MARKAL-Georgia Energy System Model

Energy Policy Analysis

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Tbilisi, Georgia
March 6, 2012

Presentation Outline

- Assessment of the Implications of Energy Efficiency and Renewable Energy Policies
- A Look at Other Priority National Objectives
- Conclusions & Next Steps

Figures in this presentation are based on a number of assumptions and the results are only indicative.

Description of Energy Efficiency and Renewable Energy Scenario

- **Renewable Energy (RE) Target:** 60% renewable energy target as a share of Final Energy Consumption excluding transport sector for 2020, and subsequent years; 20% higher than the current levels of 39% in 2009.

- **Energy Efficiency (EE) Promotion:** Demand-side policy to promote economically attractive energy efficiency technologies. Specifically promoting
  - purchase of energy efficient appliances,
  - appliance and building standards,
  - incentivizing improved devices.

- **Combined RE and EE Policies: C**ombination of supply-side and demand-side approaches examines the resulting synergies of these policy goals.

RE Target Scenario Cumulative Impact on the Reference Scenario

- Imports, reduced almost 20% saving 5.3€B in foreign payments.
- Additional electricity produced by hydro plants offsets gas consumption in end use sectors, reducing levels post 2020 by over 30%.
- Fuel switching - primarily in the industry sector, where electricity consuming technologies displace gas.
- Additional 7.96€B in power plant investment. This 3.5 fold increase in power sector investment results in overall energy system costs increasing by 4.5%, reflecting that this is partially offset by reductions in fuel payments.

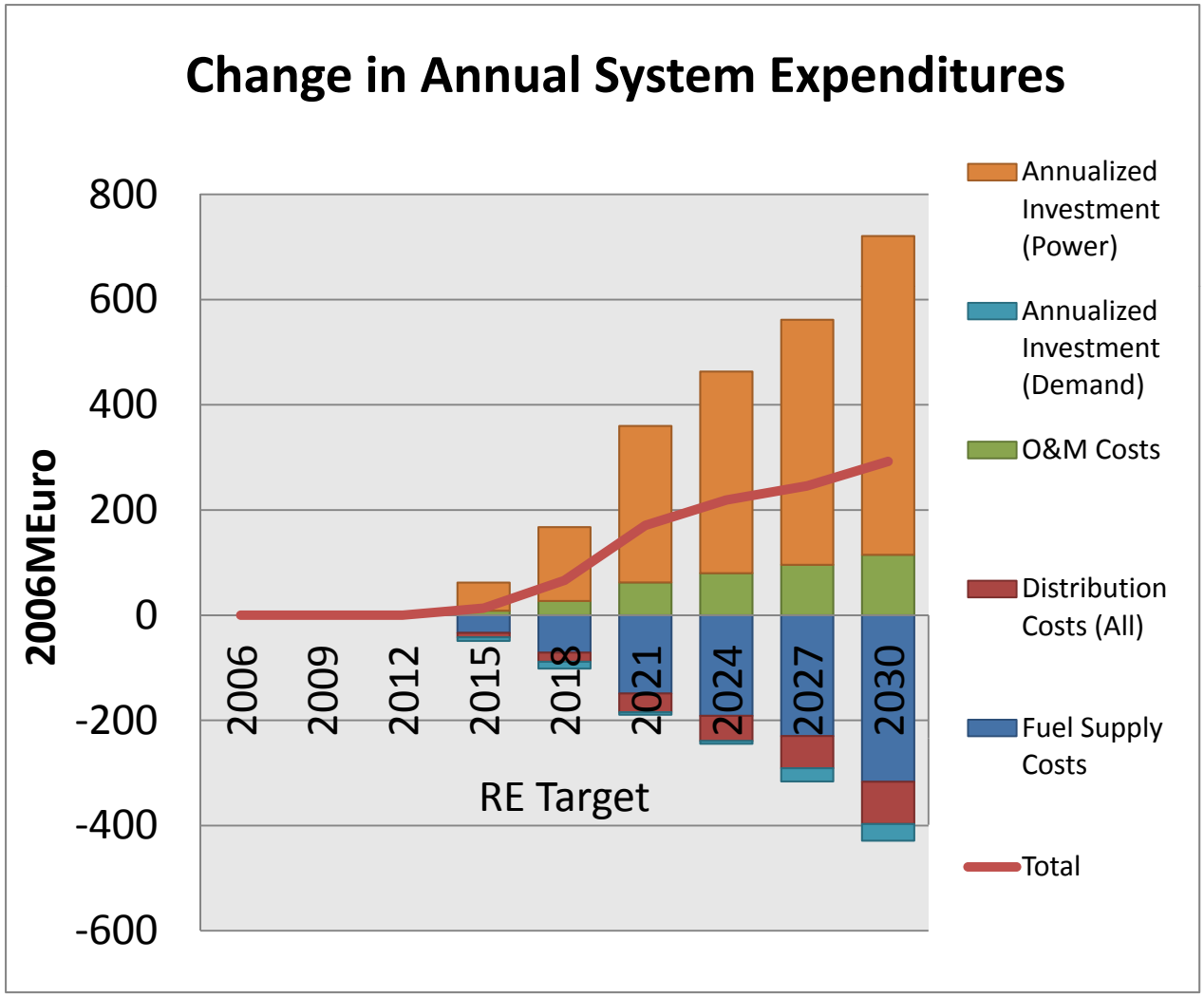
Metric	Units	Reference	RE Target Change	
Total Discounted Energy System Cost	M€2006	15,574	698	4.48%
Primary Energy Supply	Ktoe	91,467	-1395	-1.53%
Imports	Ktoe	60,229	-11,366	-18.87%
Fuel Expenditure	M€2006	11,459	-2,784	-24.30%
Power Plant New Capacity	GW	1.85	2.02	9.38%
Power Plant Investment Cost	M€2006	2,246	7,964	354.52%
Final Energy	Ktoe	82,853	-788	-0.95%
CO_2 Emissions	Kt	144,383	-26,117	-18.09%

Renewable Electricity Generation and Fuel Consumption

- Reference scenario adds 1611MW new hydro generation capacity out of a total of 1850MW of new capacity additions. The RE Target scenario requires additional 2000MW of new capacity, over 95% of which is hydro, with the rest new wind plants.
- There are only minor additional direct cost effective renewables' options.

Change from Reference (ktoe)	**2015**	**2021**	**2030**
Electricity Generation			
Hydro	136.0	487.6	953.5
Wind	0	26.7	26.7
Final Energy (non-electricity and heat)			
Biomass	2.1	0.0	0.0
Geothermal	0.0	0.0	0.0
Solar	0.0	0.9	3.3
Total RE	**138.1**	**515.2**	**983.6**

Impact on Energy System Expenditures



- Meeting the 2020 RE target requires investments in renewables to start within the next five years.
- Costs are dominated by investments in new HPPs, but show reductions in fuel payments.

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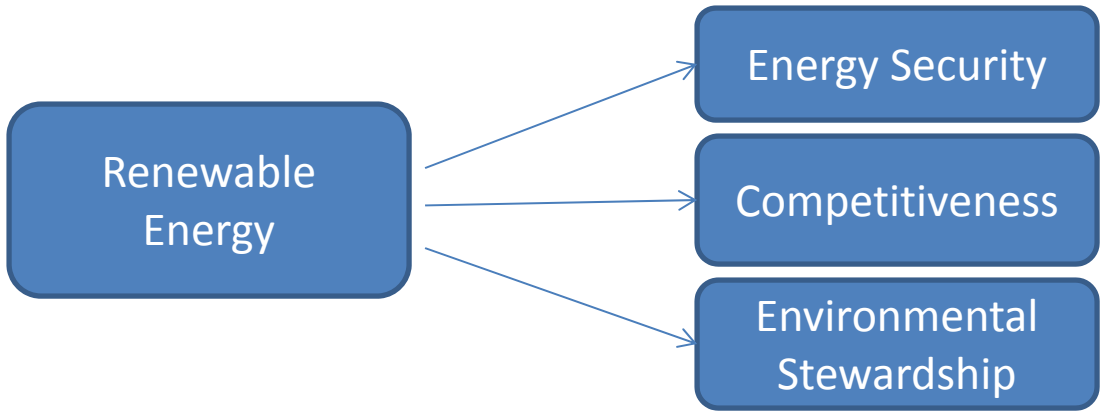
- This results in reducing the additional cost by about half.

Other Benefits Arising from a Renewable Energy Target

- Natural gas imports are reduced by almost 22% greatly improving energy security, saving 2.3€B in payments for fuel.
- Potential revenue from exports of carbon-free electricity at clean energy premium to carbon and renewable energy markets.
- A significant shift to renewable electricity causes reductions of CO_2 emissions by over 18%.

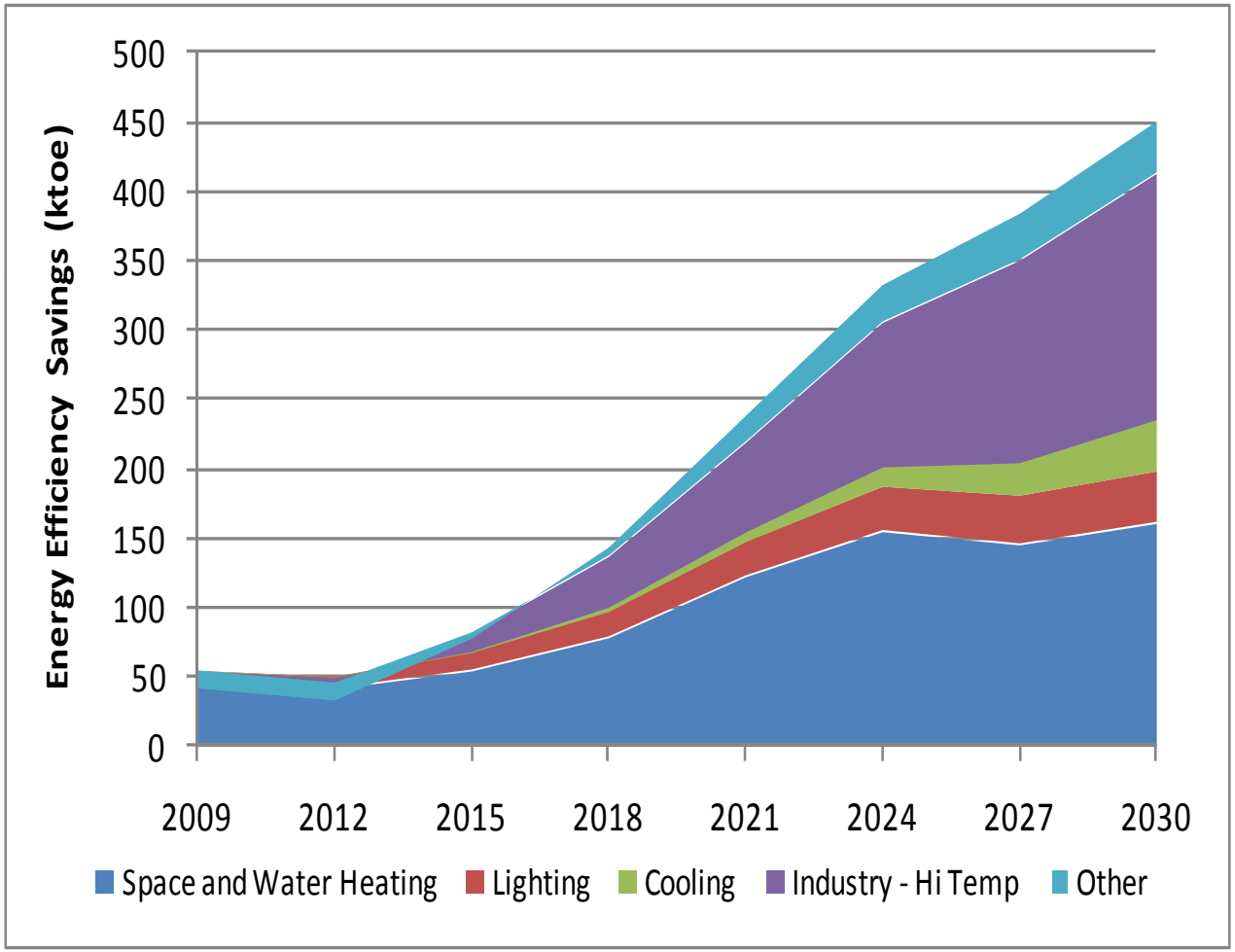


EE Promotion Scenario (Cumulative) Impact on the Reference Scenario

- Energy efficiency reduces primary energy supply by 6.4% and overall energy system costs by 3.4% compared to the Reference scenario, saving 529€M.
- Reduction in system cost is mainly due to
  - Saving in fuel expenditures over the life of energy efficient devices, with 3.2€B less in payments for imports, and
  - Lower demand for electricity requiring less new power plants.

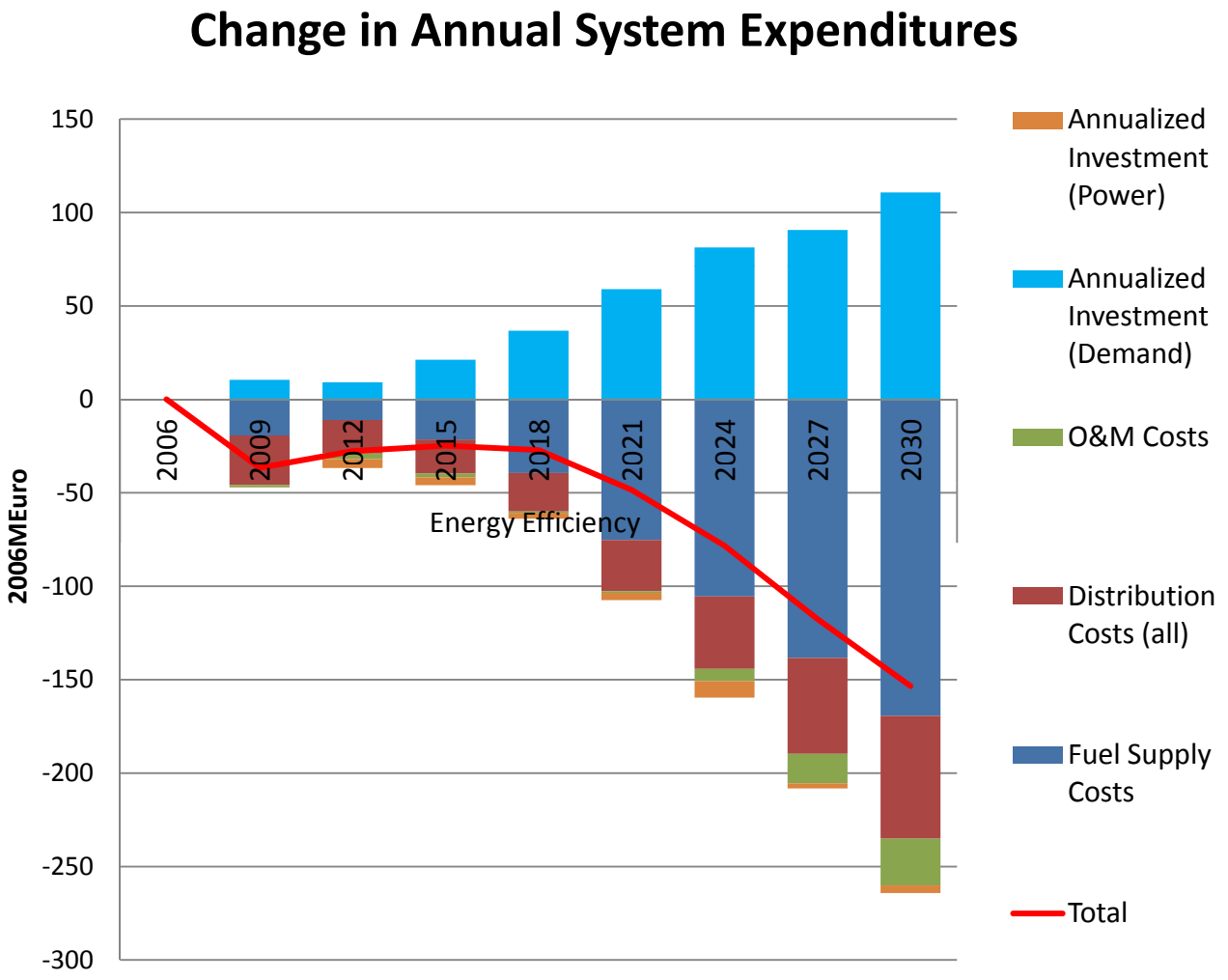
Metric	Units	Reference	Energy Efficiency Change	
Total Discounted Energy System Cost	2006M€	15,574	-529	-3.4%
Primary Energy Supply	Ktoe	91,467	-5,838	-6.4%
Imports	Ktoe	60,229	-5,222	-8.7%
Fuel Expenditure	2006M€	11,459	-1,549	-13.5%
Power Plant New Capacity	GW	1.85	-0.12	-6.5%
Power Plant Investment Cost	2006M€	2,246	-49.5	-2.2%
Final Energy	Ktoe	82,853	-5,282	-6.4%
CO_2 Emissions	Kt	144,383	-12,401	-8.6%

Energy Efficiency Savings by End-use Service



- Cost-effective reductions from improvements for space (and water) heating in residential and commercial sectors account for 54% of total savings (~2400ktoe, including ~1900ktoe of natural gas).
- More efficient new devices (including building shell improvements) require 22M€/year more investment.
- Industry sector can provide ~1300ktoe of cumulative savings (29% of total), requiring investments of 49M€/year.

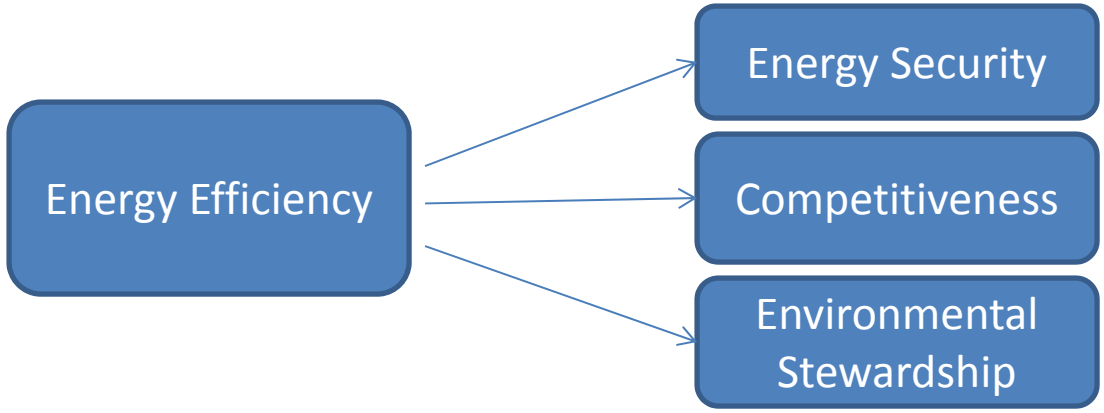
Change in Expenditures Compared to Reference Scenario



- A total of 329€M additional is needed for more efficient demand devices over 20 years.
- 235€M is saved annually on fuel costs (mostly for imported gas) by 2030.
- 31€M is saved on capital and operating expenditures for heat/power plants.
- Total net annual saving of 153€M per year by 2030.

Other Benefits of Energy Efficiency Policies

- Natural gas imports are reduced by almost 8% improving energy security and trade balance
- Fuel expenditures are cut by 1.5€B, along with reductions in new power plants and infrastructure investments.
- CO_2 emissions are reduced (cumulatively) by over 8% relative to the Reference scenario.

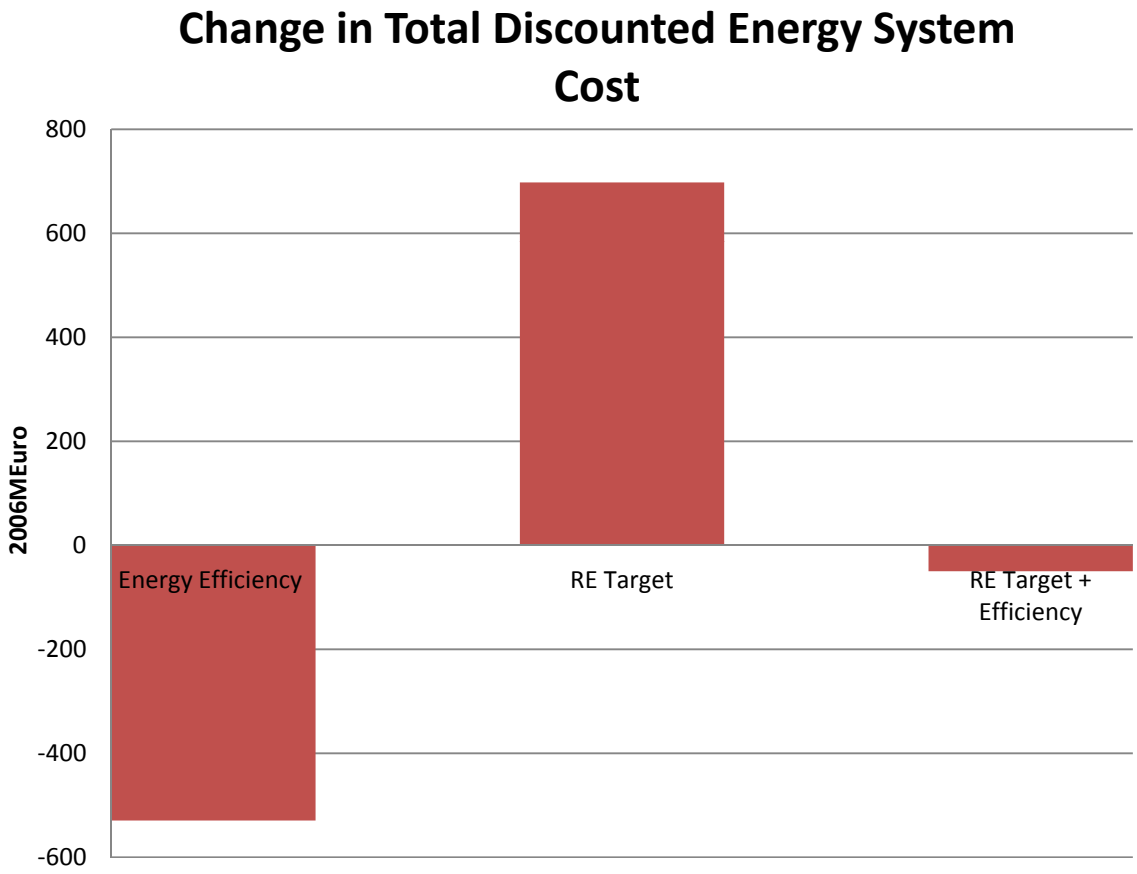


Combined RE&EE Scenario (Cumulative) Impact on the Reference Scenario

- Costs of achieve RE target is close with that of the Reference scenario when teamed with EE policies.
- Energy security is enhanced by a 23% drop in fuel imports (mostly gas), amounting to savings in fuel cost of 150-300€M/year, starting in 2021.
- An additional 1.2GWs of generation capacity is needed, requiring 4.8B€, which is 3.2B€ less than required to meet the RE target without promoting EE in tandem.
- CO_2 emission drops 23% over the planning horizon.

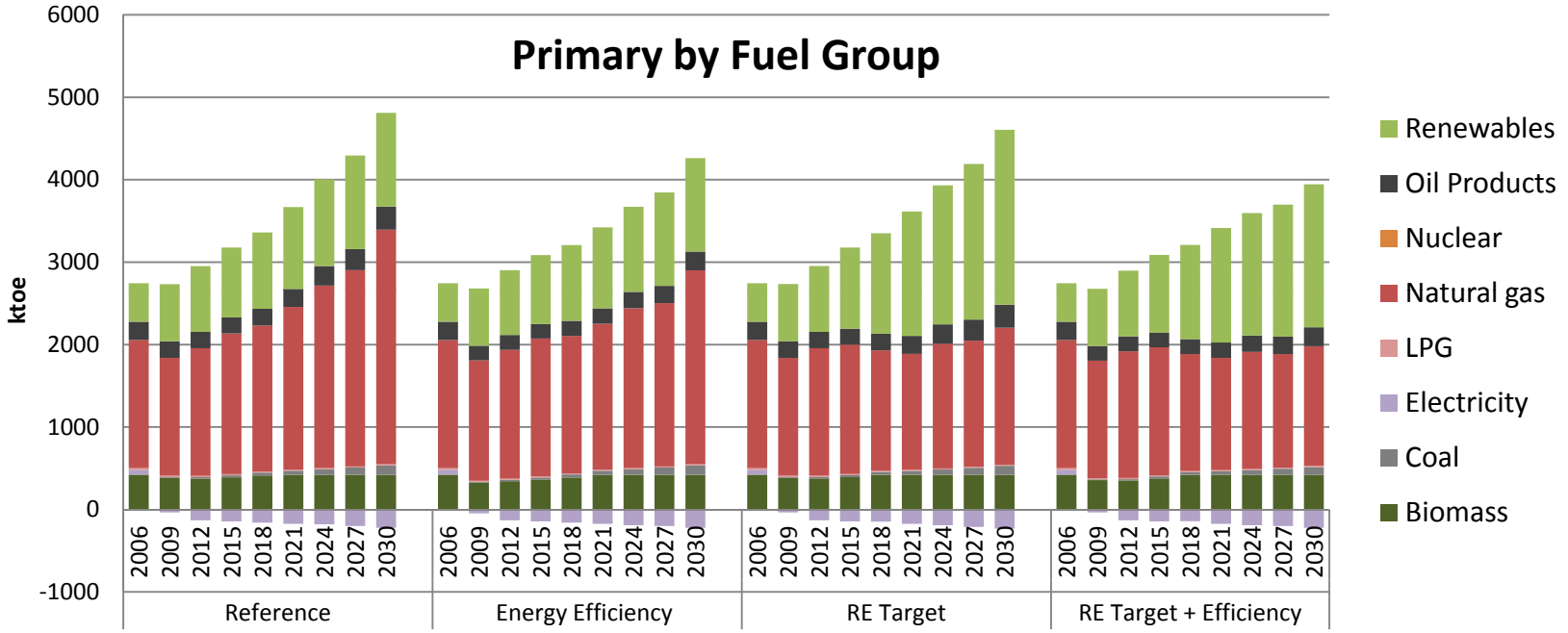
Metric	Units	Reference	EE + RE Target Change	
Total Discounted Energy System Cost	2006M€	15,574	-50	-0.32%
Primary Energy Supply	Ktoe	91,467	-7,419	-8.11%
Imports	Ktoe	60,229	-13,871	-23.03%
Fuel Expenditure	2006M€	11,459	-3,753	-32.75%
Power Plant New Capacity	GW	1.85	1.19	64.34%
Power Plant Investment Cost	2006M€	2,246	4,803	213.8%
Final Energy	Ktoe	82,853	-6,600	-7.97%
CO_2 Emissions	Kt	144,383	-32,790	-22.71%

Comparison of Overall Energy System Cost



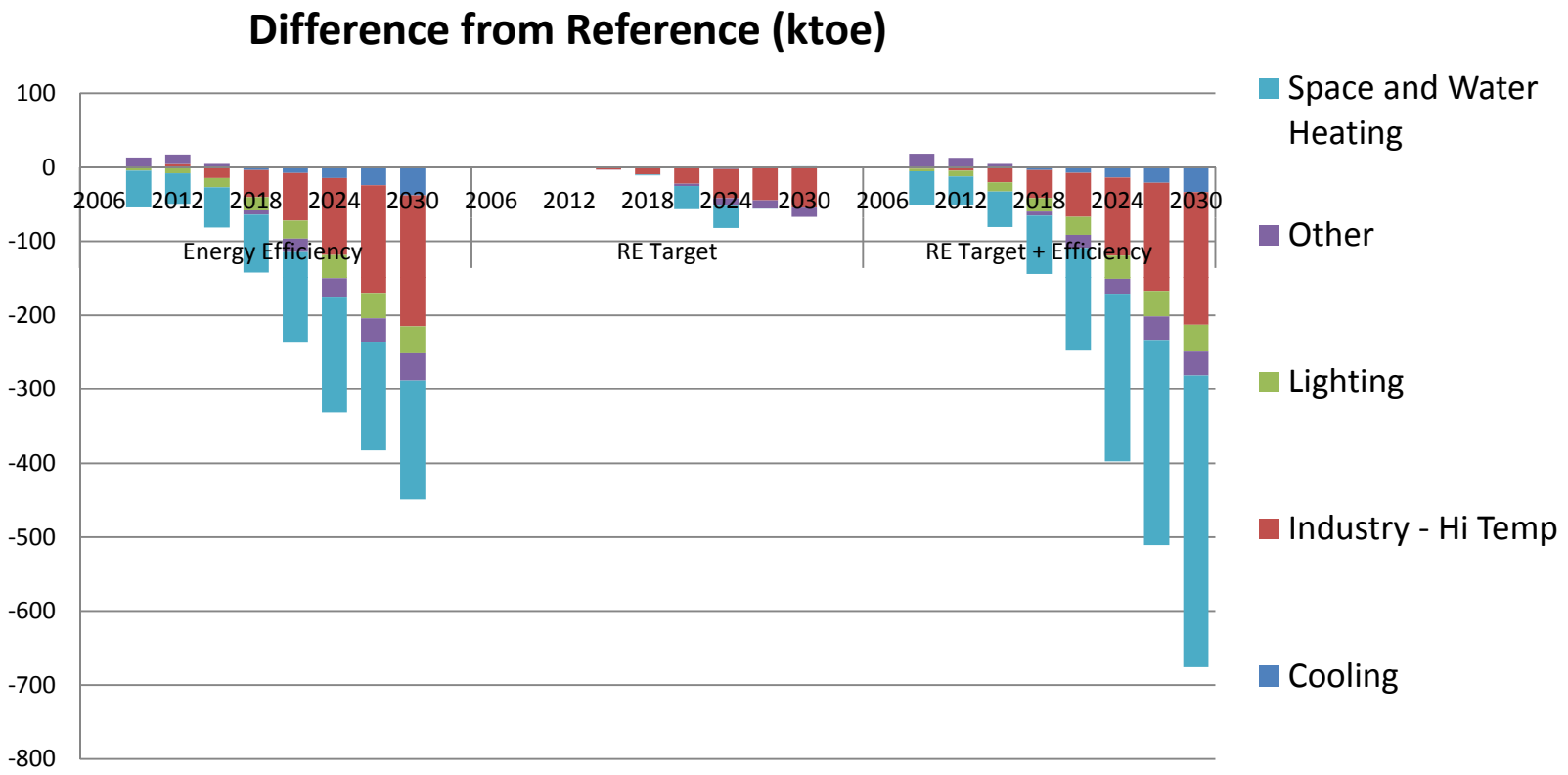
- EE policies can save a total of 529M€ or 3.4% compared to the Reference scenario.
- Achieving the RE target increases total costs 698M€ (4.5%).
- Combined policies result in achieving the RE target while still realizing an overall savings of 50M€.

Change in Energy Mix



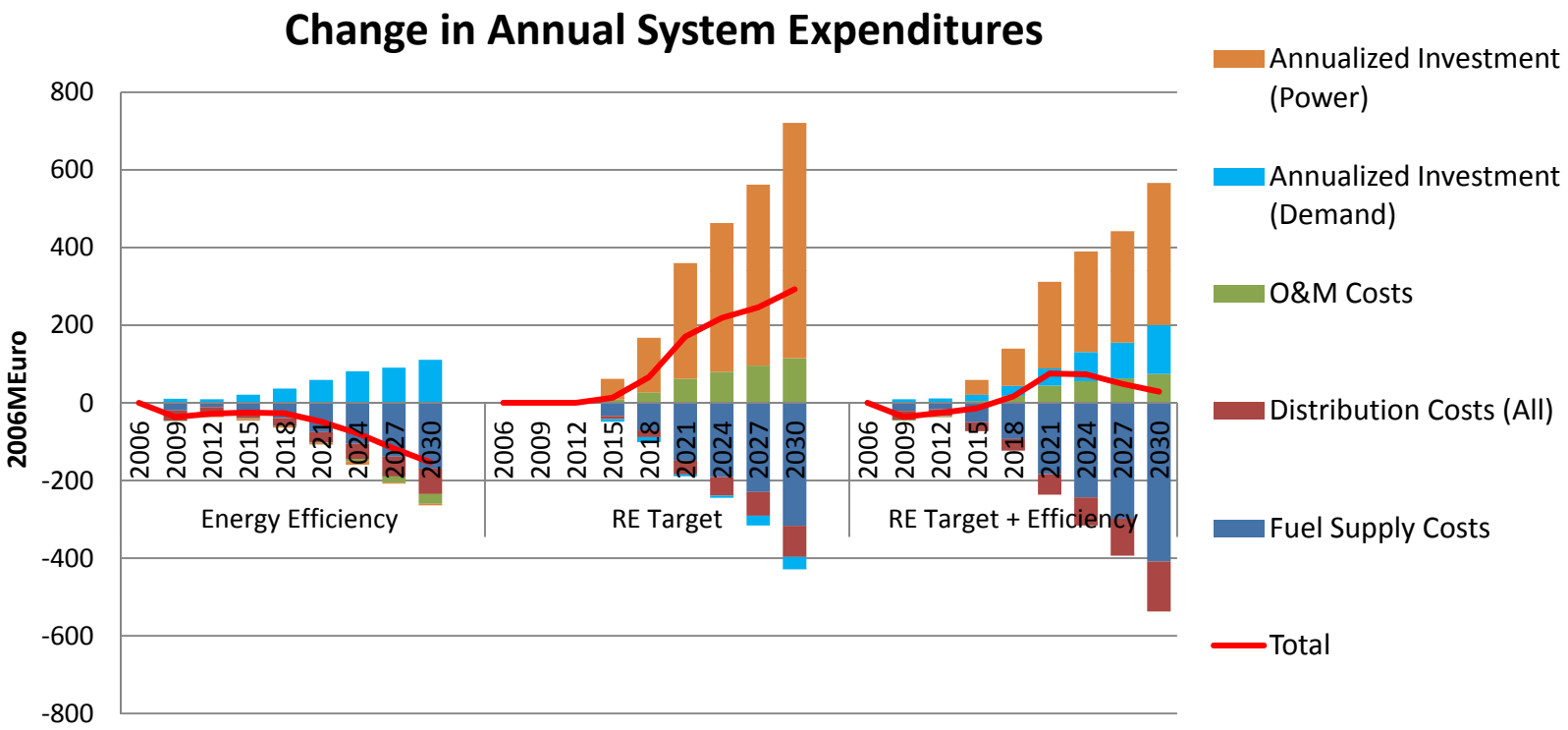
- Total primary energy is reduced by 6.4% in EE, 1.5% in RE and 8.1% in combined scenarios.
- Natural gas import are reduced by 8.6% in EE, 21.5% in RE and 25% in combined scenarios.
- Savings for foreign payments of 0.6M€, 4.7M€ and 5.6M€ per year respectively.
- RE target increases electricity generation by 35% in RE and 23% in combined scenario, displacing direct use of gas.

Energy Savings for Service Demands



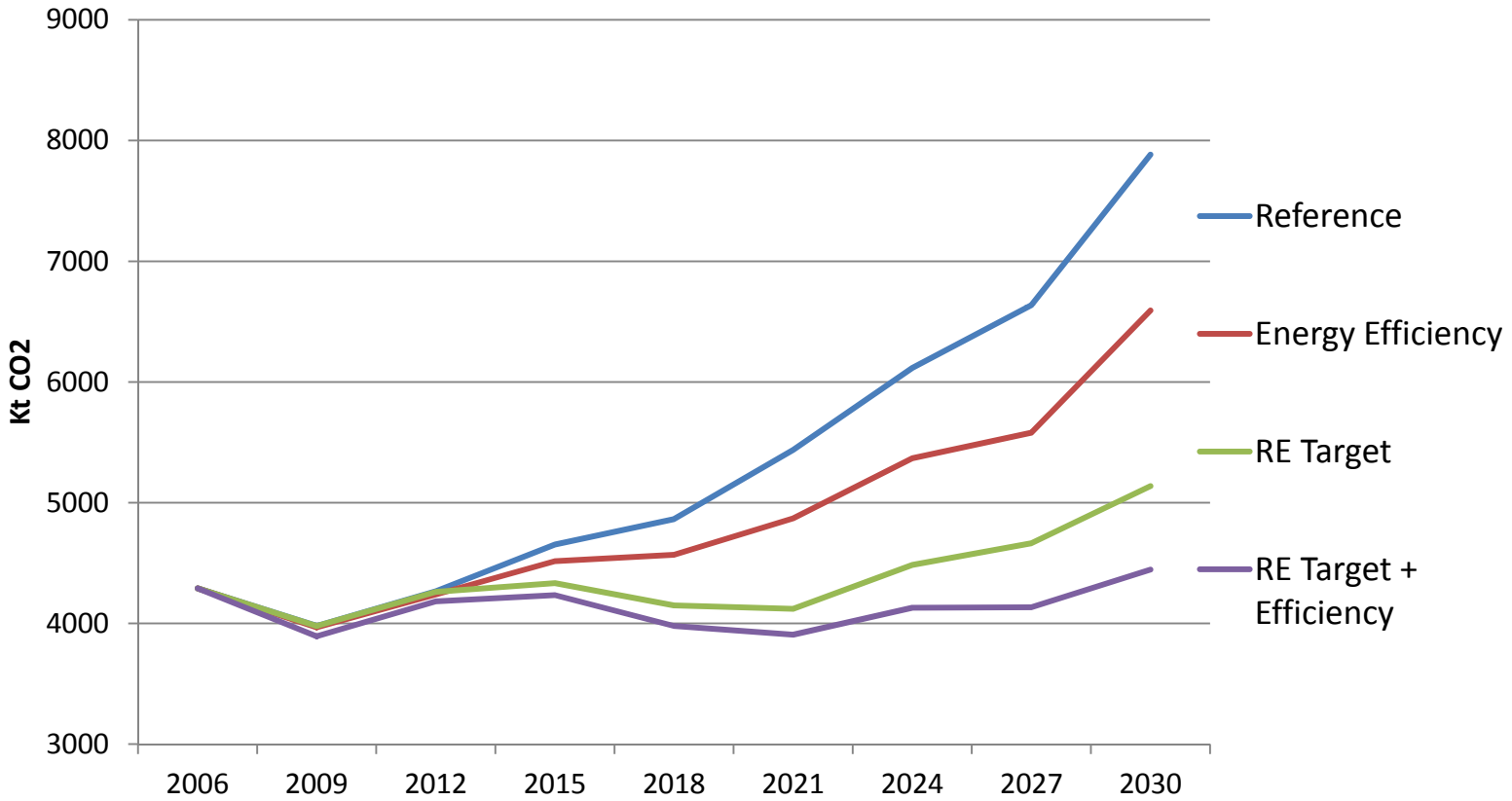
- Biggest saving is in space and water heating, to 3800ktoe cumulative (64% of total), followed by Industry with about 1400ktoe (24% of total).
- Cumulative reduction in natural gas reach ~11,000ktoe, with electricity consumption increasing by ~6,000ktoe.

Change in Expenditures Compared to Reference Scenario



- Fuel savings in all scenarios, with maximum of about 400€M in the combined scenario in 2030.
- Increased cost of the renewable power plants, is greatly reduced with increased energy efficiency.
- Increased cost of the improved demand devices, reaches over 100€M in 2030, but is fully compensated for by the fuel savings.

Climate Change Implications



- EE policies mitigate 8.1% of CO_2 emissions by 2030.
- RE target reduces CO_2 emissions by 18.1%.
- Combined policies result in achieving a 22.1% decrease in CO_2 emissions, dropping to almost the same level as 2006.

Summary Conclusions for EE&RE Policies

- Energy Efficiency measures lead to less import of fuel resulting in higher energy security.
- Achieving Renewable targets in Georgia is based on its strong Hydro potential, producing carbon-free electricity while enhancing energy security.
- Coordinating RE Targets with increased Energy Efficiency policies lowers the cost of RE compliance, owing to an overall drop in energy consumption.
- CO_2 emissions reductions can be realized at relatively modest cost when RE Targets are combined with enhanced Energy Efficiency measures.

A Look at Other Priority National Issues

- Introduction of a coal-fired power plant
- Sensitivity analysis on electricity export price
- Sensitivity analysis on natural gas price

Case Study 1 – 160 MW Coal Plant

- Base load lignite coal plant was added with the following characteristics:
  - Installed Capacity:160MW
  - Availability factor: 0.74
  - Efficiency: 0.36
  - Investment Cost: 1000EUR/KW
  - Starting year: 2015
- Two options 1 - coal plant as alternative,

  2 – coal plant forced to be built.
- Comparison allows the to check whether coal plant is economically attractive, and what it displaces if built.

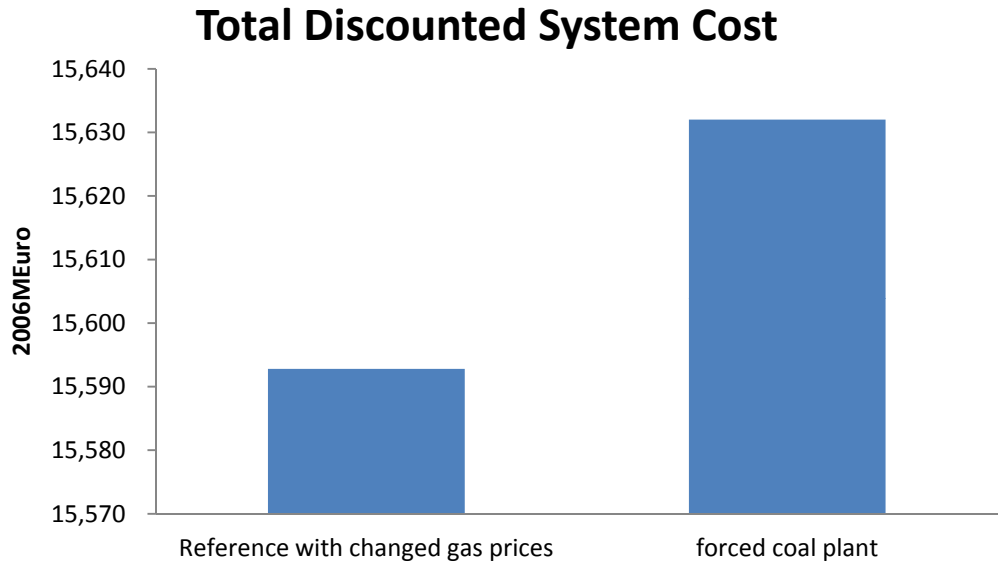
Case Study 1 – Coal Price

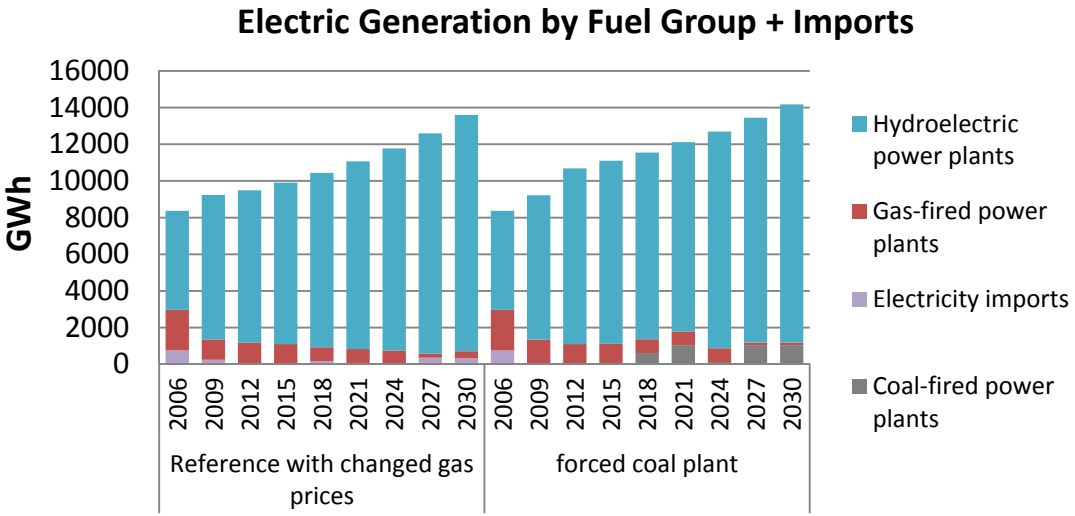
- Coal Prices:

Georgian enriched sub-bituminous coal		
5500kcal/kg	$80 /kg	2.582EUR/GJ
Ukrainian coal:		
6800kcal/kg @	$100kg	2.611EUR/GJ

- Coal prices increase gradually by 1.6% each year.

Case Study 1 – Coal Case Results





- When simply given an alternative to build a coal plant it is not chosen.
- When the coal plant forced - total system cost increases by only 39€M or 0.25% of system cost
- Only domestic coal consumed, costing 575€M.
- Coal plant results in about twice as much electricity exports.

Case Study 2 – Electricity Export Price

Scenario GE_R34_E048_a

- Export up to 3GWh electricity at price 0.048EUR/kwh and import up to 250 MWh at same price.
- Option to build coal plant and additional 300MW of regulated hydro plants at cost of 1800EUR/KW and 300MW of run of river hydro plants with investment cost of 2000 EUR/KW.

Scenario GE_R34_E048_b

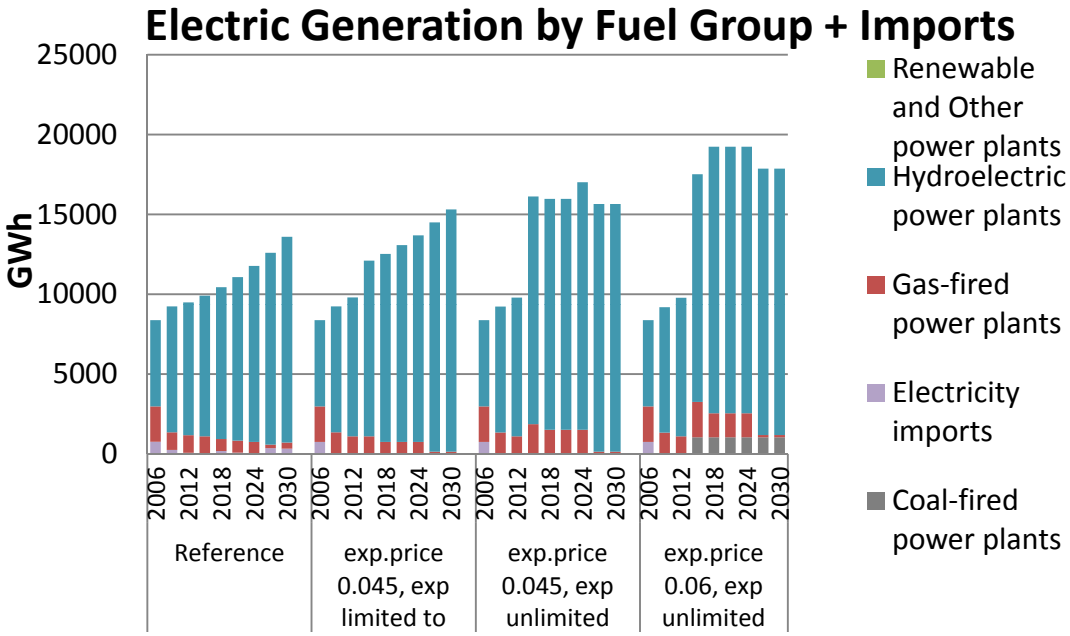
Same as above scenario, but with the possibility to export as much electricity as is economically profitable.

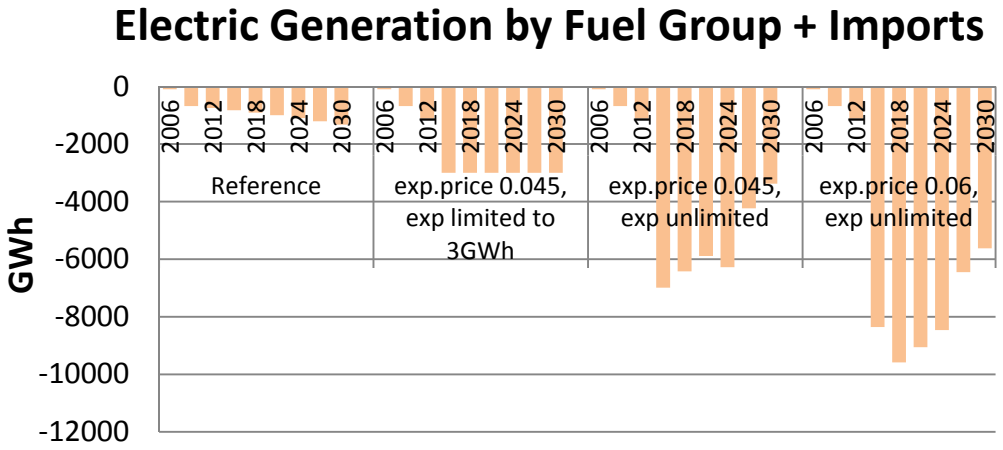
Scenario GE_R34_E06

Same as above scenario, but with Electricity export/import price of 0.06EUR/kwh.

Purpose is to check how much hydro and/or coal will be built if the export price reaches 0.048EUR/kwh.

Case Study 2 – Electricity Export Price Results





- With this higher export price additional hydro plants are built until the export limit and/or hydro potential is reached.
- The coal plant is built when the export price reaches 0.06EUR/Kwh.

Additional National Objectives to be Explored with MARKAL-Georgia

- Aggressive economic development with rapid growth in new industrial zones and touristic resorts.
- Regional electricity market with stronger interconnections and higher trade volumes to neighboring countries.
- Impact of natural gas price on consumer choices and power system development.
- More detailed look at the role of traditional fossil fuel (coal) power plants to handle uncertainty associated with hydro variability.
- Other suggestions welcome.

Conclusions and Next Steps

- MARKAL-Georgia is ready for informing decisions-on the future evolution of the Georgian energy system.
- Recently transport & refinery sectors, and CO_2 accounting has been added and some input data has been updated. *Data gathering and model testing continues.*
- MARKAL-Georgia model will be used for GHG emissions abatement study in Georgia's Third National Communication to the UNFCCC.
- A proposal for NSF-USAID (PEER) program has been submitted to add non-energy sector GHG emissions and mitigation options to MARKAL-Georgia.
- Looking for possible cooperation with Armenian Planning Team (and other countries in region) to build a regional MARKAL model to explore the possibilities of electricity trade.
- Plans should be considered by the Ministry for sustaining the modeling capacity and integrating it into the policy formulation process.

Thank You!

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