Regional Strategic Energy Planning Project

Results from Phase I

Opportunities and Benefits Arising from Enhanced Energy Efficiency and Renewables in Moldova

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Presentation Outline

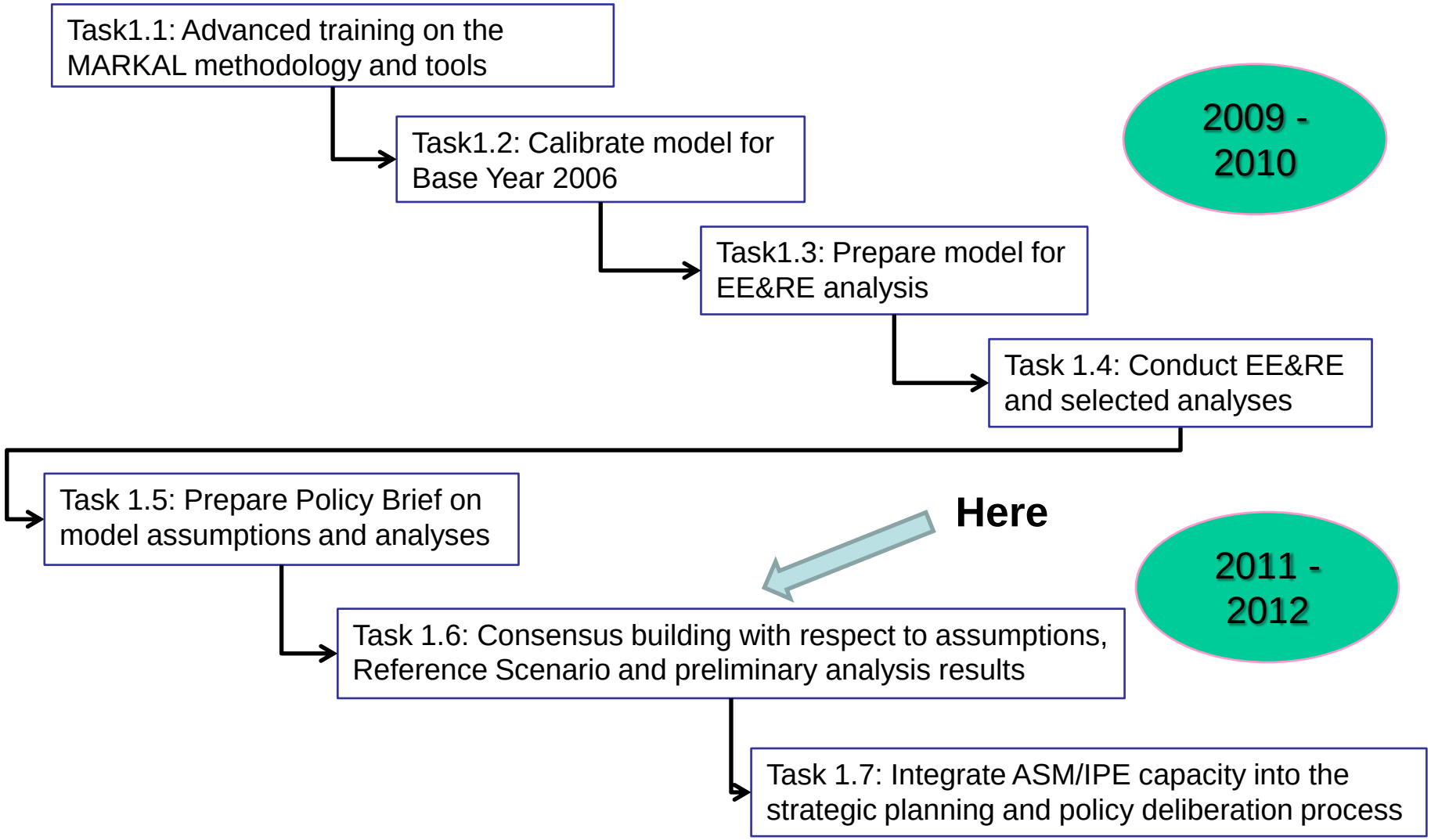
- **Establishment of MARKAL for Moldova**
- **Reference Scenario Assumptions and Evolution**
- **Energy Efficiency and Renewable Energy Scenarios**
- **Country Analyses**
- **Conclusions and Next Steps**
- **ANNEXES**

Establishment of MARKAL for Moldova

MARKAL - Moldova Model Development

- Results reported in this Briefing reflect **two years of model development and use**, jointly undertaken by the Ministry of Economy (MoE), the Institute of Power Engineering of Academy of Sciences of Moldova and the Alliance for Energy Efficiency and Renewables (AEER) Moldova.
- **In 2009**, after joining USAID/Hellenic Aid SYNENERGY Project, and with guidance of experts from International Resources Group (IRG) and Centre for Renewable Energy Sources and Saving (CRES), the **initial MARKAL- Moldova model was established**.
- The **base year is 2006**, and costs are in EURO2006PPP.
- Depiction of the Moldova energy system is based upon **official statistical data** and reports of the National Bureau of Statistics of Moldova, National Agency for Energy Regulation, and other official sources.

Establishing Moldova MARKAL Capacity



Practical Applications of MARKAL-Moldova (1/2)

International Projects (2009-2012):

- **USAID/Hellenic AID (IRG/CRES) SYNENERGY -** Strategic Planning for Policy Analysis and Formulation
- Results of MARKAL-Moldova model were used to prepare input data for **GAINS Model** (Greenhouse gas – Air pollution Interactions and Synergies)
- FP-7 Project: **PROMITHEAS-4** to look at various tools available for energy planning in the region
- **IEA-ETSAP** MARKAL/TIMES Workshop, Stockholm, Sweden, June 24, 2010 presentation

http://www.etsap.org/Workshop/Stockholm_Sweden_2010/Index.htm

Practical Applications of MARKAL-Moldova (2/2)

National projects (2009-2012)

- Various short and mid term analyses_by **request of Ministry of Economy**
  - Policy formulation for energy equipment labeling.
  - NEEAP – 20% improving energy efficiency by year 2020.
  - Energy Community Secretariat Task Force Data Requests
    - Regional Energy Strategy
    - Renewable Energy
    - Gas to Power

Related ASM/IPE Activities

- **Ministry of Economy** - During year 2010 ASM/IPE experts participated in activities of the Working Group for Policy Formulation "Promotion of electricity saving at the final use level". Order nr126 of 21.06.2010 of Minister of Economy.
- **Ministry of Environment and UNDP**- ASM/IPE experts participated in activities of the Working Group for **LEDS - Low Emission Development Strategy**. Order nr. 87 of 12.10.2010 of Minister of Environment.

Publication

- Sergiu Robu, Elena Bikova, Philip Siakkis, Dr. George Giannakidis, "**MARKAL Application** for Analysis of Energy Efficiency in Economic Activities of the Republic of Moldova and Feasible use of Renewable Energy Sources", Electronic Journal nr. 2(13) (2010), Problems of the Regional Energetics http://ieasm.webart.md/data/m71_2_145.doc

Evolution of the Energy System of Moldova Under the Reference Scenario

Reference Assumptions and Policy Considerations

Reference Scenario

- **No significant change** of the existing energy system, with the main focus being extending the operating lifetime of existing facilities (with performance improvement).
- Option to construct **coal-fired power plant** from 2015.

Key Aspects of the Energy System to be Considered

- What policies should be encouraged to shape primary energy supply to promote **energy security** and diversification (e.g., levels of renewables in the energy mix, coal power plant, long-term contracts for gas imports), a key policy objective of the government?
- How will the energy sector develop under business-as-usual conditions to meet the projected **economic growth**?
- Where should policies aimed at promoting **energy efficiency** measures be targeted?
- How to reduce reliance on **electricity imports** and diversify supply?
- What is the future for **coal and gas** in the power industry?
- What are the possibilities and requirements to move towards indicative **EC/EU targets** for energy efficiency, renewables, and CO_2 emissions?
- **What investment will be required**, and what will be the impact on the cost for energy, under various policies to shape energy future of Moldova?

Key Assumptions for the Reference Scenario (1/2)

Supply & Power Sector	Assumptions Guiding the Reference Scenario
International energy prices	Average forecast of IEA over the modeling horizon
Oil extraction	16 kt in2009, investments providing extraction of 100 kt by 2020
Gas imports	No new projects (South Stream; NABUCO)
Import of electricity , or production at Moldavian TPP	By year 2030 maximum of 25% of total electricity consumption may come from imports
Share of coal in the fuel mix	No limits on coal in the fuel mix, and no limits on capacity of new coal power plant
Hydro capacity potential	No new small hydro in Reference scenario
Wind capacity potential	Max of 200MW total technical potential potential
Solar capacity potential	Total 320MW (theoretical potential, where either solar hot water or PV but not both at the same site)
Heat production by centralized heat supply gas -boilers	Not less than 95% from total by 2015 and 80% by 2030

Key Assumptions for the Reference Scenario (2/2)

Demand Sectors	Assumptions Guiding the Reference Scenario
Fossil fuel demand for all sectors	No limits on fuel consumption
Energy saving	Limited introduction of conservation or demand management measures
End use sectors	Residential sector will remain the main energy consumer of the country (accounting for nearly 50% of total consumption)
Air conditioning	Air conditioning will increase substantially in the future due to availability of technology on the market and improved quality of life
New technologies in households, public and commercial sectors	Share of advanced technologies for space, water heating and air-conditioning will not exceed 2% in 2020 and 5% in 2030
Rehabilitation of residential and commercial buildings	Share of buildings undergoing rehabilitation not to exceed 2% in 2020 and 5% in 2030
Subsidies	Elimination of cross-subsidies for different consumer types by 2020

Key Data Sources

Data Type	Data Source/Assumptions
Primary energy supply by fuel*	Energy balance of the Republic of Moldova
Fuel processing: energy inputs and outputs	Energy balance of the Republic of Moldova
Domestic and imported fuel prices	Reports ANRE (National Agency for Energy Regulation) & IEA
Electricity import and export prices	Reports ANRE
Base-year number of households, persons per household, fuel consumption by subsector, share of consumption to each end-use, value added for each subsector, electricity for transport	Statistical yearbook of Moldova
Power Plants existing capacity, planned retirements, fuel consumption, electricity and/or heat production, efficiency and availability, ratio of electricity to heat for CHPs, minimum operation by plant type. Electricity, gas, and heat losses.	• Energy balance of the Republic of Moldova • ACTIVITY REPORT 2008 of ANRE. • Centralized heat supply Company of Chisinau – TERMOCOM
Final energy consumption: by sector and fuel	Energy balance of the Republic of Moldova
Population [by 0.28% average per year]	Statistical yearbook of Moldova; UNDP. Human development Report.
GDP [average 6% per year]	Statistical yearbook of Moldova; WB Forecasts; National Bank of Moldova
Future import and production limits	Energy Strategy of Moldova till 2020

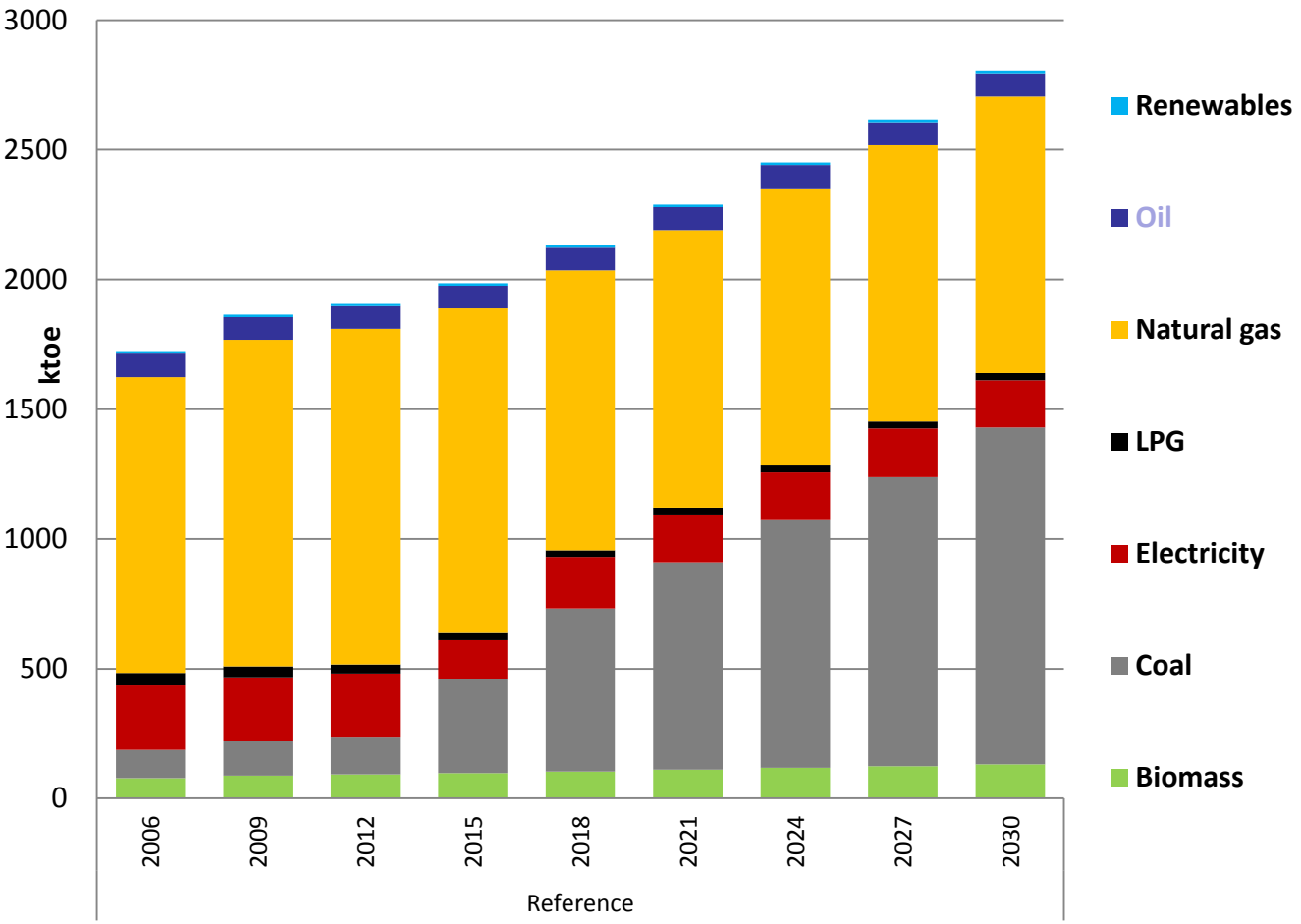
*MARKAL-Moldova is calibrated to the 2006 energy picture, and fuel prices are updated for 2009 according to National Agency for Energy Regulation information.

Key Indicators from the Reference Scenario

Indicator	2006	2030	Annual growth rate (%)	Overall growth (%)
Primary Energy (Ktoe)	1723	2806	2.1%	63%
Final Energy (Ktoe)	1324	2060	1.9%	55%
Power plant capacity (MW)	360	1400	5.8%	290%
Imports (Ktoe)	1626	2653	2.1%	63%
CO_2 emissions (Kt)	3464	7886	3.5%	128%
GDP (€ Mill. 2006PPP)	7000	28343	6.0%	305%
Population (000s)	3589	3842	0.3%	7.0%
Final Energy intensity (toe/k€GDP)	0.19	0.073	-3.9%	-62%
Final Energy intensity (toe/Capita)	0.37	0.54	1.6%	45%

- **Primary energy** supply grows by **63%** by 2030, with **final energy** consumption growing by **55%**.
- **Electricity generation capacity** expands from 360 to **1400MW**.
- Higher **imports** growing more than 60% by 2030.
- Rather optimistic assumption regarding **economic growth**, averaging around **6% per annum** (so the resulting requirements for the energy system may be on the high side of what will actually be needed).
- **Energy consumption per unit of GDP** is estimated to be **62% lower** than 2006 as a result of anticipated improvements in technologies.
- **CO_2** emissions will increase from 3,464kt to 7,886kt corresponding to a rise of **128%**.

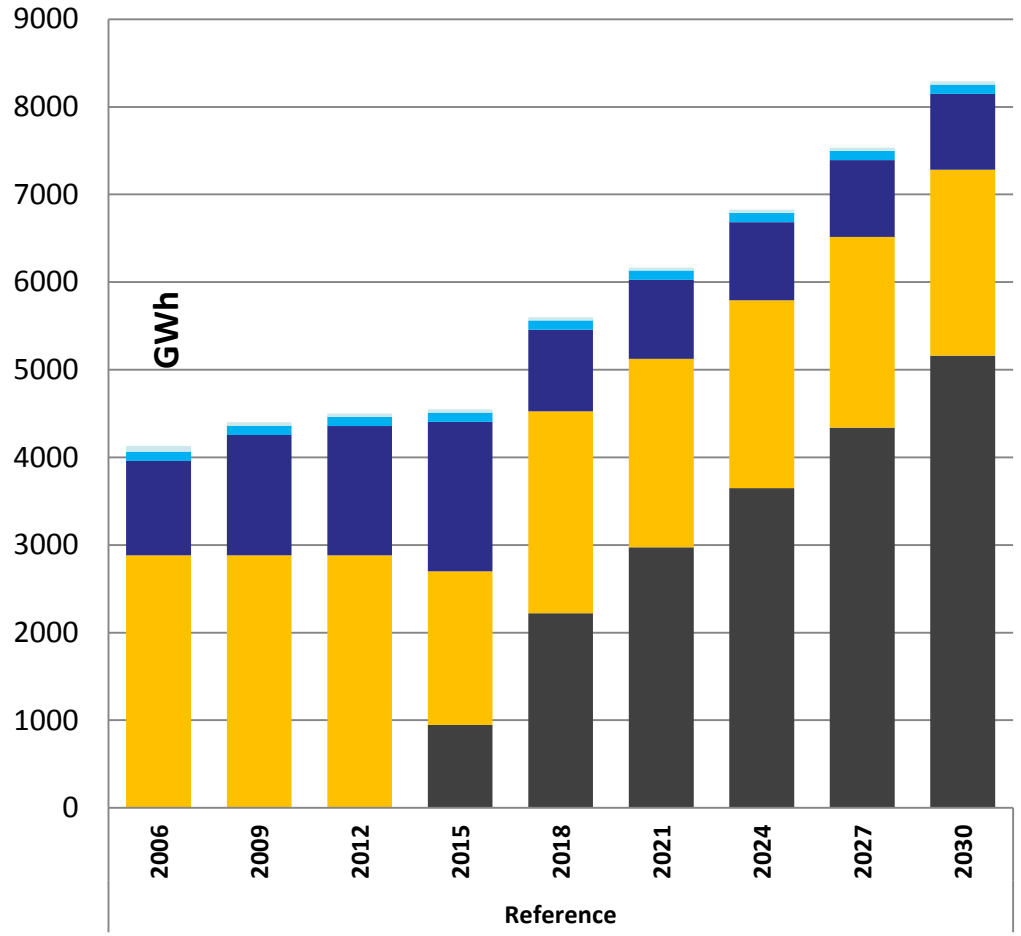
Reference Scenario – Total Primary Energy



- **Gas** use decreases due to investment in new coal-based capacity starting in 2015, moving from **66%** of primary energy supply in 2006 to **38%** in 2030.
- **Electricity imports** decrease from **14% to 6%** in 2030.
- **Biomass** supply will double, to 131 ktoe in 2030.
- **Coal** imports increase from **6.4% to 46.3%** in 2030 due to the coal-fired power plant.

Total Primary Energy Supply (TPES), ktoe

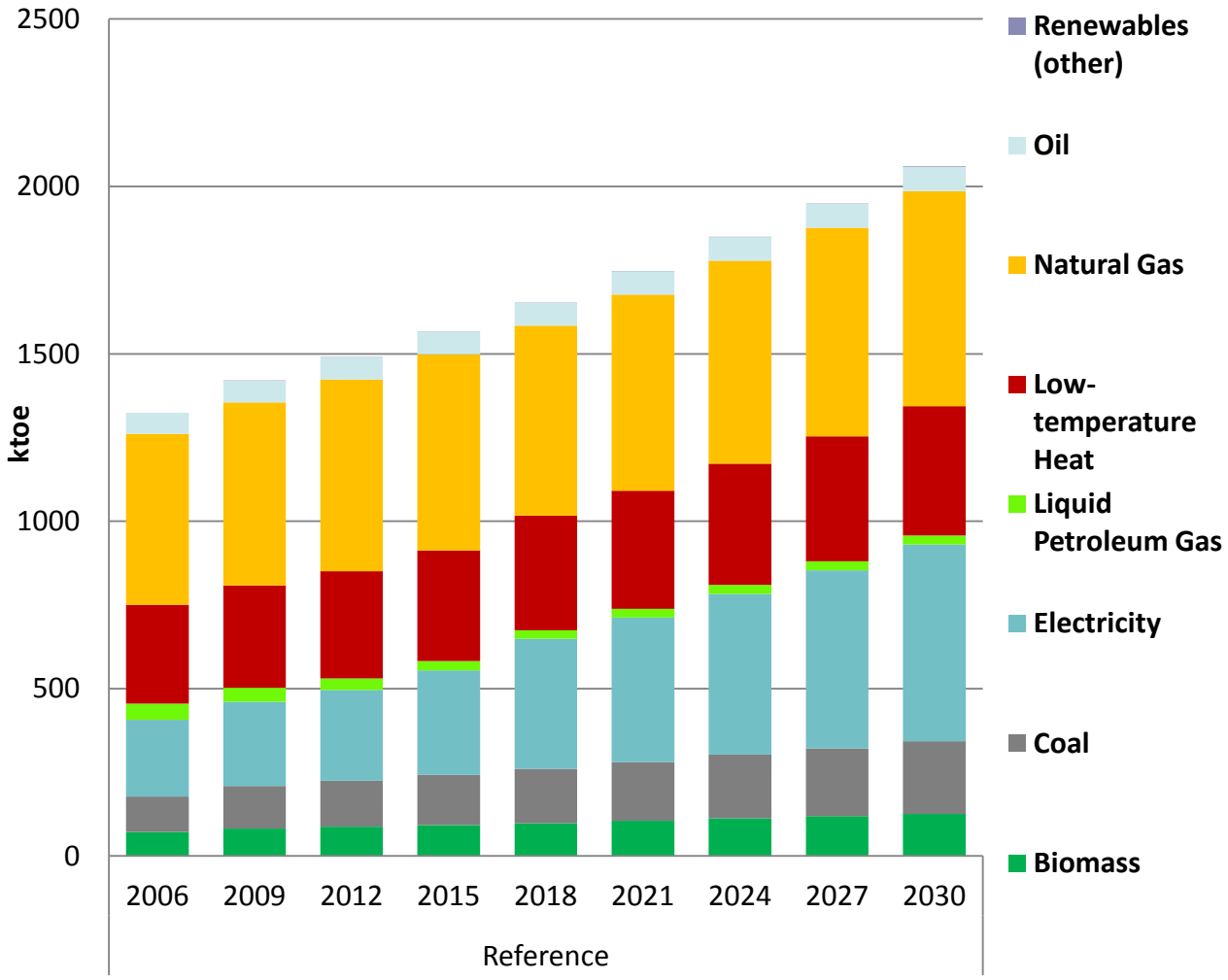
Reference Scenario – Electricity Sector



Electricity Generation, GWh

- Electricity imports were 2884 GWh or **70%** of total generation in 2006, decreasing to **25%** of total by 2030.
- Existing **gas-fired** generation decreases from 1077 GWh or **26%** in 2006 to 870 GWh (**10%**) in 2030 , due to new coal-fired power plant coming online in 2015.
- Generation from **coal** increases from 946 GWh in 2015 to 5160 GWh in 2030, reaching **60%** of total, with installed capacity reaching 710MW by 2030.
- Construction of coal PP will **cost 770 M€; and 125M€** for 330MW of new gas PP
- Hydro power plants generate **105 GWh** per year over the entire planning horizon

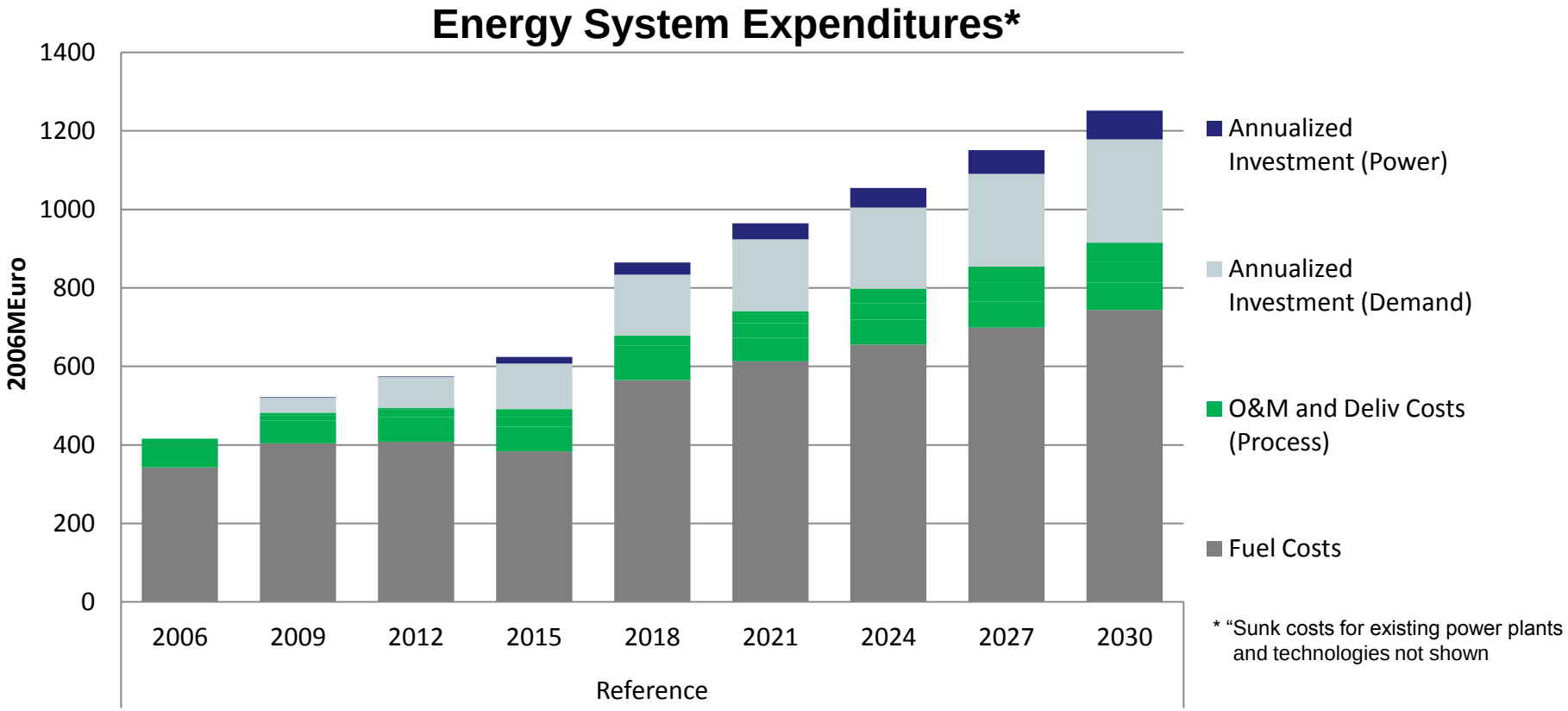
Reference Scenario – Final Energy Consumption



Total Final Energy Consumption (TFEC), ktoe

- Overall energy consumption **increases by 60%** in 2030, relative to 2006.
- The **residential remains dominant** accounting for more than 50% of total demand throughout the planning horizon.
- Natural gas remains the main fuel for direct consumption, increasing from 511ktoe to 642ktoe in 2030, however percentage wise **gas moves from 39% down to 31%**.
- **Commercial sector natural gas** increases most,60%, mainly used for heating.
- **Electricity increases from 17% to 29%** of total consumption as the new coal units come online.
- The rest of the fuels **increase proportionally** with the demands.

Reference Energy System Expenditures



- Even with moderate growth in energy prices, during next 25 years **payments for fuel will increase by 220%** to about 744M€ per year, which is **two thirds of the energy system expenditures**.
- **Purchases** of new demand devices grow to 263M€ per year by 2030, 3.5 times as much as the 73M€ per year for new power plants.

Assessment of the Implications of Energy Efficiency and Renewable Energy Policies

Policy Drivers and Implications for Alternate Scenarios

Energy Efficiency (EE) scenario examines measures to identify those demand-side options that are "economically" attractive without policies to further promote conservation and the uptake of efficient technologies.

Renewable Energy (RE) scenario explores what is most cost-effective way to achieve the EC proposed RE target for Moldova, in line with Energy Strategy RE goals.

Key Insights Arising from EE/RE Policies to be Examined

- In which sectors of the energy system will EE/RE measures have the most significant impact (benefits)?
- How much (additional) direct investment will be required to achieve the RE target?
- To what degree are investments in EE/RE projects offset by the reduction of fuel expenditures, notably for imports?
- How do EE/RE policies impact the energy and electricity generation mix?
- What is the impact on CO_2 emissions?

Key Differences From the Reference Scenario

	Reference [REF]	ENERGY EFFICIENCY [EE]	RENEWABLE ENERGY [RE]
RE Target	No target Imposed	As in Reference	Increase to 20% of Renewable Energy share of TFEC to 2020
New technologies in the residential, budget and commercial sectors	The share of new technologies will not be more than 5% by2030	New devices for heating, water heating and air conditioning may be up to 20% in 2020 and 50% in 2030	Same as Reference
Heat production by municipal boiler	Not less than 32% in total heat production by 2030	Only require 15% by 2030	Same as Reference
Heat production by municipal gas boiler houses	Not less than 80% from total heat production by boiler houses by 2030	Only require 50% by 2030	Same as Reference
Fuel consumption by road transport by 2030	N/A	As in Reference	Biofuels — not exceed 10% in fuels mix for transport
	N/A	As in Reference	Consumption by electric vehicles will not exceed 5%

Energy Efficiency Economic Potential

- Reference scenario assumes that primarily conventional demand devices and limited conservation is remain the norm.
- The EE scenario essentially removes these limits permitting up to half of all new device purchases to be advanced devices by 2030.
- Identifies most important programs and policies to consider to foster energy savings, such as establishing appliance and building standards, limiting access to inefficient devices (e.g., prohibiting incandescent bulbs).
- Determines the economic optimal penetration level of the efficient and conservation options, and the resulting energy savings and other benefits.

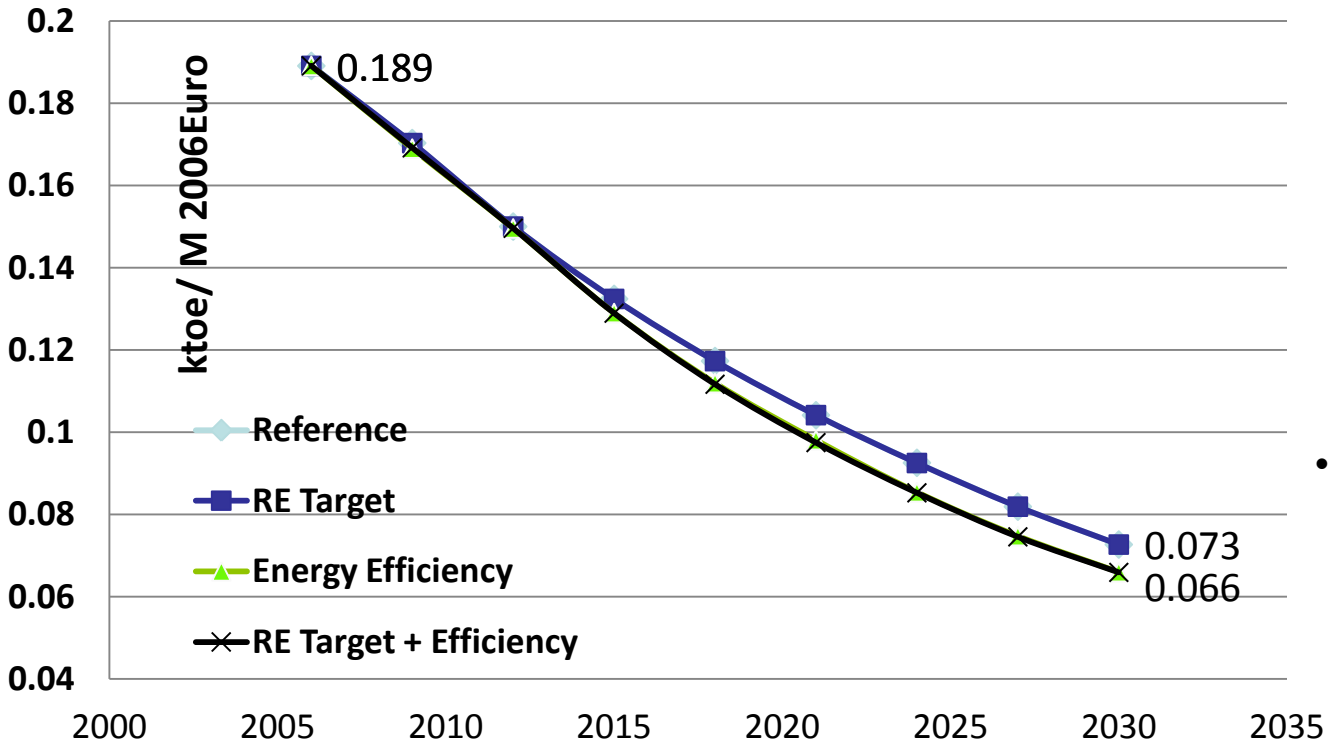
Summary of Benefits Arising from EE&RE Policies

Policy driver / Scenario	Reference	Renewables	Energy Efficiency**	Renewables and Energy Efficiency
Energy security and diversification	• Gas imports decrease to 30% • No reliance on imported electricity	• Reduces overall imports 3.1% • Encourages wind / biomass, and small PV at final users.	• Reduces overall imports 6.8%.	• Reduces overall imports 9.05% • But less wind / biomass
Energy system costs and competitiveness [*]	• Total cost of the energy system €9,187 Million	• Stimulates 260€M investment in renewable market , mainly wind & biomass • Increases energy system cost by 0.4% • Increase expenditure on biomass by 12€M	• New power plant investment are reduced by 270€M • Total of 430MW less new power plants built (180MWcoall and 250MWgas) • Saves 709€M on payments for fuel	• Reduces the cost of meeting the RE Target by 80€M • Save 795€M on payments for fuel
CO_2 mitigation	• Emissions increase by 130% by 2030 owing to increased coal and gas use	• 4.9% cumulative reduction due to less use of coal/gas-fired PP	• 8.3% cumulative reduction due to an overall 4.9% drop in consumption	• 11.6% cumulative reduction due to an overall 5.04% drop in consumption and less use of coal / gas-fired PP

*The analysis does not provide full insights into the macroeconomic impacts of these policies, as it does not account for the allocation of financial resources across other sectors of the economy, as is done by general equilibrium models. However, sustainable economic growth inherently requires minimizing the cost of the energy system.

** The costs associated with implementing EE measures are only partially captured.

Competitiveness

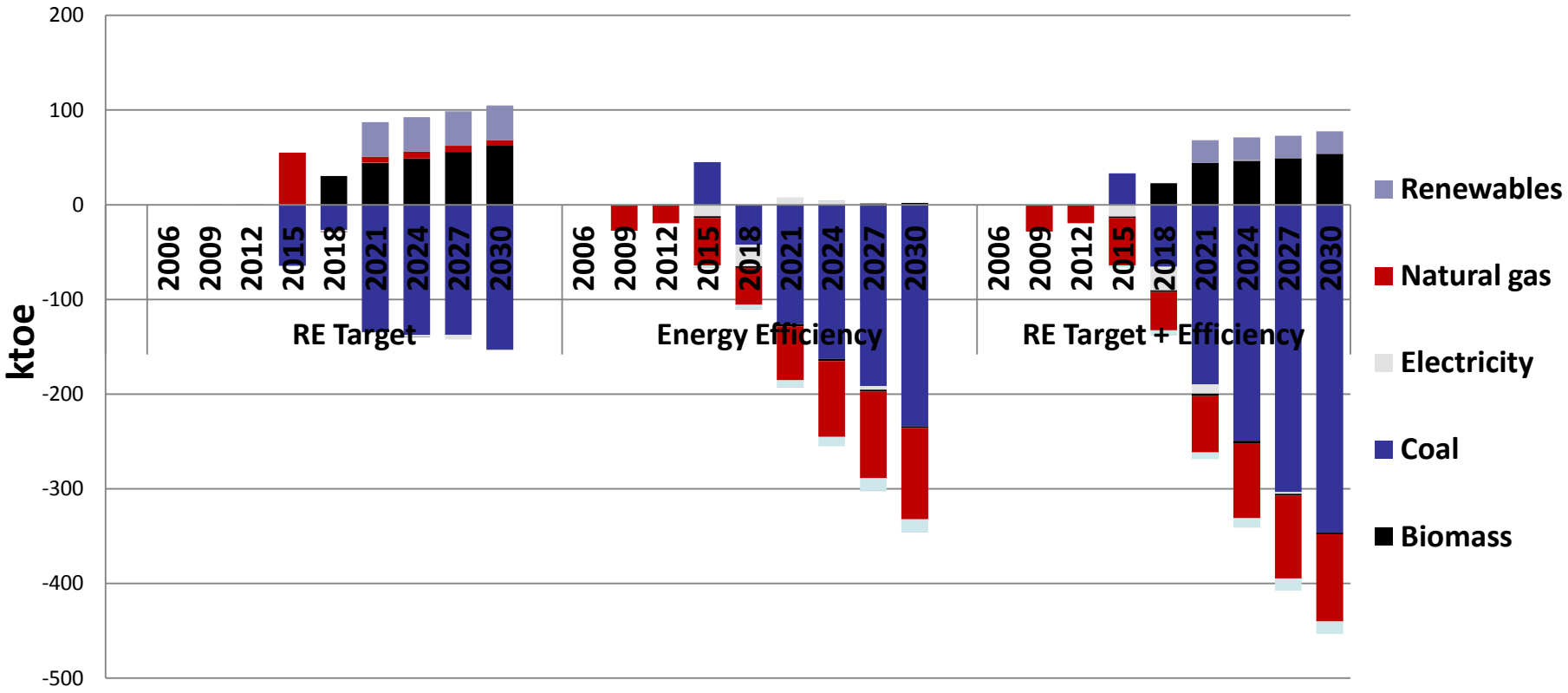


Total Final Energy Consumption (TFEC) / GDP

- The high GDP growth rate assumed and relatively slow increase in energy consumption brings energy required per unit of GDP in 2030 down to 0.073 toe/1000€, nearly **60**% lower than 2006, with another **10**% reduction under EE.
- This improvement is due to the shutting down of many energy intensive industries and older power plants, and the increasing role of the commercial sector in the economy, along with assumptions regarding basic improvement in demand devices.

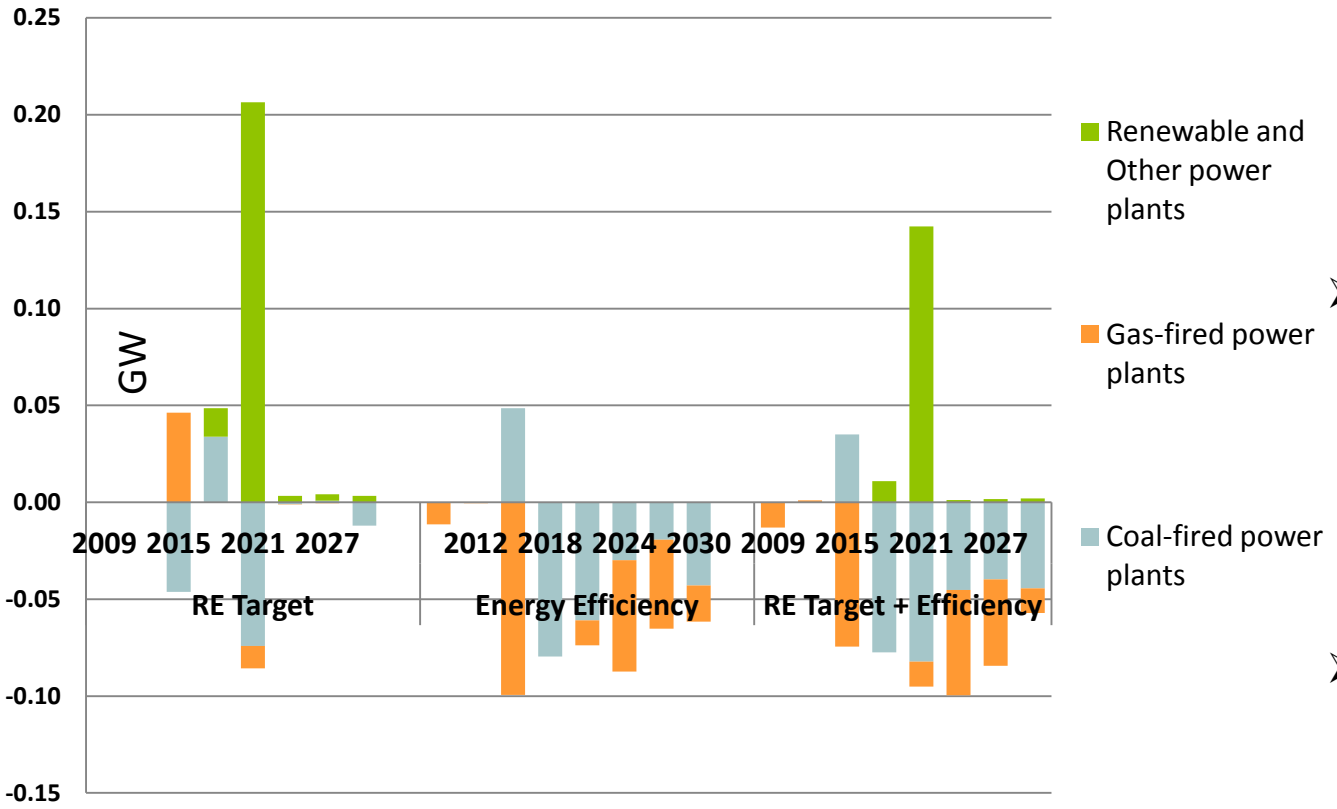
Energy Security Benefits

- Combined EE+RE policies cut total imports by 35% below Reference
- Annual imports of Coal reduced by by 340ktoe or 25% and LPG Gas by 92ktoe or 9%
- Total balance of payment for imports are reduced by 198€M, 237€M and 283€M respectively



Change in Primary Energy, ktoe

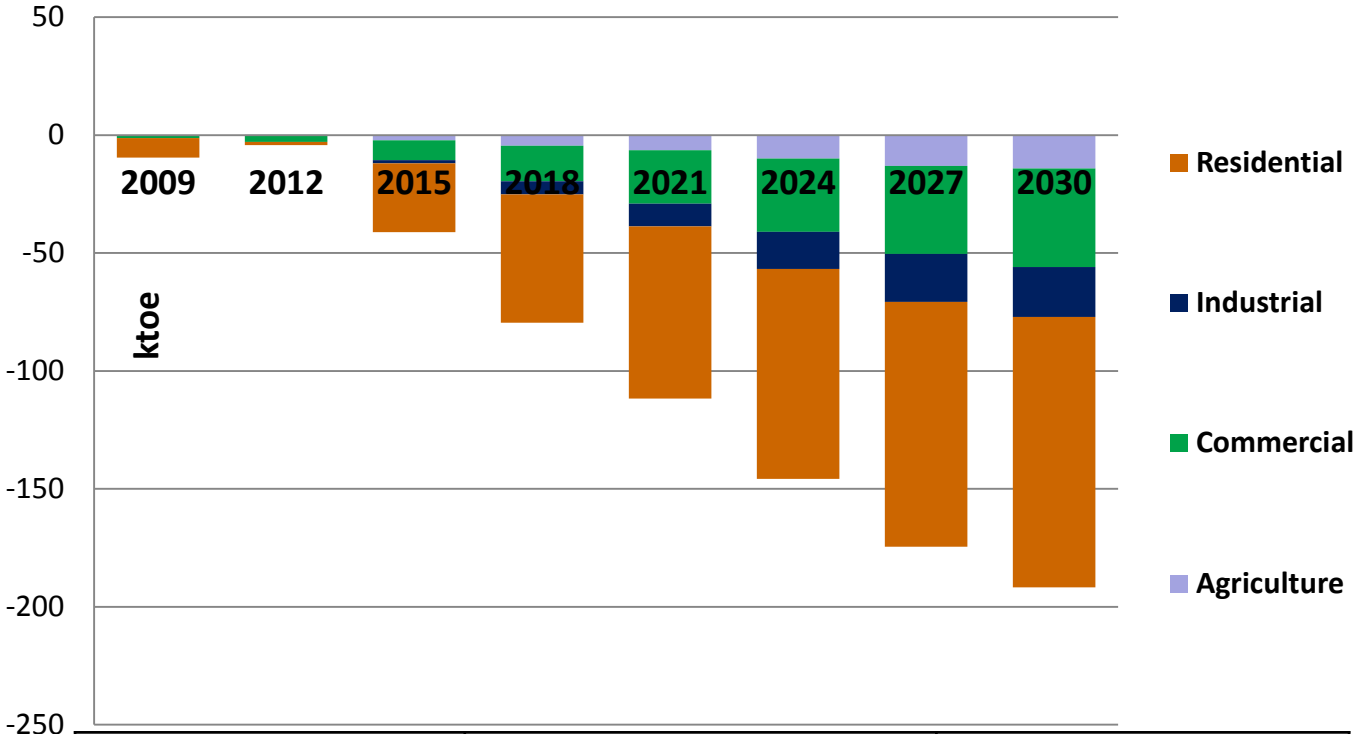
Power Plant Capacity Additions



New Power Plants Added / Avoided, GW

- To achieve the RE target requires the addition of 200 MW of new wind, in place of 100MW of coal, at a cost of 220€M.
- Policies promoting EE reduce new builds by 430MW less new gas CHP and coal plants, resulting in nearly 300€M savings over 20 years.
- Combined EE+RE policies cut new power plant requirements by 450MW compared with the Reference, with 60MW less wind compared with RE-only.

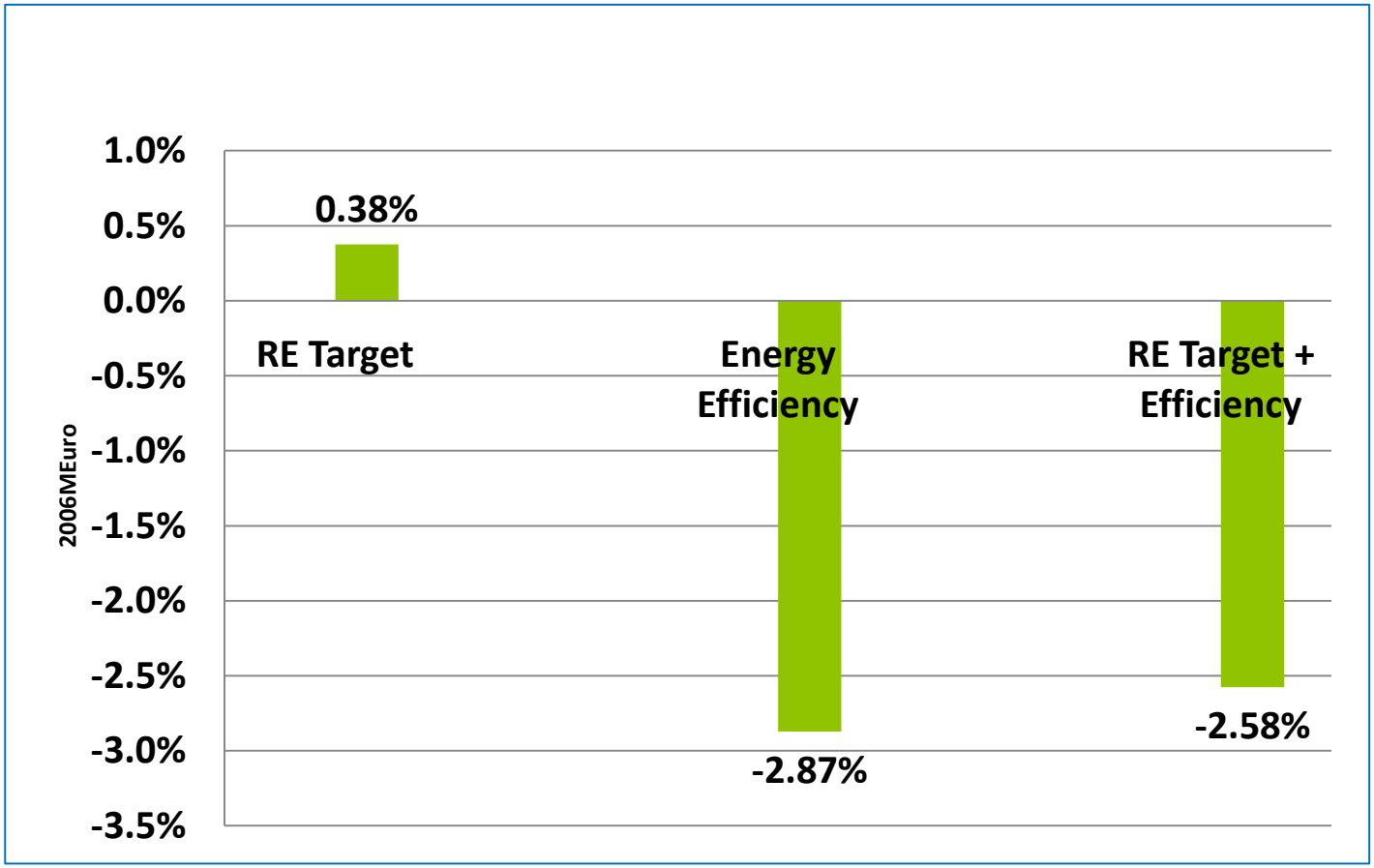
Final Energy Savings Under EE



- Opportunities for energy efficiency are economy wide.
- Main reductions occur in consumption of electricity for air conditioning (8.6%), oil for sugar CHP (7.8%) and gas for space heating (5.9%).
- By 2030 energy savings reach 190ktoe per year (9.2%).
- Additional investment in demand devices 60M€/year (average over the time horizon).
- Additional savings on fuel 75M€/year 2030.

SECTOR	Cumulative savings 2012-2030 ktoe	Share of Total
Residential	1420	62%
Commercial	480	21%
Industry	220	10%
Agriculture	150	7%
Total	**2270**	**100% (6%TFEC)**

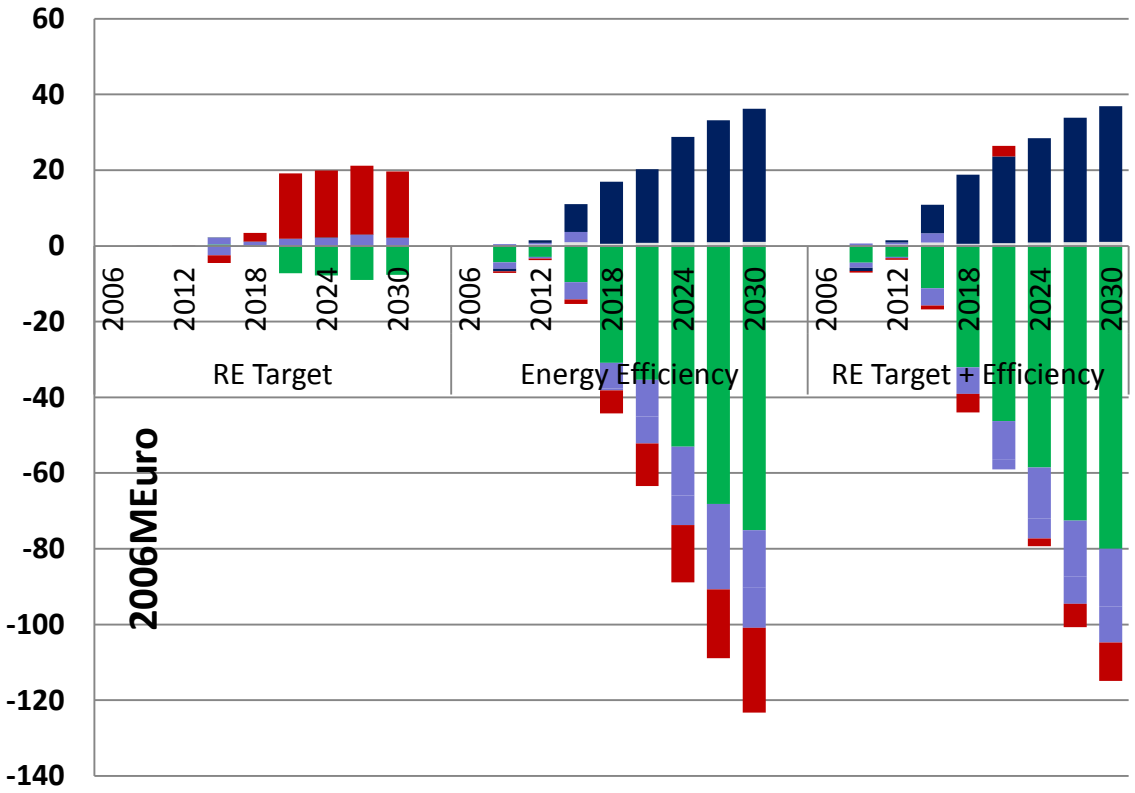
Overall Energy System Costs/Savings



Change in Total Energy System Costs, 2006MEuro

- RE Targets can be achieved at relatively modest additional costs (0.4% or 35M€).
- EE policies can save a total of 264M€ or nearly 3% compared to the Reference scenario.
- Combined policies result in achieving the RE target while still realizing an overall savings of 237M€, or 2.6%.

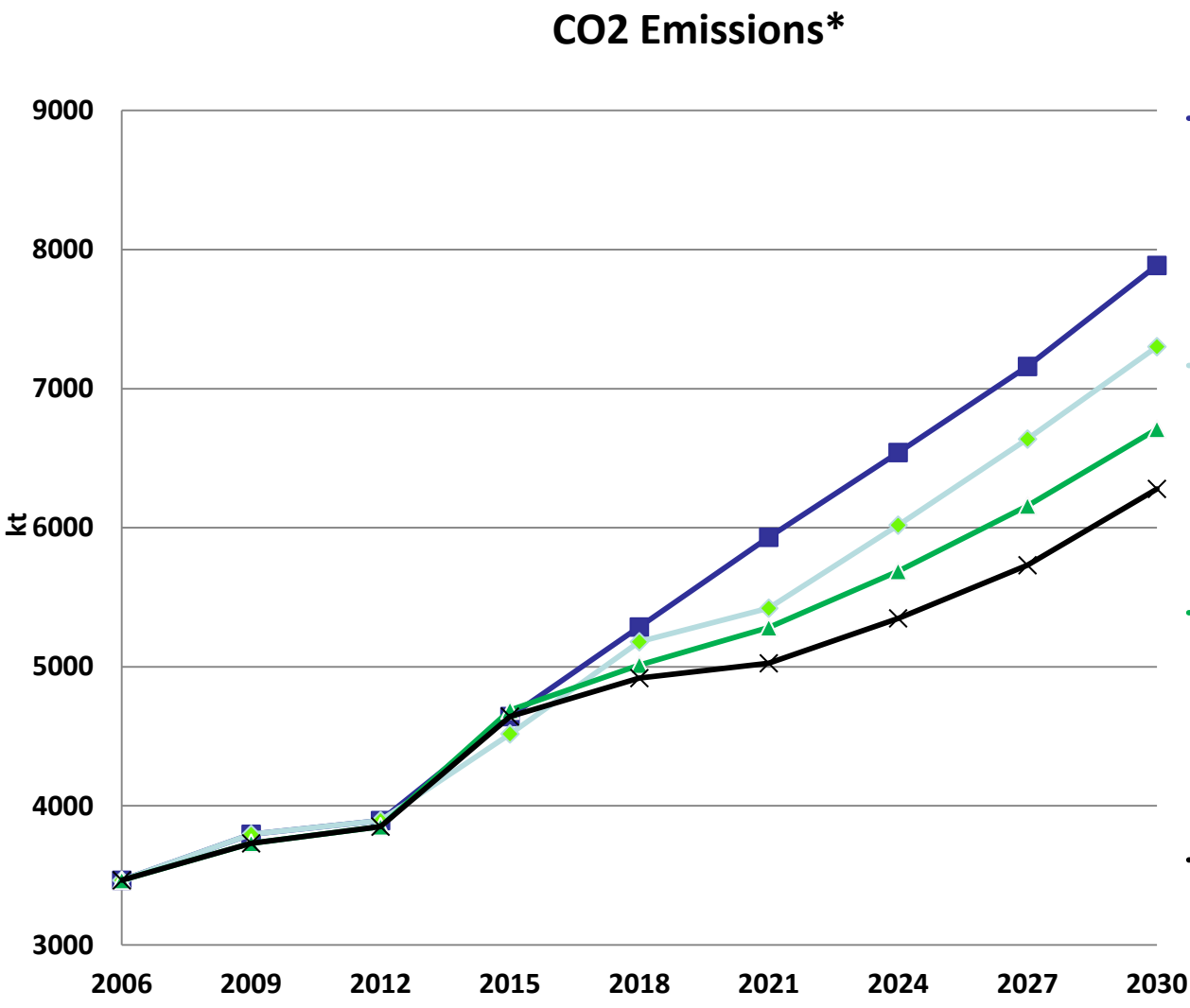
Energy System Expenditures



Change in Energy System Expenditures

- Substantial savings on fuel (green), can be seen under EE policies, reaching a cumulative reduction of **310 €M** in the combined scenario, which corresponds to a 3-to-1 savings for the investment.
- Spending on improved demand devices, which reaches a cumulative increasing of **145 €M**, is **double** compensated for by the fuel savings.
- Increased costs for renewable power plants is more than offset by the fuel savings with EE policies.
- The combined scenario achieves an overall savings of **110 €M** per year by 2030.

Climate Change Implications



* Without Transnistria, MTPP and transporation

- CO_2 emissions grow 130% by 2030, reaching 7900kt per year.
- Avoided cumulative CO_2 by scenario:
  - EE: -12Mt, -8.3%
  - RE:-7.1Mt, -4.9%
  - EE+RE: -16.8Mt, -11.6%.
- EE+RE policies curb that growth to 6300kt CO_2 per year by 2030, that is about 500% below 1990 level of 34500 kt CO_2.

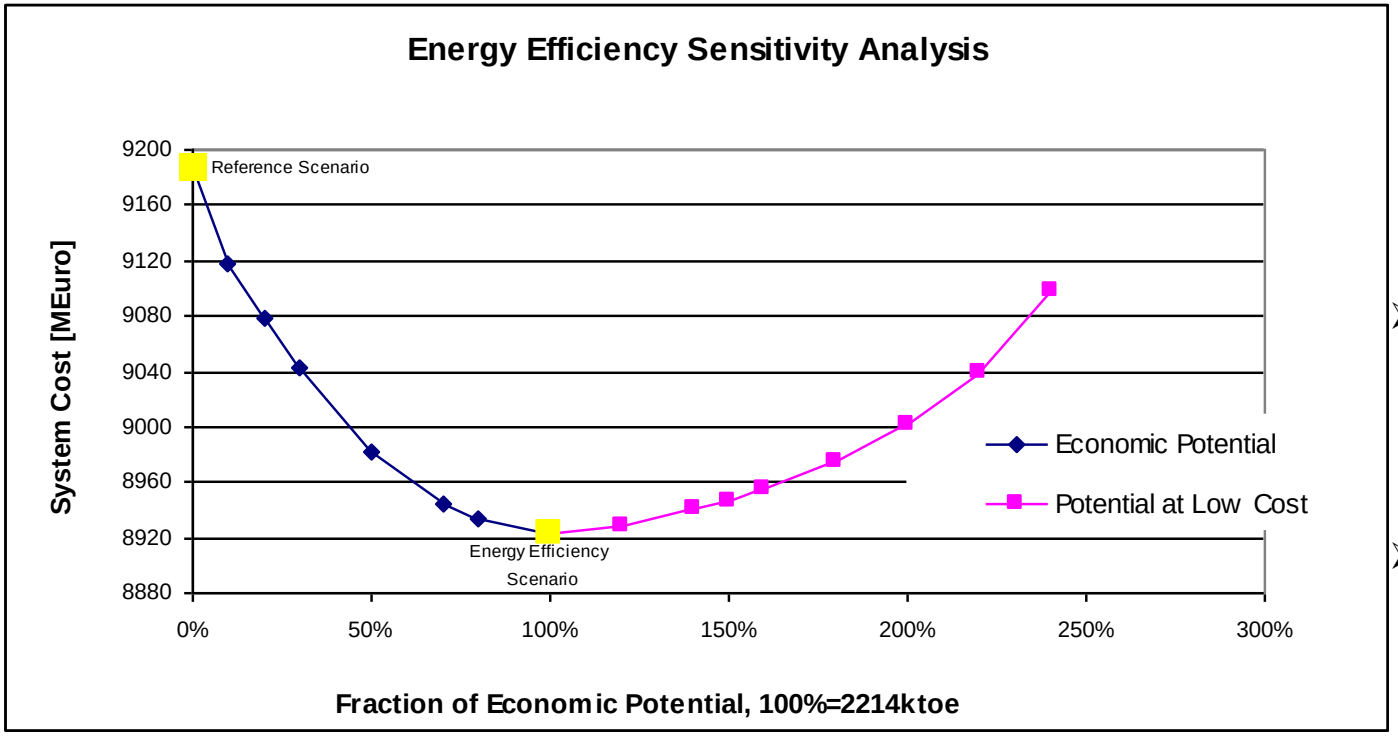
Summary Conclusions for EE&RE Policies

- Energy Efficiency measures lead to less power plants additions and payments for fuel resulting in a more competitive energy system.
- Proposed (initial) EC RE Targets can be achieved at modest cost by means of additional, wind and biomass power plants, along with more direct consumption of biomass.
- Coordinating RE Targets with increased Energy Efficiency lowers the cost of RE compliance owing to the overall drop in energy consumption, which thereby reduces the total amount of RE needed.
- Further CO_2 emissions reductions are achieved when RE Targets are combined with enhanced Energy Efficiency measures, which could be traded on the world carbon exchange.

Country Analyses

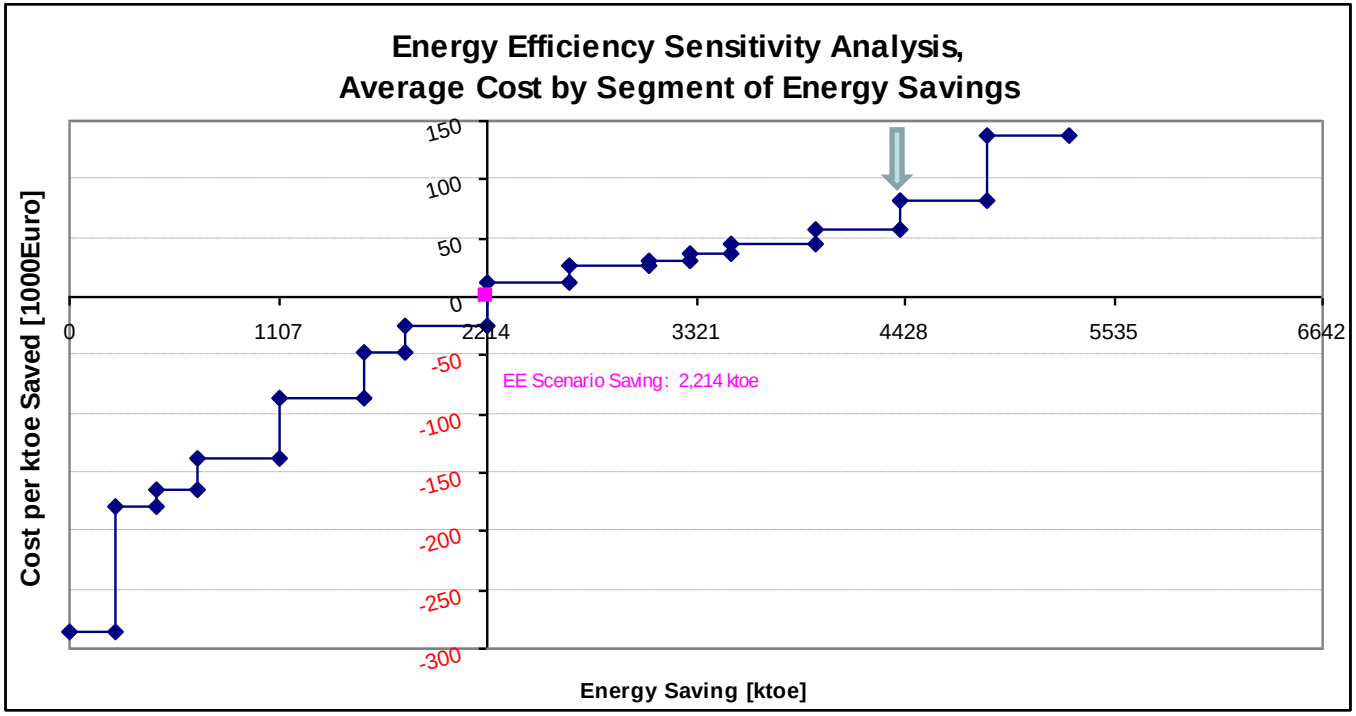
A Closer Look At Energy Efficiency

Examining Higher Levels of Energy Savings



- Total system cost decreases by 2.9% at the economically attractive level in the EE scenario, achieving a reduction of 2.2Mtoe (4.9%) in consumption.
- To achieve the national goal of 20% reduction, total system cost gradually increases, but only 78 €M or 0.9%.
- At this level additional benefits arising include further reduction of imports by another 2% (1.1Mtoe) and CO_2 by 3% (4Mt).

Incremental Measures to Achieve Higher Levels of Energy Savings



- Measures to the left of the y-axis are those that produce both energy and economic savings.
- Each line represents a 10% increase in the level of energy savings, where the wider and shorter the "step" the more savings achieved per Euro.
- So to reach the 20% reduction target of about 4400ktoe requires 78 €M.
- At each step a host of measures may be introduced including CFLs, insulation, better heat pumps and wood stoves, etc.

Most attractive measures

- Residential advanced gas technologies for heating and hot water, efficient lighting and building insulation
- Improved process heat equipment for the food industry
- Natural gas equipment in non-metallic mineral industry

Summary of Key Indicators in Response to Energy Efficiency

Final Energy Saving as % of the EE Scenario Saving	Total Energy System Costs (2006€)	Primary Energy (ktoe)	Imports (ktoe)	Fuel Expenditures (2006M€)	Power Plant Builds (MW)	Final Energy (ktoe)	CO_2 Emissions (kt)
50%	-157	-1,955	-1,960	-443	-294	-1,115	-4,280
100% (EE)	-264	-3,773	-3,783	-838	-430	-2,214	-12,047
150%	-240	-4,756	-4,719	-969	-392	-3,287	-13,806
180%	-211	-5,245	-4,803	-1,026	-335	-3,957	-14,200
200%	-186	-5,673	-4,866	-1,076	-315	-4,401	-14,475
240%	-89	-6,004	-4,872	-1,087	-151	-5,284	-14,582

- The maximum combination of energy security, economic and environmental benefits occur at about 1.5 times the strictly economically level of energy savings.

Conclusions and Next Steps

- Moldova's energy system is complex and assessing policies and alternatives to foster energy security and competiveness, while considering environmental goals, will be an ongoing necessity.
- Moldova now has in place a world-class energy system model and policy analysis framework, MARKAL-Moldova, with the expertise to use it effectively residing at ASM/IPE.
- As part of readying MARKAL-Moldova to contribute to policy deliberations, a consensus building process should be undertaken engaging key stakeholders to:
  - Determine (a range of) values for key model assumptions, and
  - Identify alternative development options and opportunities to be considered.
- Employ MARKAL-Moldova to provide insights and analytic rigor for decision-makers to formulate policies that will shape the evolution of Moldova's future energy system.

Contacts for Further Information

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ANNEXES

Macroeconomic Assumptions Under Reference Scenario, % Growth Rate

Category	Assumption
GDP growth rate	6% annual
Sectoral growth rates[14]	
Residential	2.7% Average Annual (Av.An.)
Commercial	3.0% (Av.An.)
Industry	2.2% (Av.An.) up to 2015, 1.6% (Av.An.) 2015 onwards
Agriculture	1.6% (Av.An.)
Population growth rate	0.4% (Av.An.)up to 2015, 0.2% (Av.An.)2015 onwards
HH number growth rate	1.2% (Av.An.)up to 2015, 0.9% (Av.An.)2015 onwards
Key policies modelled	
	Feed-in Tariffs (FIT) for small hydro (100 €/MWh), wind (97 €/MWh) and PV (420 €/MWh), with associated potential.

Key Cumulative Indicators (Change for the Reference Scenario)

Scenario	Savings in System Cost		Primary Energy		Imports		Power Plant Builds	
	2006M€	%	ktoe	%	ktoe	%	GW	%
Reference	9,187		59,322		55,943		1.03	
Renewable Target (RE)	35	0.38%	-1,741	-0.98%	-1,741	-3.11%	0.17	16.20%
Energy Efficiency (EE)	-264	-2.87%	-3,783	-6.36%	-3,783	-6.76%	-0.43	-41.83%
RE Target + Efficiency (EE+RE)	-237	-2.58%	-5,064	-6.96%	-5,064	-9.05%	-0.31	-29.84%

Scenario	Final Energy Difference		CO2 Emissions	
	ktoe	%	MT	%
Reference	45,175		145,788	
Renewable Target (RE)	-4	-0.01%	-7,109	-4.88%
Energy Efficiency (EE)	-2,214	-4.90%	-12,047	-8.26%
RE Target + Efficiency (EE+RE)	-2,275	-5.04%	-16,833	-11.55%

Reference Energy System in MARKAL-Moldova Model