USAID
FROM THE AMERICAN PEOPLE

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:

MACEDONIA POLICY BRIEF

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

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:

MACEDONIA POLICY BRIEF

July 2012

TABLE OF CONTENTS

List of Figures

List of Tables

ACRONYMS

AEO	Annual Energy Outlook
BAU	Business as Usual
CC	Combined cycle
CHP	Combined Heat and Power
CNG	Compressed Natural Gas
CRES	Centre for Renewable Energy Sources
EC	Energy Community
ECS	Energy Community Secretariat
EE	Energy Efficiency
EIA	Energy Information Association (US)
ESD	Energy Services Directive
ESEC	Energy Strategy of the Energy Community
EU	European Union
FIT	Feed-in Tariffs
GDP	Gross Domestic Product
GFEC	Gross Final Energy Consumption
GT	Gas turbines
HB	Pumped Hydro
HGVs	Heavy Goods Vehicles
ICE	Internal combustion engine
ICEIM-MANU	Macedonian Academy of Sciences and Arts
IEA	International Energy Agency
IPA	International Policy Analysis
IRG	International Resources Group
LCVs	Light Commercial Vehicles
LDVs	Light Duty Vehicles
LPG	liquid petroleum gas
LWR	Light Water Reactor
MARKAL	MARKetALlocation
NEEAPs	National Energy Efficiency Action Plans
NEEDS	New Energy Externalities Developments for Sustainability
NPV	Net Present Value

NREAPs	National Renewable Energy Action Plans
O&M	Operation and maintenance
PC	Pulverized coal
PET	Pan-European TIMES model
RE	Renewable Energy
REDP	Regional Energy Demand Planning
REH	Ratio of Electricity to Heat
RESMD	Regional Energy Security and Market Development
RoR	Run-of-River
RPS	Renewable Portfolio Standards
SF	Steam fossil
SSP	SYNENERGY Strategic Planning
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 Macedonian Planning Team using their national MARKAL (MARKetALlocation) integrated energy system model, MARKAL-Macedonia, 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 the 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 Macedonian Academy of Sciences and Arts – Research Center for Energy, Informatics and Materials, (ICEIM-MANU) and the Macedonian Ministry of Economy – Department of Energy, supported by International Resources Group (IRG) and the Centre for Renewable Energy Sources (CRES). The MARKAL-Macedonia 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 Strategy.

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 Macedonia, 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 Macedonia, 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 or NEEAPs). The scenario 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&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.

A number of country-specific issues have also been analyzed, including the impact of undertaking a lower emission development pathway, and the criticality of hydro and lignite power production in Macedonia. The results of these analyses are presented in Sections G and H.

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 undertaken 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 there 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 gas imports • Lignite thermal-dominated generation system	• Increased use of domestic RE resources	• Reduces fossil fuel imports by 2,869 ktoe (6%) • Lowers direct energy and electricity consumption by 3,277 ktoe (5.2%)	• Increased use of domestic RE (although at lower level than under RE case) • Final energy further reduced compared to EE, by 5.3% • Cumulative total imports reduced by over 7.5%
Enhanced competitive-ness[1]	• Electricity system expansion at a total cost of 3.7 € billion	• Only modest cost increase (0.13%) for 21% target • Potential to stimulate investment in renewable market	• Lower fuel costs, saving 6% in fuel expenditure (1,558€M) • Power sector investment reduced by 1% (43€M)	• Lower fuel costs, saving 7.5% in fuel expenditure (1,931€M)
CO_2 mitigation	• 58% higher emissions by 2030 due to increased use of coal and natural gas	• Cumulative reduction of 0.6% due to use of less fossil energy (especially gas)	• Cumulative reduction of 3% due to lower total energy consumption	• Cumulative reduction of 3.7% due to more RE and lower energy consumption

ENERGY SECURITY AND DIVERSIFICATION

Under both RE and EE scenarios, import levels are reduced by around 1.5% and 6% respectively, or by 7.5% under the Combined scenario case. In the renewable case, the reduction of imports is lower because of the higher penetration of RE sources in the Reference case. In the EE scenario, the reduction is due to lower energy demand resulting from increased energy efficiency. Gas imports are particularly

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.

affected. Under the RE scenario, the reduction of imported gas is 3%, while in the EE scenario, the reduction is 12% (or combining both goals, gas imports are reduced by 16%).

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 144€ million; however, only around a 2.4% 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 7.5% (in the combined scenario case), equivalent to a cumulative saving of 1.6€ billion on fuel, offsetting the cost of the more expensive efficient technologies. Once transformed, the energy system savings continue into the future making the Macedonia energy system more competitive over time.

The proposed 2020 RE target increases the cost of the energy system, albeit by a modest amount, 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 181 MW of RE capacity will be required by 2020. Energy system costs are 0.13% higher (47€ million Net Present Value (NPV)[2]). If the RE target is implemented in coordination with policies to promote energy efficiency, energy system costs only increase 27€ million or 0.07%, highlighting the synergies between renewable and energy efficiency policies. As currently subject to discussion with the Energy Community Secretariat (ECS), a more ambitious target of 24% has also been assessed. However, this more ambitious target requires significantly higher investment, with costs around 1.5% higher than observed in the Reference case.

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

CO_2 MITIGATION

The policies examined show strong synergies with the goal of moving towards a lower carbon pathway for the Macedonian energy economy. The combined EE & RE policy leads to cumulative reductions of 3.7% in CO_2 emissions. This is accomplished by overall reduction in demand for energy owing to the more efficient energy system, and a switch to lower carbon generation mix.

---

[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.

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 (ESEC)[3] 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-Macedonia Reference scenario shows that rapid electricity demand growth requires a more than doubling of electricity generation capacity by 2030 to 3.3 GW at a cost of nearly 3.8€ billion. 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 these priorities. The MARKAL-Macedonia analysis shows that a 2.4% reduction in final energy consumption can be achieved at a net savings of 144€ million (or 0.4%) by reducing barriers to the uptake of energy efficiency. Achieving the more ambitious NEEAP target of 9% still save 0.2% (90€ million) over the baseline, saving 1.6€ billion in fuel expenditures and reducing imports by 6% and carbon emissions by 3%. Achieving these goals does require a 9% increase in investment (or 940€ million) in more efficient demand devices, resulting in a small reduction in new power plant expenditures (over 40€ million), as the need for capacity growth is reduced by nearly 60 MW. The most cost-effective areas for energy efficiency investment identified in this analysis include residential and commercial space heating, and industrial process heat. The MARKAL-Macedonia model provides a readily available useful framework, along with market analysis, to identify key technology and building opportunities and develop targeted measures to achieve this potential.

Meeting RE targets without simultaneously promoting energy efficiency increases energy system costs by a modest 0.1% (or just under 50€ million) and requires a 3% increase in power sector capacity additions. This relatively modest increase reflects that the domestic target used is significantly lower in ambition than that proposed by the ECS, for which there is ongoing discussions. Achieving the target yields a number of benefits: a 1.5% decrease in imports and a similar reduction in fuel expenditures (350€ million). A more ambitious target of 24% was also considered, replacing the 21% target discussed above. A more ambitious RE target of 24% increased costs substantially by 1.6%, due to significantly higher levels of biofuel, wind generation, and solar technologies.

Although the investment challenges are significant, pursuing the EE&RE strategies simultaneously leads to important synergies that enhance the benefits just mentioned. The system cost does not increase as the EE savings balance the small additional costs under the RE target. The synergies from undertaking the policies in parallel are clear: a 7.5% decrease in fuel costs (1.9€ billion), 4% decrease in carbon emissions, and a 7.5% 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 Macedonia 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, and to evaluate Energy Community proposals to assess the national implications. Key areas for future analysis include how best to design feed-in tariffs (FITs) to encourage renewable development, and developing targeted energy savings policies, including standards and appliance and retrofit subsidies.

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

C. MACEDONIA BUSINESS-AS-USUAL ENERGY PATHWAY

To assess the impact of different policies and programs on the evolution of the energy system in Macedonia, 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 National Strategy for Energy Development to 2020. 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. The importance of key assumptions relating to the power sector, particularly hydro and lignite plant, are explored further in Section H. 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 significantly, by 105% in terms of final energy by 2030, driven by strong Gross Domestic Product (GDP) growth and increasing per capita consumption. This GDP forecast is at the high end of the range of estimates, This will require more than doubling electricity generation capacity from 1,470 to 3,252 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.

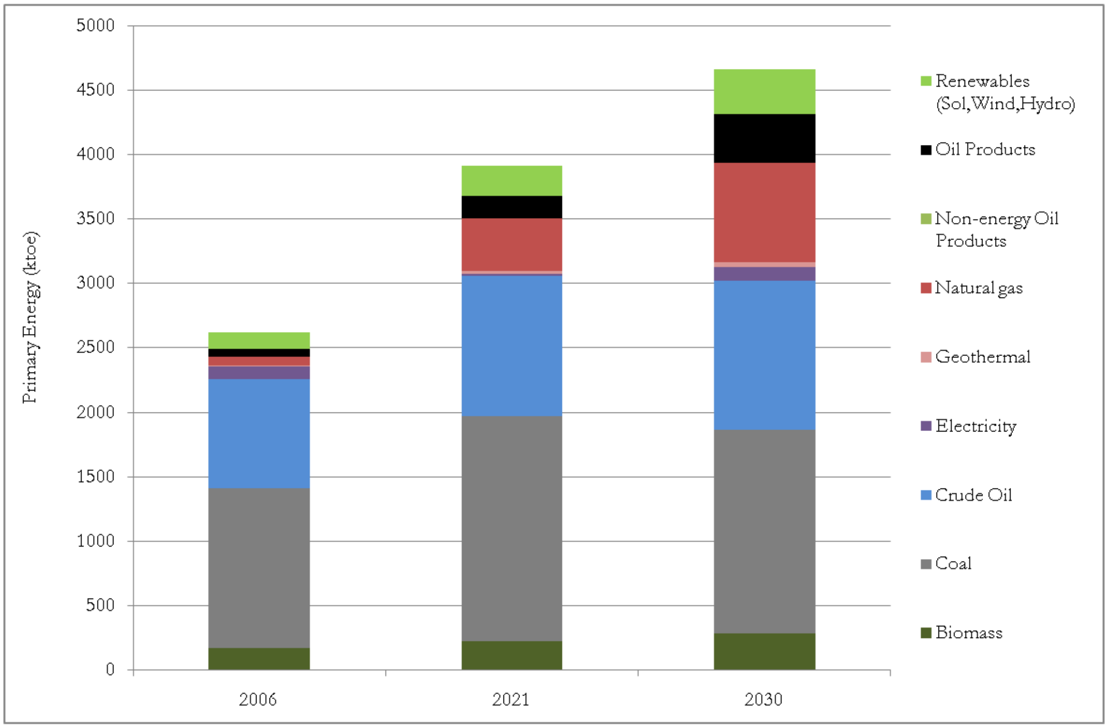
Table 2. Key Indicators for the Reference Scenario

Indicator	2006	2030	Annual Growth Rate (%)	Overall Growth (%)
Primary Energy (ktoe)	2,616	4,656	2.4%	79%
Final Energy (ktoe)	1,646	3,371	3.0%	105%
Power plant capacity (MW)	1,470	3,252	3.4%	121%
Imports (ktoe)	1,184	2,584	3.3%	118.3%
CO_2 emissions (kt)	8,359	13,253	1.9%	59%
GDP (€ Mill.)	5,082	22,544	6.4%	344%
Population (000s)	2,037	1,958	-0.2%	-3.9%
Final Energy intensity (toe/€000 GDP)	0.324	0.150	-3.2%	-54%
Final Energy intensity (toe/Capita)	0.808	1.722	3.2%	113%

Primary energy consumption in 2030 is projected to be 4,656ktoe, increasing from 2006 levels by 79%. 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 0.15toe/1,000€, a reduction of around 54%. This is a result of the continuation of current structural changes in the Macedonia economy and natural technological progress underway internationally.

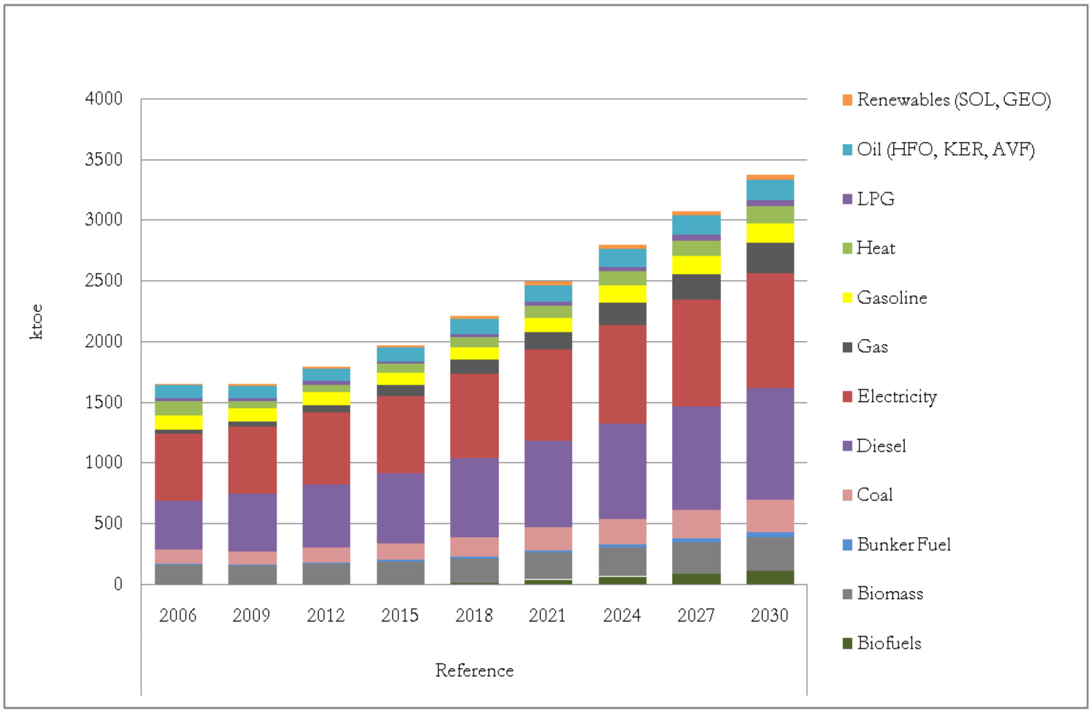
In addition to the significant growth in primary energy supply, the supply becomes more diverse. As shown in Figure 1, primary energy supply increases by 79% in 2030 with imported natural gas accounting for 17% of total supply. The growth in transport demand is reflected in the increase in oil products (imported) and crude oil. The contribution of renewable energy sources (excluding biomass) to total primary energy during this period grows from 5% to over 8%, and in absolute terms grows by 175%. This is primarily due to additional wind capacity in the power sector. The biomass contribution is almost the same at around 6%, although in absolute terms grows by 70%.

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



Total final energy consumption grows by 105% over the planning horizon, with the most significant increase from diesel and electricity use, and a greater share of natural gas, available through import.

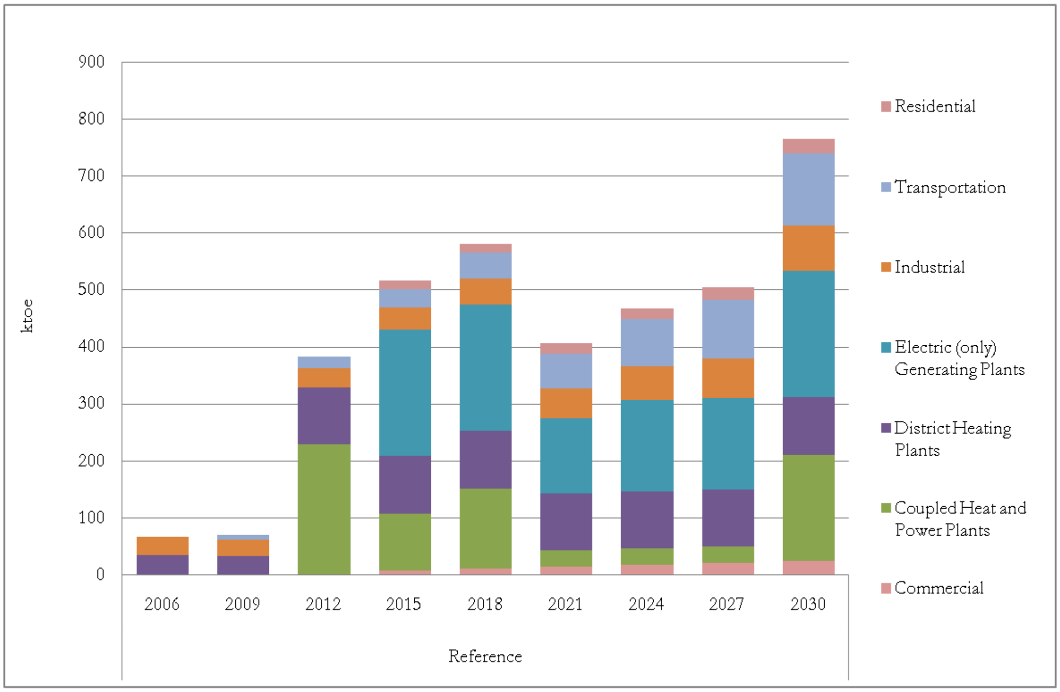
Figure 2. Final Energy Consumption by Energy Type



A more detailed view of gas consumption by sector is shown in Figure 3. Gas consumption increases significantly between 2012 and 2018, driven by heat and electricity generation. By 2021, gas consumption has decreased and only reaches levels observed in 2018 again by 2030; this is due to an increase in lignite power generation. In terms of end-use sector consumption, the main end-use consuming sectors are industry and transport. Concerning transport, there are potentially a range of costs not explicitly incorporated into the modeling relating to Compressed Natural Gas (CNG) infrastructure; therefore, additional analysis is needed to more fully assess this switch in transport fuel consumption. There is limited penetration in commercial and residential sectors, due to large investment requirements in distribution infrastructure.

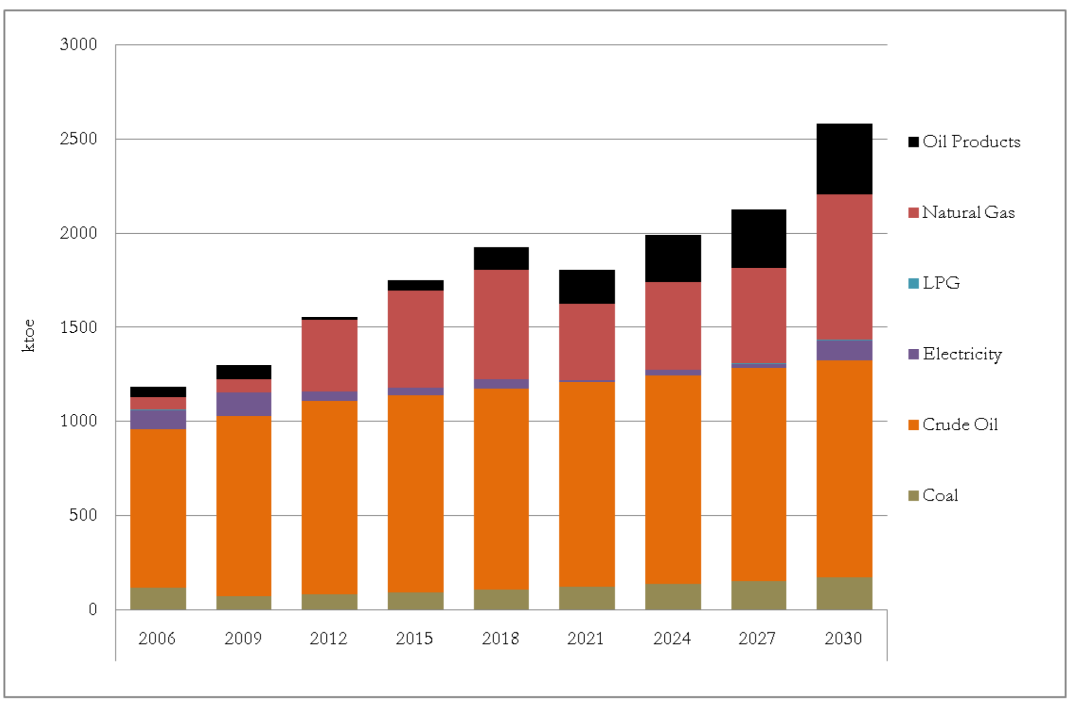
There is significant uncertainty around gas prices, which has an important impact on gas consumption in future years. The current prices, used as the base price in the model, are projected forward based on IEA regional assumptions. However, current prices are very high due to the low levels of import via the pipeline. If import levels were to increase (as predicted under the Reference case), the relative gas prices under the contract would decrease. The modeling of this issue needs further consideration as the Macedonian model continues to develop.

Figure 3. Gas Consumption by Sector and Power Plant Type



The majority of Macedonia's fossil energy requirements are imported. This demand for natural gas increases import dependency, resulting in a doubling of imports by 2030 (relative to current levels).

Figure 4. Imports by Type



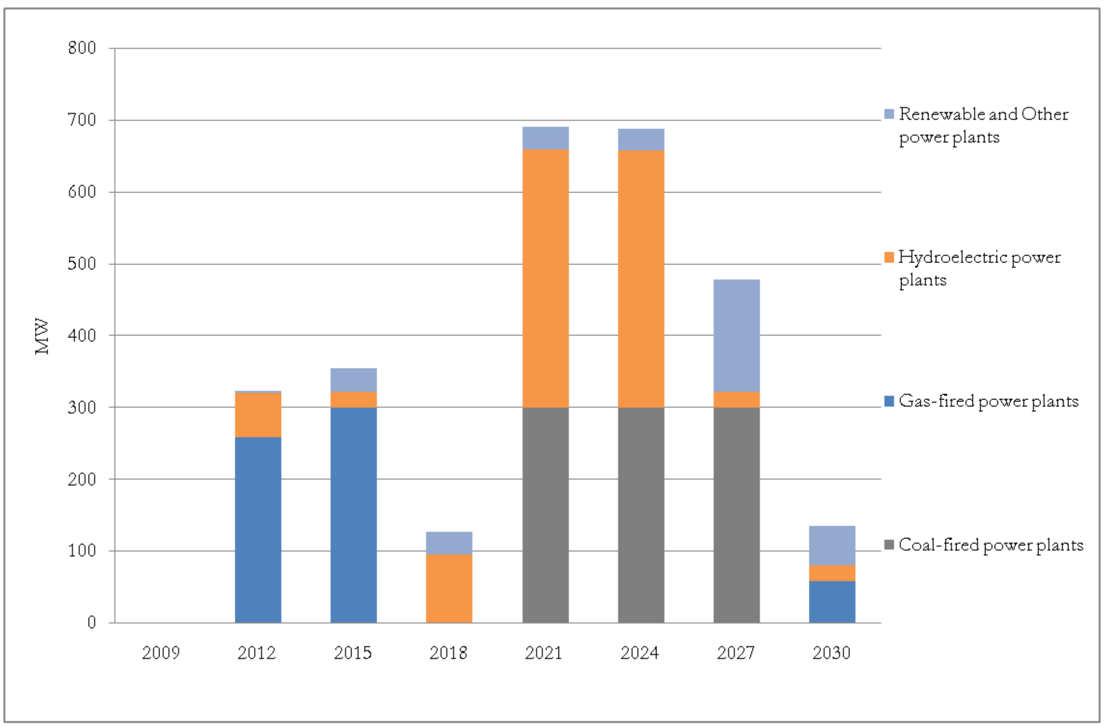
New power generation capacity additions in each three-year period are shown in Table 3. Coal power plants remain the main producers of electricity with new installed capacity of 900 MW between 2021 and 2027. The highest level of investment is in hydro power, with a cumulative additional capacity of 944 MW by 2030, while new gas power plants have a cumulative installed capacity of 619 MW. Wind, solar, and biomass (under Renewable and Other category) also make an important contribution, (340 MW) where wind is primarily incentivized by a feed-in tariff. Capacity additions and the retirement of old power plants results in 3,252 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
Coal	736	0	0	0	300	300	300	0	900
Gas		260	300	0	0	0	0	59	619
Oil	198								
Hydro	536	61	23	96	360	359	23	23	944
Renewable and Other		4	32	32	32	30	156	54	340
Total New Capacity	1470	325	355	128	692	689	479	136	2803
% of Installed Capacity		18,1%	18,2%	6.2%	25%	21.9%	14%	4.2%	

Figure 5 shows the capital investment requirements associated with the new capacity added in each three-year period.

Figure 5. Total Investment Cost of New Power Plants



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

Growth in the energy system will require significant levels of new investment and increased payments for fuel. However, in macro-economic terms, 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, as 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	660	912	1,182	1,463	1,623	1,930	2,164	2,597
Operation and maintenance (O&M) Costs	512	594	709	798	925	1,023	1,119	1,204
Annualized Investment (Demand)	269	507	754	1,158	1,566	1,933	2,182	2,441
Annualized Investment (Power)	3	30	47	66	152	245	306	314
Total	1,445	2,042	2,693	3,485	4,267	5,132	5,771	6,556

Under the Reference scenario, to add the 2,803 MW of new generation capacity by 2030, a total investment of 3,773€ billion is required, which translates to average annual payments on the order of 190€ million. At the same time, by 2030 over 540€ million annually will be required to cover the cost of new demand devices (including vehicles), 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 450€ million per year to 1.7€ billion per year.

[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.

D. EXAMINATION OF THE PROMOTION OF ENERGY EFFICIENCY IN MACEDONIA

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 demand (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 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, 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*.

The *First Energy Efficiency Action Plan of the Republic of Macedonia by 2018* was published in 2011, and included a national adopted energy savings target of 12.2% (of current consumption levels) by 2018, with an interim target in 2012 of 4%. The target was based on the methodology outlined in Annex 1 of the Directive.

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).[6]

It is also 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*.[7]

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,[8] 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.

---

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

6 In addition, no impact assessment is available against which to cross-compare the MARKAL analysis.

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

8 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).

Under such a scenario (no EE target but reduced barriers to uptake), there is only a 2.4% reduction in final energy consumption (not the required 12.2% under NEEAP), though with an overall savings to the energy system of 144€ million (or 0.4% as shown in Table 6). 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.

Policies that promote increased energy efficiency in order to meet the NEEAP target have other significant benefits, as described below. Key insights include:

- A decrease in discounted energy system costs of 0.24% (87€ million) is observed under the NEEAP target, where without programs and policies to reduce barriers to uptake the cost to meet the same target would potentially increase costs by 1% relative to the Reference case.
- A 5.9% cumulative reduction (2,869 ktoe) in imports is observed under the NEEAP target, enhancing energy security goals.
- Significant cumulative reductions in final energy of over 5% is observed (3,277 ktoe), as are strong synergies with low emission development, reducing CO_2 emissions by 3% (or 8,604 kt).

The basis for the energy efficiency target is the Macedonian 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 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 ambition to maintain improvements in energy efficiency over time.

Table 5. Energy Efficiency Targets

Approach	2012	2015	2018	2021	2024	2027	2030
NEEAP target	4%	8.1%	12.2%	12.2%	12.2%	12.2%	12.2%
Reduction totals (ktoe)*	**40**	**98**	**157**	**157**	**157**	**157**	**157**

* Reduction levels in the model are lower to take account of the inclusion of combined heat and power (CHP) measures in the model reference case.

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 taken up, incentivized 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.

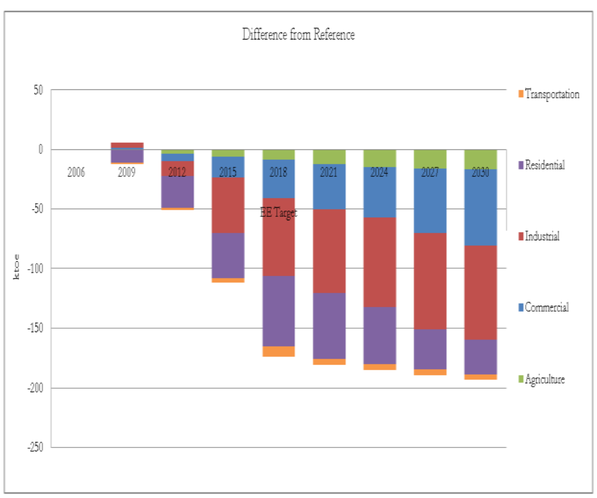
The focus of this section is on the *Energy Efficiency + Target* case, as the NEEAP is the main ongoing policy action in this area. As shown in the table, all of the key cumulative metrics (other than investment in new demand technologies) are reduced due to efficiency savings. For example, overall system cost reduces by 0.2% (or 87€ million), power plant investment reduces by 1.1%, imports drop by 6%, and fuel expenditure goes down by 6%; saving 43€ million/1.56€ billion respectively. Such savings enhance economic competitiveness and energy security.

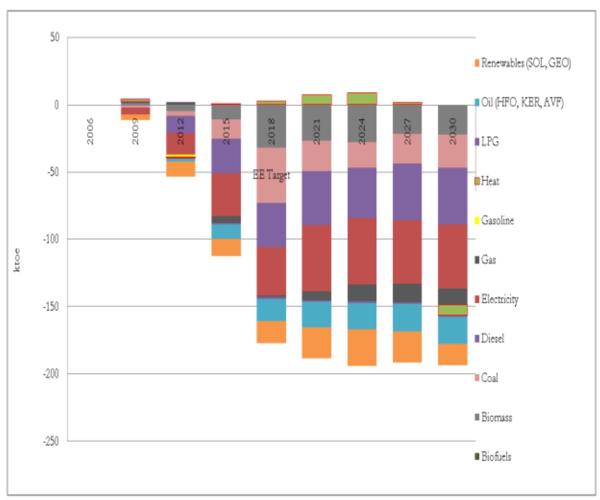
Table 6. Cumulative Impacts of the EE Target on the Energy System (Change compared to Reference Scenario)

Indicator	Units	Reference	Energy Efficiency Promotion		Energy Efficiency + Target	
Total Discounted Energy System Cost	2006M€	36,316	-144	-0.4%	-87	-0.24%
Primary Energy Supply	Ktoe	97,045	-1,227	-1.3%	-3,969	-4.1%
Imports	Ktoe	48,667	-1,201	-2.5%	-2,869	-5.9%
Fuel Expenditure	2006M€	25,807	-703	-2.7%	-1,558	-6.0%
Power Plant New Capacity	MW	2,803	-59	-2.1%	-59	-2.1%
Power Plant Investment Cost	2006M€	3,773	-43	-1.1%	-43	-1.1%
Demand Technology Investments	2006M€	10,811	251	2.3%	940	8.7%
Final Energy	Ktoe	62,960	-1,014	-1.6%	-3,277	-5.2%
CO_2 Emissions	Kt	293,805	-2,776	-0.9%	-8,604	-2.9%

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 industry sector provides the largest cumulative savings (39% of total savings), followed by the residential sector (28%), and commercial (23%).

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

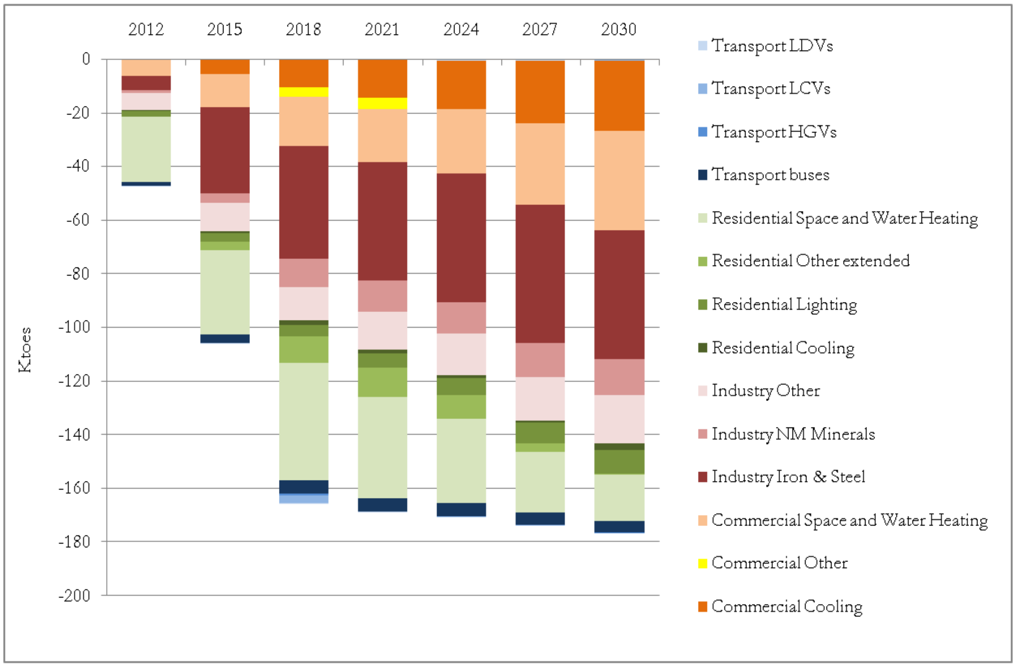




In terms of fuels, the largest near-term reductions come from electricity, diesel (transport), coal (industry), and biomass (residential). The use of distributed heat increases slightly because the fuel used for production of heat, like electricity, is not subject to the energy efficiency target.

A more detailed overview of savings by energy service demands is shown in Figure 7. The most cost-effective reductions occur in the industry iron and steel sector, particularly across gas- and oil-using technologies, with a reduction in the role of coal. In the commercial sector, more efficient provision of space and water heating and cooling technologies are introduced and, as a result, significant savings of electricity and oil are observed. There is also provision of more efficient technologies in residential space and water heating sector and this leads to reductions of electricity and biomass.

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 Macedonia to further improve the robustness of the analysis.

Under the EE target, costs are shown to decrease by 0.24% as a result of reductions in fuel expenditure. 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 (2.9% reductions) and energy security through reduced imports (6% reduction).

The costs observed for the EE target case are significantly higher if policies and programs are not introduced to reduce the barriers to uptake of energy efficient technologies, at 1% increase compared to a 0.24% 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 MACEDONIA

A Renewable Energy Directive for the EU sets targets for Member States in order to achieve the objective of sourcing 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 gas emissions and make it less dependent on imported energy. In addition, this will help develop the renewables industry, further encouraging technological innovation and employment.

The Energy Community Secretariat commissioned a study in 2009 examining illustrative RE targets for the contracting parties,[9] 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.[10] A 2020 renewables target of 29% of Gross Final Energy Consumption (GFEC) for Macedonia has been proposed by the ECS. However, this target value was based on a much higher biomass estimate in 2009, and has yet to be agreed.[11] The target value of 21%, as adopted in the *Strategy on use of renewable energy sources in the Republic of Macedonia by 2020*, is therefore used in this analysis. A more ambitious target value of 24% has also been analyzed, the results of which are briefly described below.

The MARKAL-Macedonia analysis 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 Strategy. The analysis also quantifies the benefits and costs of those measures. The timeliness of this assessment should help to provide additional underlying evidence for the Strategy as it is further developed.

Key insights are highlighted below and summarized in Table 7, then elaborated upon in the rest of this section, including:

- Cumulative energy system costs (to 2030) are a modest 0.13% higher. There is significant uptake of renewable energy in the reference scenario, meaning that the additional investment requirements under the RE target are not as significant as might have been thought. For example, under this target only 47 MW additional RE capacity is required, resulting in an additional investment cost in power sector of over 2.6% (or €98million Euros).
- Some of the key options cited in the Renewable Strategy adopted by Macedonia are included in the Reference scenario. In part, this is because renewable options form a critical part of the system evolution, particularly as the Reference case has a particularly ambitious GDP growth rate underpinning it.

---

[9] 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.

[10] 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, March 6, 2012.

[11] There are ongoing discussions concerning the biomass level estimated for 2009 between Macedonia and the ECS, which is the key issue to agreeing the RE target level.

- Energy security is enhanced with a 1.5% cumulative decrease in the imports required, as a result of increased use of indigenous electricity and increase biofuel use in the transport sector, while demand for final energy increases by 0.6%.
- This policy contributes to a move towards a lower emissions pathway, with cumulative CO_2 reduction reaching almost 0.6% (between 2009-2030).
- A more ambitious RE target of 24%increases costs by 1.6%. This increase is due to higher levels of biofuel, wind generation and solar technologies.

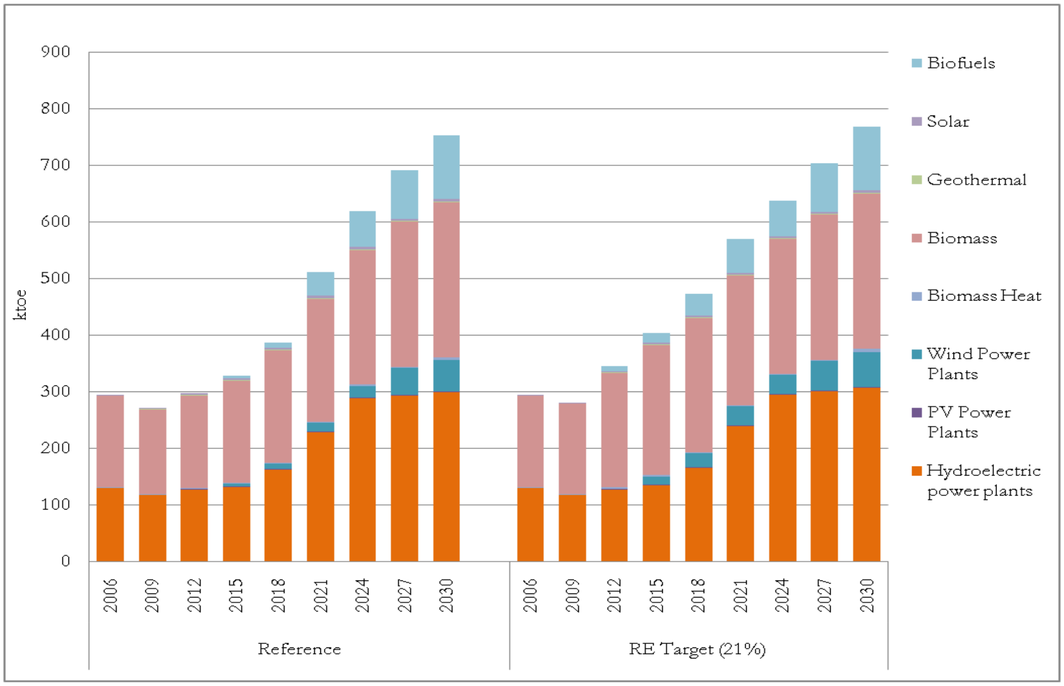
Table 7. Cumulative Impacts of the RE Target (21%) on the Energy System (Change compared to Reference Scenario)

Indicator	Units	Reference	RE Target Change	
Total Discounted Energy System Cost	M€2006	36,316	47	0.13%
Primary Energy Supply	ktoe	97,045	5	0.0%
Imports	ktoe	48,667	-734	-1.5%
Fuel Expenditure	M€2006	25,807	-347	-1.3%
Power Plant New Capacity	MW	2,803	47	1.7%
Power Plant Investment Cost	M€2006	3,773	98	2.6%
Final Energy	ktoe	62,960	348	0.6%
CO_2 Emissions	kt	293,805	-1,648	-0.6%

The Reference scenario showed an increase in new hydro and wind power generation capacity of about 1,284 MW out of a total for new capacity additions of 2,803 MW. In other words, renewable electricity generation is playing a crucial part in meeting future demand (see Figure 8) without an established renewable energy target. However, to further enhance energy security and address climate change, pursuing an even more aggressive renewables strategy has merit, though at a cost.

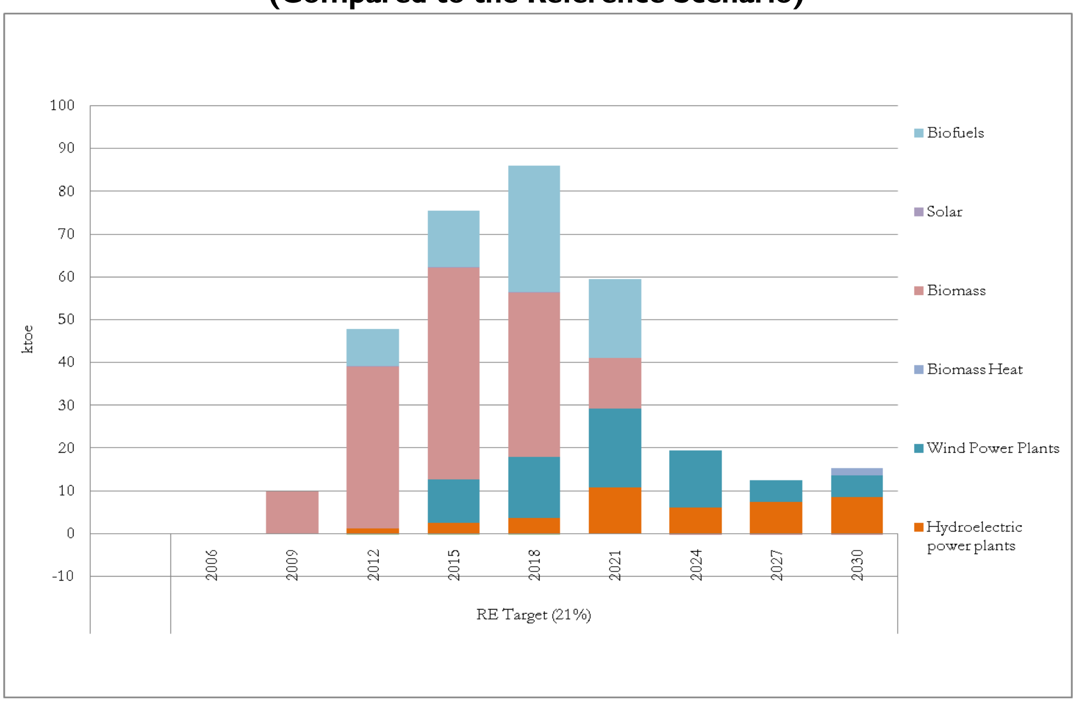
Under the RE target, cumulative additions in RE capacity total 1,354 MW out of total new capacity of 2,850MW (between 2009-2030). This is not a significant increase; however, it highlights the critical importance of RE under the Reference case, particularly driven by the ambitious growth under the Reference scenario. This is illustrated well in Figure 9 below.

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



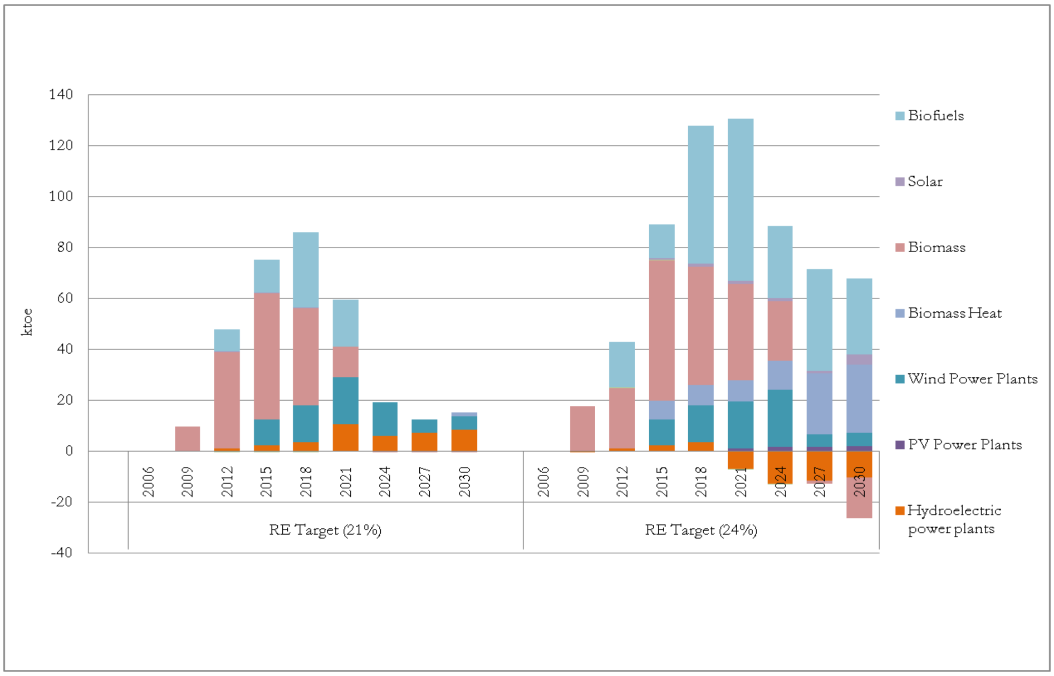
A summary of the change in renewable energy use sourced from centralized electricity and distributed technologies compared with the Reference scenario is provided in Figure 9. The main addition in RE is from biomass in residential sector, biofuels (prior to 2021), hydro, and wind. However, the size of the required additions is low, at just under 60ktoe in 2021.

Figure 9. Additional Renewable Energy under RE Target (Compared to the Reference Scenario)



Given the ongoing discussion about the specific target to use, a more ambitious RE target of 24% was assessed. A comparison of the differences in additional RE levels is shown below in Figure 10.

Figure 10. Additional Renewable Energy under RE 21% and 24% Targets (Compared to the Reference Scenario)



The energy system cost of this scenario increased by 1.6%. The costs are driven up by an increase in more expensive biomass and solar technologies in end-use sectors, increase in wind generation, and increased use of biofuels in the transport sector. There is also a move towards more efficient technologies to lower the RE requirements, as the RE target is based on a percentage of GFEC.

Further work is needed to develop the renewable options available to the model. The potential of many of the RE options is used due to the importance of such options in the Reference case, particularly given the high GDP growth assumptions. The significant increase in costs for a relatively small increase in RE energy requirements suggests the model assumptions on potential of different technologies may need to be revisited.

F. COORDINATED RENEWABLES AND ENERGY EFFICIENCY POLICIES FOR MACEDONIA

As a Contracting Party to the Energy Community Macedonia has committed to simultaneously making progress with respect to both energy efficiency and renewable headway goals. Promoting both energy efficiency and renewable energy goals in parallel may have strong policy synergies. This analysis looked at assessing both objectives at the same time. In the case of Macedonia, the NEEAP and draft Renewable Strategy will be implemented in parallel; therefore, this analysis is a better reflection of the policy reality. The analysis highlights that strong synergies do exist between these policies in terms of energy savings and CO_2 reductions, although cost synergies are less obvious for reasons outlined below.

Key insights include:

- Energy system costs increase by 27€ million or 0.07%. This cost is slightly higher than the aggregate cost observed under the individual RE and EE cases. This is primarily because biomass and biofuels use under the RE target means less lower cost efficiency gains can be made under the EE target.
- CO_2 emissions and imports are reduced by 4.6% and 6.1% respectively, illustrating important synergies and co-benefits arising from the implementing efficiency and renewable energy policies together.
- Primary energy (4.2%), final energy (5.3%), and fuel expenditure (7.5%) all decrease by more than seen in the individual EE / RE model runs, again suggesting strong synergies between these policy goals.

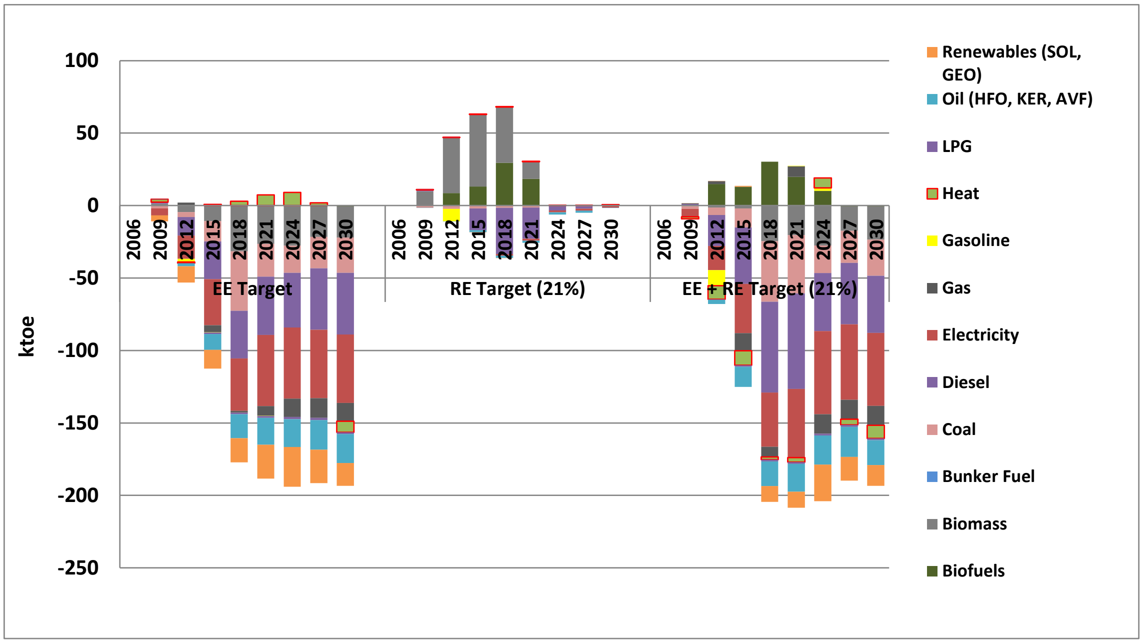
Table 8 shows the key result changes between the combined RE & EE scenario and the Reference scenario.

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

Indicator	Units	Reference	EE + RE Targets Change	
Total Discounted Energy System Cost	2006M€	36,316	27	0.07%
Primary Energy Supply	ktoe	97,045	-4,033	-4.2%
Imports	ktoe	48,667	-3,657	-7.5%
Fuel Expenditure	2006M€	25,807	-1,931	-7.5%
Power Plant New Capacity	MW	2,803	11	0.4%
Power Plant Investment Cost	2006M€	3,773	71	1.9%
Demand Technology Investments	2006M€	10,811	1,028	9.5%
Final Energy	ktoe	62,960	-3,325	-5.3%
CO_2 Emissions	kt	293,805	-10,995	-3.7%

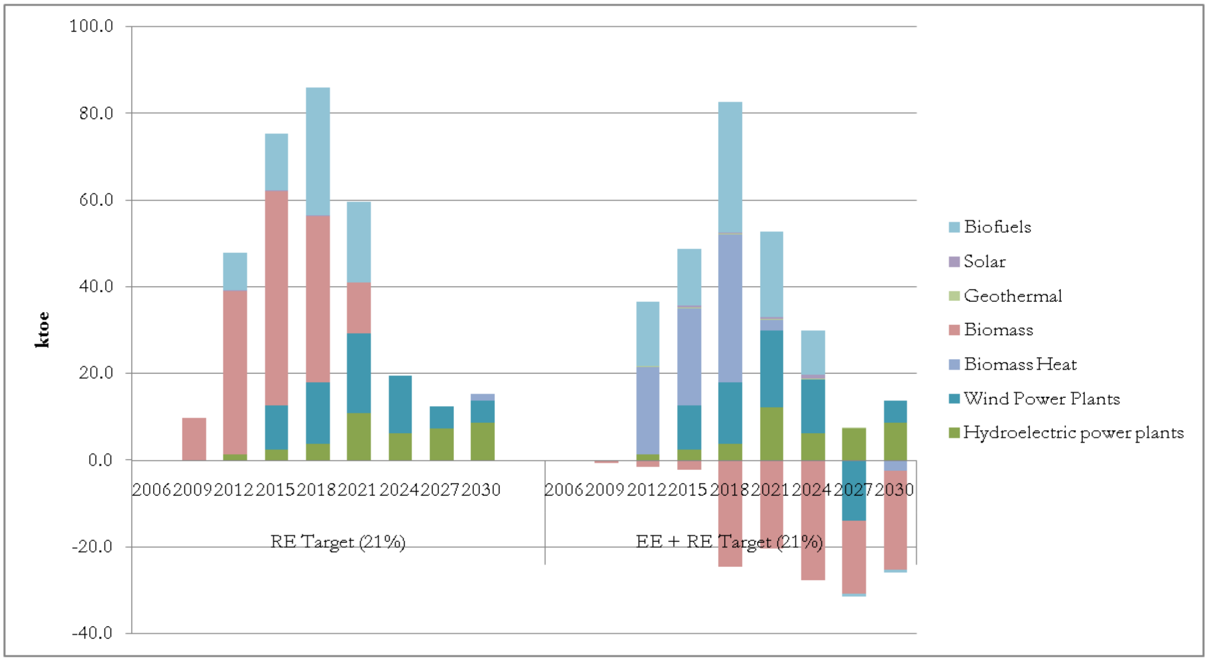
Figure 11 shows the change in final energy consumption by fuel type for three policy scenario relative to the Reference scenario. It shows the stronger energy reductions under the combined case, as efficiency measures reduce the required contribution from renewable energy.

Figure 11. Change in final energy consumption by fuel type



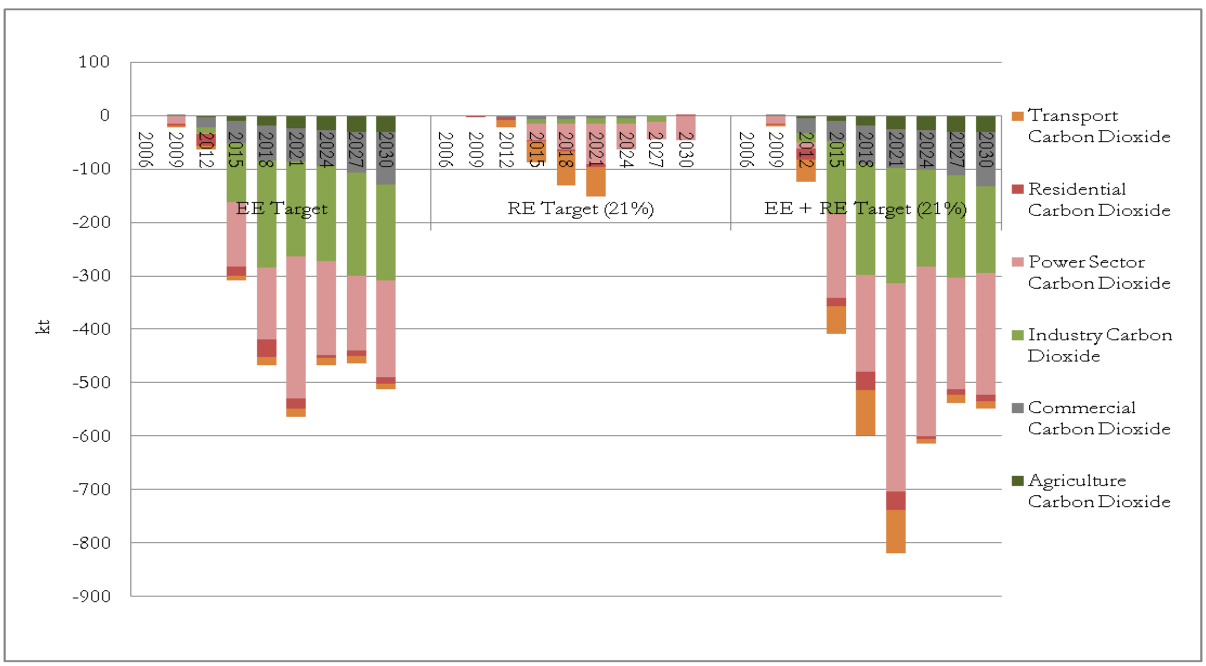
The synergies of meeting both targets at an overall lower cost are illustrated in Figure 12 below. Energy efficiency results in lower levels of renewable energy being required, as the renewable target is relative to (gross) final energy consumption. There is also an important switch away from additional biomass use to solar and increased use of biofuels in transport. This is because biomass technologies are assumed to be less efficient than other technology-fuel types.

Figure 12. Change in Renewable Energy Consumption under RE and RE&EE Combined Cases



CO_2 emission reductions are shown in Figure 13, illustrating the significant savings associated with energy efficiency and renewable policy. The most significant savings are made in the power and industry sectors. The impact of switching to an increased share of biofuels is also reflected in the transport sector emission reductions.

Figure 13. Sectoral CO_2 Emission Reductions under RE, EE and RE&EE Combined Cases



G. LOW EMISSION DEVELOPMENT PATHWAYS IN MACEDONIA

Combating climate change is a key priority of the European Union, as outlined in the EU Climate and Energy Package. Therefore, the issue is of relevance to Macedonia, highlighted by action being undertaken to increase renewable energy and promote energy efficiency (as described earlier in this policy brief). The analysis presented in this section considers the options for Macedonia under a CO_2 emission reduction policy, and the cost of taking action.

The use of the model also illustrates the increased analytical capacity enabling policy makers to explore the impacts and opportunities for low emissions development. This is particularly timely given the initiatives undertaken by the World Bank on green growth opportunities and USAID on low emission development strategies.

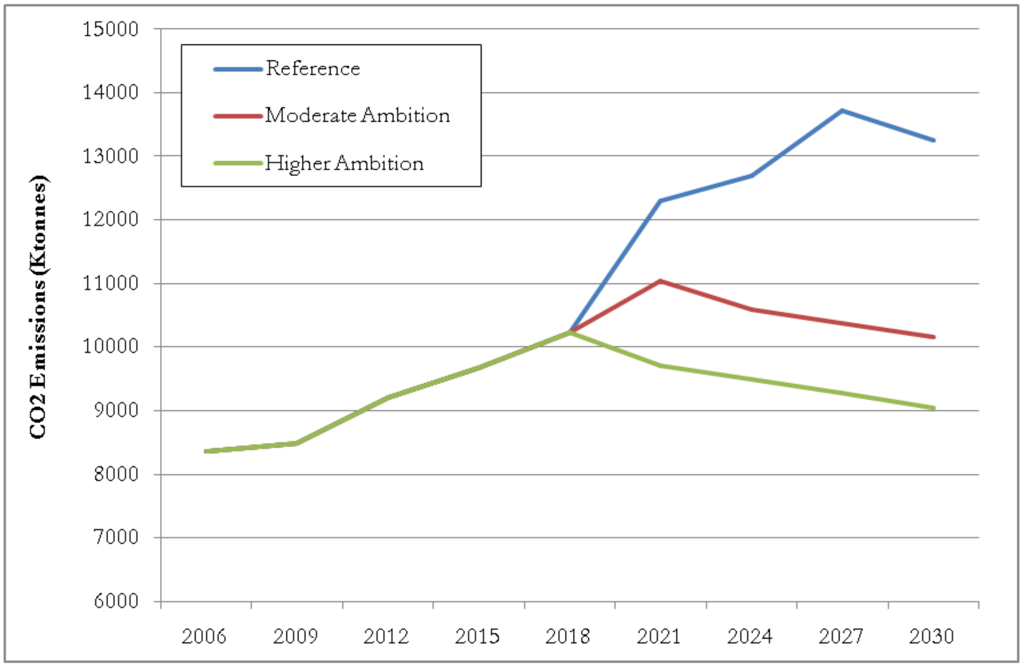
The following runs have been undertaken, representing different levels of ambition (shown in Figure 14):

- Higher ambition case: Restrict emissions to 10% higher than 1990 level in 2021, and 2.5% in 2030. This equates to the emission level being 20% lower than Reference case emissions in 2021, and 25% lower by 2030.
- Moderate ambition case: Restrict emission to 25% higher than 1990 level in 2021, and 15% in 2030. This equates to the emission level being 10% lower than Reference case emissions in 2021, and 16% lower by 2030.

Both of these cases have also been run under cumulative constraints; that is, rather than having the specified annual targets, there is a carbon "budget" set for 2015-2030, reflecting the same ambition as the above cases but providing the model the flexibility to reduce emissions in the most cost-optimal way. This is important, as it provides insights into the optimal timing of emission reductions.

These pathways are illustrative, and used to provide insights into energy system pathways under an emission reduction trajectory. They should not be considered as proposals for an emissions cap nor an indication of what the "optimal" emissions reduction strategy should be.

Figure 14. Illustrative CO_2 Reduction Pathways for Macedonia



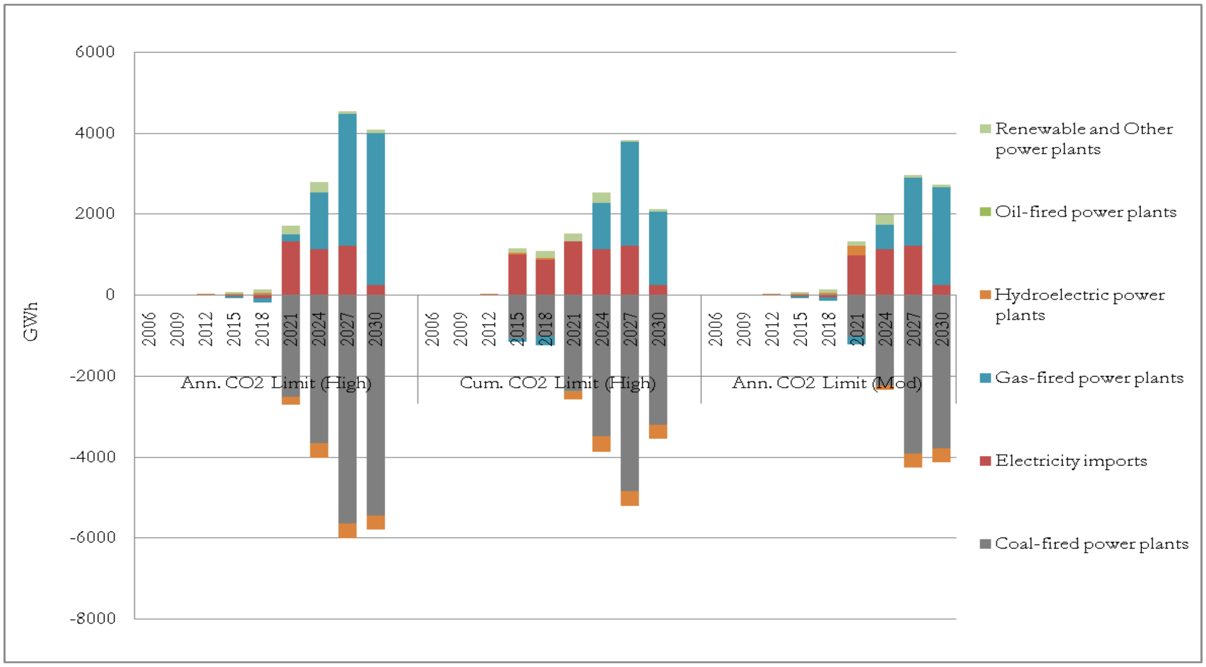
A key observation is that most of the CO_2 reductions are in the power generation sector, which is not surprising as this tends to be the most cost-effective sector. The high ambition case is considerably more expensive than the Reference case, with costs 1.9% higher, while the increase under the moderate ambition case is 1%. Under a cumulative constraint, the additional costs are reduced to 1.5% and 0.6% respectively, highlighting the importance of the timing of action. The key cumulative metrics for the annual limit runs are shown in Table 9 below.

Table 9. Cumulative Impacts of Low Emission Pathways on the Energy System (Compared to the Reference Scenario)

Indicator	Units	Reference	Higher Ambition		Moderate Ambition	
Total Discounted Energy System Cost	2006M€	36,316	676	1.9%	368	1.0%
Primary Energy Supply	ktoe	97,045	-5,780	-6.0%	-3,795	-3.9%
Imports	ktoe	48,667	4,796	9.9%	2,745	5.6%
Fuel Expenditure	2006M€	25,807	649	2.5%	307	1.2%
Power Plant New Capacity	MW	2,803	-308	-11.0%	-60	-2.1%
Power Plant Investment Cost	2006M€	3,773	-631	-16.7%	-280	-7.4%
Final Energy	ktoe	62,960	-838	-1.3%	-543	-0.9%
CO_2 Emissions	kt	293,805	-43,607	-14.8%	-25,721	-8.8%

The primary means of achieving the emission reduction targets is to reduce lignite-based generation and substitute this with gas generation and imports, as shown in Figure 15.[12] As shown in Table 9, this significantly increases imports (gas and electricity) and fuel expenditure, but reduces power sector investment, due to higher import levels and lower capital requirements of gas plant.

Figure 15. Change in Electricity Generation by Type under Emission Reduction Targets



Setting a cumulative target provides the model with more flexibility to undertake some reductions in the earlier periods because there is no stipulated annual reductions in later periods; in effect, the model "spreads" the reductions over time. An increase in the use of imports in earlier periods means lower reductions in lignite generation, and less investment in new gas plants.

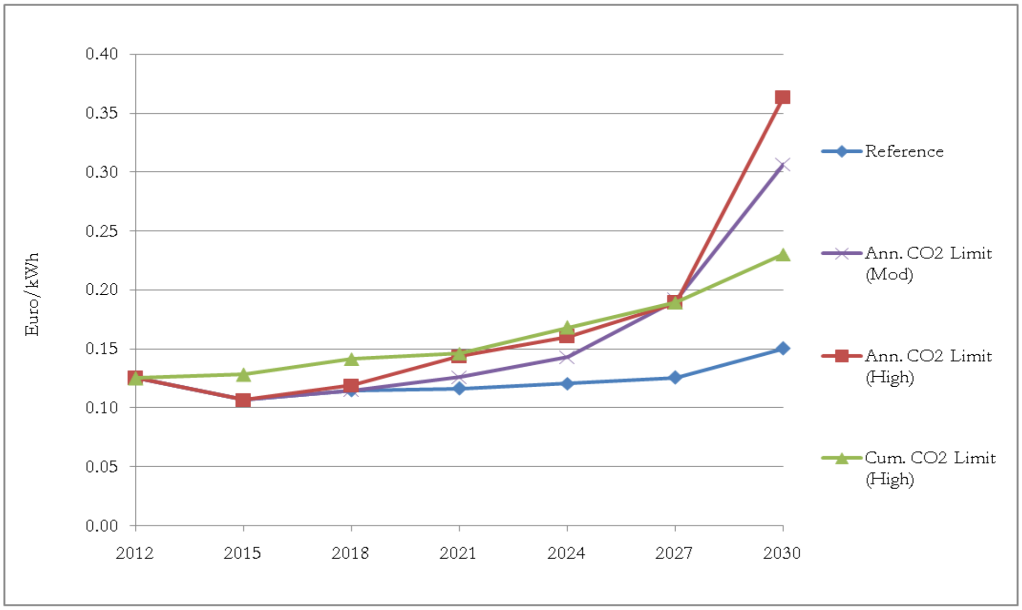
These changes in the power generation sector have implications for the electricity cost,[13] as illustrated in Figure 16. All emission reduction cases have higher costs than the Reference case. The cumulative target allows generation costs to rise gradually, while annual limits lead to more rapid increases post-2021. Under annual limit moderate and high cases, costs rise to 30 and 35 Euro cents per kWh by 2030, respectively, compared to the Reference cost of just under 15 Euro cents.

---

12 Imports in the model are considered to be carbon free. However, in reality, if neighboring countries are undertaking similar action it is likely that any carbon tax on power production could be passed through to the price of imports. This is currently not taken into account (due to the source of imports not being tracked) but is unlikely to significantly change the already high import price, Actual emissions from generation of the imported electricity will of course be accounted for in the country of origin.

13 These values represent the generation cost during day time production. Costs during the peak will be higher and lower at night.

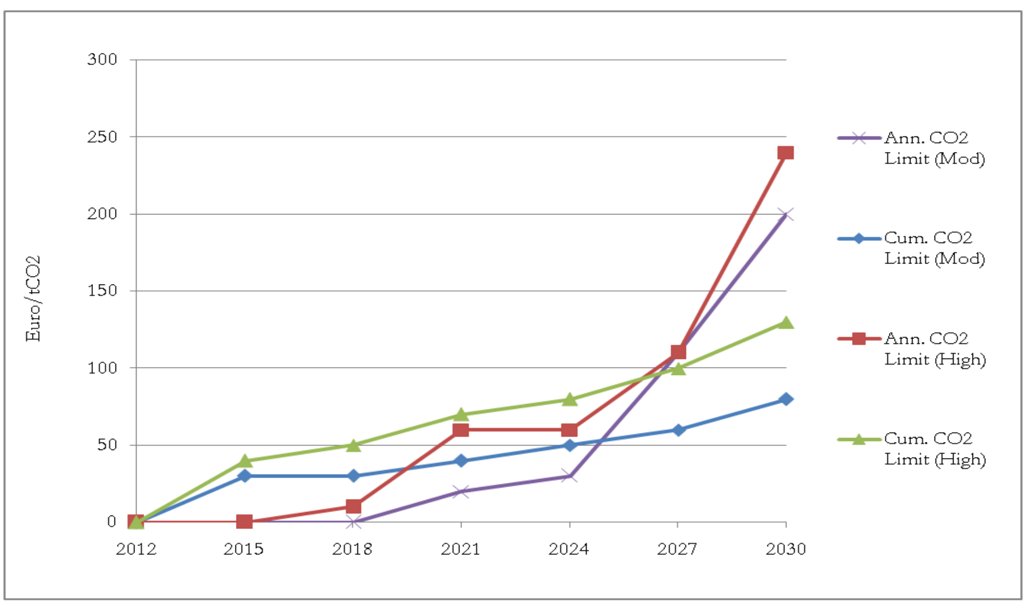
Figure 16. Electricity Costs per kWh by Type under Emission Reduction Targets



The analysis also provides an estimate of the costs of the reductions (or marginal abatement cost), expressed in Euros per tonne CO_2. These values essentially show how expensive emission reductions become under the target (for reducing the final unit of CO_2 to meet the target).

Under the annual emission limits, abatement costs increase significantly to around 250€/tCO_2, from around 100€/tCO_2 in the previous period. This indicates that the model is struggling to meet emission reduction targets; this might be partially due to the conservative assumptions about low carbon technologies in the power sector in 2030 – e.g. limits on wind and hydro capacity, and other options in the end-use sectors. However, such an analysis does illustrate the future costs of meeting a given reduction target based on current assumptions about the power generation sector.

Figure 17. Marginal costs of CO_2 Reductions under different Low Emission Cases



There are clear synergies between CO_2 reduction policies and energy efficiency and renewable policies, as would be expected. Under a combined policy case with higher ambition (including renewables and EE targets), overall costs are 1.3% higher than the Reference case under annual limits (1.9% in CO_2 only case) and 0.95% under cumulative limit (1.5% in CO_2 only case). In other words, when the model is run combining all policy targets, the costs are cheaper due to the strong synergies.

Analysis could also be undertaken using a CO_2 tax. Such a mechanism disincentivizes the use of fuels that are more carbon-intensive. In the model, if the marginal abatement costs were used as an equivalent tax, similar levels of reduction by period would be observed.

H. EXPLORING THE IMPACT OF REDUCED HYDRO CAPACITY AND LIGNITE RESOURCES

The Reference case highlights the important role that lignite and hydro power generation plays in the Macedonian power generation sector. In 2021, each accounts for 40% of total capacity, or 80% combined. In 2030, this dominance continues, although hydro has a higher share due to the retirement of some of the existing lignite capacity. Three sensitivity runs have been undertaken to explore the importance of these technologies to the system:

- Reducing the availability of lignite available from domestic mines by 50% in 2030 (with limited capacity for imports)
- Removing three large hydro options of Galiste, Gradec, and Veles, which account for 310 MW in the Reference case (or 22% of 2030 hydro capacity)
- Both of the above restrictions

Table 10 summarizes the key cumulative metrics for these technology sensitivity cases. The reduction in lignite availability is estimated to lead to additional costs of 0.7%, compared to hydro restrictions at only 0.1%. With both restrictions applied, the additional costs rise to over 1%. In particular, costs are driven up by an increasing reliance on electricity imports.

Table 10.Cumulative Impacts of Lignite Resource, Hydro Capacity and Lignite+Hydro Limits on the Energy System (Change compared to Reference Scenario)

Indicator	Units	Reference	Lignite Resource Limit		Hydro Capacity Limit		Lignite + Hydro Limit	
Total Discounted Energy System Cost	2006M€	36,316	271	0.7%	44	0.1%	348	1.0%
Primary Energy Supply	Ktoe	97,045	-2,653	-2.7%	297	0.3%	-2,441	-2.5%
Imports	Ktoe	48,667	3,602	7.4%	955	2.0%	4,447	9.1%
Fuel Expenditure	2006M€	25,807	715	2.8%	479	1.9%	1,055	4.1%
Power Plant New Capacity	MW	2,803	-19	-0.7%	-247	-8.8%	-314	-11.2%
Power Plant Investment Cost	2006M€	3,773	-219	-5.8%	-720	-19.1%	-967	-25.6%
Demand Technology Investments	2006M€	10,811	-10	-0.1%	0.5	0.0%	-48	-0.4%
Final Energy	Ktoe	62,960	-9	0.0%	1	0.0%	-23	0.0%
CO_2 Emissions	Kt	293,805	-22,524	-7.7%	1,602	0.5%	-20,394	-6.9%

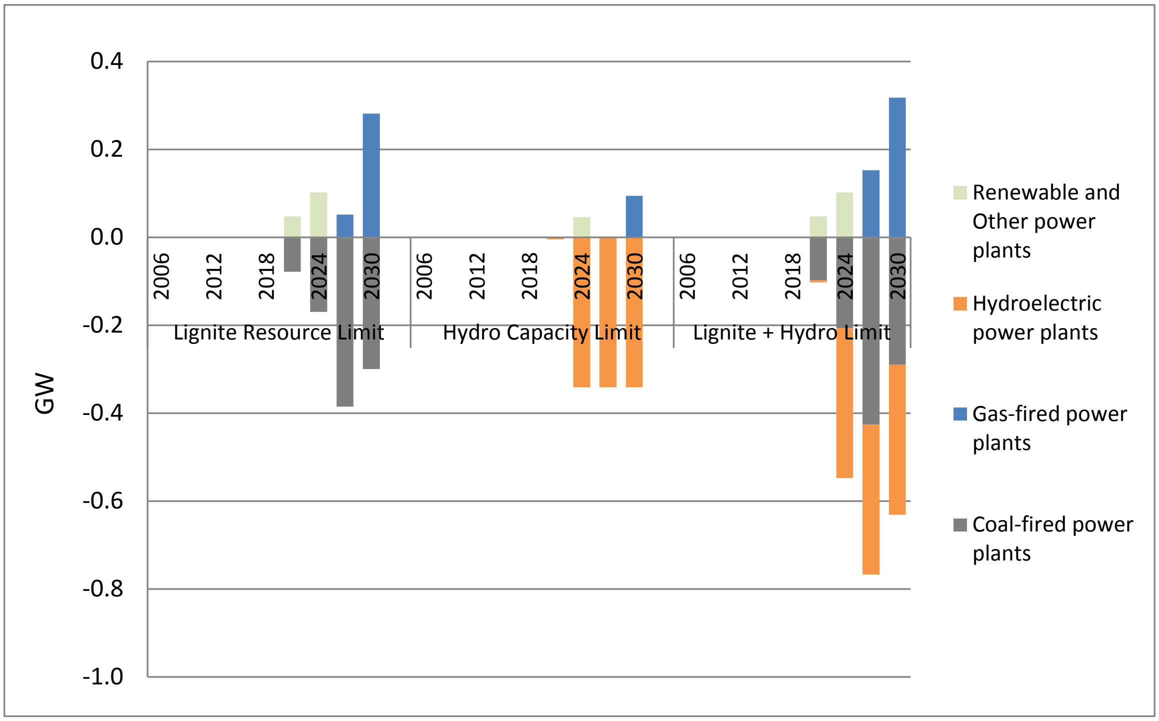
Most of the differences are of course related to the power generation sector, and are highlighted in Figure 18. In all cases, total generation decreases. In the lignite cases, it is primarily gas-fired generation and imports that "fill the gap." The same is also true in the hydro restricted case, albeit the relative change is much smaller.

Figure 18. Change in Electricity Generation by Type under Power Sector Sensitivity Cases

This overall decrease in electricity generation but increase in imports leads to a drop in capacity requirements, as shown in Figure 19. In the combined constraint case, cumulative capacity drops by over 11% compared to the Reference case, or by 314 MW.

It is clear that lignite in particular has a very important role in keeping overall system costs down. Therefore, future uncertainties concerning resource availability could have a significant impact on costs. Combined with lack of investment in new larger hydro plant, costs could be even higher, particularly if there is additional reliance on imported electricity. This highlights the importance of an increasingly diversified and efficient supply, which should be promoted through initiatives on renewables, energy efficiency, and lower carbon emissions (as discussed earlier).

Figure 19. Change in Electricity Generation Capacity by Type under Power Sector Sensitivity Cases



APPENDIX I: DATA SOURCES AND KEY ASSUMPTIONS

The Macedonia analysis is based on numerous data inputs and assumptions, and therefore requires a set of key national data sources. For Macedonia, the sources of this information are listed by data requirement in Table 11 below.

Table 11. Key Data Sources

Data Requirement	Source
2006 Energy Balance	• IEA Online Database: Energy Balances of Non-OECD and Energy Statistics of Non-OECD [2008] • National Energy Balances (from the State Statistical Office and the Ministry of Economy)
Domestic Energy Prices	• Energy Regulatory Commission (Annual report for 2009) • Energy balances of the Ministry of Economy (for 2006 and 2007) • Oil refinery OKTA • Domestic lignite price based upon feasibility study for underground exploitation of coal for the purposes of Bitola TPP from the Zhivojno mine," developed by the Mining Institute from Macedonia
Resource Potential, including imports/exports	• Strategy on Sustainable Development of Forestry in the Republic of Macedonia, Ministry of Agriculture, Forestry, and Water Economy, 2007 • Biomass Availability Study for Macedonia, A.B. van der Hem, SENTER project PSO99/MA/2/2, February 2001 • Energy from Biomass, Slave Armenski, Skopje, 2009 • Coal-Position in energetic concept of the Republic Macedonia, BorceAndreevski, Proceeding International Symposium ENERGETICS 2008, ZEMAK, 2008 • Strategy for Energy Development of the Republic of Macedonia until 2030
Installed capacity and characterization of existing electricity, heating and CHP plants	• Annual Report of ELEM for 2006 – for the electricity generation capacities • Reports of Toplifikacija AD Skopje for heating and CHP
Electricity generation plants (adjustment to the SSP plant characterizations)	• Hydro: ELEM www.elem.com.mk, MEPSO - www.mepso.com.mk • CHP: TE-TO Skopje, www.te-to.com.mk/ • Coal: Report from UBS Investment Research: European Power Prices, P. Lekander, A. Gandolfi, S. Comper, A. Wright, November 2007 • Wind: Wind Park Development Project Macedonia – Feasibility Study Bogdanci A, Infrastructure Project Facility for Western Balkans (EU's CARDS Programme, February 2010)
Timing of demands for energy services	• No data available currently in Macedonia. Assumptions are consistent with the overall electricity load profile.
Fuel consumption patterns by energy service	• Data available at sector level, but not at energy service level
Demand Drivers	• UN Projections for the Population growth • Base year GDP – Ministry of Finance • GDP growth – same as the Strategy for Energy Development of the Republic of Macedonia until 2030 (based on projections made by national experts)

Known energy policies	• Strategy for Energy Development of the Republic of Macedonia until 2030, March 2010 • Strategy on Use of the Renewable Energy Sources in the Republic of Macedonia by 2020, September 2010 • Energy Efficiency Strategy of the Republic of Macedonia, USAID, June 2010

Drawing on these data sources provisions for model development are therefore 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 e.g. feed-in tariffs for early renewable energy systems (see Table 12). They have also consulted with different sector experts to ensure that the Reference scenario is robust, and does not diverge significantly from other analyses undertaken e.g. for the Renewable Energy Strategy [*Strategy on Use of the Renewable Energy Sources in the Republic of Macedonia by 2020, Government of the Republic of Macedonia, September 2010*].

Some of the key resulting assumptions are listed in the table below.

Table 12. Key Assumptions in Reference Scenario

Category	**Assumption**
GDP growth rate	e.g. 6.73% (2006-2020), 5.87% (2020-2030)
Sectoral growth rates[14]	
Residential	2.8%
Commercial	3.4%
Industry	2.6%
Agriculture	3.3%
Population growth rate	-0.16%
Key policies modelled	
	FIT for small hydro (100 €/MWh), wind (97 €/MWh), and PV (420 €/MWh), with associated potential.

The basic parameters for the existing electricity and heat generation plants are given in Table 13 below.

Table 13. Existing Heat and Power plants

Plant Type/Fuel	**Capacity (GW)**	**Efficiency**	**Availability**	**Retirement year**
Power plant/Lignite	0.736	36.1%	74%	2024 - 2027
Power plant/HFO	0.198	33.6%	65%	2012
Power plant/Hydro	0.536	100%	35%	
Heating plant (centralized)/HFO	0.222	91.6%	53%	

[14] Overall growth rate for useful energy based on projections for the different energy services in each sector.

Plant Type/Fuel	Capacity (GW)	Efficiency	Availability	Retirement year
Heating plant (centralized)/ Natural gas	0.056	88.9%	53%	
Heating plant (decentralized)/ Biomass	0.00408	57.9%	85%	
Heating plant (decentralized)/ Lignite	0.012	39.1%	85%	
Heating plant (decentralized)/ HFO	0.099	78.5%	85%	
Heating plant (decentralized)/ Natural gas	0.0285	80.8%	85%	

A series of constraints have been introduced to ensure that the Reference case is plausible, and properly reflects the situation in Macedonia (see Table 14 below).

Table 14. Key Constraints in the Reference Scenario

I. Sector / Issue	J. Constraint
Resource supply	
Domestic resources	
RES potential	
Hydro	Limited potential for small hydro power plants (up to 200 MW total by 2020)
Wind	Limited potential for wind power plants (up to 360 MW by 2030)
Solar	Limited potential for PV installation (up to 40 MW)
Imports/Exports	• No limit • Relative high price for imported electricity, running from 4.5 - 11.8€cents/kwh
Electricity generation	
Technology availability	• Nuclear generation is not available in the Reference scenario • No thermal power plants using imported lignite (as importing lignite is not considered feasible both from economic and energy security considerations) • The location and the capacities of the large hydro power plants are limited (based on the available National Studies of the hydro potential in the country)
End use sectors	Limited penetration of advanced technologies

All of the national models draw on a set of common assumptions for future energy prices and technology characterizations. In terms of the energy prices each country model uses its 2006 "border/mine-mouth" price for energy sources (see the country sections in this Appendix), and any sectoral adjustments to these (for delivery and mark-up (but not taxes)). Then there is an overriding assumption that regardless of the 2006 prices, by 2015 all countries will be competing on the global energy market using world prices. With this in mind, the IEA World Energy Outlook 2010 energy price projections for each fuel are adopted, as shown in the table below.

Table 15: Energy Price Trajectory Assumptions (2006Euro/GJ)

Energy Form	2015	2018	2021	2024	2027	2030
Biomass	- - -	Individual	national	values	used	- - -
Coal - Brown	2.04	2.14	2.22	2.27	2.31	2.35
Coal - Hard	2.88	3.02	3.14	3.20	3.26	3.31
Coal - Lignite	2.27	2.38	2.47	2.52	2.57	2.61
Gas	5.85	6.09	6.41	6.69	6.97	7.25
Nuclear	0.800	0.800	0.800	0.800	0.800	0.800
Oil – Crude [1]	10.97	12.06	13.06	13.76	14.46	15.17
Oil – Distillate	14.26	15.67	16.98	17.89	18.80	19.73
Oil – HFO	9.55	10.49	11.37	11.98	12.58	13.20
Oil – Kerosene	15.36	16.88	18.29	19.27	20.25	21.24
Oil – LPG	12.07	13.26	14.37	15.14	15.91	16.69

The average price (across all time slices) of imported electricity for Macedonia is different from other countries. The Macedonian Planning Team sourced their projected import prices from a UBS investment research report, while most other teams used default values adapted from the EU New Energy Externalities Developments for Sustainability (NEEDS) model. Therefore, the difference between the prices used in the Macedonian model compared to other national models is significant. Note that the models do not currently trade electricity. Further work will be done in the next phase to ensure consistency across models.

Note that individual country experts may choose to adjust these price trajectories using the flexible mechanism built into the fuel price Excel workbook which prepares this information for the model.

The other two datasets that start from a common point for all the national models are repositories for the characterization of future power plants and demand devices. Tables 16, 17, and 18 present these assumptions for electricity, coupled heat and power and heating plants respectively (with centralized/decentralized distinguished in the model). There are nearly 100 instances of the various plant types available for selection by the national expert to include as options for consideration by the model.[15] These are organized by fuel and plant type, and cover new construction and estimated costs for refurbishment/life extension options for existing plants (which need to be tailored by the analyst for the individual plants under consideration for rehabilitation). Additional options may also be easily added should the national situation dictate.

Table 16. Future Electric Power Plant Characterization*

Power Plant Type	Start Date	Lifetime	Efficiency ***	Avail. Factor	Invest. Cost (M€/GW)**	Fixed O&M (M€/GW)	Variable O&M (€/MWh)

[15] The complete set of power plant characterizations as used in each national model is managed in the SSP_<country>_NEWTCH-PP Excel template, and is available for review and consideration from the national Planning Teams.

Power Plant Type	Start Date	Lifetime	Efficiency ***	Avail. Factor	Invest. Cost (M€/GW)**	Fixed O&M (M€/GW)	Variable O&M (€/MWh)
Coal Steam Turbine	2009 - 2015	35	0.46	0.85	920 - 985	40.50 - 43.0	9.20
Lignite Fired	2009	40	0.40	0.80	1000 - 1250	25.00 - 35.00	4.32
Coal IGCC	2010	35	0.51	0.85	1200	52.50	11.04
Natural Gas Steam Turbine	2009	25	0.34 - 0.58	0.80	350 - 375	7.00	2.52 - 2.7
Natural Gas CCGT	2009 - 2015	35	0.58	0.85	385 - 471	18.00 - 2`.00	5.52 - 5.91
Nuclear	2009	40	0.36	0.90	1550	38.55	3.53
Hydro	2009	60 - 80	1.00	0.27 - 0.60	3000 - 3500	45.00 - 59.00	0.72 - 1.44
Wind	2009 - 2012	20 - 30	1.00	0.06 - 0.22	1000 - 1070	40.00 -43.00	0.00
PV	2009 - 2012	30	1.00	0.10	2000 - 2950	29.40	0.00
Geothermal (dry steam)	2009	30	1.00	0.85	5000	275.00	4.32
Biomass	2009	30	0.37	0.80	1800 - 1820	43.00 - 46.00	6.84 - 7.32

* All of the assumptions above are subject to revision by Planning Teams. For example, this is particularly true of hydro investment costs and wind availability factor which depend on the site in question, therefore may differ significantly between national models.
** In some cases a range for investment costs reflects country differences, or in some cases the higher value is the current cost and the lower value that in 2030.
*** Efficiency for hydro, wind, solar and geothermal are effectively 1.0 for the model as no actual fuel is consumed.

Table 17. Future Coupled Heat and Power Plant Characterization

Power Plant Type	Start Date	Life-time	Heat / Electric Ratio	Effic-iency	Avail-ability Factor	Investment Cost (M€/GW)	Fixed O&M (M€/GW)	Variable O&M (€/MWh)
Biomass	2009	25	1.74	0.31	0.85	1600 - 1873	71.75 - 77.0	6.48
Hard coal	2009	35	1.43	0.35	0.85	1200	54.50	9.20
Lignite	2009	30	1.25	0.29	0.80	1400	28.00	4.75
Natural gas	2009	30 - 35	1.00 - 2.59	0.23 - 0.45	0.80 - 0.85	585 - 650	13.00 - 30.00	2.77 - 5.52
Heavy fuel oil	2009	18 - 25	0.88 - 1.93	0.30 - 0.42	0.85	750 - 850	35.00 - 65.00	27.0 - 50.4*

* These values seem extremely high and will be adjusted in the next phase. However fuel oil based power plants are not generally competing to enter the models.

Table 18. Future Heating Plant Characterization

Power Plant Type	Start Date	Life-time	Effic-iency	Availability Factor	Investment Cost (M€/PJa)	Fixed O&M (M€/PJa)	Variable O&M (M€/PJ)
Biomass	2012	30	0.78	0.80	8	0.16	1.52
Brown coal	2009	30	0.78	0.80	8	0.16	0.88
Lignite	2009	30	0.78	0.80	8	0.16	0.96
Distillate	2009	30	0.78 - 0.85	0.80	7	0.13	0.56
Natural Gas	2009	30	0.78 - 0.85	0.80	6	0.12	0.56
Geothermal	2009	30	1.00	0.80	10	0.20	1.20
Heavy fuel oil	2009	30	0.78 - 0.85	0.80	7	0.13	0.56
LPG	2009	30	0.78	0.80	7	0.14	0.56

For Macedonia, the characteristics of the key new power plants that are chosen by the model are shown in Table 19. The characteristics of the existing power plants are shown in Table 13.

Table 19. Characterization of Key Power Plant Options

Power Plant Type	Start Date	Life-time	Effi-ciency*	Avail-ability Factor	Investment Cost (M€/GW)	Fixed O&M (M€/GW)	Variable O&M (€/MWh)
Lignite Fired	2021	30	0.40	0.80	1417	23.72	1.20
Natural Gas CCGT	2015	35	0.58	0.85	440	18.00	1.53
Gas CHP**	2010	20	0.50	0.85	735	7.57	0.36
Biomass CHP**	2015	25	0.85	0.85	1750	71.75	1.80
Hydro - SvPetka	2012	50	1.00	0.19	1500	4.19	0.19
Hydro - Boskov most	2017	50	1.00	0.22	1217	4.19	0.19
Hydro - Galiste	2024	50	1.00	0.16	1344	4.19	0.19
Hydro - Lukovo	2018	50	1.00	0.32	10600	4.19	0.19
Hydro - Gradec	2021	50	1.00	0.51	3718	4.19	0.19
Hydro - Veles	2024	50	1.00	0.37	3505	4.19	0.19
Hydro - Chebren	2022	50	1.00	0.12	1243	4.19	0.19
Pumped hydro - Chebren	2020	50	0.64	0.29	1243	4.19	0.19
Small hydro	2012	30	1.00	0.29	1600	4.19	0.19
Wind (central), with FIT	2015	20	1.00	0.14-0.32	1400-1500	30.00	2.00
Wind (central)	2015	20	1.00	0.14-0.32	1414-1515	30.00	2.00
Solar PV (decentralized)	2009	30	1.00	0.098-0.1745	2000-2950	29.40	0.00

* Total plant efficiency for CHP plants
** Ratio of electricity to heat (REH) 0.57 for biomass and 8.0 for natural gas plant
*** Summer day

Note that in the case of wind there are two alternatives modeled. 150MW of wind can be invested in that can qualify for an FIT of 97€/MWh.

In terms of demand devices, the approach taken involves drawing on the technology characterizations that were employed in the EU NEEDS model, 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/).

Base device characterizations are used to 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 base devices 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 the table below.

Table 20. 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

Energy Service Demand	Demand Device	Investment Cost (€/GJ)	Efficiency (Fraction)
	Ground source heat pump	20.13	3.33
	Solar heat pump	16.78	4.00
	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	Incandescent bulbs	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. Furthermore, for each improved device increment there is also a price escalator that may be applied that reflects imperfections in the market (due to lack of knowledge and such) and other impediments to a particular device entering the market. For most of the EU and near EU accession countries smaller cost add-ons are employed; for some of the less developed economies these values approach an extra 20%. All these assumptions may be adjusted for national circumstances, though most use this standard approach just described.

Note that due to lack on data on the process details of Macedonian industry, an approach that calibrates to the current energy intensity of each industrial demand and has up to a three-step suite of generic options that follow the same increased price/performance improvements rather than representing specific process/device options.

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 21) 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 Annual Energy Outlook (AEO) 2011.[16] 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

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

Table 21. 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	1.1	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		
	ELC	22	8721	393		

16 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/.

Figure 20. LDV Efficiency by Type in Macedonia MARKAL Model

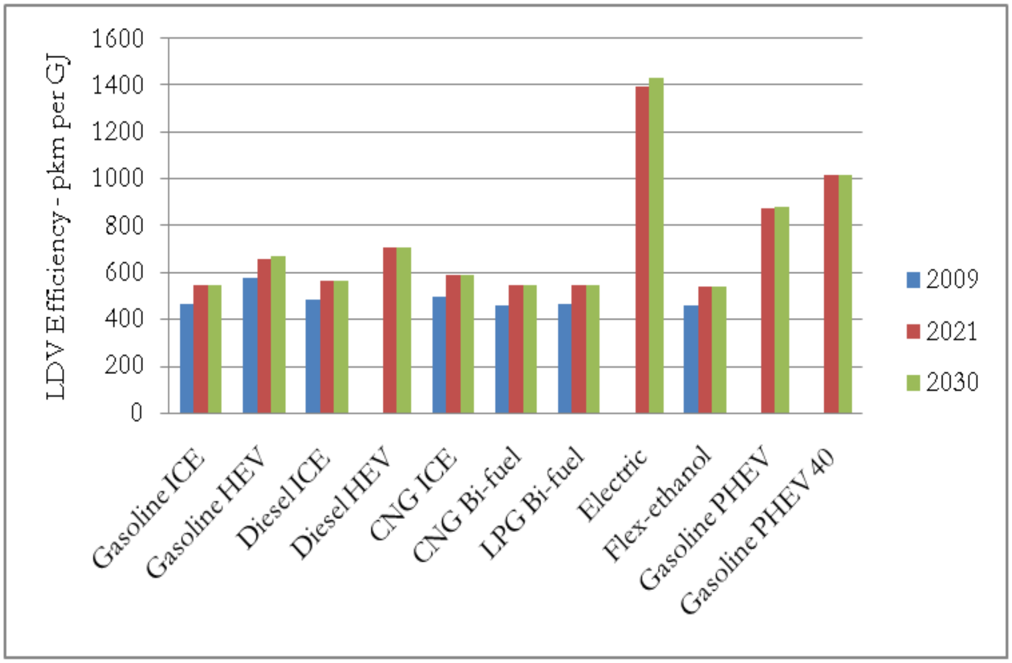
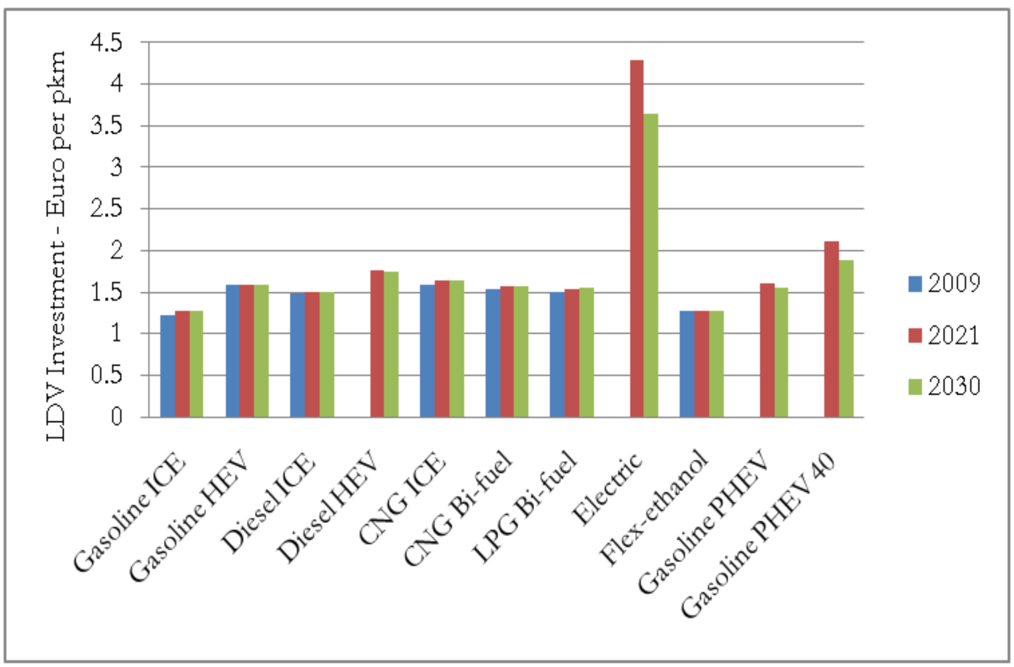


Figure 21. LDV Efficiency by Type in Macedonia MARKAL Model



For year 2006, the transport sector is calibrated to the national energy balance. The transport sector energy totals have been disaggregated using Macedonia statistics and other information sources, such as those provided by the 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 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 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 own (even if past performance lifetime), buy only what 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 and United Kingdom 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 purchases 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 describes 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 the 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.

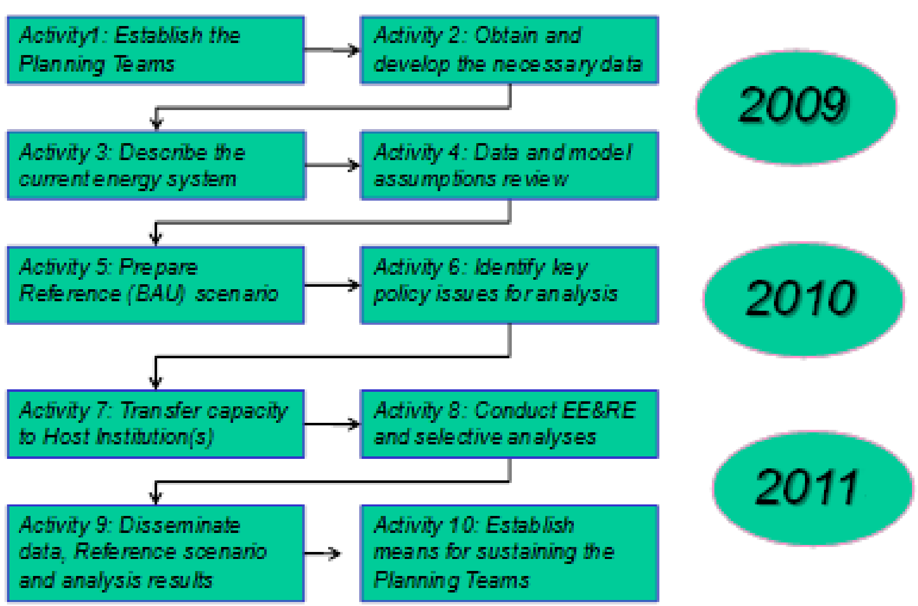
APPENDIX III: PROJECT ACTIVITIES AND METHODOLOGY EMPLOYED

MAJOR PROJECT ACTIVITIES

The consultant teams for International Resource Group (IRG) and the Centre for Renewable Energy Sources (CRES) worked with key personnel from the Ministry of Economy, Department of Energy, and the Research Center for Energy, Informatics and Materials, at the Macedonian Academy of Sciences and Arts (ICEIM-MANU) to establish a credible MARKAL-Macedonia 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 22). 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 22. 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.

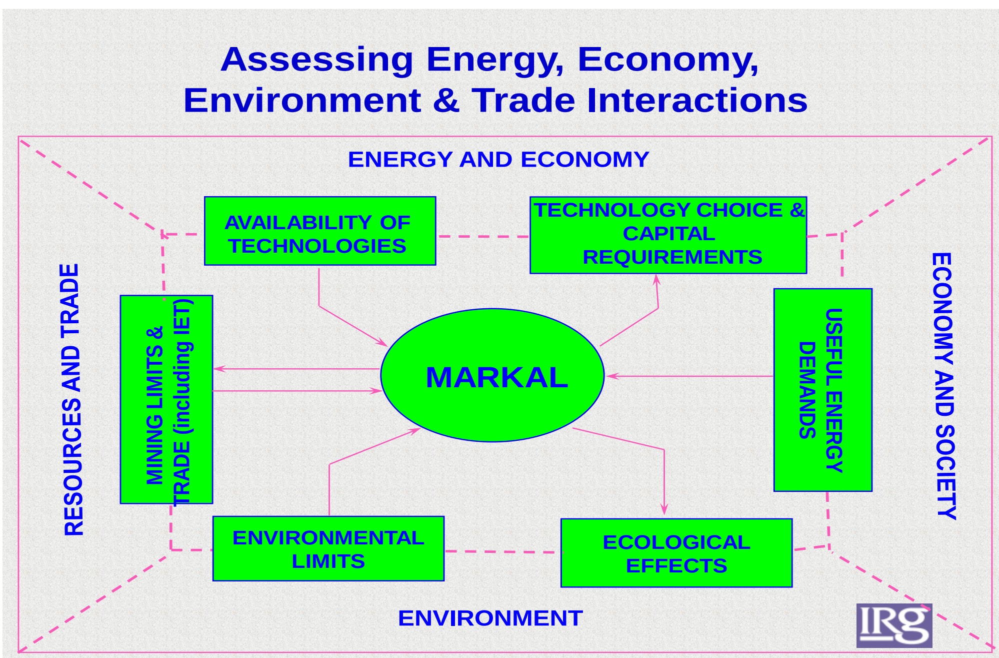
At least as important as the energy balances themselves, and the accompanying information systems, is the process of building a team of professionals in each country who can work with the data, maintain the information systems, and support higher level analytical approaches. This team-building should 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 23).

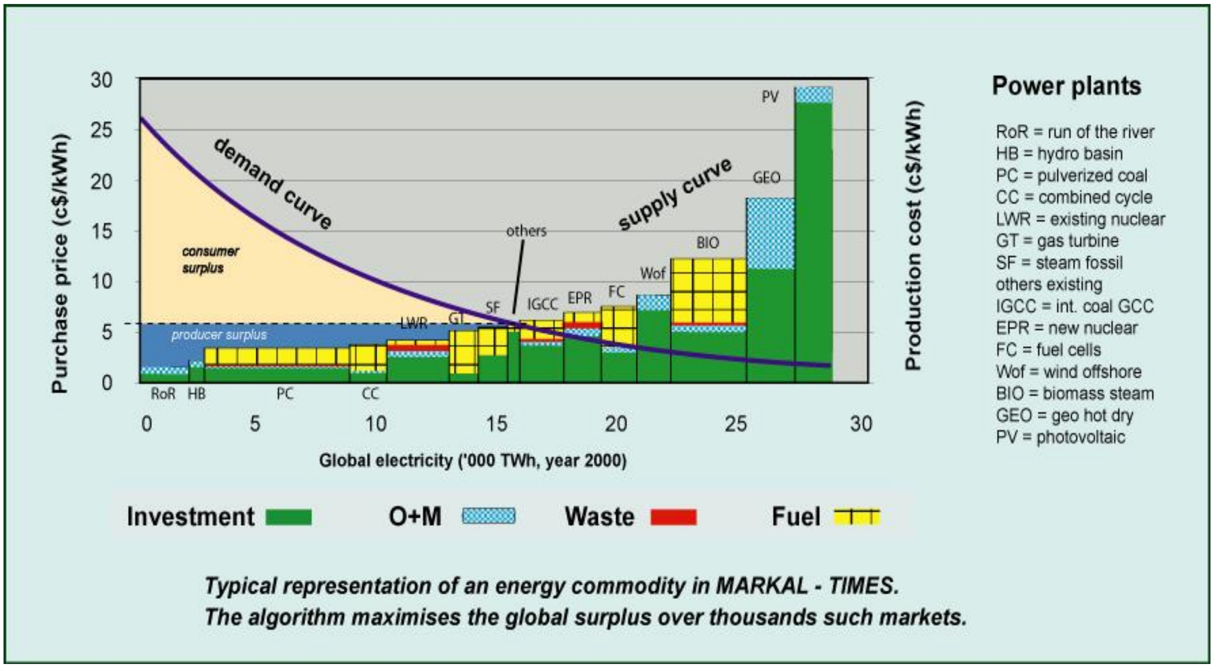
Figure 23. Interactions in the MARKAL/TIMES Model



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 24) 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 24. Power Plant Dispatch in the MARKAL/TIMES Model



One of the most relevant suite of studies conducted recently 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)[17] undertaking. The Pan-European TIMES model (PET)[18] evolved from the original NEEDS model and has been employed for a series of high profile EU projects, including RES2020[19] examining the EU renewable directive,[20] REALISEGRID[21] 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).[22] Another pair of high-profile uses of MARKAL/TIMES is the IEA Energy Technology Perspectives[23] and UK Climate Change Policy "White Paper."[24]

---

17 http://www.isis-it.net/needs/
18 http://www.res2020.eu/files/fs_inferior01_h_files/pdf/deliver/The_PET_model_For_RES2020-110209.pdf
19 http://www.res20202.eu
20 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:140:0016:0062:EN:PDF
21 http://realisegrid.rse-web.it/
22 http://reaccess.epu.ntua.gr/TheProject/ProjectObjectives.aspx
23 http://www.iea.org/techno/etp/index.asp.
24 http://www.ukerc.ac.uk/ResearchProgrammes/EnergySystemsandModelling/ESM.aspx.

U.S. Agency for International Development
1300 Pennsylvania Avenue, NW
Washington, DC 20523
Tel: (202) 712-0000
Fax: (202) 216-3524
www.usaid.gov