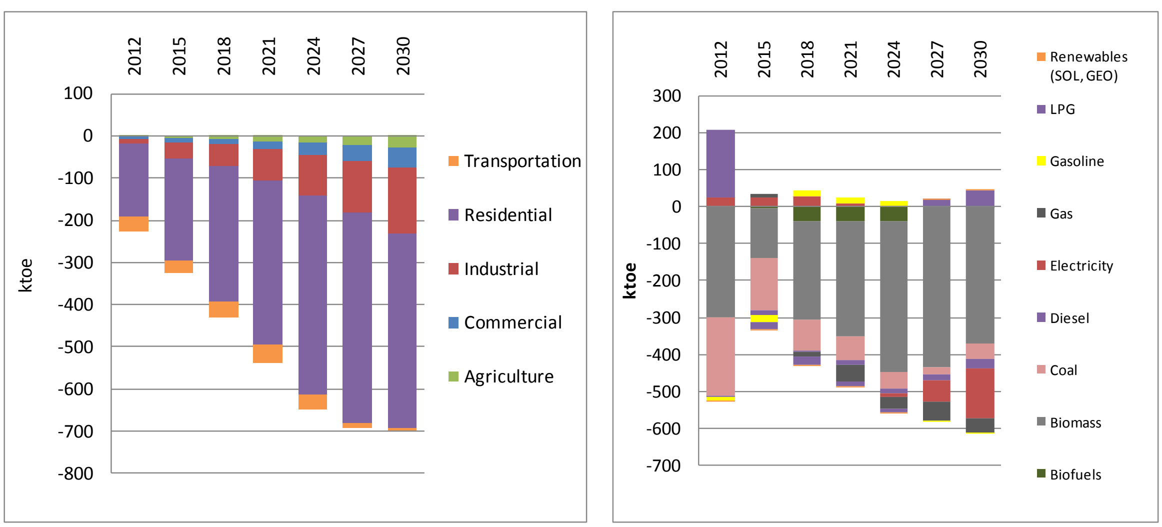
The slightly higher overall cost of the energy system is due to the increased expenditure for better-performing demand devices that, despite policies and programs, still command a premium over conventional devices, though this is lower than would otherwise be the case in the absence of such actions. At the end of this section we briefly discuss variants of the EE analysis to look more at energy efficiency policy in BiH.

Table 6.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€	72,649	-934	-1.29%	261	0.36%
Primary Energy Supply	Ktoe	230,484	-3,090	-1.34%	-8,598	-3.73%
Imports	Ktoe	83,145	-1,045	-1.26%	-586	-0.7%
Fuel Expenditure	2006M€	39,475	-191	-0.48%	-1,515	-3.84%
Power Plant New Capacity	MW	600	-227	-37.9%	0	0%
Power Plant Investment Cost	2006M€	968	-367	-37.9%	0	0%
Demand Technology Investments	2006M€	17,872	-150	-0.84%	1,055	5.9%
Final Energy	Ktoe	129,397	-3,155	-2.44%	-10,718	-8.28%
CO_2 Emissions	Kt	492,074	-2,237	-0.45%	-3,433	-0.7%

The contribution of different sectors to the targets is shown in Figure 6, indicating that energy-saving potential is economy-wide, and that all sectors provide a significant contribution. Under the energy efficiency target, the residential sector provides the largest savings (59% of total savings), followed by the industry sector (20%) and transport (13%) through a move to hybrid vehicles and more efficient conventional (internal combustion engine or ICE) vehicles.

Figure 6. Final Energy Reduction by Sector and Fuel under Energy Efficiency Target

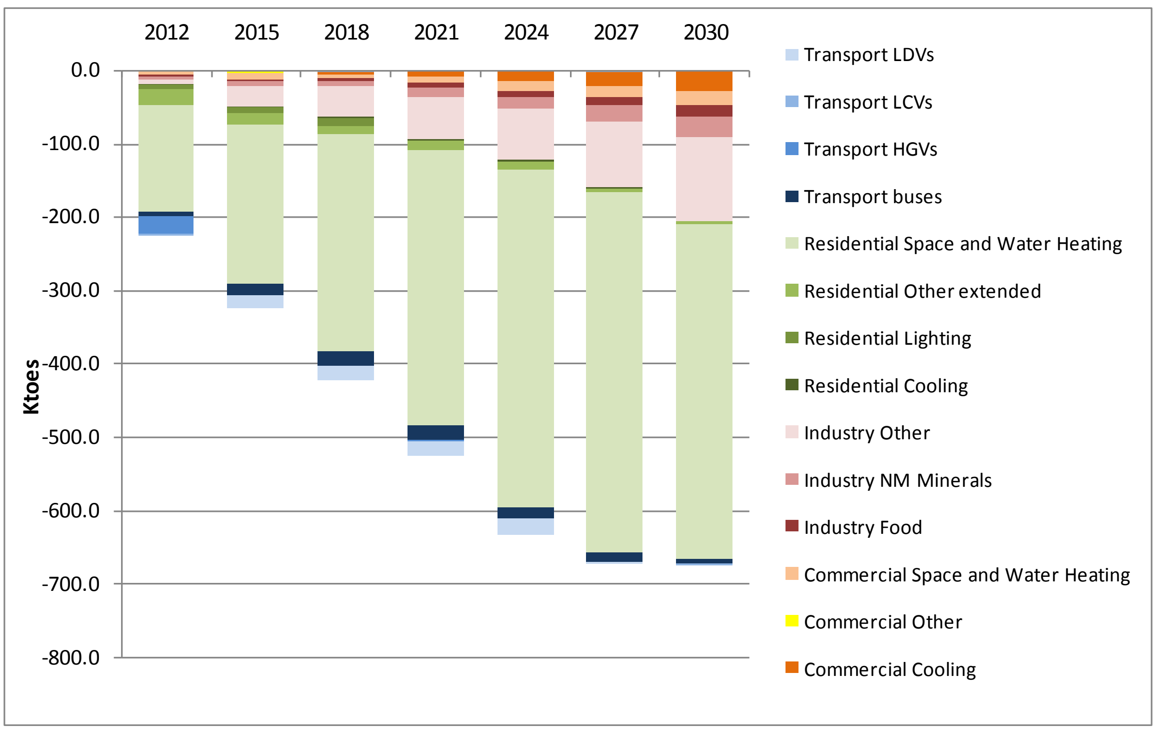


In terms of fuels, the largest near-term reductions come from biomass (residential), coal (industry), and diesel (transport). Later in the time horizon (2024) onwards, large reductions in gas for space heating in the residential sector are observed due to switching to more efficient appliances, as described below.

A more detailed overview of savings by energy service demands are shown in Figure 7. The most cost-effective reductions occur in space and water heating, with a strong uptake of heat pumps (using electricity) and use of more efficient appliances. This leads to a fairly strong reduction in gas consumption whilst electricity consumption levels increase by a small percentage. For the transport sector, there is an increasing uptake of hybrid vehicles across light duty vehicles (LDVs), light commercial vehicles (LCV)s, and heavy goods vehicles (HGVs). There is also some penetration of plug-in hybrid electric vehicles in the LDV stock from 2018. The bus fleet moves towards more advanced ICE technology.

In industry, savings are most prevalent in the food and non-metallic mineral industries, where savings from process heat are realized. Much of the commercial savings are in cooling and heating, owing to the uptake of more efficient appliance and some increased penetration of heat pumps. Lighting does not change much as much of the efficiency savings are realized in the Reference scenario due to assumed market restrictions on the sale of incandescent bulbs.

Figure 7. 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 data in the model for use in future analyses, assessing new data available in BiH to further improve the robustness of the analysis.

Under the EE target, costs are shown to increase overall despite significant reductions in fuel expenditure. This is because the model uses higher discount rates for more advanced appliances (as described earlier and more fully in Appendix II) to reflect the market barriers and costs of policies to overcome them. However, the cost increases are modest, just 0.36% higher than the Reference scenario. In addition, the analysis does not reflect the wider economic benefits that could come from energy efficiency promotion, in terms of export competitiveness or stimulating new industries e.g. for solar water heaters. At the same time, there are significant co-benefits arise from pursuing energy efficiency goals, including CO_2 reductions (0.7% reductions) and energy security through reduced imports (0.7% reduction).

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 BOSNIA AND HERZEGOVINA

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,[8] 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.[9] A 2020 renewables target of 34% of Gross Final Energy Consumption (GFEC) for Bosnia and Herzegovina has been proposed by the ECS and was used in the analysis presented here.

Key insights are summarized in Table 7 and elaborated upon in the rest of this section.

- Cumulative energy system costs (to 2030) are 1.3% higher. While this is a relatively modest increase it is important to highlight significant additional power sector investment is needed out to 2030 increasing by 256%, or 1,540 MW.
- Energy security is enhanced with a 2.14% cumulative decrease in the imports, as a result of increased use of indigenous electricity and increase biofuel use in the transport sector.
- This policy contributes towards moving to a lower emissions pathway, with a drop in final energy of 1.3% cumulative CO_2 reduction reaching almost 4.3% or 21,321 kt.

[8] Study on the Implementation of the New EU Renewable Directive in the Energy Community to Energy Community Secretariat, IPA Energy + Water Economics, United Kingdom, February 2010.

[9] 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 7.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	M€2006	72,649	978	1.35%
Primary Energy Supply	Ktoe	230,484	1,434	0.62%
Imports	Ktoe	83,145	-1,779	-2.14%
Fuel Expenditure	M€2006	39,475	-2,033	-5.15%
Power Plant New Capacity	MW	600	1,540	256.7%
Power Plant Investment Cost	M€2006	968	2,811	290.5%
Final Energy	Ktoe	129,397	-1,701	-1.31%
CO_2 Emissions	Kt	492,074	-21,321	-4.33%

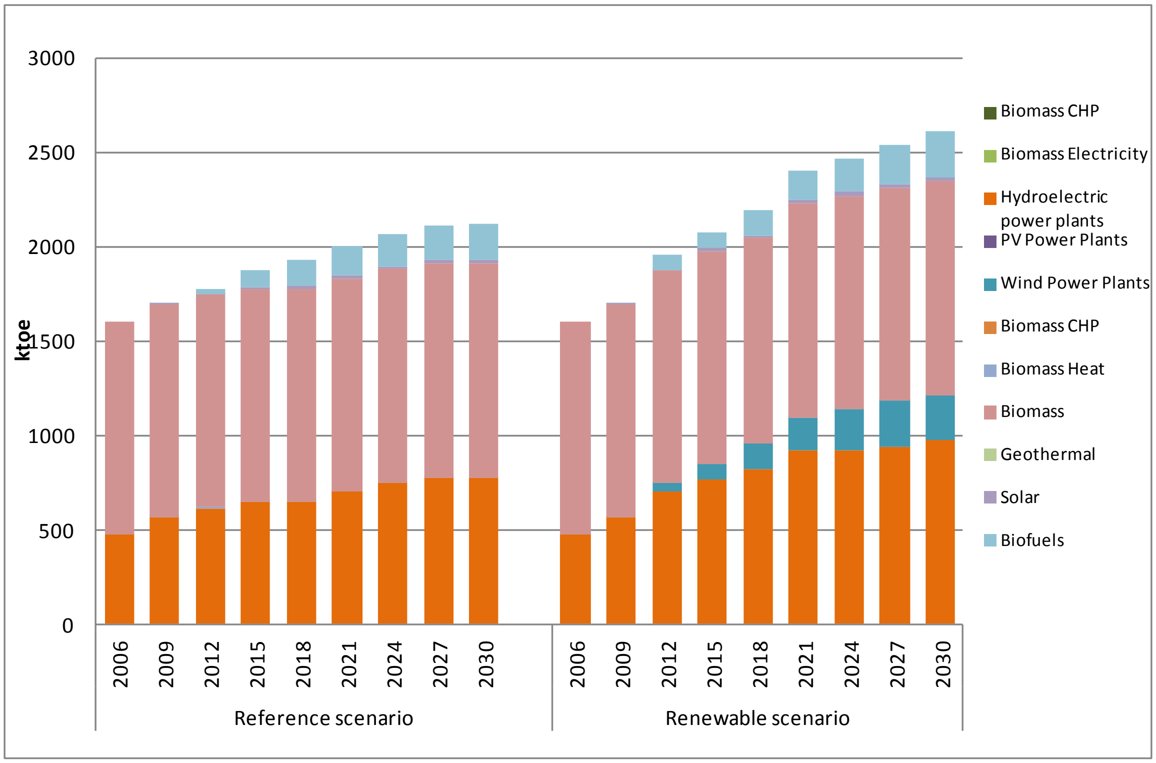
Under the RE target case, all 2,140 MW of new capacity are RE sources (hydro and wind). This suggests that meeting the target and critically sustaining it beyond 2020 will require strong policies to stimulate investment and attract high levels of capital in the power generation sector. The additional capital required under the RE target in the power generation sector is estimated at 2.8€ billion.

By 2020, when the target has to be met, the additional investment (above that observed in the Reference scenario) is 1,344 MW, requiring 2.4€ billion, with some investment in hydro plant brought forward compared to that observed under the Reference scenario. The large increases in capacity above the Reference case are well illustrated in Figures 8 and 9.

A consequence of this substantial increase in more expensive renewable generation is a doubling of the electricity price (based on the levelized 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.

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

Figure 8. Total Renewable Energy under Reference and RE Target Cases



Sustaining the target after 2020 becomes significantly more difficult owing to the overall growth of the energy system (making the same percentage share much higher in absolute terms). This results in the increased uptake of solar in the final period, increased investment in wind, and some uptake of biomass electricity generation (particularly with all hydro potential taken). This suggests that it is critical for decision-makers to take into consideration the post-2020 regime and plan for even steeper investment if the RE target share is to be maintained.

Adapting the energy system to meet the target increases total energy system costs by 1.35%, or 978€ million relative to the Reference scenario over the entire planning horizon.

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 2.14% and CO_2 emissions are reduced (cumulatively) by almost 4.33% relative to the Reference scenario. This suggests strong synergies between an ambitious renewable policy and other policies relating to low emission strategies, energy security, and competiveness. Furthermore, as discussed in Section F, coordinating policies that encourage energy efficiency can dramatically enhance the benefits and lower the cost of meeting renewable targets.

It is also worth highlighting the issue of the system's climate resilience. Increasing investment in hydro generation, with limited diversification, could leave BiH more vulnerable to climate change impacts, particularly reduced precipitation levels. Further sensitivity analysis was therefore undertaken to explore how BiH can achieve the RE target if it reduces its reliance on a hydro-dominated system.

F. COORDINATED RENEWABLES AND ENERGY EFFICIENCY POLICIES FOR BOSNIA AND HERZEGOVINA

Promoting both energy efficiency and renewable energy goals in parallel has strong policy synergies. Key insights are highlighted here and expand upon below.

- Energy system costs increase by 915€ million or 1.26%, indicating that undertaking both policies in parallel is lower in cost than if undertaken in isolation. In isolation, the RE target case increases system costs by 1.35% and the EE case by 0.36% (or 1.71% when considered separately).
- The efforts to reduce final energy through energy efficiency (by 8.26%) means that a lower level of total renewable energy required, resulting in lower overall costs.
- CO_2 emissions and imports are each reduced by 4.89% and 2.48%, illustrating important synergies and co-benefits arising from the implementing efficiency and renewable energy policies together.

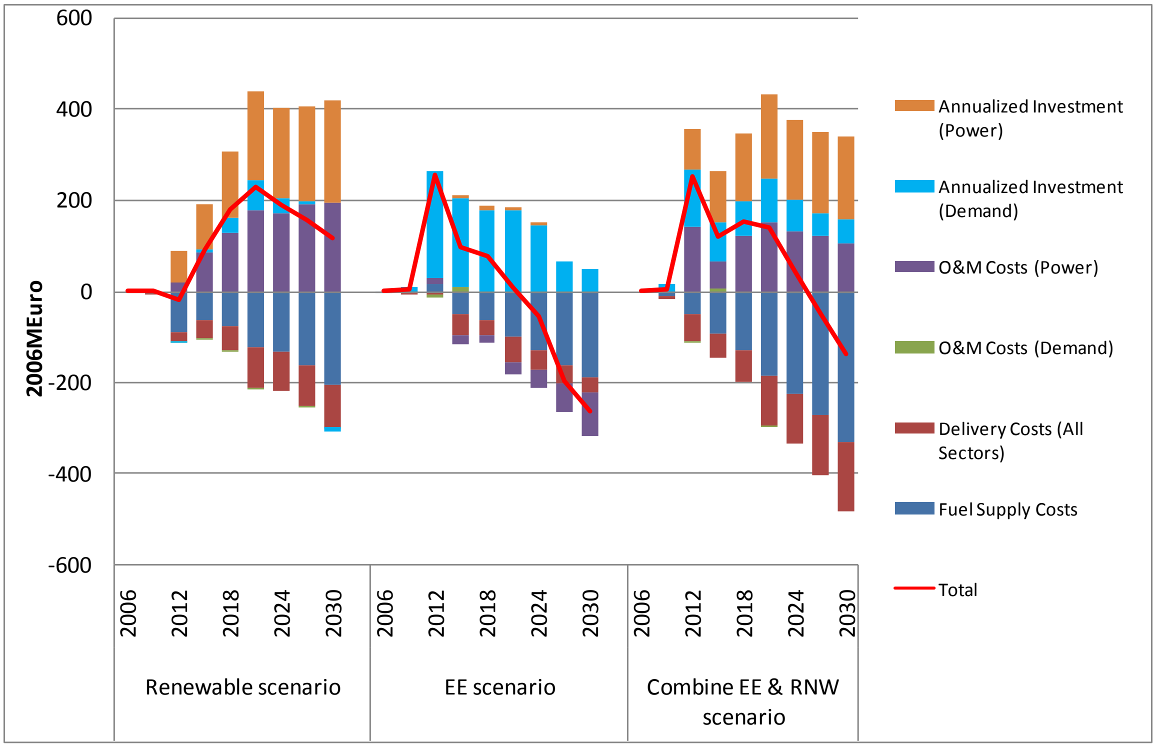
Table 8 shows the key results as changes between the Reference combined RE & EE scenarios.

Table 8.Cumulative Impacts of Combined RE/EE Targets on the Energy System (Compared to Reference Scenario)

Indicator	Units	Reference	EE + RE Targets Change	
Total Discounted Energy System Cost	2006M€	72,649	915	1.26%
Primary Energy Supply	Ktoe	230,484	-6,634	-2.88%
Imports	Ktoe	83,145	-2,064	-2.48%
Fuel Expenditure	2006M€	39,475	-3,363	-8.52%
Power Plant New Capacity	MW	600	1,275	213%
Power Plant Investment Cost	2006M€	968	2,306	238.3%
Demand Technology Investments	2006M€	17,872	571	3.2%
Final Energy	Ktoe	129,397	-10,685	-8.22%
CO_2 Emissions	Kt	492,074	-24,063	-4,89%

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 due to the additional investment needs for renewable generation capacity and the additional costs of energy efficient demand devices. Fuel savings (in dark blue) can be seen in all scenarios, reaching over 330€ million per annum in the combined scenario by 2030 that will continue out into the future.

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

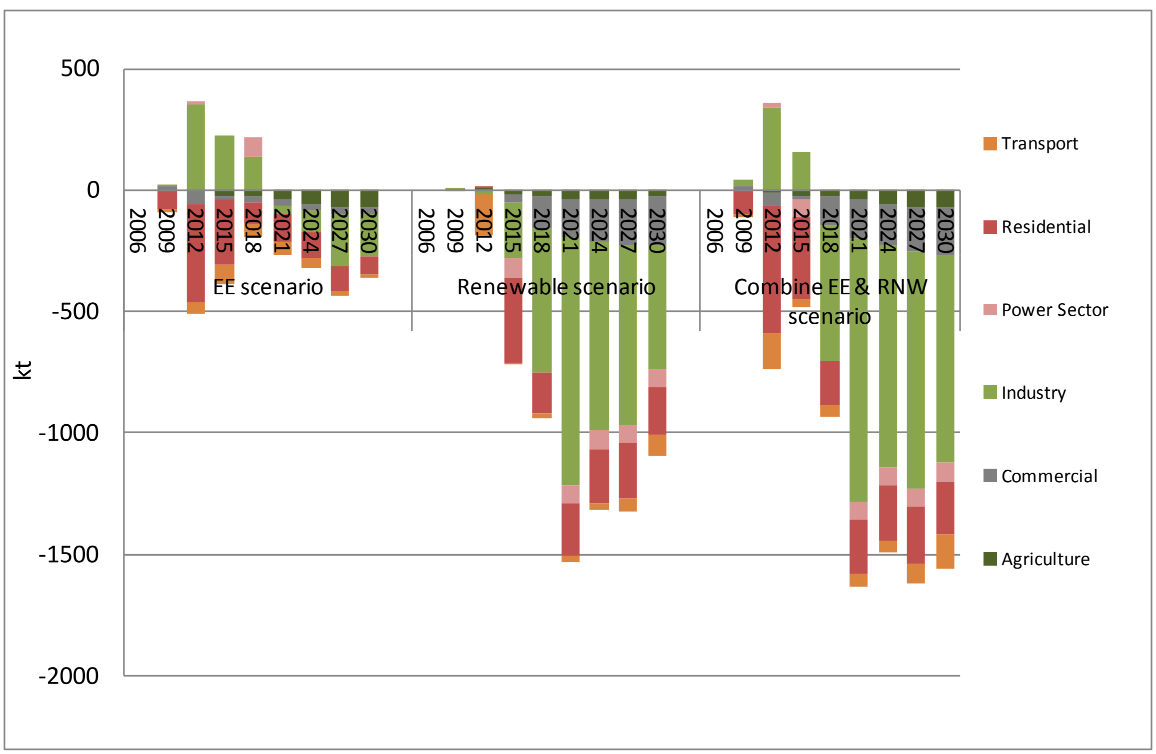


The synergies of meeting both targets at an overall lower cost are illustrated in Figure 10 below. Energy efficiency results in lower levels of renewable energy being required, as the renewable target is relative to (gross) final energy consumption.

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.

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



APPENDIX I: DATA SOURCES AND KEY ASSUMPTIONS

The Bosnia and Herzegovina 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 9 below.

Table 9.Key Data Sources

Data Requirement	Source
2006 Energy Balance	B&H Energy Sector Study made by Energy Institute Hrvoje Požar for B&H Government
Domestic Energy Prices	Ministry of Foreign Trade and Economic Relations
Resource Potential, including imports/exports	Ministry of Foreign Trade and Economic Relations
Installed capacity and characterization of existing electricity, heating and CHP plants	Ministry of Foreign Trade and Economic Relations Independent System Operator in Bosnia and Herzegovina (ISOBiH)
Electricity generation by plant (type)	Independent System Operator in Bosnia and Herzegovina
Timing of demands for energy services	Ministry of Foreign Trade and Economic Relations Independent System Operator in Bosnia and Herzegovina
Fuel consumption patterns by energy service	Bosnia and Herzegovina Agency for Statistics (BHAS)
Demand Drivers	Bosnia and Herzegovina Agency for Statistics
Known energy policies	N/A

Drawing on these data sources provisions the resulting model is reasonably strong. However, there are some specific areas where data availability and quality could be further improved, 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. 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.

A set of key assumptions provide the basis for developing the Reference case, which properly reflects the situation in Bosnia & Herzegovina (see Table 10).

Table 10.Key Assumptions in the Reference Scenario: Power Sector

A. Plant Type & Decommissioning profiles Data

	Last year of operation year	Existing Capacity (GW) 2006	Residual Capacity - RESID/decommissioning profile (GW) 2009	2012	2015	2018	2021	2024	2027	2030
Biomass Power Plant		-	-	-	-	-	-	-	-	-
Brown Coal Power Plant	2035	0.810	0.810	0.810	0.810	0.810	0.992	0.992	0.992	0.992
Hard Coal Power Plant		-	-	-	-	-	-	-	-	-
Lignite Coal Power Plant	2035	0.520	0.520	0.520	0.820	1.170	0.970	0.970	0.970	0.970
			-	-	-	-	-	-	-	-
Heavy Fuel Oil Power Plant		-	-	-	-	-	-	-	-	-
Other Oil Power Plant		-	-	-	-	-	-	-	-	-
Natural Gas Power Plant		-	-	-	-	-	-	-	-	-
Hydro Power Plant	2035	1.999	1.999	1.999	2.035	2.035	2.035	2.035	2.035	2.035
Nuclear Power Plant		-	-	-	-	-	-	-	-	-

B. Calibration of power and heat generation

Calibration of power and heat generation	Existing Capacity	Fuel consumption	Electricity Produced	Base Year Capacity factor	Availability	Efficiency			Energy Input INP(ENT)c
		From EB	Est/known elc prod	Calc. from Elc and Cap	Max capacity factor AF	Based on elc:fuel ratio	Standard/ Estimate	Model input	(1/'Model input eff')
Centralized without CHP	GW	PJ	PJ	%	%	%	%	%	
Biomass Power Plant		-		-		-	30.0%		
Brown Coal Power Plant	0.8100	39.76	10.96	42.9%	60.00%	27.6%	35.0%	**27.6%**	**3.629**
Hard Coal Power Plant		-		-		-	37.0%		
Lignite Coal Power Plant	0.5200	33.59	9.46	57.7%	65.00%	28.2%	35.0%	**28.2%**	**3.551**
HFO (secondary fuel for Lignite plant, if applicable)		-		-		-			
Heavy Fuel Oil Power Plant		-		-		-	35.0%		
Other Oil Power Plant		-		-		-	37.0%		
Natural Gas Power Plant		-		-		-	31.0%		
Hydro Power Plant	1.9988	22.24	19.97	31.7%	35%	89.8%	93.0%	**89.8%**	**1.114**
Nuclear Power Plant		-		-		-	33.0%		

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€/PJ) and performance characteristics for a subset of the key base devices are shown in Table 11.

Table 11. Characterization of Key Base Demand Devices

Energy Service Demand	Demand Device	Investment Cost (€/GJ)	Efficiency (Fraction)
Commercial cooling	Central air conditioning	2.70	3.00
	Air heat pump	6.26	3.40
	Split air conditioner	2.74	3.00
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 lighting	Incandescent bulbs	5.00	1.00
	Halogen lamps	30.00	2.00
	Fluorescent lamps	20.00	4.00
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	0.78
Iron & Steel Mechanical drive	Motor drive (Electricity)	5.00	0.91
Iron & Steel Low temperature heat	Low temperature heat	10.00	0.78
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 space heating	Electric Furnace	4.49	0.86
	Gas Furnace	5.61	0.67
	Oil Furnace	6.78	0.62
	Solar thermal (with oil)	15.85	0.68
	Solar thermal (with gas)	13.58	0.70
	Ground source heat pump	20.13	3.33
	Solar heat pump	20.33	4.00
	Biomass furnace	5.72	0.57
	Coal furnace	4.98	0.60
	LPG furnace	6.45	0.67
	Heat pumps	13.42	1.90
Residential lighting	Incandescent bulbs	15.28	1.00
	Halogen	19.10	2.80

Energy Service Demand	Demand Device	Investment Cost (€/GJ)	Efficiency (Fraction)
	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, though most use this standard approach as described.

Note that due to lack on data on the process details of Albania 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 12) but adjusted to take account of country specific data / assumptions.

- Information on the relative efficiencies across different types of LDVs and the difference in costs (now and in future years) is based on information from AEO 2011.[10] Only the relative efficiency numbers are used and applied to information from the Sultan Tool mentioned above. Relative cost values are applied to user provided information on standard gasoline/diesel vehicles. LDV costs and efficiencies are shown in Table 12.

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

[10] AEO refers to Annual Energy Outlook. This is an annual publication focusing on energy projections prepared by the US Energy Information Association (EIA). For more information, go to http://www.eia.gov/analysis/

Table 12. 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
Medium trucks	DSL	204	328	1.61	15,992	25,674
Rail Pass.	DSL	20	2453	124.61		
	ELC	32	3949	124.61		
Rail Freight	DSL	14	5431	392.98		
	ELC	22	8721	392.98		

Figure 12. LDV Efficiency by Type in Bosnia and Herzegovina MARKAL Model

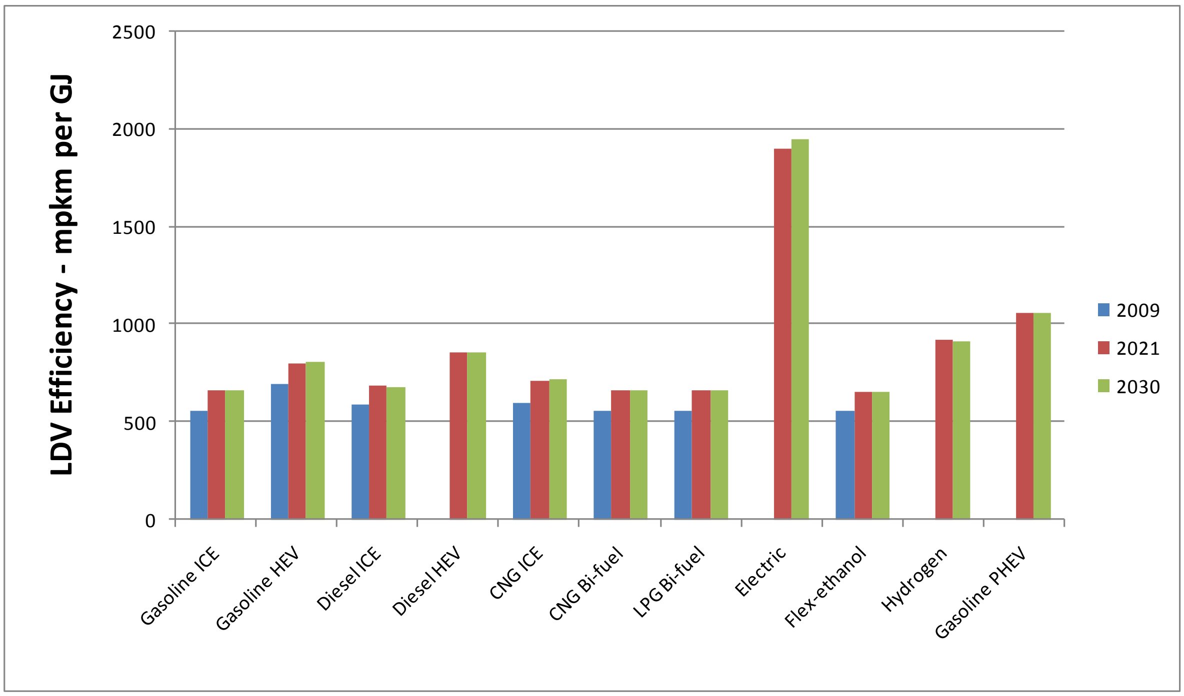
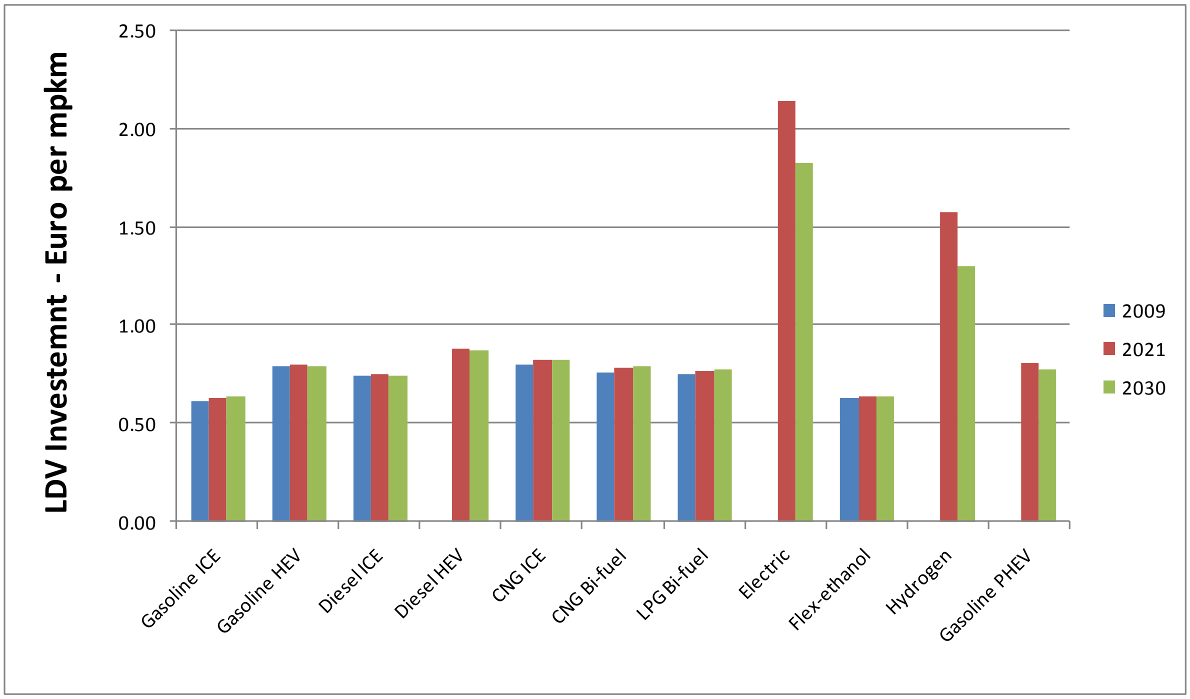


Figure 13. LDV Efficiency by Type in Bosnia and Herzegovina MARKAL Model



For 2006, the transport sector is calibrated to the national energy balance. The transport sector energy totals have been disaggregated using BiH statistics, and other information sources, such as those provided by the 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" rate 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 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.

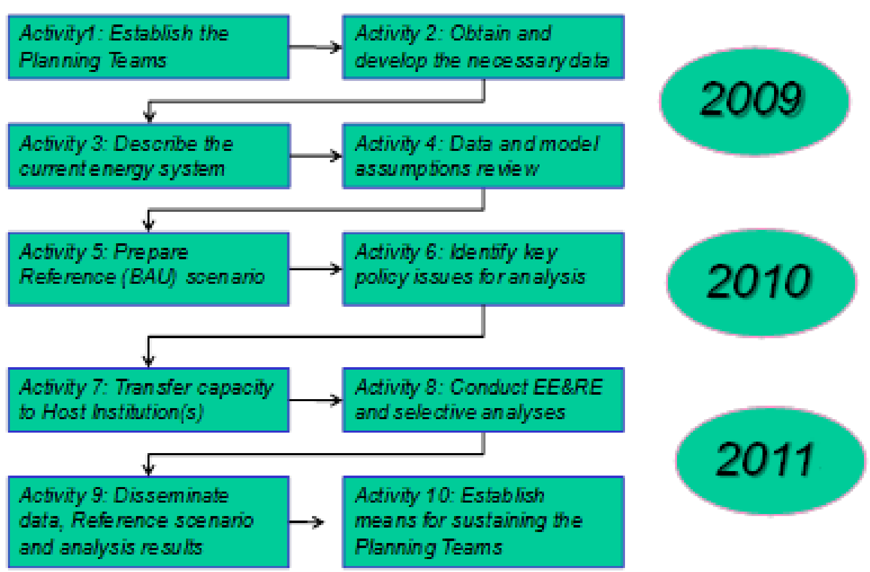
APPENDIX III: PROJECT ACTIVITIES AND METHODOLOGY EMPLOYED

MAJOR PROJECT ACTIVITIES

The consultant teams for International Resource Group (IRG) and the Centre for Renewable Energy Sources (CRES) worked with planning team from the Ministry of Foreign Trade and Economic Relations of BIH (MOFTER) to establish a credible MARKAL-BIH 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 14. 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.

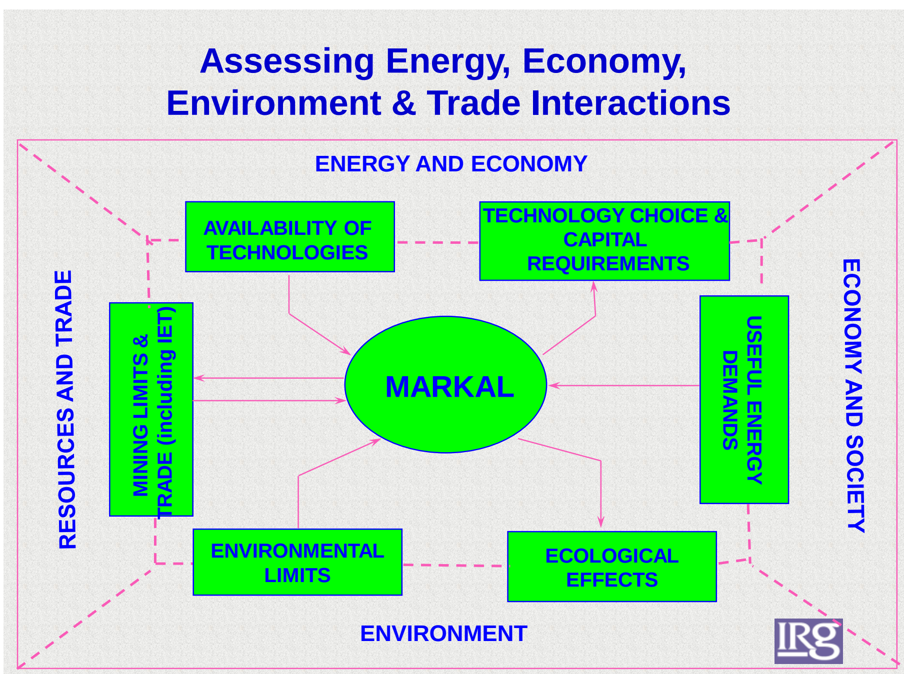
At least as important as the energy balances themselves, and the accompanying information systems, is the process of building a team of professionals in each country who can work with the data, maintain the information systems, and support higher level analytical approaches. This team building should 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).

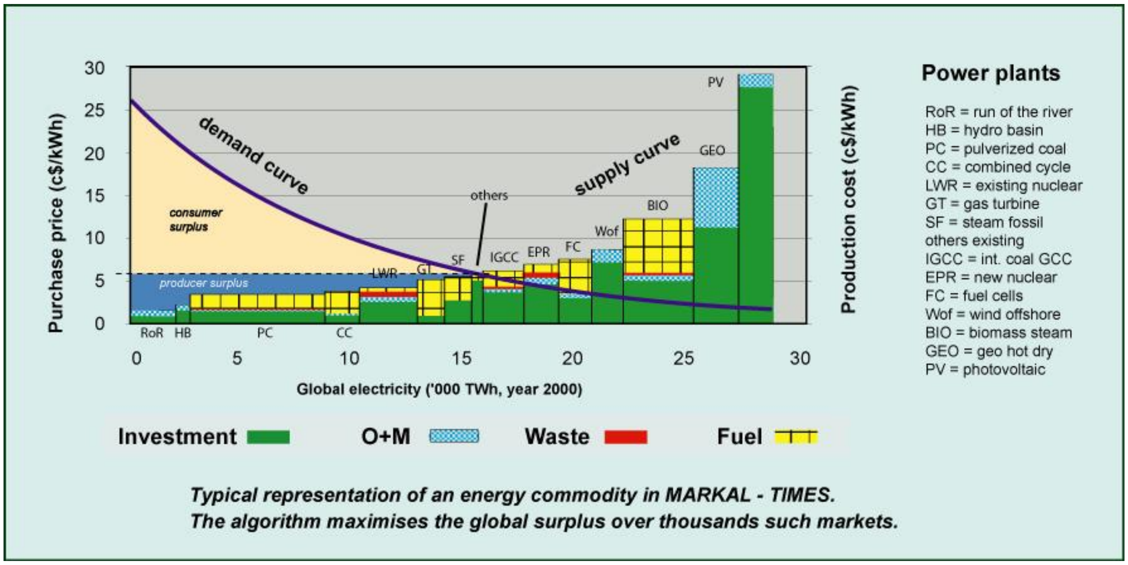
Figure 15. Interactions in the MARKAL/TIMES Model



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 16. 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) [11] undertaking. The Pan-European TIMES model (PET)[12]evolved from the original NEEDS model and has been employed for series of high profile EU projects, including RES2020 [13] examining the EU renewables directive,[14]REALISEGRID[15] 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).[16] Another pair of high-profile uses of MARKAL/TIMES is the IEA Energy Technology Perspectives[17] and UK Climate Change Policy "White Paper."[18]

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[11] http://www.isis-it.net/needs/

[12] http://www.res2020.eu/files/fs_inferior01_h_files/pdf/deliver/The_PET_model_For_RES2020-110209.pdf

[13] http://www.res20202.eu

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

[15] http://realisegrid.rse-web.it/

[16] http://reaccess.epu.ntua.gr/TheProject/ProjectObjectives.aspx

[17] http://www.iea.org/techno/etp/index.asp.

[18] http://www.ukerc.ac.uk/ResearchProgrammes/EnergySystemsandModelling/ESM.aspx.

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