
# Impact Assessment of the Energy Efficiency Directive (2012/27/EU) for the Energy Community

DecisionWare Group

July 2014

Energy Efficiency



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- **Enhance the security of supply;**
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* This designation is without prejudice to positions on status, and is in line with UNSCR 1244 and the ICJ Opinion on the Kosovo declaration of independence.

# Final Report for

# Assessment of the impact of the Energy Efficiency Directive, 2012/27/EU, if this is adopted by the Contracting Parties of the Energy Community

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*By DecisionWare Group in cooperation with*

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*Macedonian Academy of Sciences and Arts –*
*Research Center for Energy, Informatics and Materials, and*

*Ukraine National Academy of Sciences - Institute for Economic Forecasting*

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# List of Acronyms

| | |
|---|---|
| DWG | DecisionWare Group LLC |
| CCGT | Combine Cycle Gas Turbine |
| CHP | Coupled Heat and Power |
| CO2 | Carbon Dioxide |
| CP | Contracting Parties (of the Energy Community) |
| EnC | Energy Community |
| ECS | Energy Community Secretariat |
| EC-TIMES | Energy Community TIMES (model) |
| EE | Energy Efficiency |
| EED | Energy Efficiency Directive |
| EEO | Energy Efficiency Obligation |
| EETF | Energy Efficiency Task Force (of the Energy Community) |
| EPBD | Energy Performance of Buildings |
| E&E | Europe and Eurasia |
| ERDB | European Bank for Reconstruction and Development |
| EPC | Energy Performance Contracting |
| ESCO | Energy Saving Company |
| ESD | Energy Saving Directive (of the Energy Community) |
| EU | European Union |
| ICEIM–MANU | Research Center for Energy, Informatics and Materials - Macedonia Academy of Sciences and Arts |
| IEA-ETSAP | International Energy Agency's Energy Technology Systems Analysis Program |
| IRG | International Resources Group |
| kt | kilo tons |
| LCPD | Large Combustion Plant Directive |
| MARKAL | MARKet ALlocation |
| NEEAP | National Energy Efficiency Action Plan |
| NREAP | National Renewable Energy Action Plan |
| RE | Renewable Energy |
| REDP | Regional Energy Demand Project (USAID project) |
| RES | Reference Energy System |
| RESMD | Regional Energy Security and Market Development (USAID project) |
| RESTF | Regional Energy Strategy Task Force (of the Energy Community) |
| SECC | Selected Energy Community Countries (excludes Ukraine) |
| SO | Supplier Obligation |
| TIMES | The Integrated MARKAL/EFOM Energy System (model) |
| UNAS-IEF | Ukraine National Academy of Sciences - Institute for Economic Forecasting |
| USAID | United State Agency for International Development |
| USEA | United States Energy Association |

# Final Report for Assessment of the Impact of the Energy Efficiency Directive, 2012/27/EU

## Executive Summary

The Ministerial Council of the Energy Community has proposed implementation of Directive 2012127|EU, in each Contracting Party, but with certain modifications[1]. Therefore, this study was commissioned to assess the costs and benefits of implementing four specific elements of the Energy Efficiency Directive (EED) as modified for the Energy Community (EnC) Contracting Parties[2] (CPs) and to provide a basis for justification of proposed changes to particular articles within the Directive as it relates to the CPs.

The study assessed the following four articles:

Task 1 - National Targets – Article 3;

Task 2 - Exemplary role of public bodies' buildings – Article 5;

Task 3 - Energy efficiency obligation schemes – Article 7, and

Task 4 - Promotion of efficiency in heating and cooling – Article 14.

The study conclusions and recommendations, which are based upon the best available data and assumptions regarding the cost, performance and availability of energy efficient devices in each sector, are summarized below:

1. Implementation of the EED is shown to be feasible for the CPs, but the level of the target can have a significant impact on the cost. The EE Target 18-25% case is recommended for adoption because it the most cost-effective of the three options, and sharp increases in the required investment costs, especially in 2027 and 2030, for the EE Target 19-27% and EE Target 20-30% cases do not justify the associated incremental energy savings. The EE Target 18-25% levels are shown to be an achievable significant progression of ambition for each of the CPs.
2. Renovation of central government buildings is beneficial for the CPs, but government ownership is still too large in comparison to EU member states. Therefore, the 2% goal is recommended as being the most appropriate approach for the CPs to achieve the goal of a government implemented demonstration program in its own buildings as example for other public and private sector entities to follow suit.
3. Supplier obligation was recommended to follow the 1.5% annual savings rate because the incremental national cost is insignificant in light of the overall EE target savings, as many of these obligated savings can come from the more-cost-effective of these measures while also allowing the CPs to include other measures, such as excluding industrial activities that are covered under the EU

[1] Recommendation of the Ministerial Council, R/2013/01/MC-EnC on Energy Efficiency, ANNEX 17/11 MC/25-06-2013.
[2] Throughout this document, Kosovo* is used without prejudice as to positions on status, and is in line with UNSCR 1244 and ICJ Opinion on the Kosovo declaration of independence.

Emissions Trading Scheme, or including savings achieved in the energy transformation, distribution and transmission sectors, including efficient district heating and cooling infrastructure.

4. Adoption by investors of cost-effective combined heat and power options will be beneficial to the CPs in the long run, and the cost of administering the program and preparing the cost-benefit analysis is small compared to these benefits. In addition, the number of eligible projects may be up to ten times greater with a 20MW threshold in comparison with a 50MW threshold. Therefore, the recommendation is to keep the EED threshold level of 20 MW compared to increasing it to 50 MW, which would limit its applicability to only large cities, power plants and very large industries.

The study shows that the EED can accelerate energy efficiency implementation bringing significant benefits as long as it is implemented after full consideration of the specific conditions in each CP, and the differences from EU conditions in terms of current levels of infrastructure, markets, policies and institutional capacity are taken into consideration.

# 1. Background and Introduction

The Ministerial Council of the Energy Community, based on a recommendation from the Permanent High Level Group, has proposed implementation of Directive 2012127|EU, in each Contracting Party, but with certain modifications[3].

The goal of this study is to assess the costs and benefits of implementing four specific elements of the Energy Efficiency Directive (EED) as modified for the Energy Community (EnC) Contracting Parties[4] (CPs) and to support development of a basis for justification of proposed changes to particular articles within the Directive as it relates to the CPs.

The study is structured according to four main tasks in accordance with the Scope of Work and the Articles of the Directive to which they relate.

Task 1 - National Targets – Article 3

Task 2 - Exemplary role of public bodies' buildings – Article 5

Task 3 - Energy efficiency obligation schemes – Article 7

Task 4 - Promotion of efficiency in heating and cooling – Article 14

This Final Report builds upon the updated Interim Report, and is designed to allow members of the EnC Energy Efficiency Coordination Group (EECG) to review the study results and recommendations, regarding the EnC and each CP, and provide inputs to help shape the final study report.

# 2. Technical Approach and Methodology

The overall approach of the DecisionWare Group (DWG) team has been to conduct this study using a combination of knowledge and experience with the Directive and quantitative analyses using the EC-TIMES

3 Recommendation of the Ministerial Council, R/2013/01/MC-EnC on Energy Efficiency, ANNEX 17/11 MC/25-06-2013.

4 Throughout this document, Kosovo* is used without prejudice as to positions on status, and is in line with UNSCR 1244 and ICJ Opinion on the Kosovo declaration of independence.

regional energy system planning model. The model depicts each of the nine (9) CPs[5] national energy systems as distinct regions within an integrated (by means of electricity and gas trade) framework. Appendix A contains a detailed description of the EC-TIMES energy system model, which is the culmination of seven years of development work and capacity building supported by the U.S. Agency for International Development (USAID).

The EC-TIMES regional model has been benchmarked against the Regional Energy Strategy Task Force (RESTF) data call and international references. Also, some of the national model assumptions were harmonized, such as international oil prices and costs for new advanced technologies, and a regional Reference scenario developed that is based upon the best available data for the energy systems of the region, and reviewed by the EnC Energy Efficiency Coordination Group (EECG). In addition, key technology cost and performance data for demand devices in the residential and commercial sectors was updated based on recently released data sources, for all countries other than Ukraine (due to the recent turmoil there interrupting aspects of work).

The EC-TIMES model provides a consistent framework for analyzing the impacts of the EED requirements and the various options for implementation that are to be evaluated. The team has utilized the EC-TIMES model to identify key actions and study the impacts of the proposed measures. The model insights were used by the team, along with their detailed knowledge and experience of the current status and environment in the CPs and European Union (EU) with respect of EED, to identify justifiable modifications to the EED. The specific approach for each task is described in the sections below along with their preliminary analysis results, with supporting details on the methodology and Reference scenario provided in the Appendices.

Table 1 provides a short summary of the scenarios discussed in this final report.

**Table 1: List of Scenarios**

| Scenario | Description |
|---|---|
| Reference - Basic | Business as usual (no change in 2009 policies and practices). |
| Reference - Benchmark | Reference with assumed achievement of the 9% Energy Savings Directive (ESD) by 2018, the2020 RE Targets and the Large Combustion Plant Directive. |
| EE Target 18-25% | National EE target proposed by the ECS for reductions of 18% FEC by 2025 and 25% by 2030. |
| EE Target 19-27% | National EE target proposed by the ECS for reductions of 19% FEC by 2025 and 27% by 2030. |
| EE Target 20-30% | National EE target proposed by the ECS for reductions of 20% FEC by 2025 and 30% by 2030. |
| Supplier Obligation 1-1.5% | ECS proposed cumulative target of achieving 1% of new savings each year from January 2015 to December 2025, increasing to 1.5% from 2025 to 2030. |
| Supplier Obligation 1.5% | ECS proposed cumulative target of achieving 1.5% of new savings each year from January 2015 to December 2030. |

[5] Croatia is included in EC-TIMES as an internal region, though not reported on in the tables and figures of this report.

In addition, further sensitivity runs were done too look at combinations of the EE and Supplier Obligation (SO) scenarios to assess the effects of meeting both goals simultaneously.

In presenting the results graphs and tables often segregate the Ukraine from the rest of the CPs, designated as Selected Energy Community Countries (SECC)[6] in this report, not to overshadow the implications for the CPs owing to the sheer size of the Ukraine energy economy.

# 3. Task 1 - National EE Targets

The objective of Task 1 is to analyze the impact of the recommended energy saving targets for 2025 and 2030 for each CP and assess the relative costs and benefits of adjustments to the EU EED energy saving targets to make them more suitable to the EnC CPs, identifying specific technologies and measures, and the policies necessary to promote them.

## 3.1 Approach

The approach to this task was organized into a series of activities, which are summarized below.

### 3.1.1 Summarize the Reference Scenario

The Interim Report included a summary of the EC-TIMES Basic Reference scenario, which covered the model development process, the key data sources and assumptions, demand projections, a summary of the model's calibration to the current energy system, and a description of the likely evolution of each CP's energy system to 2030. This Basic Reference scenario assumes no changes from 2009 policies and practices. However, for this study a Benchmark Reference scenario was defined to include the energy efficiency (EE) target of 9% by 2018 in accordance with the Energy Savings Directive (ESD), the 2020 renewable energy (RE) targets adopted in 2012, as well as the Large Combustion Plant Directive (LCPD). Appendix B provides a summary of this Benchmark Reference scenario.

### 3.1.2 Analyze Proposed National Energy Efficiency Target

Analysis of national EE target proposed by the ECS for reductions of 20% FEC by 2025 and 30% by 2030 started with the specification of the new targets, which merge with the current ESD target in 2018. For the Reference Benchmark scenario, the ESD reduction levels for the 2012 to 2018 periods were modelled as absolute reductions using values taken from the Member profile page for each CP, which provides the country-specific NEEAP targets[7]. For the EE target scenarios, these same 2012 to 2018 reduction levels were used to ensure consistency between the runs, and the new EE target starts to diverge from the ESD target in 2018 and reaches 20% in 2025 and 30% in 2030. Just as the ESD target levels were based on a Reference basic scenario, the final energy reductions required to achieve each EE target for the post-2018 periods were established relative to the Reference Basic scenario final energy levels. However, all economic and final energy comparisons are done against the Reference Benchmark scenario to avoid counting the already agreed to economic and energy savings impacts of the ESD. Because there are

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[6] Albania, Bosnia and Herzegovina, Croatia, Kosovo*, Macedonia, Moldova, Montenegro, and Serbia.

[7] http://www.energy-community.org/portal/page/portal/ENC_HOME/MEMBERS/PARTIES, go to the page of any CP and click on Energy Efficiency Facts and Figures.

residual effects of the ESD target post 2018, the final energy reductions shown in most of the charts will not show the full extent of the final energy reductions.

### 3.1.3 Alternate Scenario Designs

In addition to the proposed EE target reductions of 20% FEC by 2025 and 30% by 2030, two alternative target scenarios were also analyzed to better understand the relative impact of less aggressive EE targets on the key economic metrics. The first alternative assumes a 19% FEC reduction by 2025 and a 27% by 2030, and the second alternative assumes an 18% FEC reduction by 2025 and a 25% by 2030.

Table 2 shows the annual rate of efficiency improvement that would be required by each individual CPs to achieve the three EE Target levels. Each scenario starts with the current ESD target, which has an annual rate of energy savings between 2009 and 2018 of 1%/years. The EE Target 20-30% requires a step up to almost 1.6% annual savings rate for the 2018 to 2025 and steps up to 2% annual rate for the 2025-2030 period. The EE Target 19-27% and the EE Target 18-25% cases have slightly lowers annual rates but retain the characteristic of increasing ambition over time.

**Table 2: Annual Rate of Efficiency Improvement by Time Period for Each Target Case**

| Time Period | EE Target Scenario | | |
|---|---|---|---|
| | 20-30% | 19-27% | 18-25% |
| ESD: 2009-2018 | 1.0%/yr | 1.0%/yr | 1.0%/yr |
| EED: 2018-2025 | 1.57%/yr | 1.43%/yr | 1.29%/yr |
| EED: 2025-2030 | 2.00%/yr | 1.60%/yr | 1.40%/yr |

## 3.2 EE Target Scenario Results

The EC-TIMES model produces a wide array of regional and national results that provide insights into the most cost-effective actions for each CP. This chapter presents a variety of results that summarize the regional economic and energy system impacts of these alternative EE target levels. These results include identification of the suite of energy efficiency measures that appear to be the most cost-effective choices across the region by sector and end-use application, the associated investment, fuel and operating costs, and the energy savings achieved. Chapter 7 of the report provides detailed results for each of the CPs that includes identification of the energy efficiency measures that appear to be the most cost-effective choices for each CP by sector and end-use application, along with the associated investment, fuel and operating costs, and the energy savings achieved.

### 3.2.1 Total Energy System Cost

The total discounted energy system cost is the net present value of all the investments, device purchases, fuel expenditures and operating and maintenance costs throughout the entire energy system over the 25 years planning horizon. Figure 1 shows the change in total system cost for the SECC, as Ukraine is shown separately due to its size. For the SECC the total system cost increases by 2.7% (EUR 8.2 billion) over the Reference Benchmark case for the EE Target 18-25% case. In the EE Target 19-27% case, the incremental cost goes to 4.2% (EUR 13 billion), while turning to more costly measures, and the EE Target 20-30% case results in jump of 12.2% (EUR 37.8 billion) based on the need to resort to even more costly efficiency measures, as will be discussed.

Figure 2 shows results for Ukraine only, where the total discounted system cost increases by 8.1% (EUR 43 billion) over the Reference Benchmark case for the EE Target 18-25% case. In the EE Target 19-27% case, the incremental cost goes to 10.1% (EUR 54 billion), while turning to more costly measures, and the EE Target 20-30% case results in a jump to 16% (EUR 86 billion) based on the need to resort to even more costly efficiency measures.

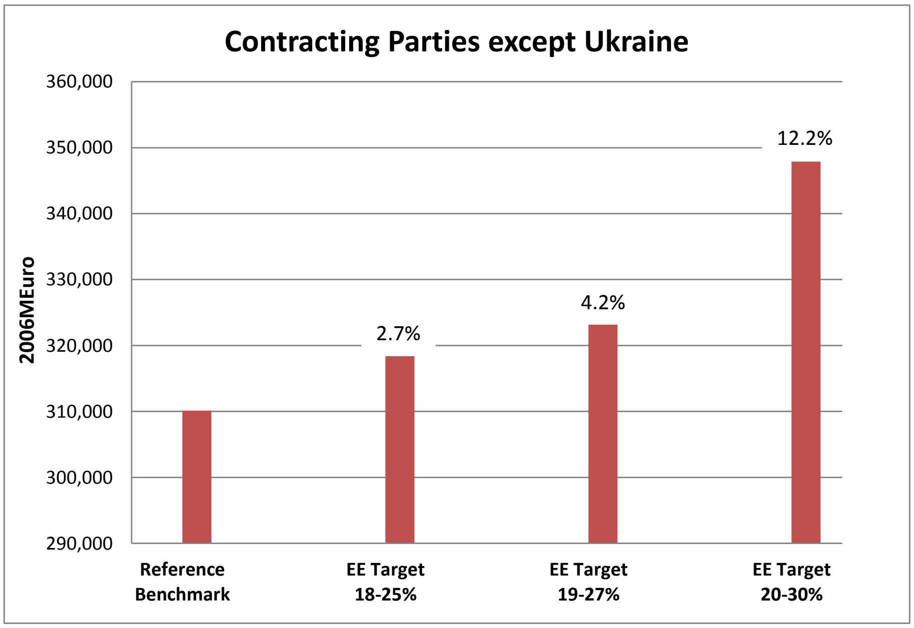



**Figure 1: Regional Total System Cost for Reference Benchmark and EE Target Scenarios – w/o Ukraine**

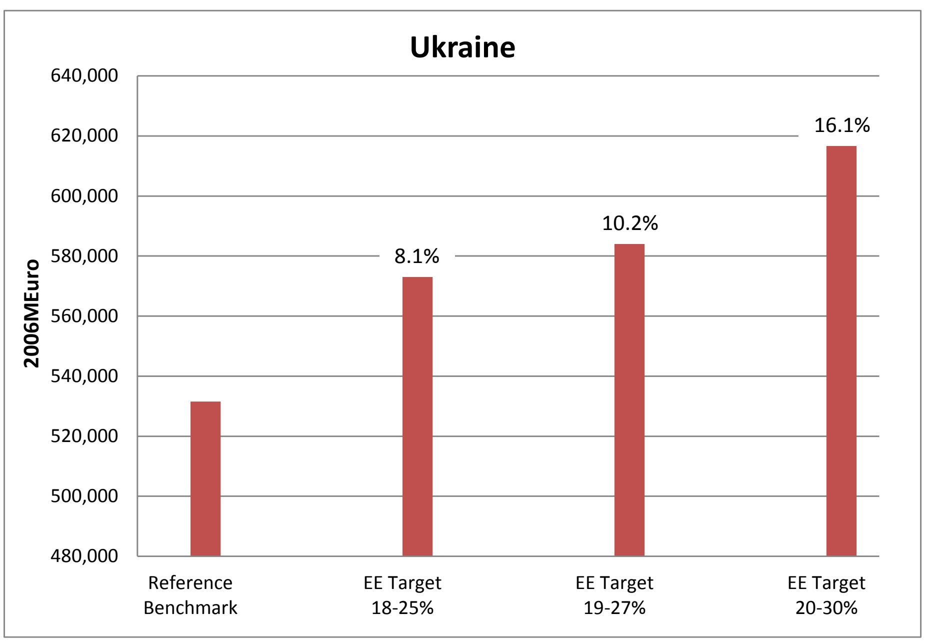


**Figure 2: Regional Total System Cost for Reference Benchmark and EE Target Scenarios – Ukraine**

These results clearly indicate that the more stringent EE Target 20-30% case will put significant pressure on the CPs to take expensive measure to meet its requirements,. Whereas, the substantive though more modest goal of 18% reduction in 2025 and 25% reduction in 2030 can be achieved with significantly less overall cost.

One reason for the higher percentage cost increase in Ukraine compared with the other CPs is that because of the turmoil there, the Ukrainian members of the team (UNAS-IEF) were essentially unavailable for several months. The result was not having time to review optimistic assumptions for the adoption of energy efficiency in the Reference baseline and introduce the new residential and commercial energy efficiency measures that were added for the other CPs. While further study might lower the overall cost impact to Ukraine, we do not believe this alters the conclusions of this section, which are based on the relative changes between the three alternative scenarios.

### 3.2.2 Examining Components of the Energy System Cost

The components of the total energy system cost include:

- Purchases of demand devices (e.g., air conditioners, automobiles, industrial boilers);
- Investments in supply technologies (e.g., power plants and refineries);
- Resource supply;
- Fuel and electricity delivery costs, and
- Operating and Maintenance (O&M) costs.

Figure 3 shows that for the CPs, without the Ukraine, most of the increase in system cost comes from the added investment in more efficient demand technologies. For the EE Target 18-25% case, the annual expenditure grows to about EUR 13 billion by 2030, but more than a third of this additional expenditure by consumers is offset by reduced fuel expenditures. For the EE Target 19-27% case, the annual expenditure grows to about EUR 19 billion by 2030, with more than a quarter of this additional expenditure offset by reduced fuel expenditures. For the EE Target 20-30% case, the annual expenditure grows to about EUR 31 billion by 2030, with less than one sixth of this additional expenditure offset by reduced fuel expenditures. The figure illustrates the steeply increasing cost of reaching the 30% target in 2030, and while the other two scenario also show a sharp cost increase in the 2030 period, these are far less onerous and thereby much more achievable.

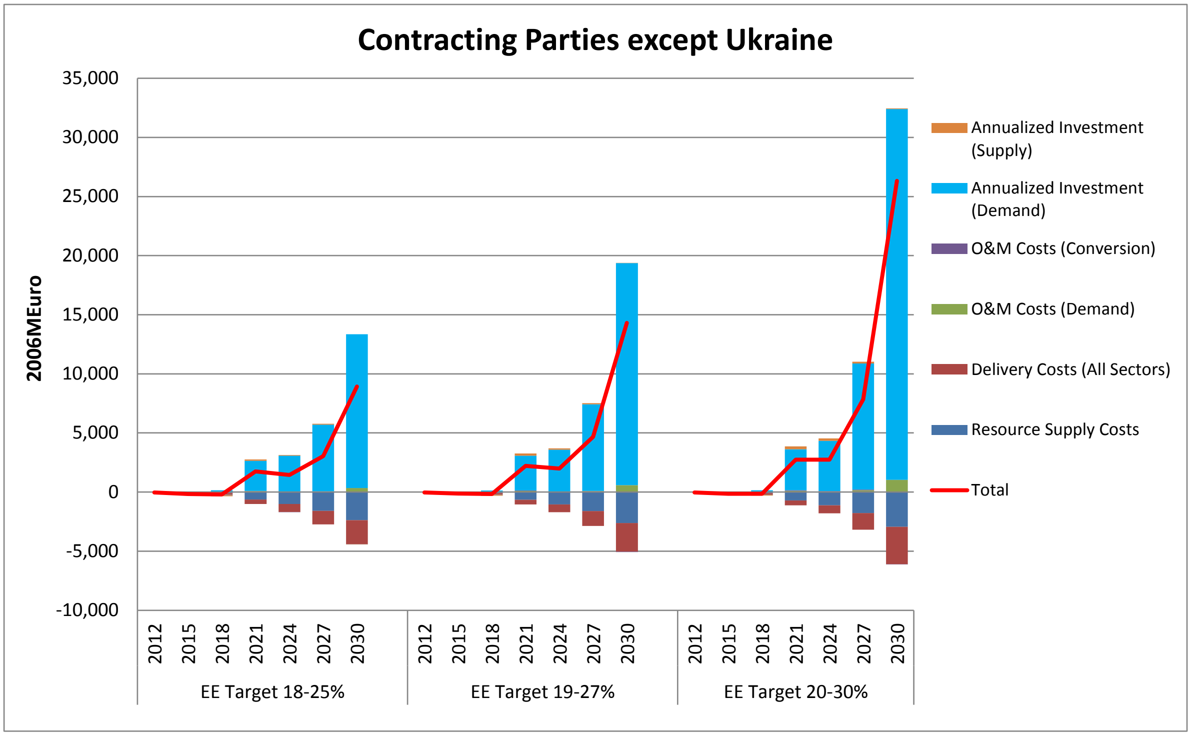



**Figure 3: Change in Energy System Costs for Reference Benchmark and EE Target Scenarios – Regional w/o Ukraine**

As shown in Figure 4, the results for Ukraine are similar, although the increased costs for the EE Target 19-27% and EE Target 20-30% cases are relatively larger than for the rest of the CPs, and the proportion offset by reduced fuel expenditures is smaller thus making the net costs there relatively higher. In addition, the jump in costs for the 2030 period is even more pronounced – especially in the EE Target 20-30% case.

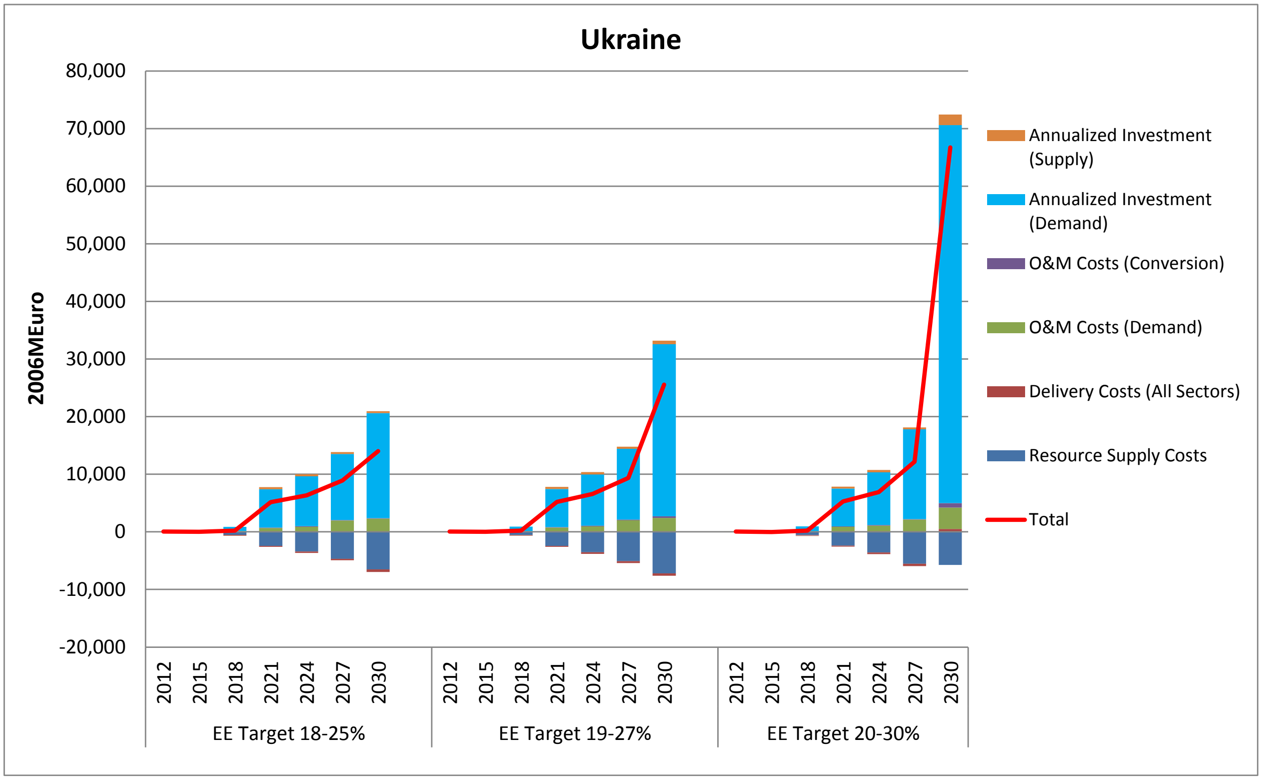



**Figure 4: Change in Energy System Cost for Reference Benchmark and EE Target Scenarios – Ukraine**

### 3.2.3 Reductions in Final Energy Consumption

Figure 5 shows final energy consumption by fuel type for the region without Ukraine, and illustrates that the major savings are achieved through reductions in the use of biomass, coal, diesel and gasoline. There are small decreases in coke, district heat and other petroleum products, and there are increases in electricity and natural gas consumption, particularly in the later periods. The figure also illustrates that significant reductions are required in the 2021 to 2030 periods in all cases, but that the level of reductions are similar in each of the scenarios, except in the 2027 and 2030 periods, where the EE Target 19-27% and EE Target 20-30% cases show incremental reductions.

The following two tables provide some cumulative measures to help provide a better context for the three EE Target cases. Table 3 provides details for all CP without Ukraine, and Table 4 provides the same details for Ukraine. Note that cumulatively the EE Target 20-30% case achieves only about 20% additional energy savings compared to the EE Target 18-25% case. A similar picture is seen for primary energy, and regarding power plant builds, the EE Target 18-25% case shows a slight reduction in requirements, but the other two cases require small incremental additions because of fuel shifting to electricity.

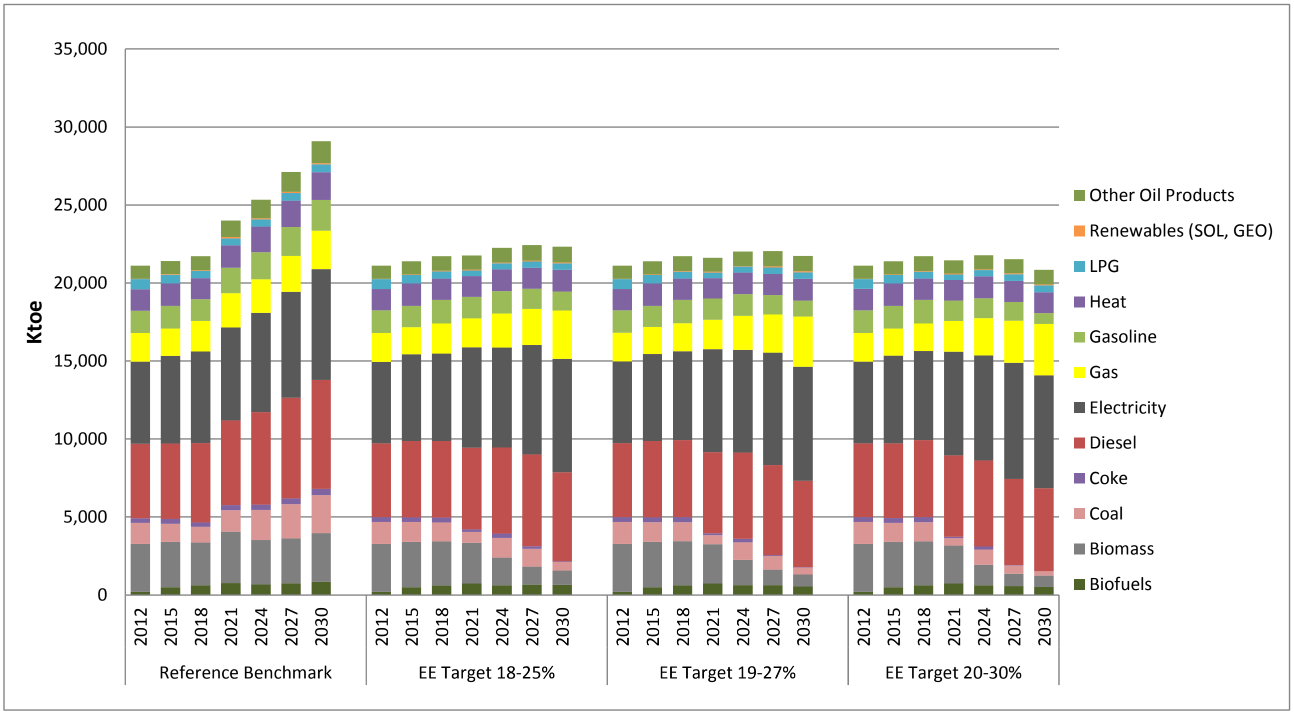



**Figure 5: Final Energy Consumption for Reference Benchmark and EE Target Scenarios – Regional w/o Ukraine**

While the numbers are much larger, the results for Ukraine are similar. Cumulatively the EE Target 20-30% case achieves less than 20% additional energy savings compared to the EE Target 18-25% case, although there is a slightly greater reduction in primary energy use. Regarding power plant builds, all three cases require some new additions, but the increase is very dramatic for the EE Target 20-30% case, highlighting the need for more building efficiency measures in the Ukraine model.

**Table 3: EE Target Scenario 2015-2030 Cumulative Metrics – All CP w/o Ukraine**

| Scenario | Final Energy | | Primary Energy | | Power Plant Builds | |
|---|---|---|---|---|---|---|
| | ktoe | % | ktoe | % | GW | % |
| Reference Benchmark Level | 448,237 | | 627,647 | | 12.98 | |
| EE Target 18-25% Difference | -50,318 | -11.23% | -52,395 | -8.35% | -0.02 | -0.13% |
| EE Target 19-27% Difference | -54,480 | -12.15% | -54,830 | -8.74% | 0.11 | 0.85% |
| EE Target 20-30% Difference | -59,854 | -13.35% | -57,012 | -9.08% | 0.27 | 2.10% |

**Table 4: EE Target Scenario Cumulative Metrics – Ukraine**

| Scenario | Final Energy | | Primary Energy | | Power Plant Builds | |
|---|---|---|---|---|---|---|
| | ktoe | % | ktoe | % | GW | % |
| Reference Benchmark Level | 1,551,378 | | 2,515,958 | | 8.70 | |
| EE Target 18-25% Difference | -194,388 | -12.53% | -220,203 | -8.75% | 1.24 | 14.27% |
| EE Target 19-27% Difference | -205,780 | -13.26% | -220,243 | -8.75% | 3.52 | 40.47% |
| EE Target 20-30% Difference | -219,129 | -14.12% | -255,230 | -10.14% | 5.10 | 58.57% |

The subsections that follow provide more details on a sector by sector basis for all the CPs excluding Ukraine. Detailed results for each CP, including Ukraine, are provided in the country-specific sections of Chapter 7.

### 3.2.4 Regional Results by Demand Sector

For the Residential sector, Figure 6 shows that achieving the EE targets requires significant reductions in final energy use for space heating (60%) with some savings coming from water heating (14%) and thermal insulation (14%) as well. Lighting changes little as most efficient lighting options are chosen in the Reference Benchmark case because of the directive to phase out incandescence lamps and their inherent performance advantage. The figure also shows that final energy use changes only slightly between the three target cases, although additional marginal savings are achieved. Figure 7 shows the corresponding additional investment (above the Reference Benchmark case) needed to achieve the energy savings. Investments in space conditioning (heating and cooling) along with insulation and water heating grow slightly as the EE target level is increased. Note that part of the increased expenditure in heating devices is for heat pumps and insulation, which serve both the heating and cooling demands. However, as the target level increases further, the additional investment required for a variety of appliances (refrigerators, clothes washers and dryers, dishwashers, others) increases dramatically, especially in 2030, pointing to the need for appliance standards and perhaps targeted rebate programs. But the nearly doubling of expenditures required in that last period to achieve the EE Target 20-30% is hard to justify for the marginal increase in energy savings above the other scenarios.

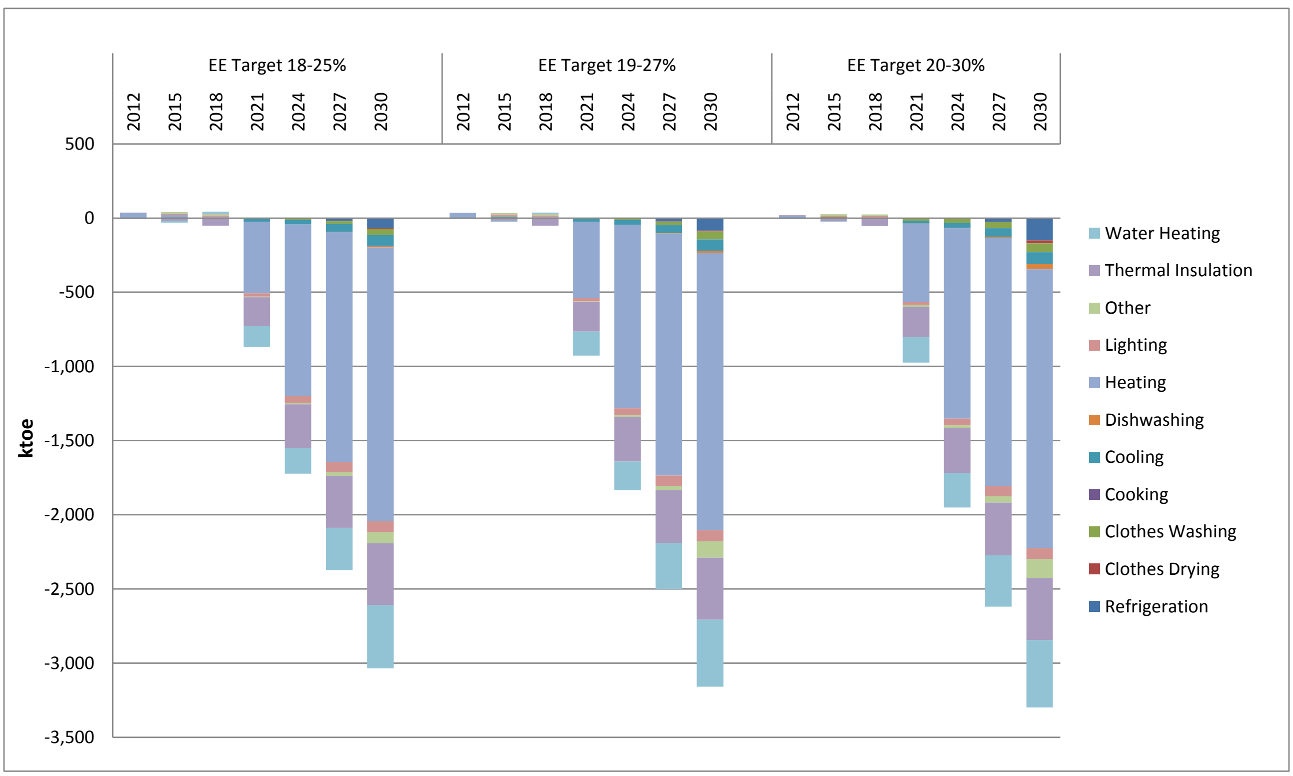



Figure 6: Residential Final Energy Use – Change from Reference Benchmark

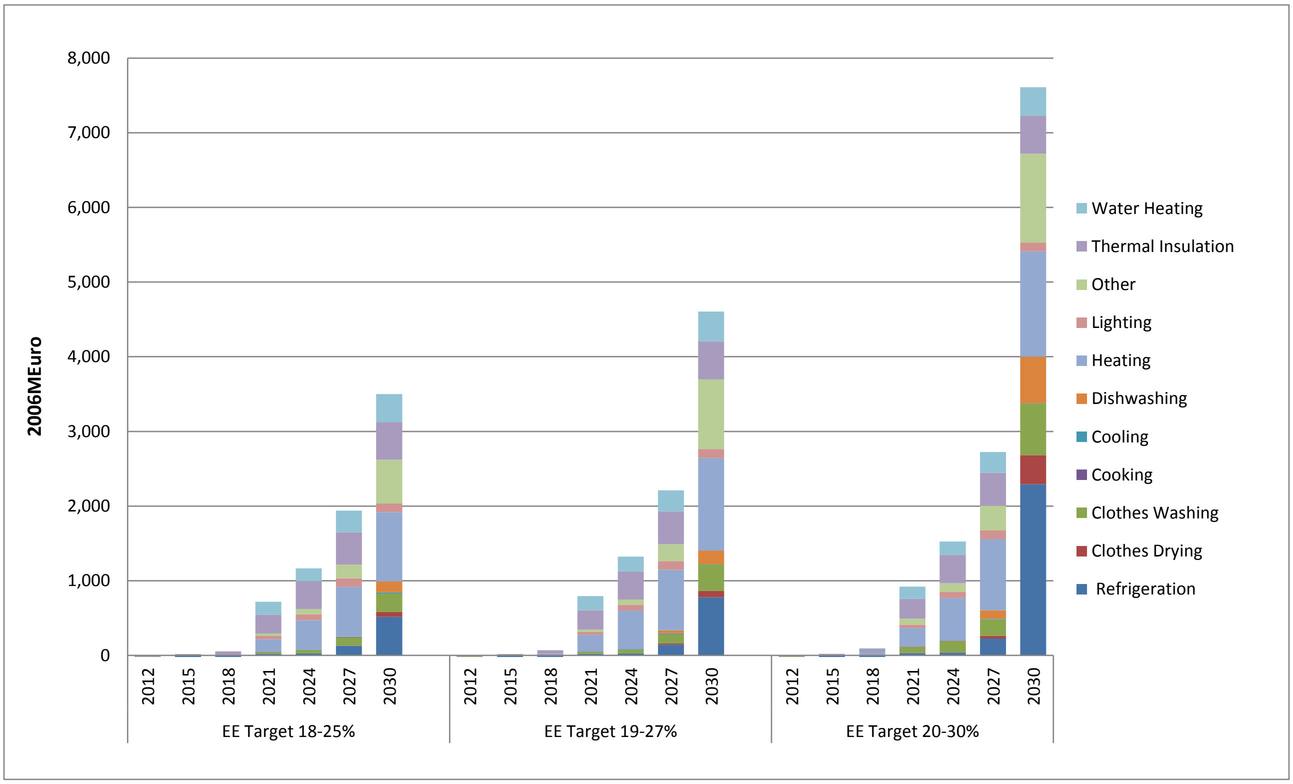



**Figure 7: Residential End-Use Device Investment – Change from Reference Benchmark**

For the Commercial sector, Figure 8 shows that achieving the EE targets requires significant reductions in final energy use for space heating (39%, including heat pumps also serving cooling) and from building retrofits (36%), along with contributions from lighting (9%) and space cooling (8%). The figure also shows that final energy use changes only slightly between the three target cases, with some additional savings in space cooling in the final period, particularly in the EE Target 20-30% case. Figure 9 shows that the additional investments required to achieve these savings starts with building retrofit measures along with lighting and space heating measures, including heat pumps. However, by 2030 (and even in 2027 for the EE Target 20-30% case) there is a need for more efficient space cooling equipment, where the additional investment increases by a factor of 5 between the EE Target 18-25% and EE Target 20-30% cases.

For the industrial sector, Figure 10 shows that achieving the EE targets requires significant reductions in final energy use primarily from the non-metallic minerals, iron and steel, and food subsectors. It also shows that final energy use in the industrial sector changes only slightly between the three target cases, with incremental additional savings needed in the final two periods for the more ambitious reduction cases. Figure 11 shows that the additional investment required to achieve the EE target increases incrementally in the 2021 to 2030 time periods in the two more aggressive cases, with a 33% overall increase in the cumulative expenditure needed to achieve the EE Target 20-30% case compared to the EE Target 18-25% case.

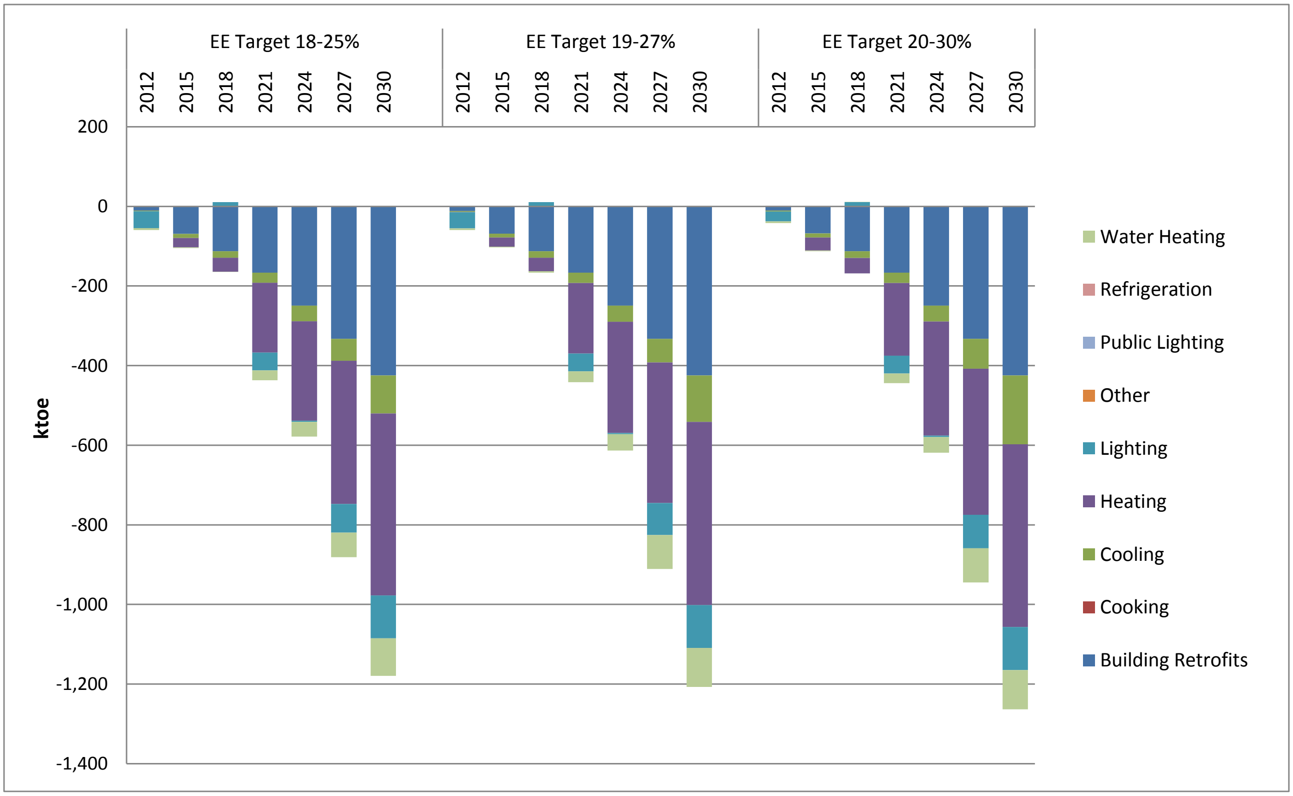



**Figure 8: Commercial Final Energy Use – Change from Reference Benchmark**

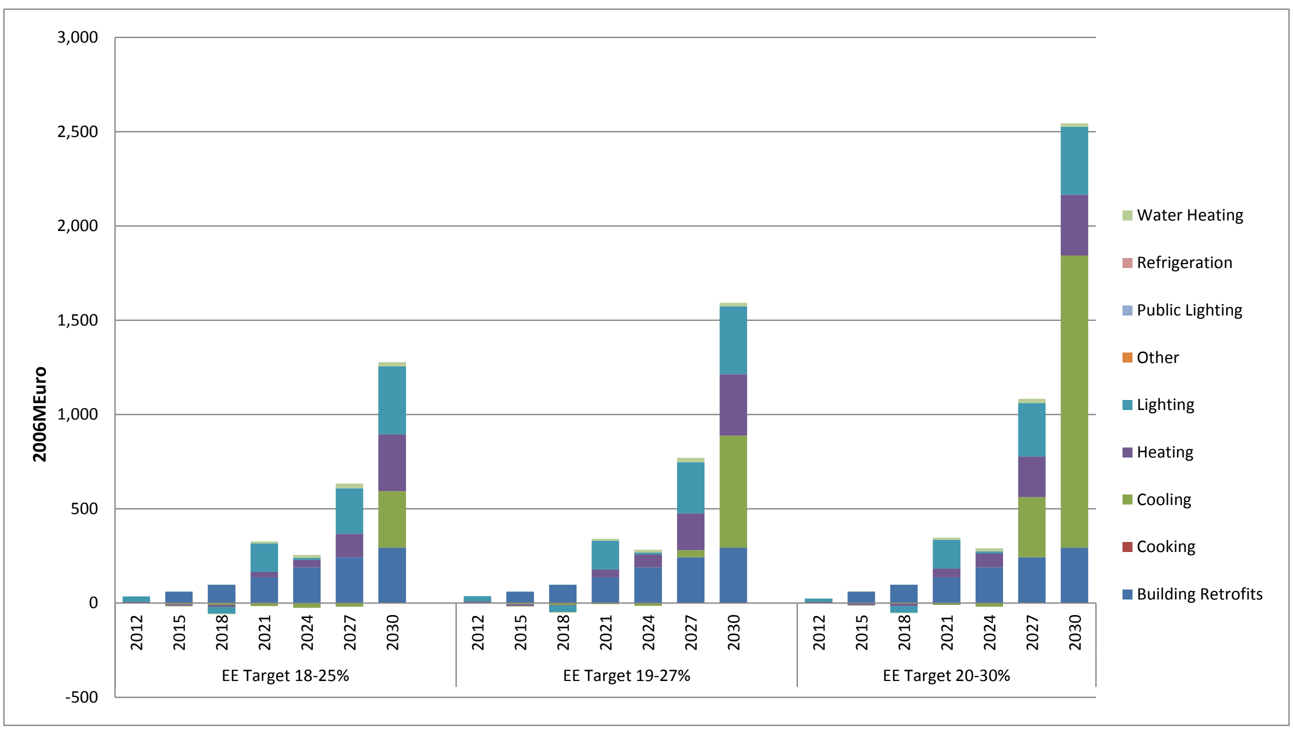



**Figure 9: Commercial End-Use Device Investment – Change from Reference Benchmark**

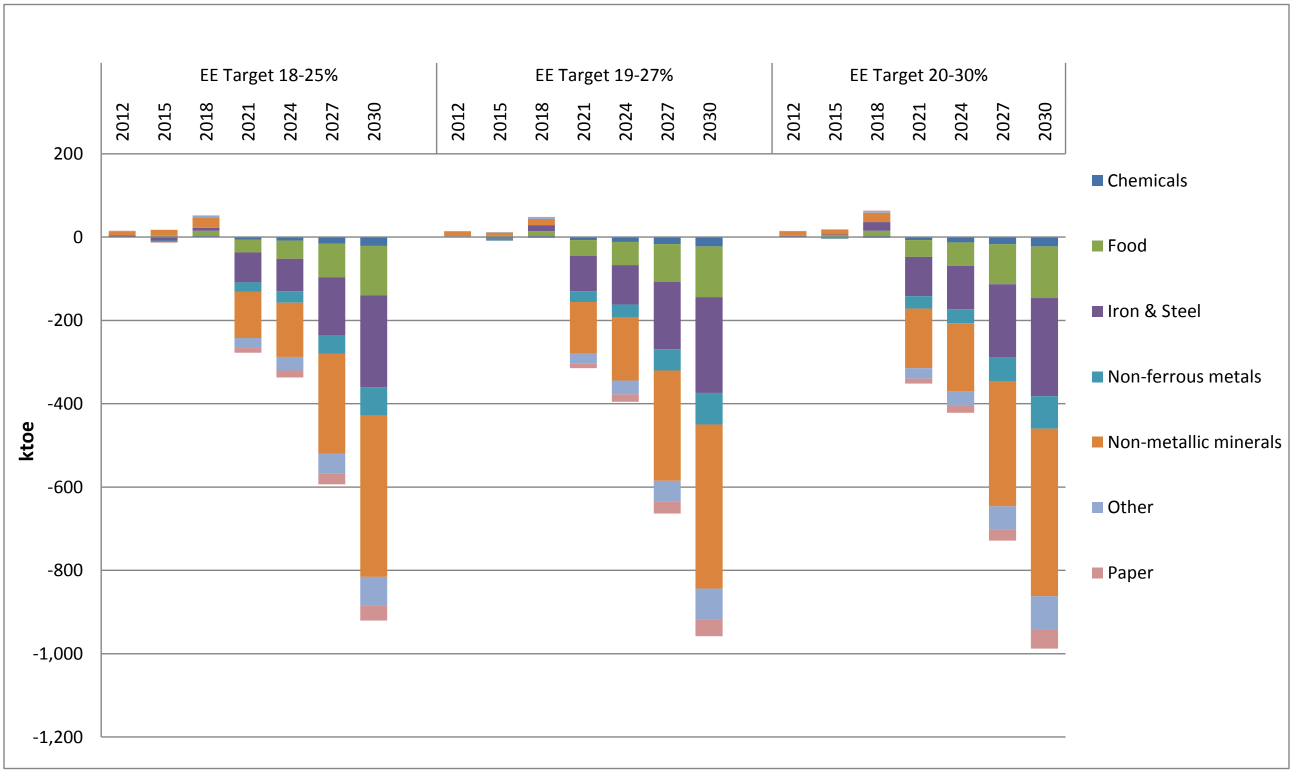



**Figure 10: Industrial Final Energy Use – Change from Reference Benchmark**

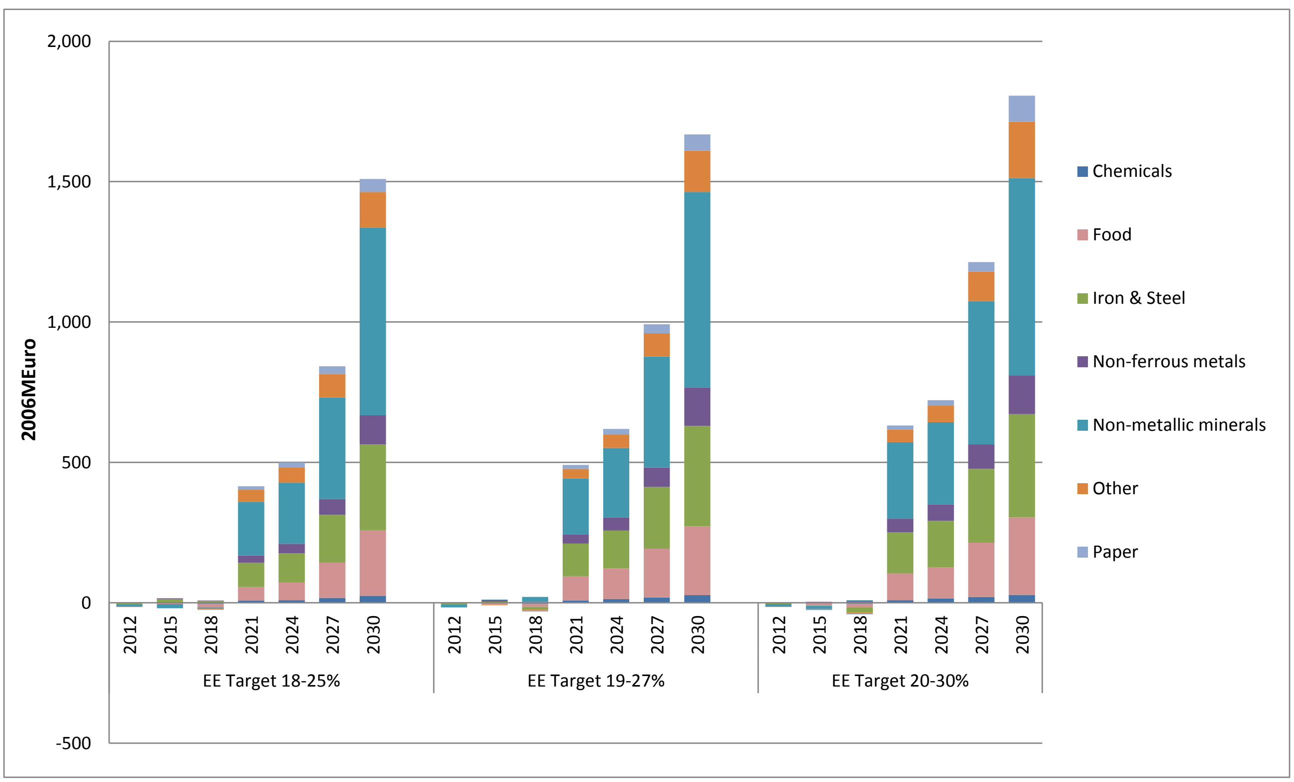



**Figure 11: Industrial End-Use Device Investment – Change from Reference Benchmark**

For the transportation sector, Figure 12 shows that achieving the EE target requires significant reductions in final energy use for heavy trucks (43%), light duty vehicles (29%), light commercial trucks (16%) and buses (10%). It also shows that overall reduction in final energy use in 2030 increases by over 60% between the EE Target 18-25% case and the EE Target 20-30% case, with most of this increased reduction coming from new light duty vehicles. Figure 13 illustrates a dramatic increase in investment for light duty vehicles is required to achieve the EE Target 20-30% compared to the other cases. The new technologies implemented are hybrid heavy trucks and light commercial vehicles, along with plug-in hybrid cars in the latter two periods. In the more stringent target cases, there is also a need for electric buses along with more plug-in hybrid cars and diesel hybrid commercial vehicles.

### 3.2.5 Investment Cost per unit Energy Saved

Figure 14 shows the incremental investment per unit of energy saved in each sector by end-use, sub-sector, or transport mode. These values are an indication of the cost-effectiveness of various measures, and are calculated from the incremental energy savings and investment charts presented above averaged over the 2018 to 2030 time periods.

The Residential sector figure shows that the most cost-effective investments are in the areas of space heating and cooling, water heating and thermal insulation, and that the unit cost of meeting the target increases by 15% and 18% for the EE Target 19-27% and EE Target 20-30% cases compared to the EE Target 18-25% case.

The Commercial sector figure shows that the most cost-effective investments are in the areas of space heating and cooling, water heating and building retrofits, and that the unit cost of meeting the target increases by 18% and 30% for the EE Target 19-27% and EE Target 20-30% cases compared to the EE Target 18-25% case, with almost all of the increase coming from new high efficiency cooling devices. Note that in the EE Target 18-25% case, the cooling unit cost is low because the building retrofits offset the need to buy more cooling devices, but that as the target increases and the potential for building retrofits is reached, then the unit cost for cooling increases by a factor of ten (10).

The Industry sector figure shows that investment costs are similar between industry subsectors and that unit cost of meeting the target increases by 7% and 18% for the EE Target 19-27% and EE Target 20-30% cases compared to the EE Target 18-25% case.

The Transport sector figure shows that the most cost-effective investments are for light commercial vehicles, heavy trucks and light duty vehicles, and that the unit cost of meeting the target increases by 14% and 102% for the EE Target 19-27% and EE Target 20-30% cases compared to the EE Target 18-25% case, with the increase for the EE Target 20-30% case coming from these modes as well as from rail and shipping modes.

Looking across sectors, Figure 14 shows that actions in the Commercial and Industry sectors are in general the most cost effective, and that measures to reach a 30% reduction target will require structural changes in transportation. These are general results for the region, more specifics results and conclusions are provided in each of the CP-specific parts of Chapter 7.

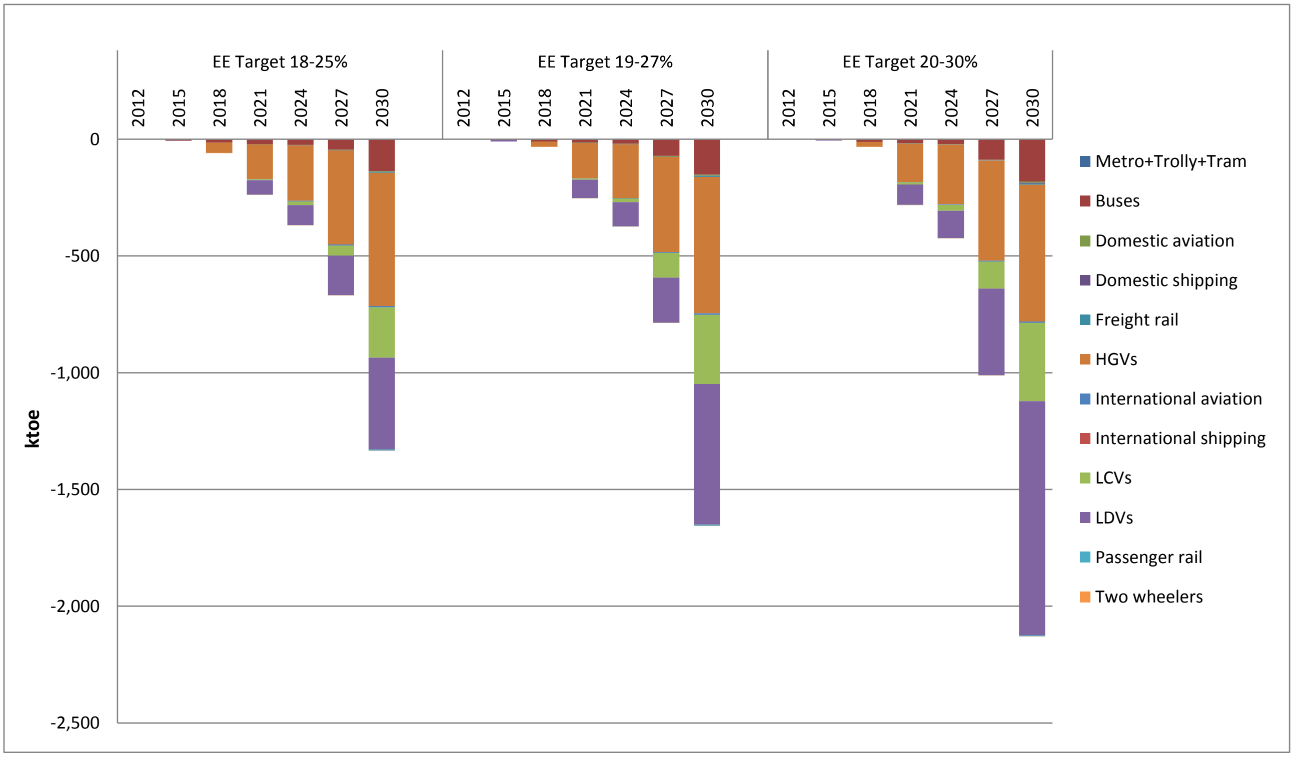



**Figure 12: Transportation Final Energy Use – Change from Reference Benchmark**

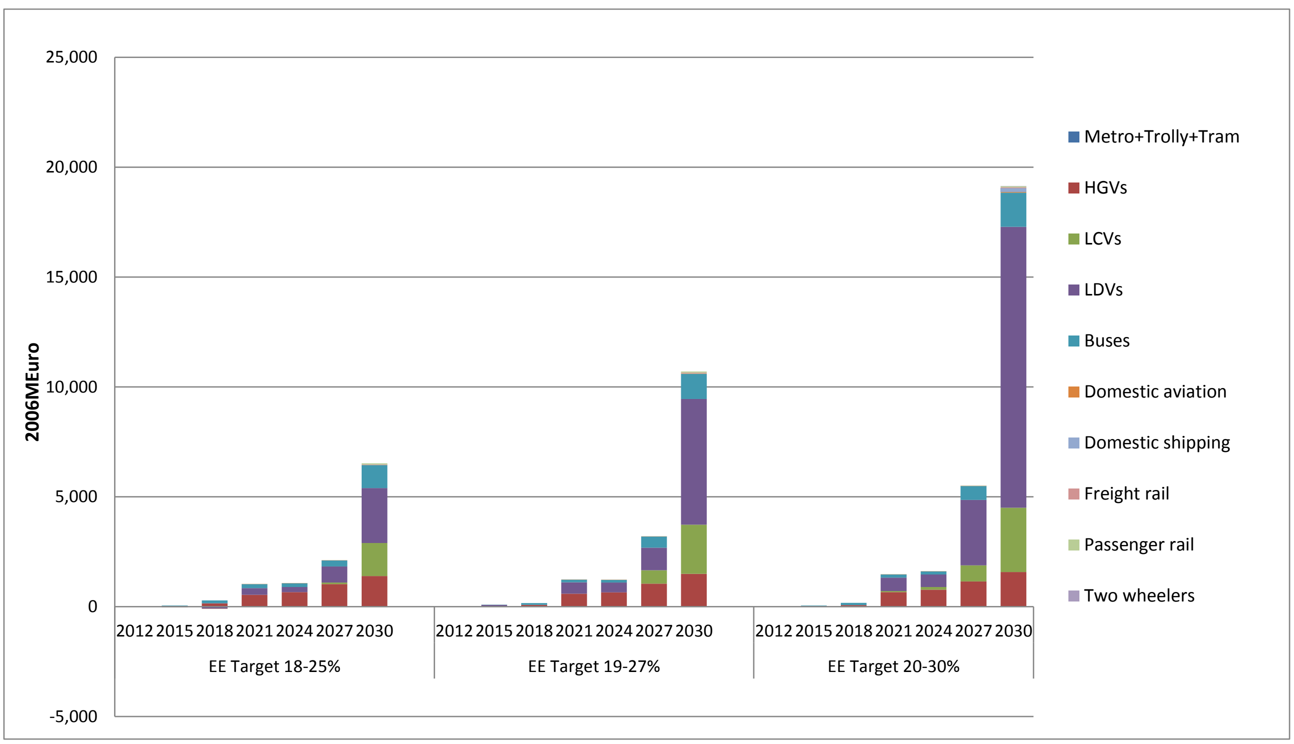



**Figure 13: Transportation End-Use Device Investment – Change from Reference Benchmark**

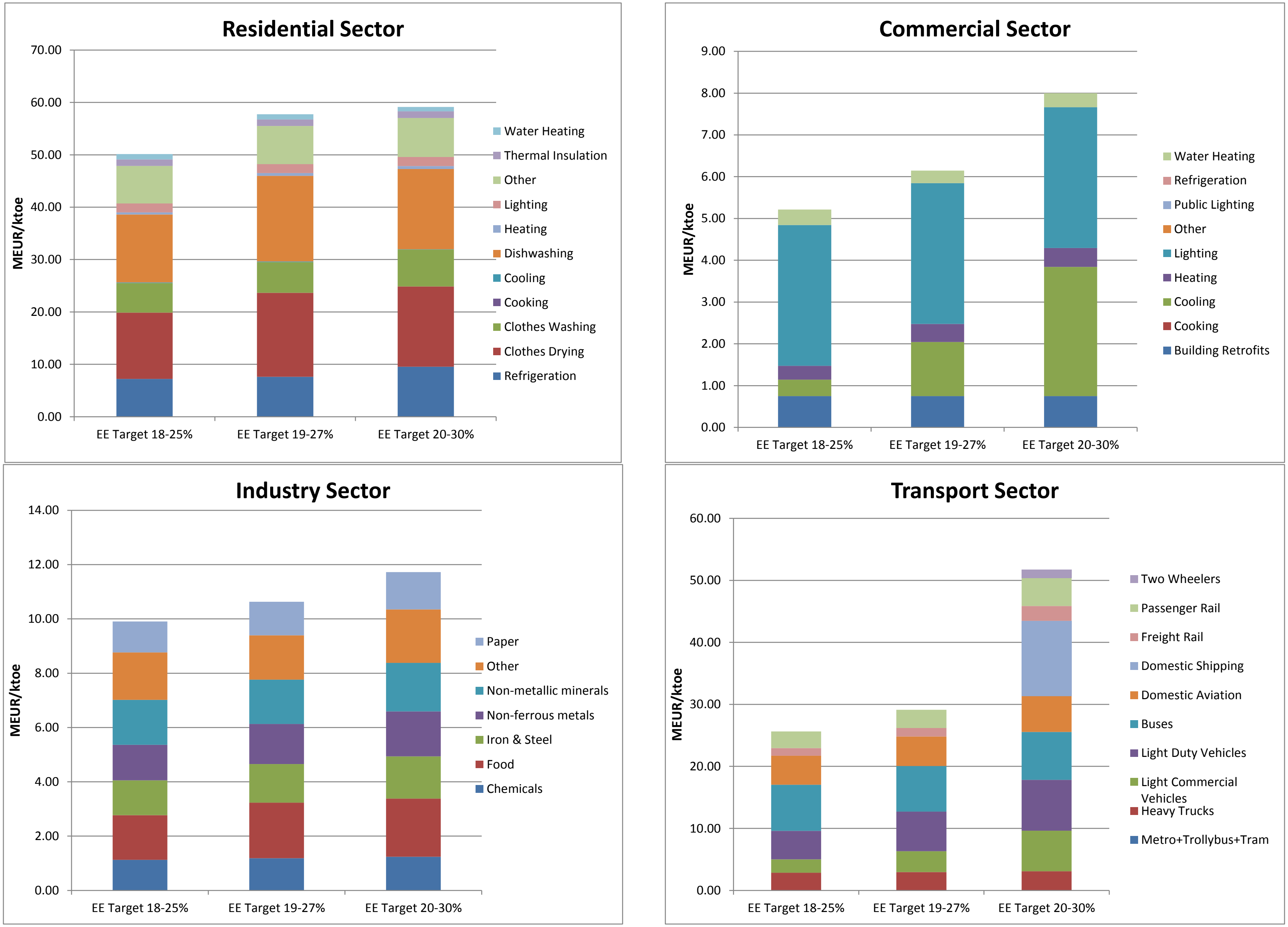



**Figure 14: Investment per unit Energy Saved by Sector and End-Use – Change from Reference Benchmark**

### 3.2.6 Energy Security and Environmental Benefit Arising from EE Targets

In addition to the obvious achievement of lowering final energy consumption, the EE target cases also generate important benefits related to energy security, economic competiveness and the environment arising from lower imports, payment for energy, and $CO_2$ emissions, as reflected in Table 5. It is interesting to note that these benefits do not vary all that much between the scenarios, increasing by only 10 to 15%, and that just implementing the EE Target 18-25% goal achieves substantive benefits, with only marginal additional benefit arisign from the more aggressive targets. For Ukraine, shown in Table 6, the 20-30% case drives more electrification of demand, which produces in higher electricity prices, and leads to a preference for imported gas over domestic coal for electricity generation, especially in 2027-2030. This results in lower import reductions and higher CO2 emission reductions for that case.

**Table 5: Energy Security and Environmental Benefits Arising from EE Targets – Cumulative 2015-2030 Values for CPs w/o Ukraine**

| Scenario | Imports | | Fuel Expenditures | | $CO_2$ Emissions | |
|---|---|---|---|---|---|---|
| | ktoe | % | 2006M€ | % | kt | % |
| Reference Benchmark Level | 266,218 | | 182,872 | | 1,687,315 | |
| EE Target 18-25% Difference | -30,078 | -11.3% | -17,239 | -9.4% | -134,333 | -8.0% |
| EE Target 19-27% Difference | -32,109 | -12.1% | -18,250 | -100% | -140,608 | -8.3% |
| EE Target 20-30% Difference | -33,662 | -12.6% | -20,020 | -11.0% | -149,145 | -8.8% |

**Table 6: Energy Security and Environmental Benefits Arising from EE Targets – Cumulative 2015-2030 Values for Ukraine**

| Scenario | Imports | | Fuel Expenditures | | $CO_2$ Emissions | |
|---|---|---|---|---|---|---|
| | ktoe | % | 2006M€ | % | kt | % |
| Reference Benchmark Level | 740,369 | | 448,789 | | 5,384,617 | |
| EE Target 18-25% Difference | -89,911 | -12.1% | -52,642 | -11.7% | -631,829 | -11.7% |
| EE Target 19-27% Difference | -98,720 | -13.3% | -56,364 | -12.6% | -657,680 | -12.2% |
| EE Target 20-30% Difference | -82,976 | -11.2% | -53,412 | -11.9% | -784,456 | -14.6% |

### 3.2.7 Cross-country Cost Comparison

Figure 15 gives the change in total system cost relative to the Reference Benchmark case for each CP under the three EE target levels. Note that for each of the CPs there is a significant increase in the overall cost of reaching the target for the EE Target 20-30% case, and that this case is not feasible in EC-TIMES for Albania because of its relatively high proportion of electricity consumption in its demand sectors, which means it cannot take advantage of relatively cost-effective fuel switching options for heating that some of the othe CPs can implement.

As is shown in Table 7 the additional cost at the country level increases from between 25% and 65% when moving from the EE Target 18-25% case to the EE Target 19-27% case, and that the increase is between 97% and over 600% when when moving from the EE Target 18-25% case to the EE Target 20-30% case.

These results indicate a rather significant reduction in cost for a small relaxation in the target values, indicating that there is a tipping point after which the marginal benefit is heavily outweighed by the increased cost.

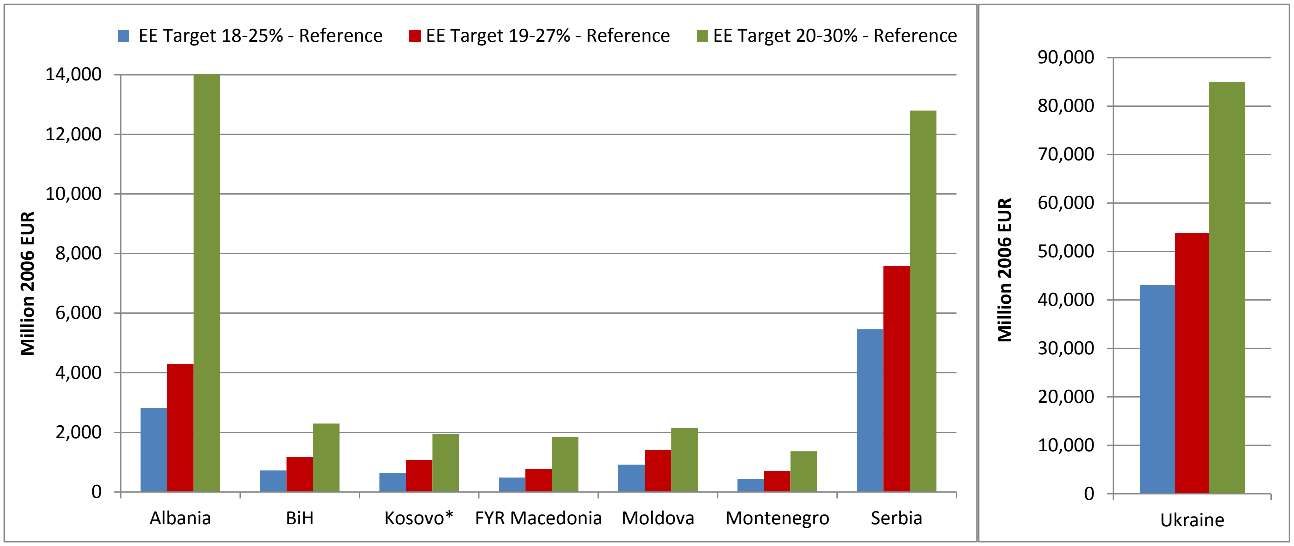



**Figure 15: Relative Impact of Alternate EE Target on Energy System Cost**

**Table 7: Increase in the Change in System Cost compared to EE Target 18-25%**

| Country | EE Target 19-27% | EE Target 20-30% |
|---|---|---|
| Albania | 52% | 645% |
| BiH | 64% | 219% |
| Kosovo* | 66% | 203% |
| Macedonia | 61% | 283% |
| Moldova | 55% | 135% |
| Montenegro | 65% | 217% |
| Serbia | 39% | 135% |
| Ukraine | 25% | 97% |

### 3.2.8 Recommendations with Regards to Target Setting

These summary results, and the country-specific details that follow, all point to the following conclusions:

- The EE Target 18-25% case is the most cost-effective policy of the three, and
- Sharp increases in the required investment costs, especially in 2027 and 2030, for the EE Target 19-27% and EE Target 20-30% cases do not justify the associated energy savings.

Table 8, which shows the increase in energy system cost above the Reference Benchmark for each target case, clearly indicates the sharp increases in cost that result from moving beyond the EE Target 18-25% level, especially given that Table 3 and Table 4 show that the increase in cumulative final energy reductions is only in the range of 10% to 20%. ***Based on all these considerations, the EE Target 18-25% case is recommended for adoption and is shown to be a significant progression of ambition for each of the CPs.***

**Table 8: Increase in Energy System Cost for Each EE Target Case relative to the Reference Benchmark**

| Country | EE Target 18-25% | EE Target 19-27% | EE Target 20-30% |
|---|---|---|---|
| Albania | 2,823 | 4,299 | 21,036[8] |
| BiH | 720 | 1,180 | 2,295 |
| Kosovo* | 641 | 1,062 | 1,941 |
| FYR Macedonia | 480 | 774 | 1,838 |
| Moldova | 913 | 1,412 | 2,149 |
| Montenegro | 430 | 710 | 1,360 |
| Serbia | 5,458 | 7,581 | 12,799 |
| Ukraine | 43,027 | 53,766 | 84,827 |
| Total | 54,492 | 70,784 | 128,245 |

## 3.3 Additional Administrative Burden

An inevitable feature of any energy efficiency program is the costs incurred for preparatory and operating expenditures of the program. In addition to the standard costs for staff to operate the program, these costs also include professional preparation of programs, dissemination of information, project evaluation expertise, advisory service to applicants, management, etc. These costs are additional to any subsidy cost, and they can be categorized into two parts, which are:

- Administrative costs: those incurred by the organizer of the program, such as the state, and
- Transaction costs: those incurred by an applicant for the preparation and approval process of its project.

Analysis of these additional costs was based upon data gathered from actual projects and programs. As the most detailed information were gathered from the Czech Republic we have focused on examples of concrete programs implemented and completed in the past in that country. Three different energy savings programs were selected as representative examples.

- Program ECO-ENERGY operated by the Czech Ministry of Industry and Trade 2007 – 2013, supported EE measures in industry.
- Program Green to Savings operated by State Environmental Fund, provided subsidies to residential sector.
- Operational program Environment, Part 3 – Energy savings operated by the Ministry of Environment that focused on public buildings.

Analysis of these additional costs identified the following conclusions:

- Transaction costs represent the major part of the additional costs. They are paid by the applicants, who usually have to fulfill many requirements of the program and prepare their proposed programs for immediate implementation even in case they aren't successful, where usually without a subsidy these projects would never be implemented.

[8] This run is actually infeasible, which means that EC-TIMES is unable to find a solution in Albania for this scenario with the options available to the model without using a dummy supply technology.

- Administrative costs turn out to be the smaller part of the additional costs. Administrative costs are paid by the Government and/or Program Operator. They involve program design, development of detailed program steps procedure and rules, control process, etc. Following the initial program design, there are the day-to-day costs of operating of the program.

The key metrics of the three programs are presented in Table 9. The additional costs have reached up to 15% of all the financial support provided by the programs. As for the administrative part of these additional costs, we have identified the range from 3 to 5% of the investment subsidy provided by each of the program. As presented in the bottom line of the table, these programs have a weighted average administrative cost of 4%, which we have assumed for all the Balkan countries, except Albania and Ukraine, as discussed below.

**Table 9: Analysis of Energy Efficiency Program Costs in Czech Republic**

| Energy savings Program | OPPI EKO-ENERGIE | Green Energy Savings | Operational program Environment - priority area 3 | Total/Average |
|---|---|---|---|---|
| **Number of projects** | 1044 | 74662 | 1304 | **77010** |
| **Total projects cost (M€)** | 582 | 1259 | 749 | **2590** |
| **Investment subsidy (M€)** | 219 | 763 | 658 | **1640** |
| **Energy savings per year (PJ)** | 8 | 8.9 | 2.52 | **19** |
| **Investment subsidy per annual energy savings (M€/PJ)** | 27.4 | 85.7 | 261 | **84.4** |
| **Total additional cost (M€/PJ)** | 4.07 | 12.93 | 28.9 | **11.4** |
| **Administrative cost (M€/PJ)** | 0.9 | 4.2 | 8.1 | **3.3** |
| **Total Additional cost share (%)** | 14.9% | 15.1% | 11.1% | **13.4%** |
| **Administrative cost share (%)** | 3.2% | 4.9% | 3.1% | **4.0%** |

Of the total project cost identified in Table 9, on average 60% was covered by some form of investment subsidy. The level of subsidy ranged from 40% to almost 90%, which is understandable given the breadth of the programs, technologies and sectors. For this analysis, each CP was assumed to develop and administer a variety of public and private sector programs to cover a 60% subsidy level, and an annual average investment level was derived from the cumulative investment required over the 2015 to 2030 period. Table 10 presents these estimates of administrative costs, where only a 3% administrative costs ratio was assumed for Albania due to the higher average investment cost, and 3% for Ukraine, where the significantly larger program size should offer some economies of scale.

**Table 10: Estimates of Energy Efficiency Program Costs (Million EUR - undiscounted)**

| Country | Average Annual Investment Requirement | Average Annual Investment Subsidy | Administrative Cost |
|---|---|---|---|
| Albania | 997 | 598 | 18 |
| BiH | 532 | 319 | 13 |
| FYR Macedonia | 218 | 131 | 5 |
| Moldova | 303 | 182 | 7 |
| Kosovo* | 158 | 95 | 4 |
| Montenegro | 113 | 68 | 3 |
| Serbia | 1,921 | 1,153 | 46 |
| Ukraine | 9,049 | 5,429 | 163 |

# 4. Task 2 - Exemplary Role of Public Bodies' Buildings

Article 4 of the EED calls for the establishment a long-term strategy for investment in the renovation of residential and commercial buildings with the aim of improving their energy efficiency over the long term. Based on the principle that public bodies should lead by example, Article 5 requires that 3% of the total floor areas of heated or cooled buildings owned and occupied by central government bodies are renovated each year to meet national minimum energy performance requirements.

The objective of Task 2 was to analyze the impact of the proposed staged approach of a minimum of 2% of central government owned and occupied buildings that must be renovated from June 2015 to June 2019, increasing to a minimum of 3% for the period July 2019 to June 2025. The approach is summarized below, and study results are discussed in the next section.

## 4.1 Identify the Categories of Public Buildings

Article 4 of the EED calls for establishment of a publicly available inventory of heated and/or cooled central government buildings, excluding buildings exempted because they are officially protected for specific reasons or buildings owned by the armed forces or central government and serving national defense purposes. These inventories do not yet exist, and the DWG team, particularly ICEIM-MANU and UNAS/IEF, have used the best available data to identify the categories of public buildings (education, health, offices, etc.) that are owned and occupied by the central government and estimated their floor surface, for each CP.

Preliminary estimates of public building floor space owned by the central government were presented in the Interim Report, and taking into consideration the comments and suggestions from the EECG representatives, the data was updated. The studies used to develop this data do not have all the necessary details for some of the countries regarding the floor space (area) or the number of the building under central versus local government ownership, so data from some of the countries, where available, was used to develop the following assumptions for these shares: 60% of Administrative buildings are under Central Government, 10% of Educational building and all Health care facilities (having in mind that in most of the CPs the health care buildings are under Central Government). The rest of the public buildings are assumed to be under local self-government. The detailed assumptions for each of the CPs are given in Appendix C, and Table 11 provides a summary of the updated estimates on public building floor space owned and occupied by the central government, including the allowed exclusions.

These figures are not precise and should not be interpreted as official figures. However, they are based on the best available data with some reasonable assumptions made to fill data gaps between countries, and we believe they are sufficiently accurate to estimate likely cost and performance impacts of alternate applications of Article 5 of the Directive.

**Table 11: Breakdown of Total Commercial Building Floor Space[9]**

| Contracting Party | Total Commercial Building Floor space, $m^2$ | Public Buildings Floor space, $m^2$ | Central Government Public Buildings Floor space, $m^2$ | Percent of Central Government in Total Commercial Buildings |
|---|---|---|---|---|
| Albania | 16,348,000 | 8,451,260 | 2,139,810 | 13% |
| Bosnia-Herzegovina | 15,890,000 | 7,456,099 | 3,258,843 | 21% |
| Kosovo* | 11,766,300 | 5,601,231 | 1,473,593 | 13% |
| FYR Macedonia | 8,483,400 | 2,265,944 | 902,854 | 11% |
| Moldova | 6,544,900 | 6,002,005 | 1,975,712 | 30% |
| Montenegro | 4,893,615 | 3,414,441 | 1,828,339 | 37% |
| Serbia | 53,152,000 | 26,202,920 | 10,591,458 | 20% |
| Ukraine | 115,725,700 | 108,806,459 | 32,353,319 | 28% |

## 4.2 Determine Average Renovation Costs for Public Building Types

The average renovation costs for each building type and the typical amount of energy savings arising from each renovation were developed by SEVEn Energy based on their experience and a data base available for the Czech Republic and other countries in the region. The initial data on average renovation costs and typical energy savings were described in the Interim report, and are presented in Appendix D to this report. This data, based on the cost per unit energy saved, was converted into a number of building energy conservation measures that when purchases result in lower heating and cooling demands. These new building efficiency measures were incorporated into each country model except Ukraine, as noted in Section 3.2.1.

These estimates were developed after review and assessment of a wide range of actual building renovation costs for various categories of building retrofit energy savings measures encompassing a wide range of building insulation and efficiency improvement projects and programs. The individual project costs vary significantly, but the range of costs were evaluated across project types to estimate median costs for each type of retrofit measure and building type. The basic building retrofit measures are:

- Thermal insulation of the envelope (external walls, roof, eventually floor or ceiling below the lowest heated floor);
- Replacement of windows and doors;

[9] Total Commercial buildings include all public and private non-residential building types.

- Regulation of the heating system (primarily measurement and control systems, eventually an installation of valves, pipe insulation or replacement of pumps), and
- Installation of a heat recovery unit to reduce ventilation losses (including the distribution system).

Based on SEVEn's knowledge and experience in Central Europe, the data for a typical office building was further developed into an average cost per square meter of floor space for each of the primary retrofit measures. A single average for all EnC countries in the region was considered suitable, as government buildings in the region are based on similar design and construction standards. Table 9 provides the cost of individual measures in €/m2 of floor area. Prices include materials, labor and related construction work (especially in the case of insulation of the ground floor). In general, to be conservative, we assumed the sloped roof insulation measures rather than the flat roof insulation measure, and we used the ground floor insulation measure rather than the floor to basement insulation measure.

**Table 12: Building Retrofit Cost Data (EUR/m$^2$ of floor area)**

| Measures | | Cost of measure (€/m2 of floor area) |
|---|---|---|
| | | Offices/education/health Buildings |
| Measures to reduce heating losses | Window replacement | 26 |
| | External insulation (100 mm) | 25 |
| | Roof insulation - slope | 12 |
| | Roof insulation - flat | 7 |
| | Ceiling insulation | 3 |
| | Insulation of the ground floor | 18 |
| | Floor to basement | 6 |
| Regulation of a heating system | | 4 |
| Installation of a heat recovery unit and air distribution | | 31 |

Based on the estimation of the central government public buildings floor space (Table 11) and the retrofit costs data from Table 12, the annual cost of retrofitting a share of central government building was estimated for the Balkan countries and Ukraine (Table 13). The estimation was made for annual renovation rate of 2% and 3% of the floor space.

**Table 13: Estimated annual cost of retrofitting central government buildings (Million EUR - undiscounted)**

| Country | Annual Cost to Renovate 2% share of central government building floor space | Annual Cost to Renovate 3% share of central government building floor space | Incremental Cost |
|---|---|---|---|
| Albania | 5,093 | 7,639 | 2,546 |
| Bosnia-Herzegovina | 8,603 | 12,905 | 4,302 |
| Kosovo* | 3,507 | 5,261 | 1,754 |
| FYR Macedonia | 2,149 | 3,223 | 1,074 |
| Moldova | 4,702 | 7,053 | 2,351 |
| Montenegro | 4,351 | 6,527 | 2,176 |

| | | | |
|---|---|---|---|
| Serbia | 25,208 | 37,812 | 12,604 |
| Ukraine | 77,001 | 115,501 | 38,500 |
| **Total** | **130,614** | **195,921** | **65,307** |

The incremental cost of a 3% renovation rate compared to a 2% rate is EUR 65.3 million annually, with 59% going to Ukraine, 19.3% to Serbia and 6.6% to BiH. The rest have 2 to 4% shares.

### 4.3 Recommendations on Implementation

The goal of Article 5 is to have the government implement a demonstration program in its own buildings as incentive for other public and private sector entities to follow suit. The 2% goal is assessed to be the most cost-effective approach to achieving that goal. The total building floor area that would require retrofitting would vary from about 20,000 $m^2$ in FYR Macedonia to 65,000 $m^2$ in Bosnia-Herzegovina to over 200,000 $m^2$ in Serbia to almost 650,000 m2 in Ukraine**.** ***Therefore, it is recommended that the ECS adopt a requirement goal to retrofit 2% of central government owned and occupied buildings annually.*** The 2% rate is especially appropriate for the countries with a high share of buildings owned and occupied by the central government as Montenegro or Ukraine. The countries which own and occupy a very low share of commercial buildings could adopt the higher rate of 3% if they were able to take over the additional financial burden.

## 5. Task 3 - Energy Efficiency Obligation Schemes

EU Article 7 of the EED requires CPs either set up an energy efficiency obligation scheme to ensure that certain energy distributors or retail energy sales companies achieve a cumulative annual end-use energy savings target, or adopt alternative policy measures to achieve equivalent energy savings. These alternative policy mechanisms and measures include energy taxation schemes, energy efficiency funds, regulations and standards, or other efficiency-promoting actions that align with or exceed EU norms.

The target for EU member states is to achieving new savings each year of 1.5 % of the annual energy sales to final customers of all energy distributors or all retail energy sales companies by volume, averaged over the most recent three-year period prior to 1 January 2013. The sales of energy, by volume, used in transport may be partially or fully excluded from this calculation. Therefore, each CP has options for designating which fuels and sectors will be qualified to meet obligations under this Article. In addition, actions to achieve the obligated reductions may be shared between qualified suppliers/distributors, or by alternative policy mechanisms. Supplier-based programs can be through direct supplier actions or through their consumers supported by the supplier in some way (e.g., rebates for more efficient devices and/or building improvements). Alternative measures can also be designed to encourage the most cost-effective measures to meet the annual reduction target to be pursued.

The objective of Task 3 is to analyze the impact to each CP of setting up an energy efficiency obligation scheme based upon achieving either:

- 1% of new savings each year from January 2015 to December 2025, increasing to 1.5% from 2025 to 2030 (1-1.5% case), or
- 1.5% of new savings each year from January 2015 to December 2030 (1.5% case).

The analysis using EC-TIMES does not distinguish between whether the obligation is met through a requirement on every qualified energy distributors and/or retail energy sales companies, if it is met through alternative measures, or if it is met by a combination of the two approaches. The model identifies the most cost-effective set of measures in all sector that meet the obligation. Because qualified suppliers would be able to generate savings in the most cost-effective manner they choose and do not have to all come from the energy carrier they provide, the model assumption of cost-effective decision-making is valid. Similarly, alternative measures would facilitate the most cost-effective measures to meet the annual reduction target.

## 5.1 Approach

This task started with establishing the cumulative energy savings targets for each country under the two alternative annual rate scenarios, imposed incrementally on a (3-year) period basis. These requirements were modelled and analyzed using EC-TIMES to determine their impact on the energy system, and a portion of that information was used to calculate key metrics by sector, including the total energy saved by sector, the investment required by sector and the investment cost per unit of energy saved. The latter will be a key metric for this analysis.

### 5.1.1 Establish targets for energy suppliers

In the EC-TIMES model, energy distributors and energy sales companies are represented generically by processes that deliver each fuel type to each sector. The projected amounts of final energy consumption for each energy distributors and energy sales company in each CP is determined from the Reference basic scenario, and the amount of obligated energy savings required to be met is imposed against this level of final energy supply to each sector.

The basis for the annual amount of obligated energy savings for each country, sector and fuel type have been based on results from EC-TIMES for the period 2011 to 2013, and these values have been cross-checked against available historical data[10]. This value represents the annual energy sales to final customers of all energy distributors or all retail energy sales companies by energy content (not volume). In addition, as there is no information on how each CPs would treat energy used in transport, it is currently assumed that all energy used by the transport sector is excluded from this target.

Table 14 provides the average over the 2011 to 2013 period of final energy consumption subject to the obligation in each CP aggregated over qualified fuels and sectors. These values are the basis for determining the amount of annual savings required in each period. The values shown for 2015 thru 2030 are the annual cumulative amounts of savings required for the ECS proposed target of achieving 1% of new savings each year from January 2015 to December 2025, increasing to 1.5% from 2025 to 2030. Table 15 provides the annual cumulative amounts of savings required for achieving 1.5% of new savings each year from January 2015 to December 2030.

[10] The FEC subject to the Supplier Obligation for Ukraine differs from the reported IEA statistics because of different accounting and categorizing approaches. When these differences are resolved, the model results are in reasonable agreement with IEA statistics.

**Table 14: Annual Energy Savings under 1-1.5% Supplier Obligation Scheme (ktoe)**

| CP | 2012 Aggregate FEC less Transport | 2015 | 2018 | 2021 | 2024 | 2027 | 2030 |
|---|---|---|---|---|---|---|---|
| **Albania** | 1,056 | 21 | 52 | 84 | 121 | 169 | 216 |
| **BiH** | 1,874 | 37 | 93 | 149 | 215 | 299 | 384 |
| **Kosovo*** | 785 | 15 | 39 | 62 | 90 | 125 | 161 |
| **FYR Macedonia** | 1,159 | 23 | 58 | 92 | 133 | 185 | 237 |
| **Moldova** | 1,356 | 27 | 67 | 108 | 156 | 217 | 278 |
| **Montenegro** | 560 | 11 | 28 | 44 | 64 | 89 | 115 |
| **Serbia** | 5,746 | 114 | 287 | 459 | 660 | 919 | 1,178 |
| **Ukraine** | 77,305 | 1,546 | 3,865 | 6,184 | 8,890 | 12,368 | 15,847 |

**Table 15: Annual Energy Savings under 1.5% Supplier Obligation Scheme (ktoe)**

| CP | 2012 Aggregate FEC less Transport | 2015 | 2018 | 2021 | 2024 | 2027 | 2030 |
|---|---|---|---|---|---|---|---|
| **Albania** | 1,056 | 31 | 79 | 126 | 174 | 221 | 269 |
| **BiH** | 1,874 | 56 | 140 | 224 | 309 | 393 | 477 |
| **Kosovo*** | 785 | 23 | 58 | 94 | 129 | 164 | 200 |
| **FYR Macedonia** | 1,159 | 34 | 87 | 139 | 191 | 243 | 295 |
| **Moldova** | 1,356 | 40 | 101 | 162 | 223 | 284 | 345 |
| **Montenegro** | 560 | 16 | 42 | 67 | 92 | 117 | 143 |
| **Serbia** | 5,746 | 172 | 431 | 689 | 948 | 1,206 | 1,465 |
| **Ukraine** | 77,305 | 2,319 | 5,797 | 9,276 | 12,755 | 16,234 | 19,713 |

### 5.1.2 Analysis with EC-TIMES

The 1-1.5% and the 1.5% supplier obligation cases were analyzed with the EC-TIMES model and the results were compared to the Reference Benchmark case and to each other. A range of model results were evaluated and the following key metrics were considered the most relevant measures of the energy, economic and environmental impacts of implementing the supplier obligation:

- Energy saved by sector;
- Investment required by sector, and
- Investment cost per unit of energy saved.

## 5.2 Analysis Results

### 5.2.1 Final Energy Reductions

Figure 16 shows the total final energy consumption for the CPs without Ukraine under the Reference scenario and the two Supplier Obligation scenarios. The figure shows that the energy savings required by this article, while significant, are substantially less than the savings required by the any of EE Target levels. The figure shows that the change in final energy comes mostly from coal, diesel and electricity, with smaller contributions from natural gas. In the 1.5% case, the increases relative to the 1-1.5% case come from additional savings in coal and natural gas.

Figure 17 gives details of the change in final energy by end-use application for the Commercial sector, and shows that energy savings are primarily due to improvements in space heating and cooling, lighting, water heating and building insulation, which is similar but with a lower scale compared to the EE Target cases. The other sectors relevant to this article (Residential and Industry) were examined and similarly implement the same measures as are in the EE Target scenarios. Recall that fuels to the transport sector are excluded from this obligation scheme.

### 5.2.2 Investments in Demand Side Measures

Figure 18 provides, as an example, the changes in demand side investment for the Commercial sector by end-use application. Each sector was examined, and as in the EE Target scenarios, the investment requirements and energy savings were combined into the investment cost per unit energy saved, as a key figure of merit.

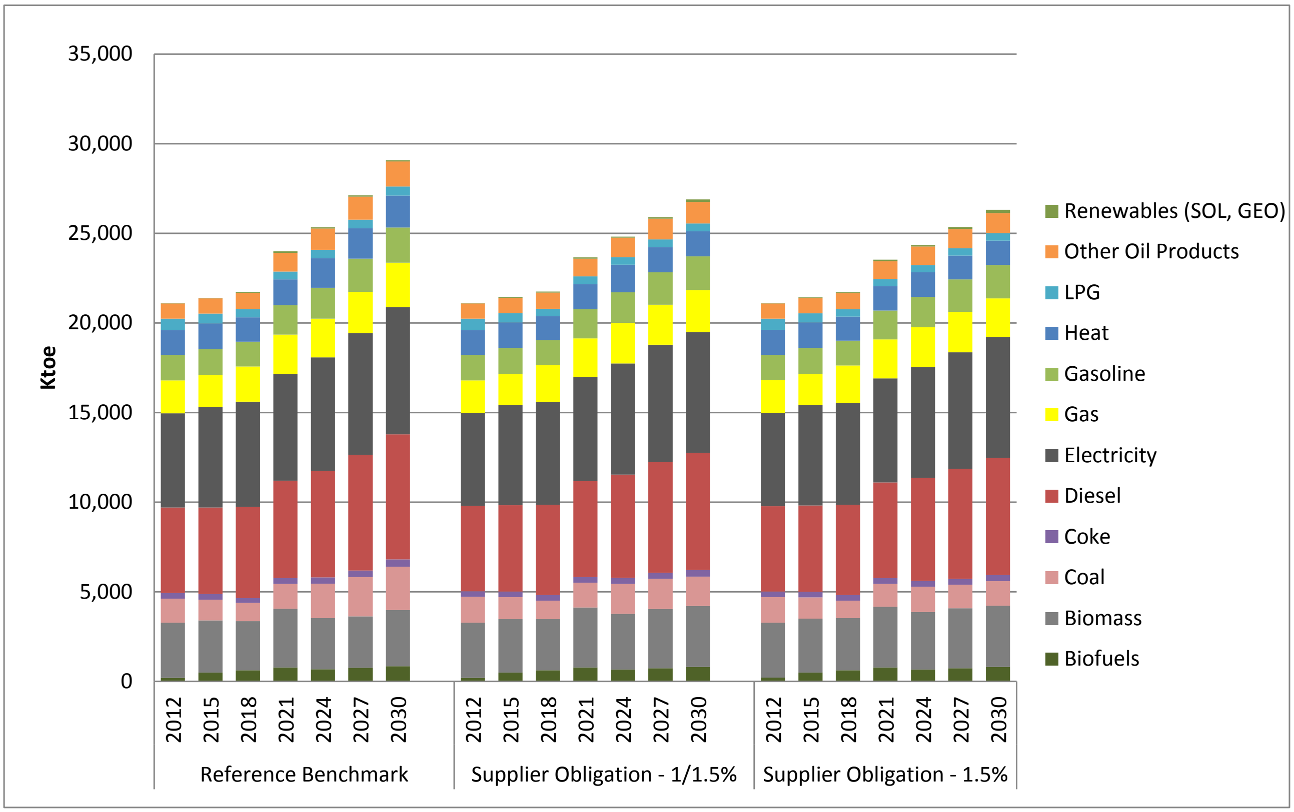



**Figure 16: Final Energy Consumption for Reference versus Supplier Obligation Scheme – CPs w/o Ukraine**

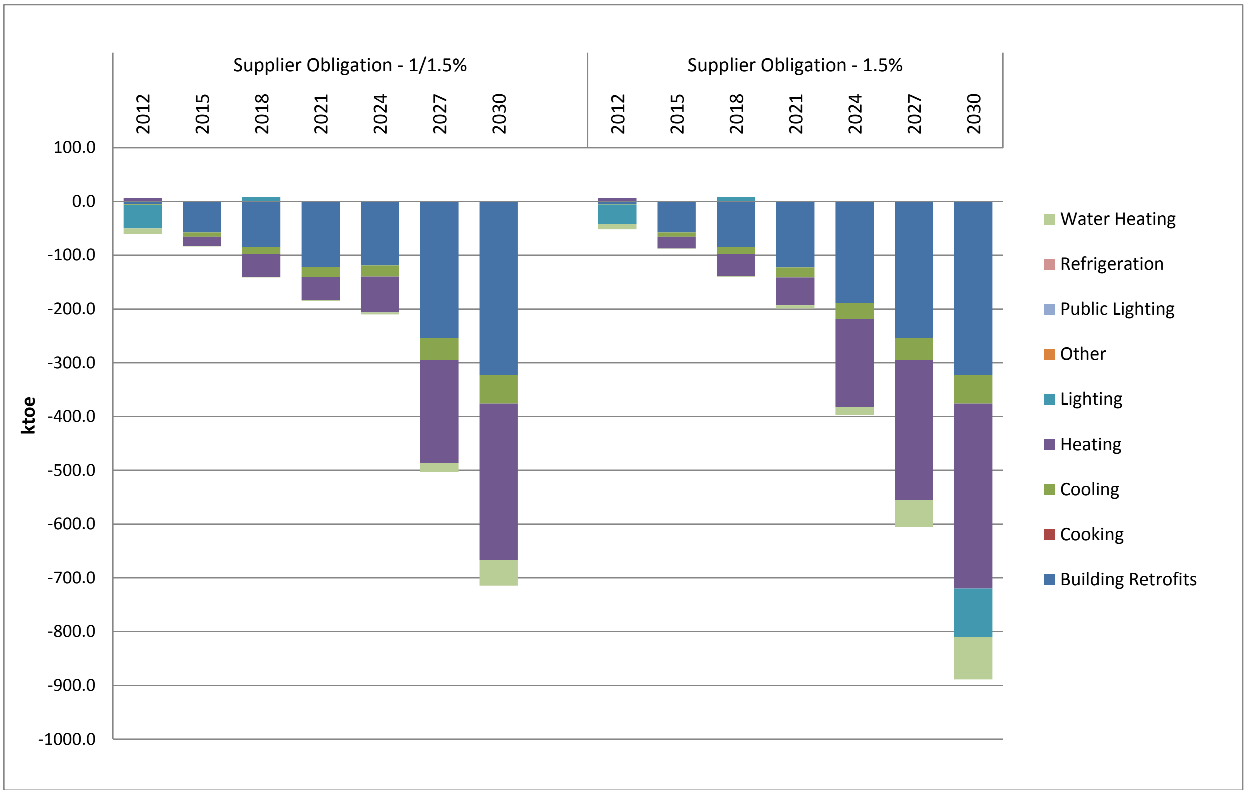



**Figure 17: Change in Commercial Energy Use for Supplier Obligation vs Reference Benchmark – CPs w/o Ukraine**

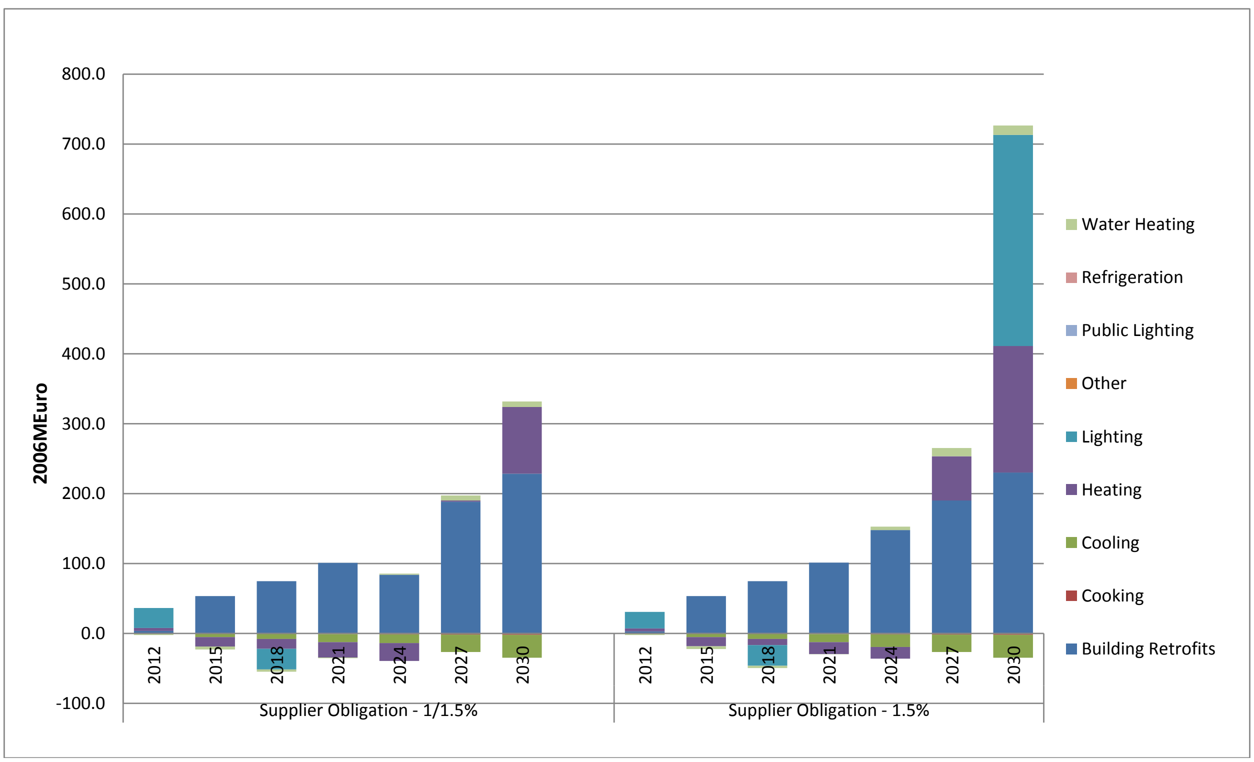



**Figure 18: Change in Commercial Investment for Supplier Obligation vs Reference Benchmark – CPs w/o Ukraine**

### 5.2.3 Metrics for Each Contracting Party

As the individual measures identified for the Supplier Obligation cases were similar for those identified for the EE Target cases, the following key metrics charts were prepared for each of the CPs for which we have demand-side models (so excluding Kosovo* and Montenegro). The figure for each country shows the three key metrics for the 1-1.5% and the 1.5% Supplier Obligation cases. First is the change in demand device investments by sector; second is the amount of energy saved; and third is the cost per unit of energy saved. In general throughout the CPs, the demand sector investment requirement doubles between the 1-1.5% case and the 1.5% case, while the energy saved increases almost 50%, and the unit cost of savings goes up about 25%. Figure 19 presents Albania; Figure 20 presents Bosnia-Herzegovina; Figure 21 presents FYR Macedonia; Figure 22 presents Moldova, Figure 23 presents Serbia, and Figure 24 presents Ukraine.

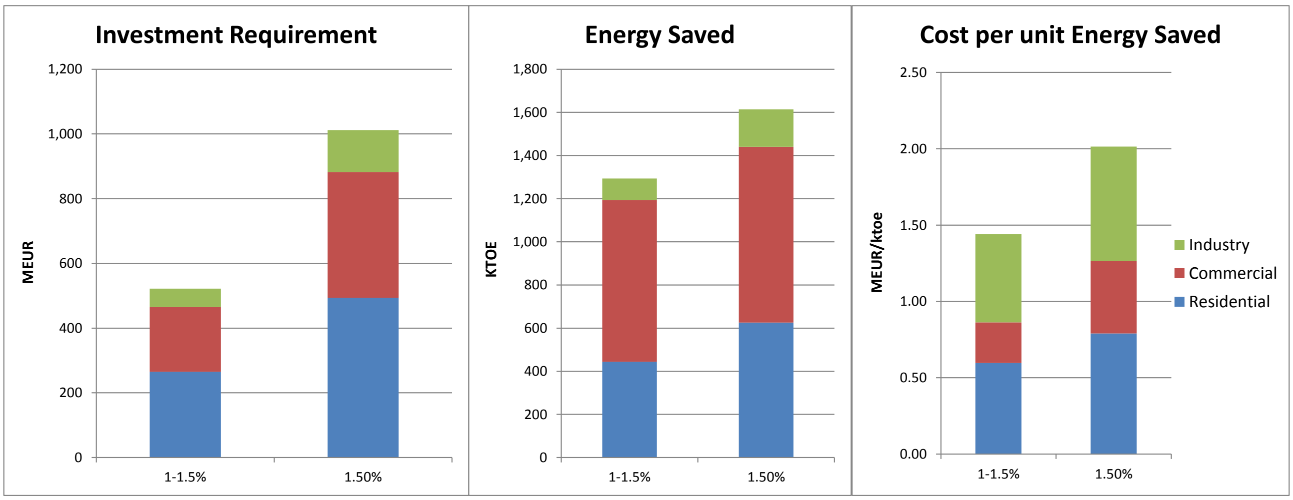



**Figure 19: Albania - Supplier Obligation Key Results**

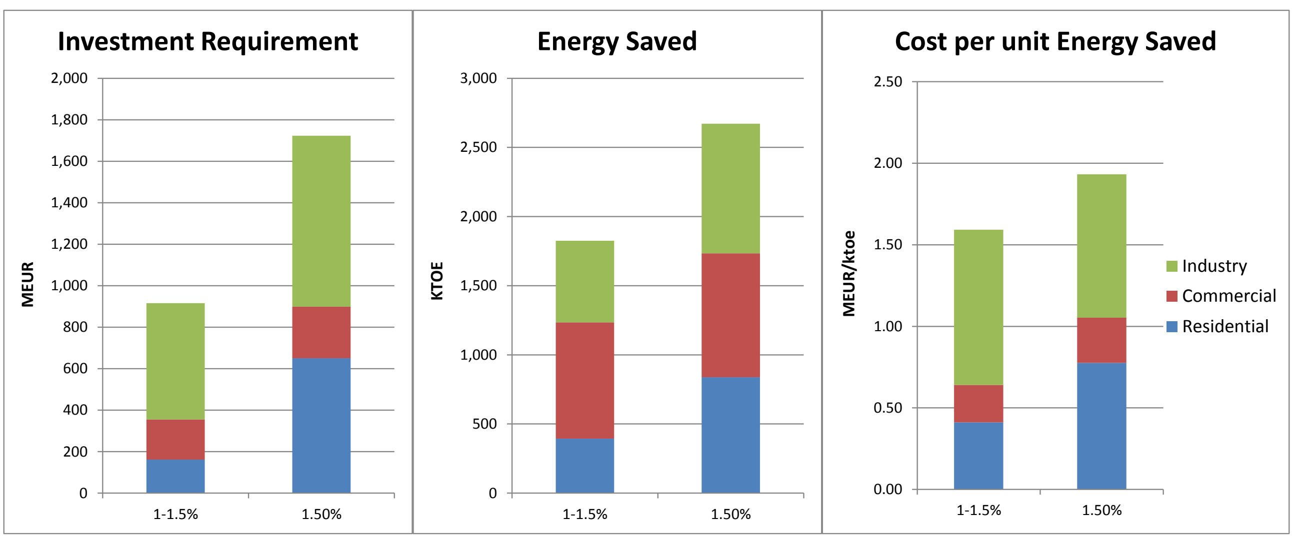



**Figure 20: Bosnia-Herzegovina - Supplier Obligation Key Results**

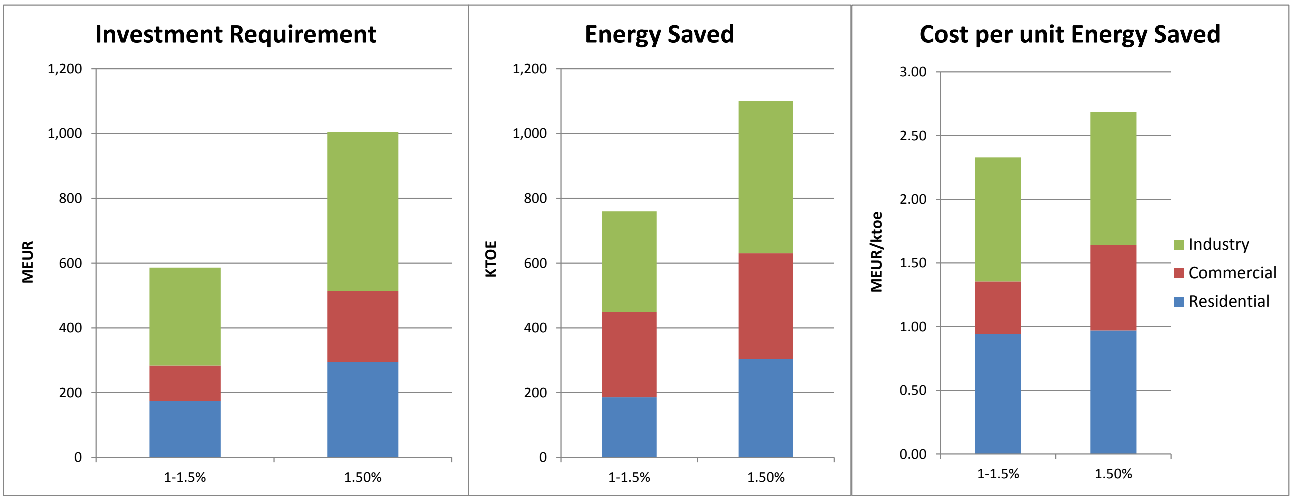



Figure 21: FYR Macedonia - Supplier Obligation Key Results

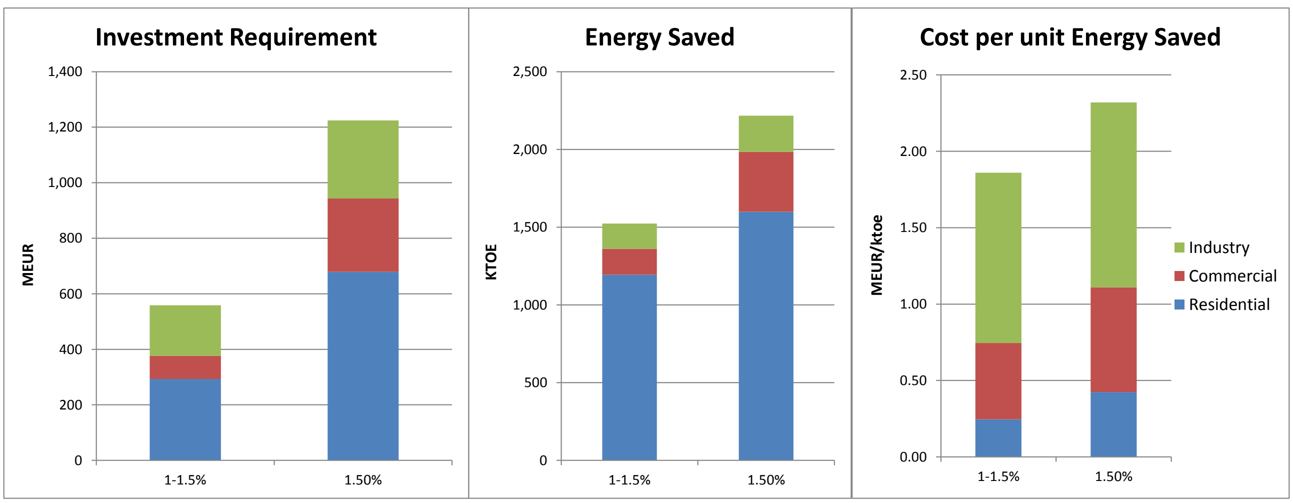



Figure 22: Moldova - Supplier Obligation Key Results

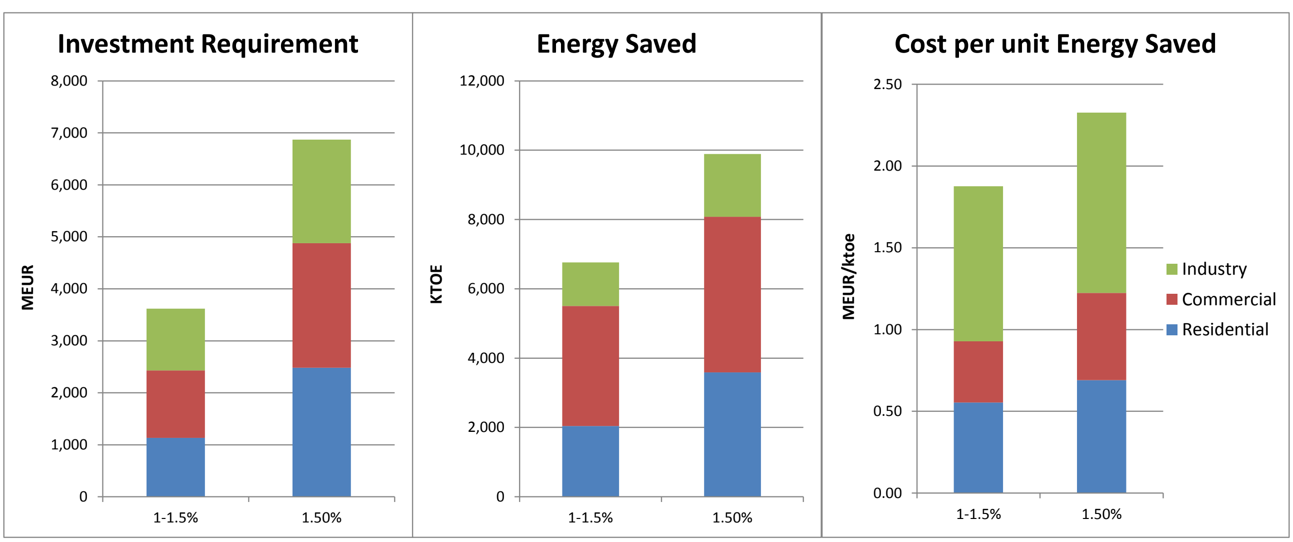



Figure 23: Serbia - Supplier Obligation Key Results

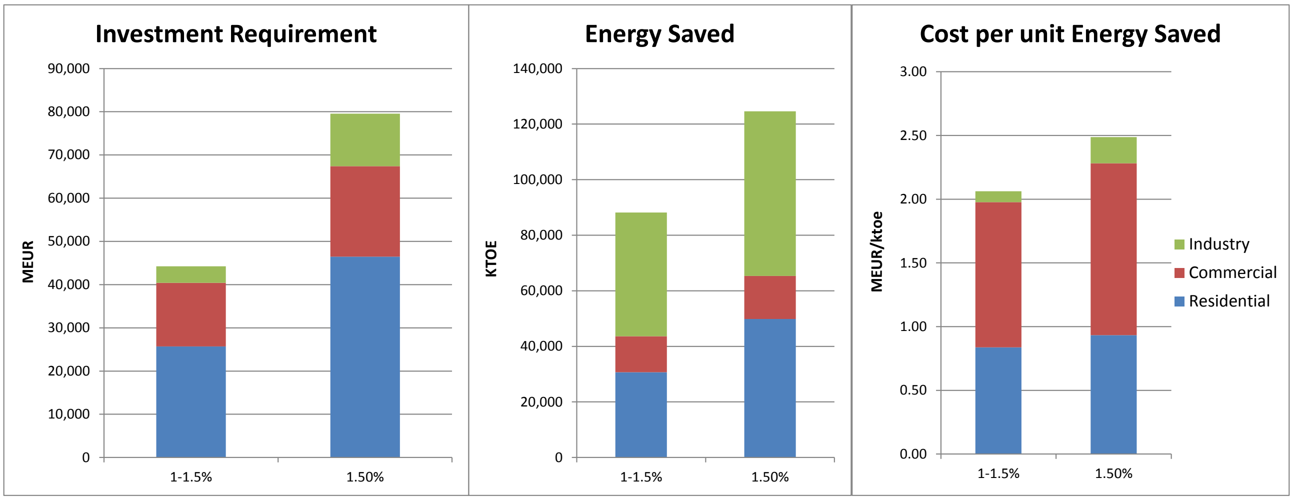



Figure 24: Ukraine - Supplier Obligation Key Results

## 5.3 Conclusions and Recommendation

### 5.3.1 Main Results

Based on these results, the incremental cost of adopting the 1.5% savings level increases the unit cost of compliance by on average about 25% (15% to 40% range), which is a reasonable amount given the increased savings achieved. In addition, it is important to place this obligation into perspective next to the overall EE target of Article 2, which will require much greater energy savings, of which the supplier obligation savings are but a part. Looked at in this light, there is no real incremental cost to the country of adopting the 1.5% versus 1-1.5% scenario. In addition, many of these obligated savings can come from the more cost-effective measures identified in detail in the EE Targets section of this report, whether specific suppliers/distributors are obligated to achieve them, or if the government takes some or the entire obligation under alternative measures. ***Therefore, we recommend the ECS adopt the 1.5% savings level for the CP supplier obligation.***

This recommendation also allows any of the CPs to utilize Article 7, para 2. of the Directive, which allows them to replace up to 25% of their cumulative obligated savings with other measures, such as excluding industrial activities that are covered under the EU Emissions Trading Scheme, or include savings achieved in the energy transformation, distribution and transmission sectors, including efficient district heating and cooling infrastructure. Because any exceptions to the mandatory target cannot exceed more than 25% of the required energy savings, the ability to use these other measures would be consumed by the lower target level. These other measures were not included explicitly in this analysis, and would lessen the cost of meeting the supplier obligation. Indeed, as Figure 25 shows, the incremental cost for the supplier obligation measures alone (in absence of the larger EE target) would largely be cost-effective in the early periods, with fuel savings outweighing investment costs through about 2024.

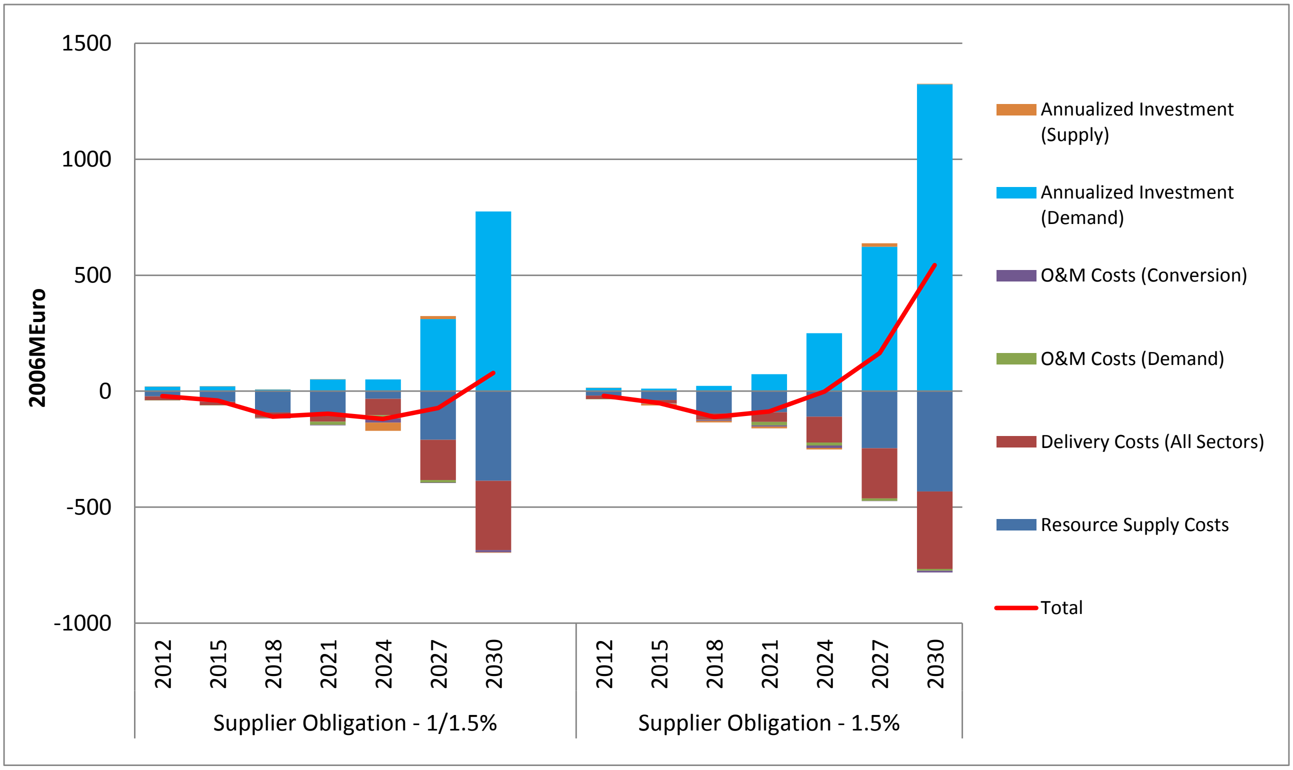



Figure 25: Components of the change in System Cost - Supplier Obligation for Serbia

### 5.3.2 Additional Sensitivity Run

At the EECG workshop, the question was raised as to whether the EEO target 1.25% could be adopted with the additional allowance that up to 25% of the targeted savings could come from supply –side measures. A sensitivity run was made of a 1.25% EEO between 2015 and 2025, which increased to 1.5% from 2026 to 2030. As shown in the example below for Serbia (Figure 26), the amount of energy saved for the 1.25% case is midway between the other two cases, but the investment cost increase from the 1-1.5% case is only 34% compared to 90% for the 1.5% case. As a result, the cost per unit of energy saved increases by only 6% compared to 24% in the 1.5% case. These results are typical of the other CPs, and this options appears to be a cost-effective target level for the EEO.

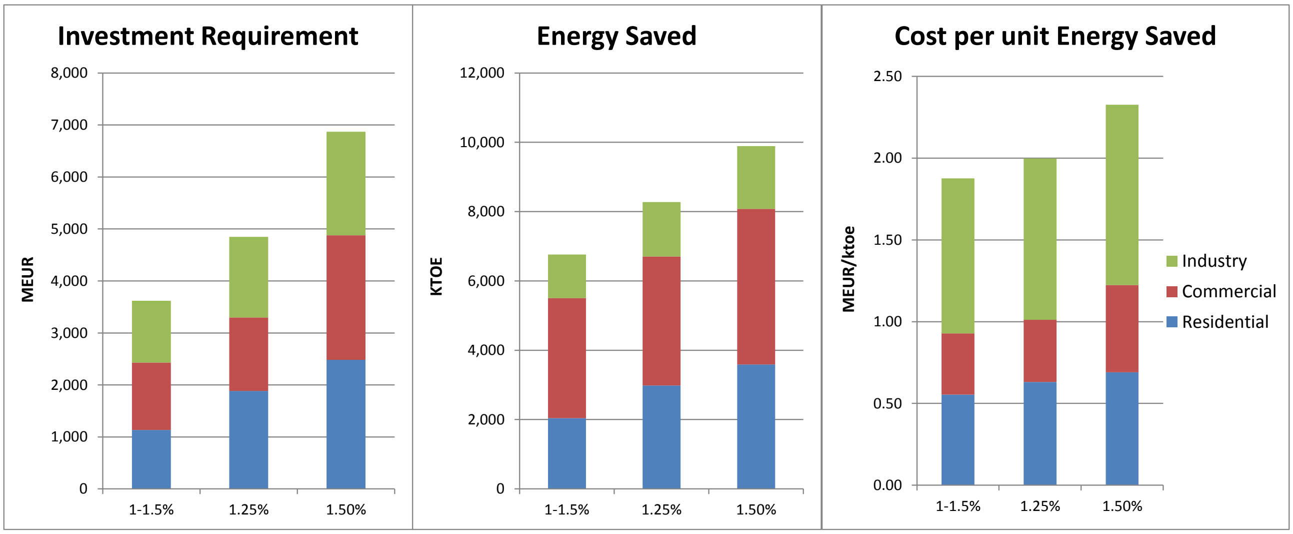



**Figure 26: Components of the change in System Cost - Supplier Obligation for Serbia**

## 5.4 Discussion of Implementation Options

In essence, Article 7: Energy Efficiency Obligation Schemes is a requirement that specific identifiable, programs are implemented to help meet the overall requirements of the Directive. It specifies an obligatory energy savings amount, but provides great flexibility in how the obligation will be achieved. Each of the CPs can use this flexibility, their local knowledge and some of the information in this report to craft a country-specific program.

### 5.4.1 Current EU Experience and Lessons Learned

Before the CPs begin to develop their own strategy and plan for implementation of the Energy Efficiency Obligations, it is beneficial to learn from the current developments in the EU. Below we have provided a review of the most important experiences, which were derived from the first reports submitted by the Member States in compliance with requests of the EED. The requirements of EED turned out to be difficult to reach for many Member States. Only one country - Denmark - has fulfilled all of the requirements without any concerns expressed by the evaluators. Many Member States have not credibly demonstrated how they will achieve new savings equivalent to 1.5% per year.

The reports vary in terms of scope, level of detail and quality. Almost half the reports do not comply fully with the requirements outlined in Article 7 and Annex V of the EED. Only Denmark, Croatia and Ireland provided plans which demonstrate in a credible way in which the target can be reached. But their plans include potentially non-eligible measures, which could lead to missing the target.

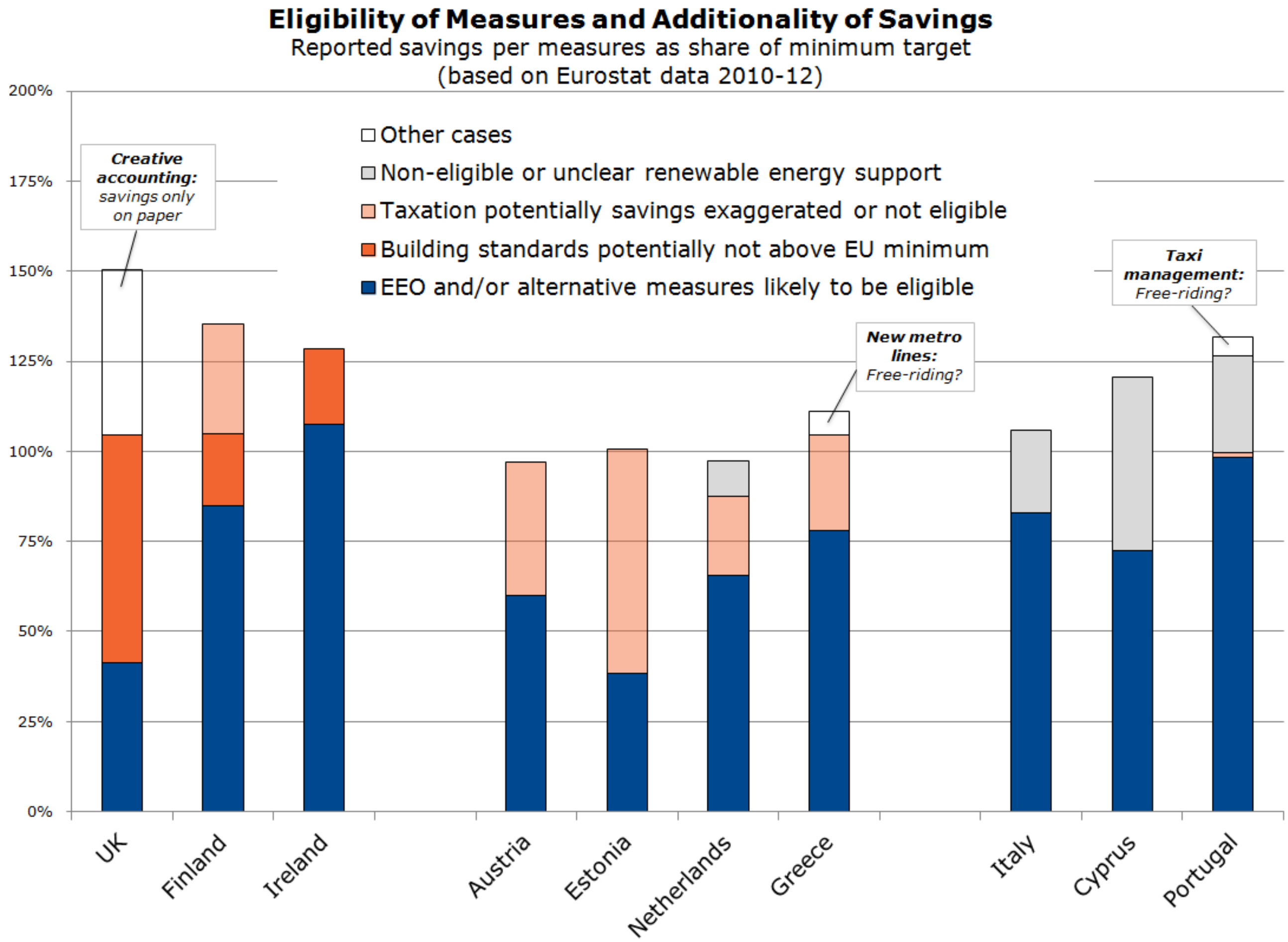
For several Member States, the reported target values deviate in some cases significantly from the Eurostat based data. For example, in the case of Finland and Czech Republic calculations are incorrect leading to a lower baseline and target than required. Several Member States report savings below the minimum expected (Austria, Belgium, Cyprus and Estonia) for unclear reasons. However, most Member States report a minimum savings target above what is expected from Eurostat data.

*Almost all countries make the maximum use of possible exemptions.* In reality, the level of obligated savings could be around 0.8% annually instead of 1.5%. Except for Sweden and those with insufficient information (Romania and Hungary), all countries excluded transport from the baseline, though most plan to achieve significant savings in this sector. Also apart from Denmark, Sweden and those with insufficient information (Romania and Hungary), all countries made use of exemptions to further reduce the target by a maximum of 25%.

The result is that almost two thirds of the EU Member States have an Energy Efficiency Obligation (EEO). The rest decided to switch fully to alternative options. In fact, EEOs are becoming more common in the EU, where 16 Member States have or plan to introduce an EEO. This is a doubling of the number of EEOs in the EU. EEOs must be viewed by Member States as successful instruments, since none of the countries that already had an EEO in place plan to abolish the system. In addition there are Member States (such as the Czech Republic, Croatia and Estonia) that are considering establishing an EEO. There is a large diversity in the set-up of EEOs, as well as in the level of detail in the description of the EEO. Of the 16 EEOs to be in place, only four will deliver 100% of the obligated energy savings. The remaining 12 will deliver between 20 and 90% of the target. Almost all countries put the obligation on either the energy distributors or the energy suppliers, and the mix is evenly divided over the countries. In a few countries, both are obliged.

Another finding is that special attention should be provided to the eligibility of proposed measures. For those Member States that reported specific measures, all have included some non-eligible measures and/or non-additional savings in their EEOs. (The reports of Bulgaria, Czech Republic, Hungary, Lithuania, Romania and Slovenia do not include a description of measures and thus we cannot say whether measures are eligible.) Most Member States use diverse tax and VAT provisions, although it is clear that the main objective of these is not energy efficiency. Other common non-eligible measures are actions that are not above the baseline of EU regulation; these can be found mainly in the buildings sector. A third category consists of policy measures promoting both energy efficiency and renewable energy.

Figure 27 illustrates the difficulties that Member States have had with the eligibility and additionality of their EEO measures. Only dark blue columns fully comply with the directive. On other hand, we should see a convergence of energy efficiency policies and greater shared learning from one another’s best practices. The doubling of the countries that will have an EEO is a very positive sign, now the majority of countries will have an EEO. This is an important reason CPs should prepare a simile strategy for future.




*Source: The Coalition of Energy Savings, 2014*

**Figure 27: Eligibility and Additionally of EU Member State Energy Efficiency Obligation Programs**

### 5.4.2 Recommendations to CPs with Respect to EEO Programs

As presented above, the EEO is quite a demanding task for Member States of the EU. That is why the CPs should be very prudent in the transposition of Article 7 and consider careful each step before its implementation. In spite of the fact that general advice can be a risky proposition, in this case we have afforded to sketch a direction to consider.

1. As energy sectors in the CPs are not yet stabilized and will continue to go through changes, we do not recommend putting additional difficult tasks on utilities and energy companies. Implementation of Article 7 should begin with alternative approaches implemented by the governments in compliance with the paragraph 6 of Article 7. Each CPs should design specific policy measures to support the EEO program design. For example, they can cover part of the costs through introduction of energy tax or $CO_2$ tax, which is allowed in paragraph 9a) of Article 7.
2. Later on governments should diversify energy saving activities and combine the alternative approach with an energy efficiency obligation imposed on designated parties. Energy distributors and/or retail energy sales companies should take over a certain part of the target. Based on actual

results up to that time, the governments should calculate the portion of the obligation the qualified suppliers will be required to deliver in order to meet any remaining gap.

3. It is highly recommended to Include para 2. Other measures in the design of the EEO namely paragraph 2 c, which includes also energy efficiency measures on supply side.

### 5.4.3 Estimate of Administrative Costs

The administrative cost of an energy efficiency obligation program can be estimated as was done for the EE target programs, in the following two parts:

1. Administrative costs: those incurred by the organizer of the program, such as the state, and
2. Transaction costs: those incurred by an applicant for the preparation and approval process of its project.

Table 16 provides estimates of the administrative costs for supplier obligation programs based on the same energy efficiency program costs identified in Table 9 and an adminsistrative cost ratio of 4% of the investment subsidy. For this analysis, each CP was assumed to develop and administer a variety of public and private sector programs to cover a 50% subsidy level, and an annual average investment level was derived from the cumulative investment required over the 2015 to 2030 period. A 3% administrative costs ratio was assumed for Albania due to the higher average investment cost per measure, and 3% for Ukraine, where the significantly larger program size should offer some economies of scale.

**Table 16: Estimates of Supplier Obligation Program Costs (Million EUR - undiscounted)**

| Country | Average Annual Investment Requirement | Average Annual Investment Subsidy | Administrative Cost |
|---|---|---|---|
| Albania | 56 | 28 | 0.8 |
| BiH | 96 | 48 | 1.9 |
| FYR Macedonia | 56 | 28 | 1.1 |
| Moldova | 68 | 34 | 1.4 |
| Kosovo* | 18 | 9 | 0.4 |
| Montenegro | 14 | 7 | 0.3 |
| Serbia | 382 | 191 | 7.6 |
| Ukraine | 4,420 | 2,210 | 66.3 |

# 6. Task 4 - Promotion of Efficiency in Heating and Cooling

## 6.1 Introduction

Article 14 of the EU Directive aims to promote the deployment of high-efficiency cogeneration and effective utilization of waste heat. It requires Member States ensure that cost-benefit analysis for each installation of the new equipment or reconstruction, which has an input power of more than 20 MW, are carried out. The cost-benefit analysis is to review all feasible alternatives that enable installation of high-efficiency technologies. Further, Member States should foster construction of the installations recommended by the analyses.

The objective of this Task is to perform an analysis of the impact of setting a higher threshold of total thermal input (50MW compared to 20MW in the directive) of energy technologies for which a costs-benefit analysis must be undertaken to assess the potential for the application of high-efficiency cogeneration.

The first reading of the requirements of the Directive leads to the impression that the only way to meet the requirements of the Article 14 is to build each high-efficiency cogeneration for which its cost-benefit analysis results in a positive NPV (net present value). However, the directive leaves some discretion to decide for Member States. While the requirement to perform the cost-benefit analysis is clear and very well specified in details, a similar obligation concerning construction is missing in the Directive. On one hand, some general wording may provide a background for the governments, which want to introduce compulsory construction of all economically meaningful cogeneration units into a national legislation. On other hand, the wording of the Directive also allows the interpretation that governments are not responsible for bringing high-efficient co-generation into the implementation phase.

What do these requirements mean in practice? In principle, it is mainly to highlight the possibility of introducing high efficiency, modern technology, in cases where such a step will prove to be meaningful and economically beneficial. As an example we can assume a city with population of ten thousand people. If half of the apartments are connected to a district heating system, then a heat production boiler with 25MW of capacity should be sufficient.

If the owner of this 25MW boiler decides to renovate the boiler, the simplest way is to exchange the old boiler for the new one without having considered other options. The Directive does not allow such an easy approach. The Directive requires that in such a case the owner has also to consider other options. The owner must conduct a cost-benefit analysis. It may show that combined heat and power (CHP) generation would be feasible and profitable. However, the Directive does not require investor to choose the most efficient variant but rather to make the investor acquainted with all variants and their economic parameters. The owner might have valid reasons for not proceeding with the CHP option. For example, the combined production option may require significantly more investment, which the owner does not have, even in larger investment has an attractive pay back due to higher revenue. On the other hand, the owner might go for additional financing to afford the large investment if the return on investment is sufficiently attractive.

This example also gives a sense of the scale of systems that will be affected. The number of systems with an input power of 20MW or higher will vary according to the country. Boilers of this size, for instance, appear in middle-sized and large industrial companies and middle-sized and large cities with district heating infrastructure. In addition almost all power plants using fossil fuel exceed this power level.

If we increase the threshold from 20MW to 50MW the number of installations will decrease significantly, roughly ten times. It would then apply mainly to the power sector, some large industrial plants and a few large cities.

In order to answer the question of increased threshold of total thermal input, we have divided our explanation into three subchapters as follows:

1. Obligations resulting from the Article 14 of the Directive and its implementation;
2. Assessment of costs related to the Article 14, which is based on the way of implementation explained in previous subchapter, and
3. Conclusions and recommendations.

## 6.2 Obligations Resulting from the Article 14

EU Member States shall ensure that a cost-benefit analysis is carried out when:

- a new thermal electricity generation installation with a total thermal input exceeding 20 MW is planned;
- an existing thermal electricity generation installation with a total thermal input exceeding 20 MW is substantially refurbished;
- an industrial installation with a total thermal input exceeding 20 MW generating waste heat is planned or substantially refurbished, and
- a new district heating and cooling network is planned or in an existing district heating or cooling network substantially refurbished with an installation with a total thermal input exceeding 20 MW.

Part 1 the Annex IX of the Directive describes the “General principles of the cost-benefit analysis”. Part 2 of the Annex is titled “Principles of the purpose of Article 14 (5) and (7)”. It stipulates that “Member States shall set guiding principles for the methodology, assumptions and time horizon for the economic analysis” This wording enables to Member States to introduce all safety requirements in the analysis (including risk analysis) and ensure that all outputs of the cost-benefit analysis are reliable and not misleading for businesses.

Further, paragraph 7 of Article 14 requires that “ Member States shall adopt authorization criteria as referred to in Article 7 of Directive 2009/72/EC, or equivalent permit criteria, to:

(a) take into account the outcome of the comprehensive assessment referred to in paragraph 1;

(b) ensure that the requirements of paragraph 5 are fulfilled, and

(c) take into account the outcome of cost-benefit analysis referred to in paragraph 5.”

Points (a) and (b) can easily be achieved by including cost-benefit analysis among the mandatory requirements for a building permit for respective projects. Point (c) can be fulfilled in several ways, either to foster construction of energy-efficient cogeneration (in case NPV is high enough) or just ensure the investor reflects the outcome of the analysis.

The Directive itself does not provide any strict command for the developer, which may be intending to invest hundreds of millions of Euros in the energy sector. The intention of the process is to ensure that high-efficient cogeneration options that may be useful and profitable projects are evaluated. The assumption is that clever investors should follow the more cost-effective approach. However, the final decision and project risks stay with the investor. Governments need only ensure the investor has carried out a detailed and well elaborated cost-benefit analysis and considered all the outcomes. In order to fulfill point (c) a governmental organization (e.g. construction office) can ask for explanation in case a profitable efficient technology is not included in the final project submitted for authorization or approval. This is how the government can ensure the outcome of cost-benefit analysis has been taken into account. The government is not required to ask for a different project design from the one submitted as long as the investor explains his reasons why.

## 6.3 Assessment of the Costs Related to Article 14 and Paragraphs 5 and 7

In response to the explanation presented above, we can assess the total cost of the implementation of the obligations associated with paragraphs 5 and 7 of Article 14. The costs consist of an investors' part and a governmental part.

The government part will be generated by activities of the governmental bodies, which will need to prepare a new legislation and rules for carrying out cost-benefit analysis (initial costs) and ensure proper and continuous administration of the process through the permanent activity of certain number of trained officials (administrative costs).

The costs for the investor will consist of the payment for elaboration of the cost-benefit analysis and a certain amount of time and effort for negotiation with the respective governmental body (i.e. with construction officer or authorization officer). In case the analyses fulfill its goal and brings a significant improvement to the project, as well as increasing profit of the project, investors' costs of the analysis become negligible when compared to the additional benefit.

For example, we assume a country with population about 10 million. An average cost for providing one cost-benefit analysis is € 20,000. Presumed number of cases a year depends on a number of sources in the country. For a country with a population of 10 million people, we can assume a number of sources above 20 MW in the range between 500 and 1,000. It may generate up to 100 new constructions and/or reconstruction projects a year. Based on these assumptions we have generated the following calculation of the overall costs below.

| Project size: 20 MW+ | Government cost | Investor cost | Total |
|---|---|---|---|
| Initial costs | € 30,000 | 0 | € 30,000 |
| Annual administrative costs | € 20,000 | € 2,000,000 | € 2,020,000 |

When we raise the level of thermal input from 20 MW to 50 MW, the number of projects which are subject to the legislation decreases by about 90%. But the average cost of a cost-benefit analysis is twice as high because large projects are more complex and expensive. Since the purpose of the Article 14 is to find new opportunities for high-efficiency cogeneration as a profitable business, in our opinion, the number of real opportunities will be very low in the 50 MW variant considered below.

The decline in opportunities when increasing the limit up to 50 MW appears due to two reasons. First, there is a significant decrease of number of projects that will comply with the legislation – it is easy to understand. The second reason is that the projects between 20MW and 50MW provide usually more opportunities for the introduction of high-efficient cogeneration.

Large energy sources, such as power plants, are usually not situated in a highly populated area and therefore the size of a cogeneration unit is restricted by low heat consumption. Opportunities exist largely in district heating systems in medium to large cities. Many of these systems that are powered by boiler houses over 50MW have often been designed with electricity production in the past. The conversion of an old cogeneration plant for a new more efficient one yields much less savings in comparison to construction of a new cogeneration unit where only heat was generated previously.

District heating systems in cities with population less than 100,000, which are most common in EnC member countries, consist of boiler houses mostly below 50MW, sometimes even below 20MW. These sources often represent a suitable target for combined heat and electricity production because in the past such small sources were not considered practical for electricity production.

Increasing the thermal input threshold from 20 MW to 50 MW leads to the cost stated below.

| **Project size: 50 MW+** | **Government cost** | **Investor cost** | **Total** |
|---|---|---|---|
| Initial costs | € 30,000 | 0 | € 30,000 |
| Annual administrative costs | € 2,000 | € 400,000 | € 402,000 |

If we compare the government expenditures, the difference between project sizes of 20 MW+ and 50 MW+ is really small, less than € 20,000. For investors, the level of expenditures drops substantially, but this calculation does not account for the benefits that might accrue to the investors if the process leads to a more profitable project design.

For this report, we have not tried to calculation the increased profits to those investors who do decide on a high-efficiency cogeneration project, or the benefits that will accrue to the country, as a result of the new measures evoked by the Directive. Given the relatively small level of expenditures compared to the typical cost of even a 20 MW size project (approximately 0.1% increase in overall cost), we would expect that if only one such new decision a year is taken by investors, then the overall costs and benefits will be balanced in the country. Looked at from a national perspective, if all the costs and benefits are summed over the country, this article should be of interest to any government. In the case where a single €20 million CHP investment is considered profitable for an investor it should yield 10% (at least), i.e. € 2 million during the project lifetime. All investors and government pay together € 2,020,000 a year, so the costs and benefits are balanced in the country. If more projects appear in one year, the benefit to the country will be much higher than the cost.

## 6.4 Conclusion and Recommendation

Final recommendation for the most feasible way to the implementation of the Directive concerning the Article 14 is to introduce the whole process of carrying out of cost-benefit analysis and enable investors to decide about more expensive, but more profitable project if the analysis identifies such a possibility. The role of the government is to ensure that any investor understands and considers the outcome of the analysis. If desired, the government may provide various support measures (including financial contribution) to encourage the best solution in case it leads towards high-efficiency cogeneration. But the government should not enforce its implementation through a strict command in national legislation.

As for the threshold for carrying out the obligatory cost-benefit analyses, our calculation resulted in about one million euro a year which might be saved when the threshold is increased from 20 MW to 50 MW. But this calculation does not include all benefits, which will be generated from the projects using advanced energy technology. Our estimate is this profit will exceed all the costs if such a solution appears.

***Therefore, we do not recommend raising the threshold from 20 MW to 50 MW.*** When the lower threshold is kept the probability that investors find a profitable high-efficiency cogeneration will significantly increase. In long run, the number of the projects evaluated may be up to ten times higher with the 20MW threshold in comparison with the 50MW threshold. The expected benefits from construction of profitable high-efficiency cogeneration, based on a well-founded cost-benefit analysis, will outweigh all the costs and so the interest of governments should lead towards raising the number of such occurrences in the country.

# 7. Detailed Country Results

## 7.1 EE Target Scenario Details - Albania

This section provides a country-specific understanding of the impacts of the EE Target levels for Albania. The section examines the changes in Final Energy Consumption (FEC) and the related changes in end-use device purchases by sector and end-use application, industry subsector or transport mode. This section first provides the overall results for Albania by fuel type and demand sector and then examines the results for each sector in detail. No specific results for the Supplier Obligation scenario are provided because the measures implemented are the same as those identified as most relevant to this scenario.

### 7.1.1 System Cost Impacts

Figure 28 shows that the total discounted system cost increases by 8% over the Reference Benchmark case for the EE Target 18-25% case of 18% in 2025 and 25% in 2030. In the EE Target 19-27% case, the incremental cost goes to 12.2%, while turning to more costly measures, and the EE Target 20-30% case results in jump of 59.5% based on the need to resort to even more costly efficiency measures, as will be discussed.

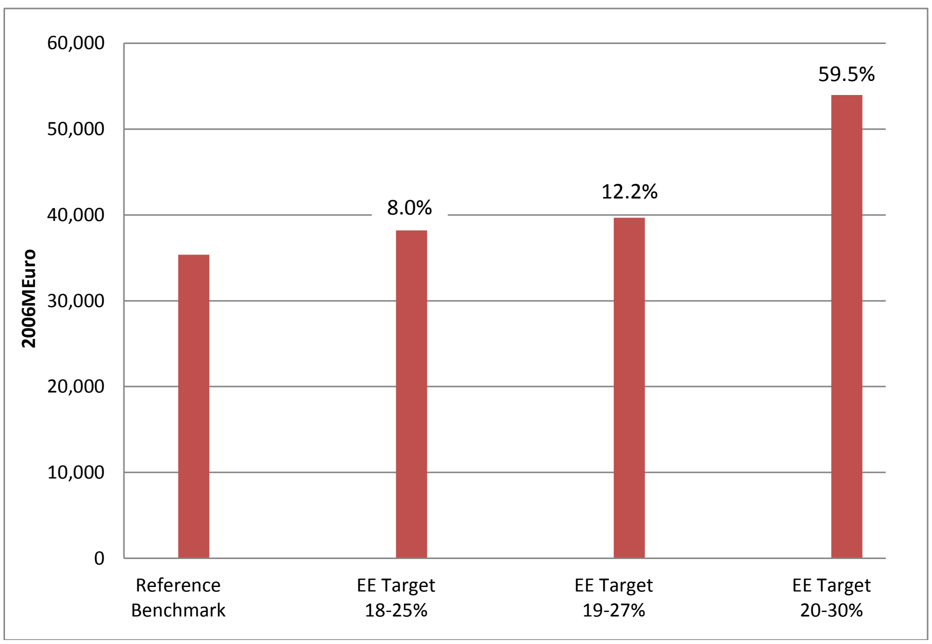



**Figure 28: Albania Total System Cost for Reference Benchmark and EE Target Scenarios**

In the sections that follow the trends for some key aspects of the national energy system evolution over the 20-year planning horizon are shown for these EE target scenarios against the Reference Benchmark.

### 7.1.2 Reductions in Final Energy Consumption

Figure 29 shows final energy consumption by fuel type, and illustrates that the major savings are achieved through reductions in the use of biomass, along with coal, gasoline, diesel as well as other oil products. The figure also illustrates that significant reductions are required in the 2021 to 2030 periods in all cases. It also shows that the reductions are similar in each of the scenarios. Figure 30 shows that these energy savings come primarily from reductions in residential sector as a result of improvements in space conditioning arising from a move to more efficient devices and improved building shells and transport sector from diesel reduction due the change in the more efficient vehicle types The sections that follow provide more details on a sectoral basis.

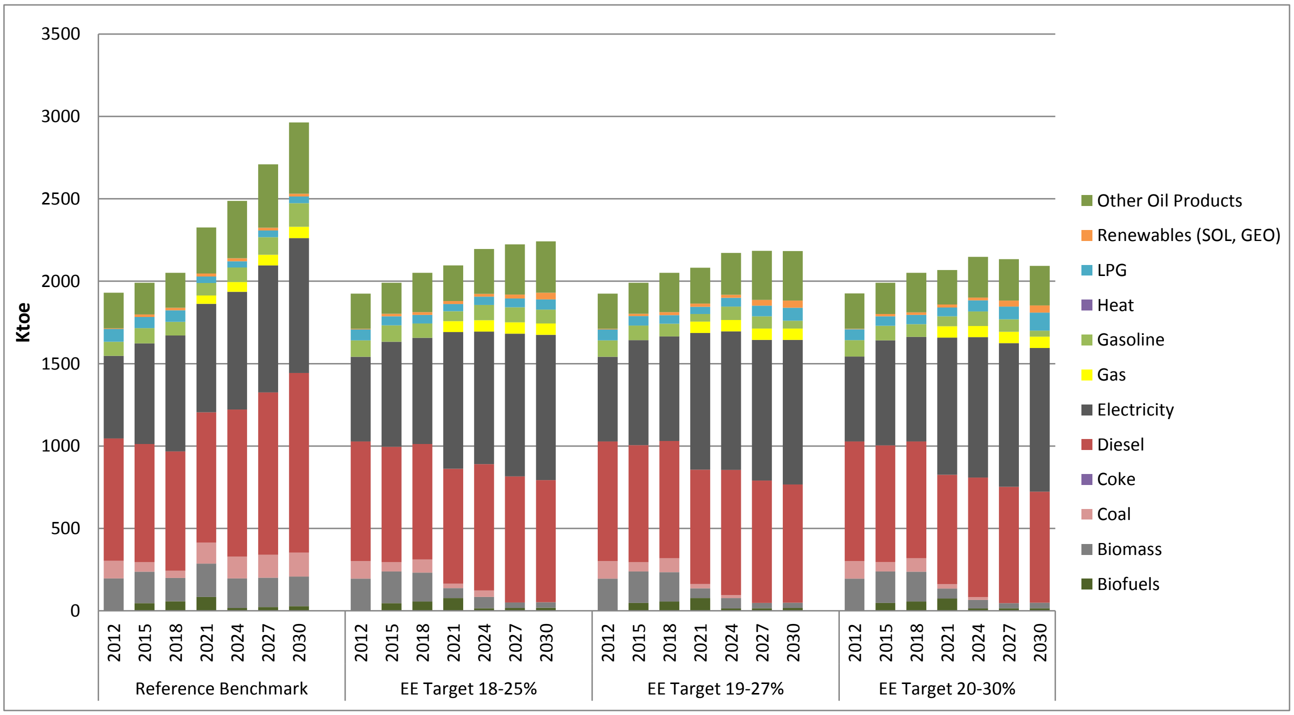



**Figure 29: Final Energy by Fuel Type for Reference Benchmark and EE Target Scenarios**

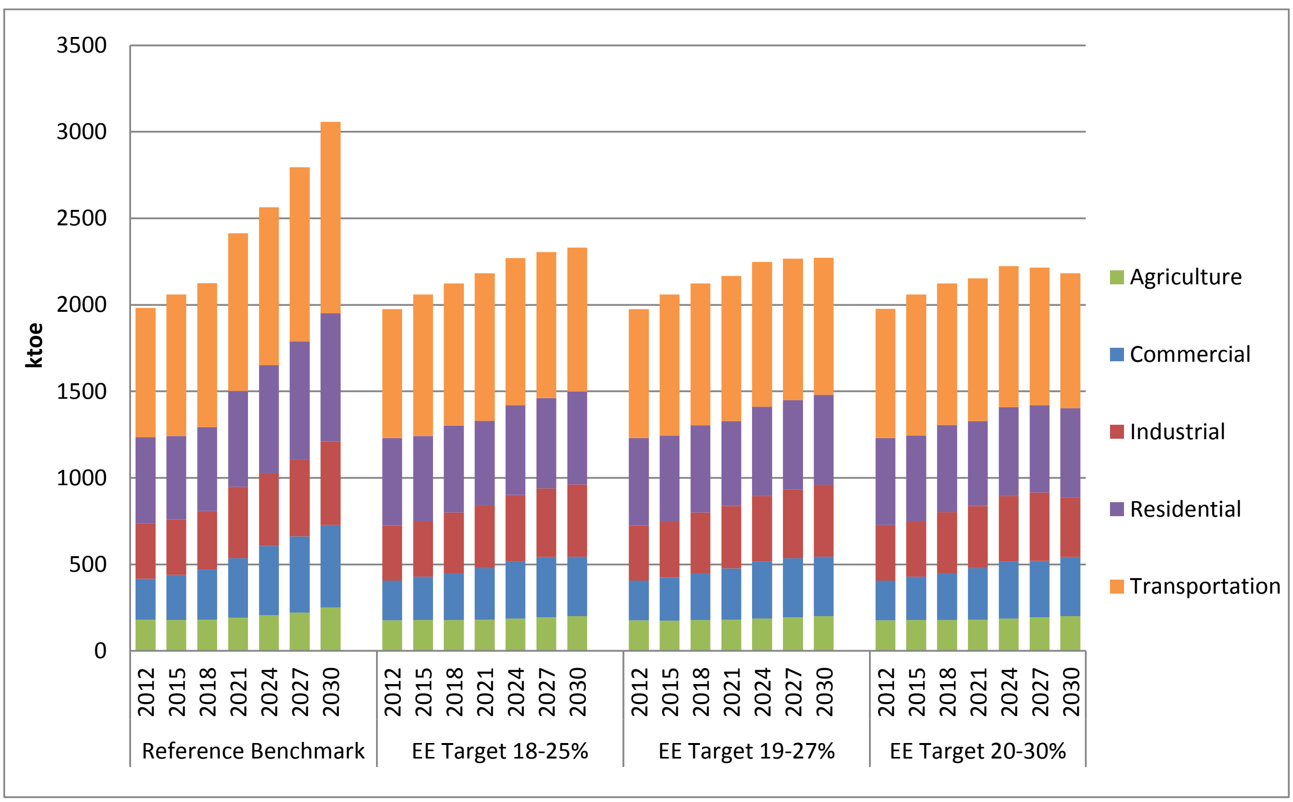



**Figure 30: Final Energy by Sector for Reference Benchmark and EE Target Scenarios**

### 7.1.3 Residential Sector Impacts

Figure 31 shows that achieving the EE targets in the residential sector requires significant reductions in final energy use for space heating with some savings for water heating. Lighting changes little as most lighting options are implemented in the Reference Benchmark case. It also shows that final energy use changes only slightly between the three target cases. Figure 32 shows that the investment needed to achieve the increased savings in all the cases requires significant increases in the areas of space conditioning (heating and cooling) along with insulation, with contribution from other appliances necessary in 2030, particularly for the EE Target 20-30% case. This result points to the need for appliance standards and perhaps targeted rebate programs. Note that part of the increased expenditure in heating devices is for heat pumps and insulation, which serve both the heating and cooling demands.

Figure 33 shows that the investment per ktoe of energy saved does not increase much (around 20%) to meet the EE Target 19-27% case, and only 1.5% higher from there to reach the EE Target 20-30% case as low use devices such as dishwashers, clothes dryers and washing with higher costs save only a relatively small amount of energy.

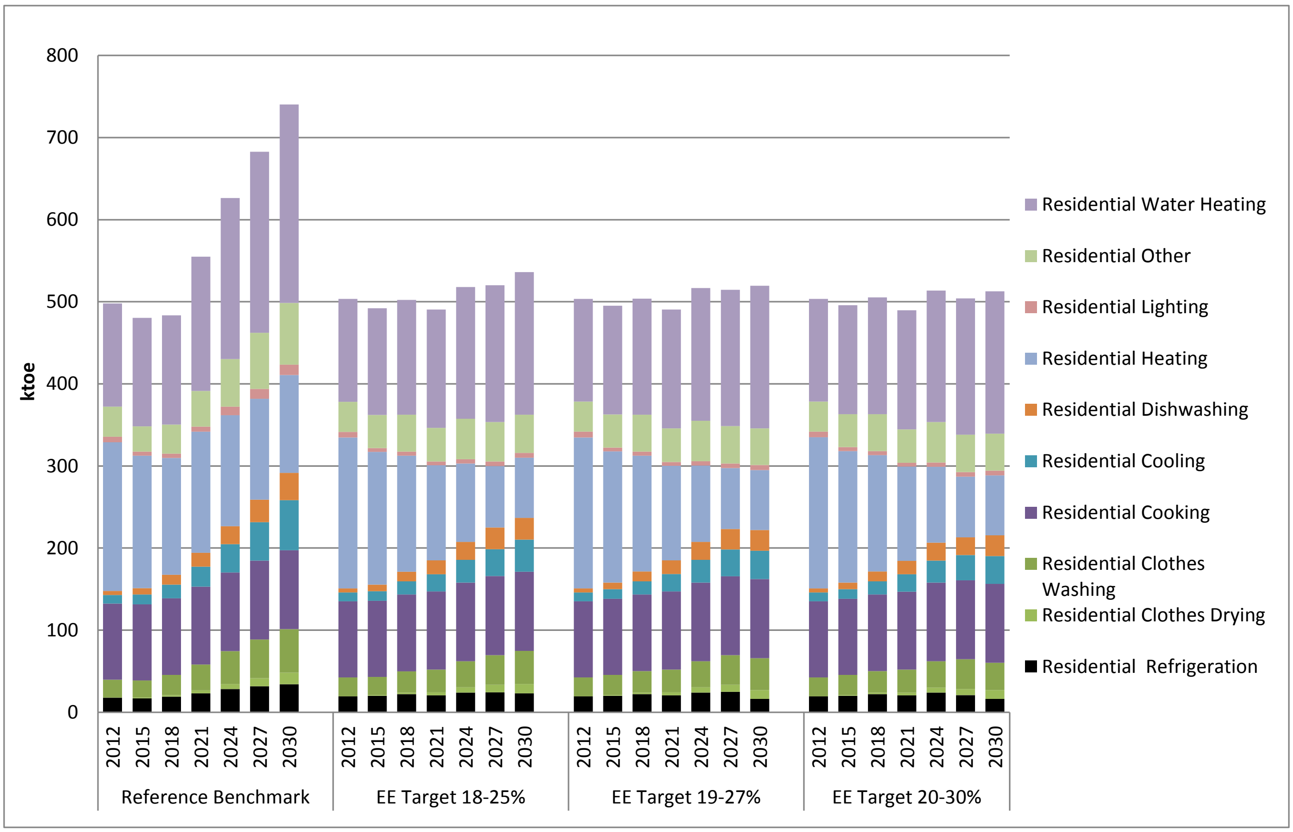



**Figure 31: Residential Energy use by Application for Reference Benchmark and EE Target Scenarios**

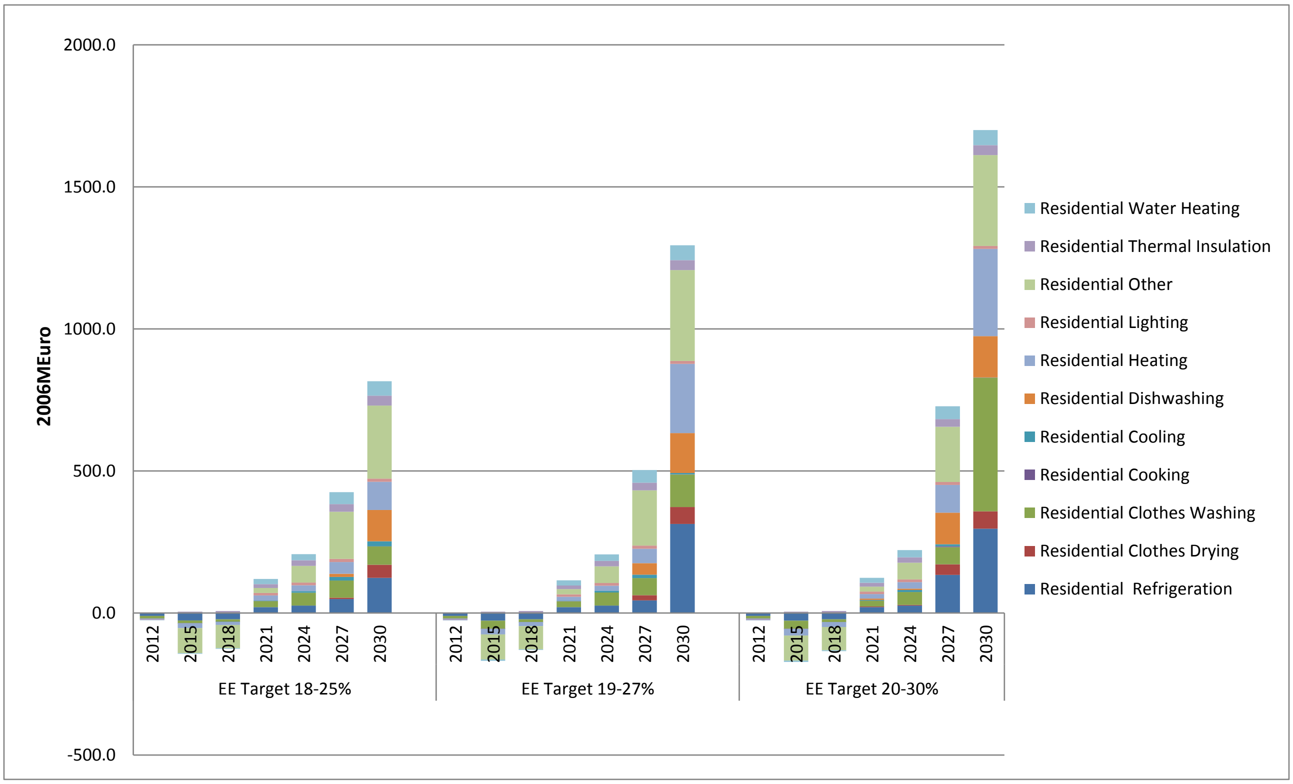



**Figure 32: Residential Investment by Application - Difference from Reference Benchmark**

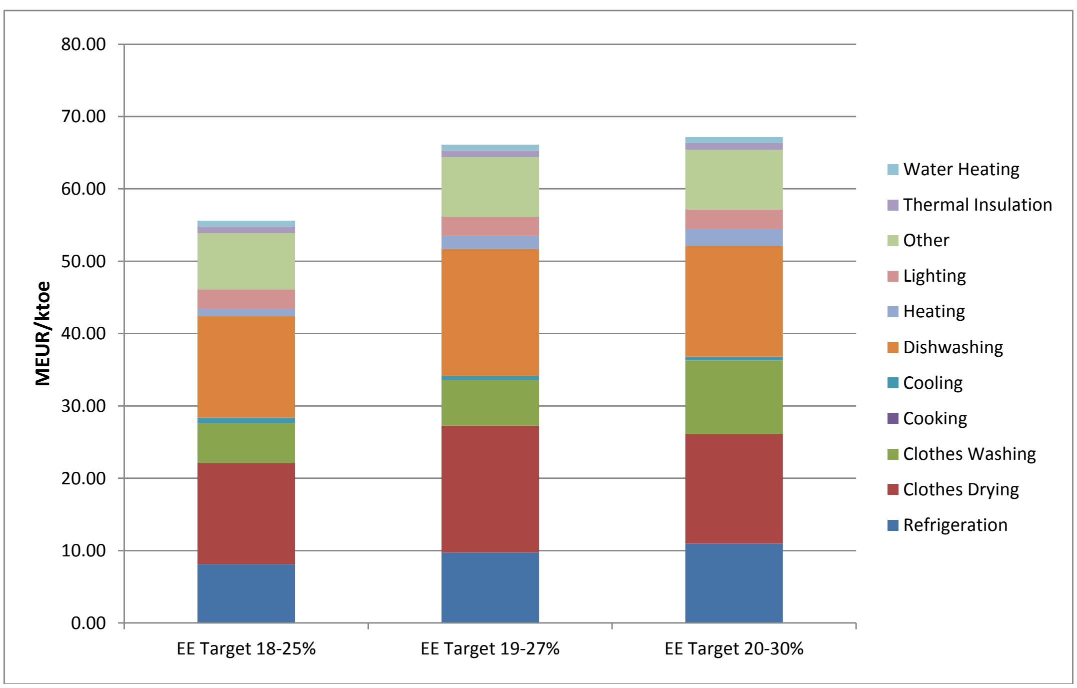



**Figure 33: Residential Device Investment per unit Energy Saved**

Table 17 presents the change in expenditure divided by the change in energy saved from the Reference Benchmark as a measure of cost-effectiveness of actions for each energy service. It shows that high efficiency space cooling and heating are extremely important, with water heaters and thermal insulation following as the most cost-effective measures to pursue in the residential sector. Note that investments in thermal insulation reduce heating and cooling demands and the investments in building insulation allows a slightly lower investment in cooling devices. Heat pump technology and the value of residential building insulation are clearly priority areas for incentives as identified from these results.

**Table 17: Residential Investment per unit Energy Saved (MEUR/ktoe)**

| Energy Service | EE Target 18-25% | EE Target 19-27% | EE Target 20-30% |
|---|---|---|---|
| Refrigeration | 8.14 | 9.73 | 10.96 |
| Clothes Drying | 13.99 | 17.56 | 15.18 |
| Clothes Washing | 5.52 | 6.25 | 10.17 |
| Cooling | 0.73 | 0.62 | 0.50 |
| Dishwashing | 14.03 | 17.53 | 15.28 |
| Heating | 1.04 | 1.80 | 2.43 |
| Lighting | 2.65 | 2.65 | 2.65 |
| Other | 7.78 | 8.24 | 8.24 |
| Thermal Insulation | 0.95 | 0.95 | 0.95 |
| Water Heating | 0.77 | 0.80 | 0.81 |

### 7.1.4 Commercial Sector Impacts

Figure 34 shows that achieving the EE targets in the commercial sector requires significant reductions in final energy use for space heating and space cooling, along with lighting. It also shows that final energy use changes only slightly between the three target cases, with some additional savings in space cooling and water heating in the final period, particularly in the most stringent reduction scenario.

Figure 35 shows that the investments required to achieve the savings in all of the EE Target cases require a significant shift to more efficient space cooling and heating devices, especially in the 2030 period, but also in the 2027 periods for the EE Target 19-27% and EE Target 20-30% cases. In all scenarios the increase in building insulation and move to heat pumps lowers somewhat the expenditure for cooling equipment in the 2021-2027 timeframe.

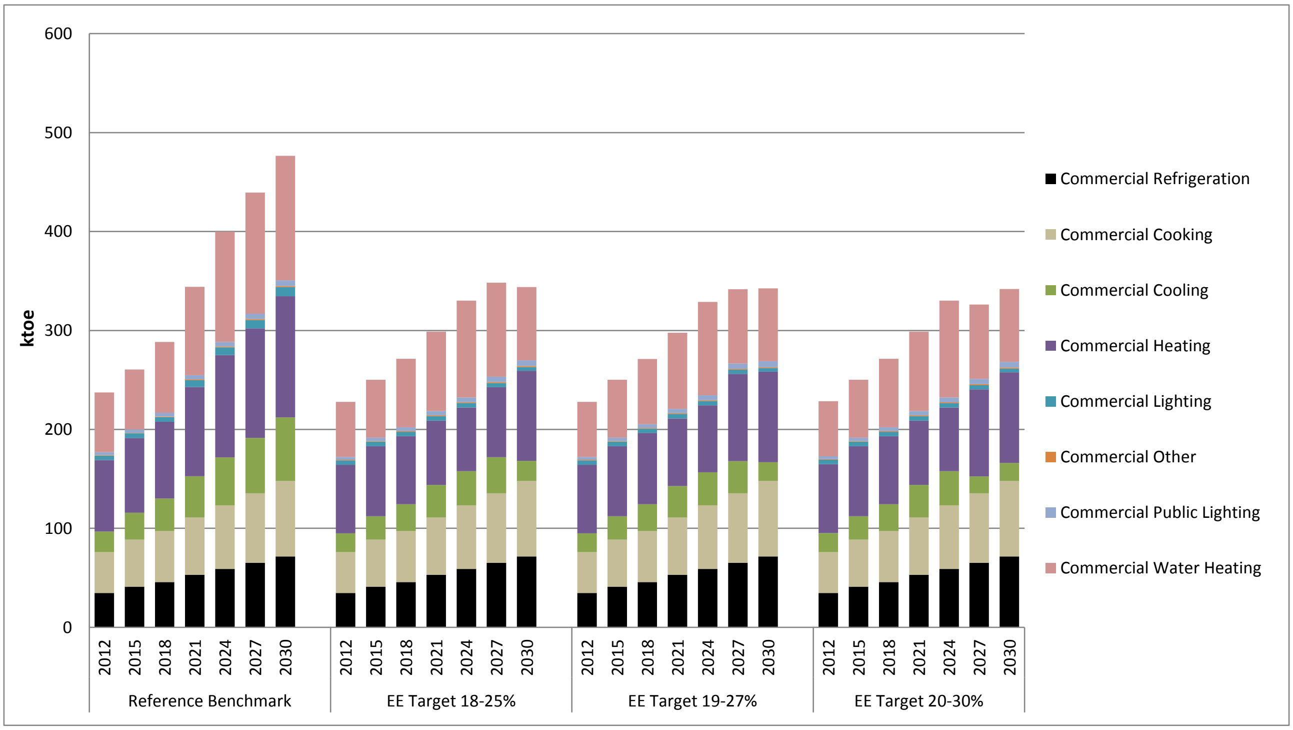



**Figure 34: Commercial Energy use by Application for Reference Benchmark and EE Target Scenarios**

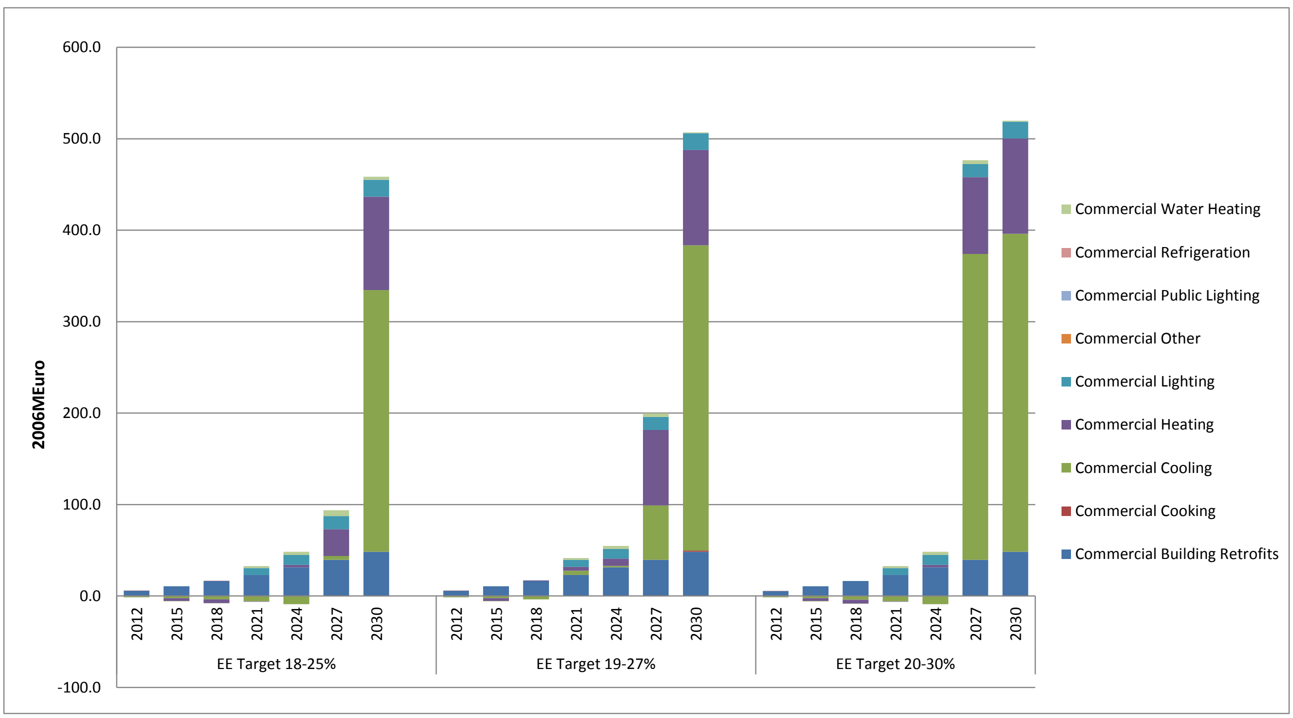



**Figure 35: Commercial Investment by Application – Difference for Reference Benchmark**

Table 18 shows that water heating is the most cost-effective types of investments. Space conditioning (heating and cooling) and building retrofits are also cost-effective, where the latter leads to savings in space heating and cooling device investments in this sector. Note that the building retrofits facilitate some reductions in cooling device investments. Commercial scale heat-pump technologies and commercial building retrofits are highlighted by these results for incentive programs.

**Table 18: Commercial Sector Investment per unit Energy Saved (MEUR/ktoe)**

| Energy Service | EE Target 18-25% | EE Target 19-27% | EE Target 20-30% |
|---|---|---|---|
| Building Retrofits | 0.49 | 0.49 | 0.49 |
| Cooling | 1.38 | 2.63 | 3.74 |
| Heating | 1.01 | 1.85 | 1.77 |
| Lighting | 3.37 | 3.37 | 3.37 |
| Water Heating | 0.20 | 0.11 | 0.16 |

### 7.1.5 Industry Sector Impacts

Figure 36 shows that achieving the EE target in the industrial sector requires significant reductions in final energy use from the non-metallic minerals, food and other subsectors. It also shows that final energy use in the industrial sector changes only slightly between the three target cases.

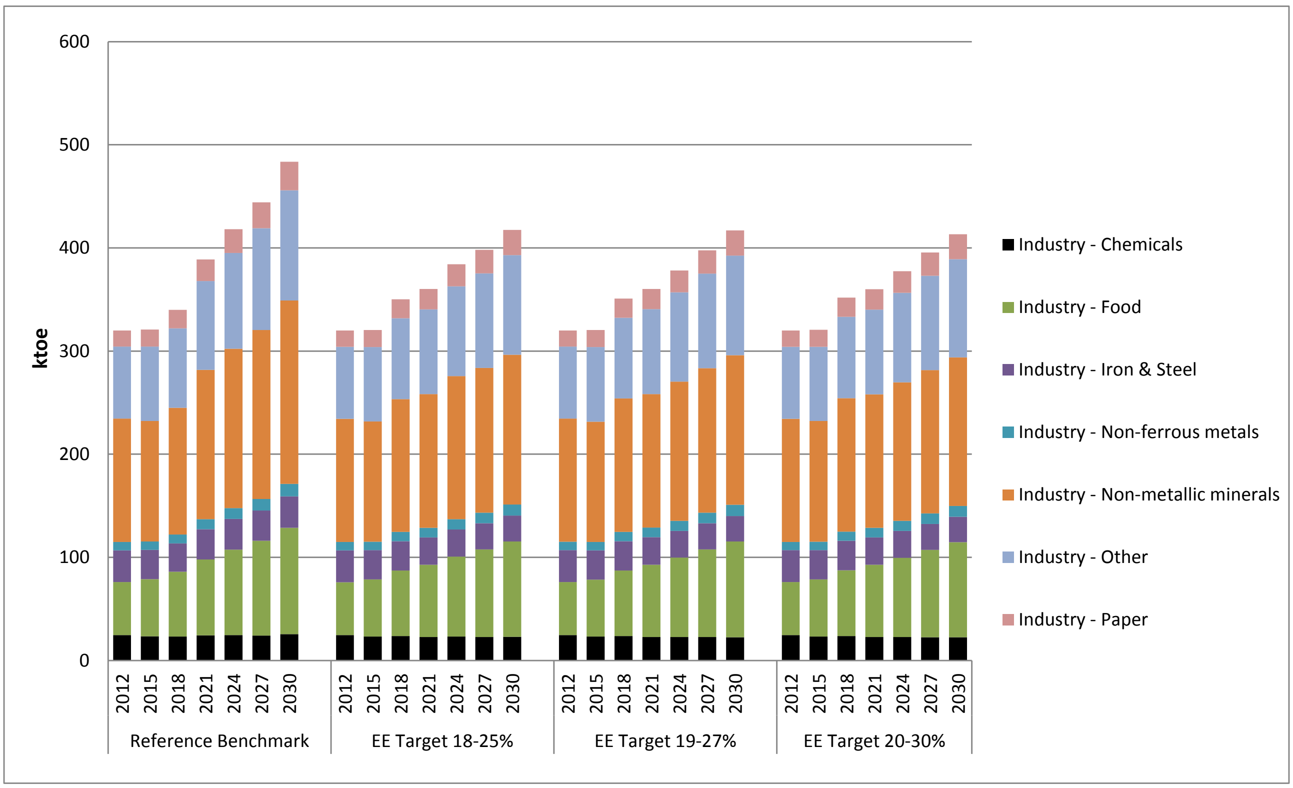



**Figure 36: Industrial Energy use by Application for Reference Benchmark and EE Target Scenarios**

Figure 37 shows that the investment required to achieve the EE target increases significantly in the 2030 period for all of the EE target cases, with around a 70% increase in expenditure needed to achieve the 2030 level in the 18-25 and 19-27 target cases and almost 200% in 20-30 EE target case.

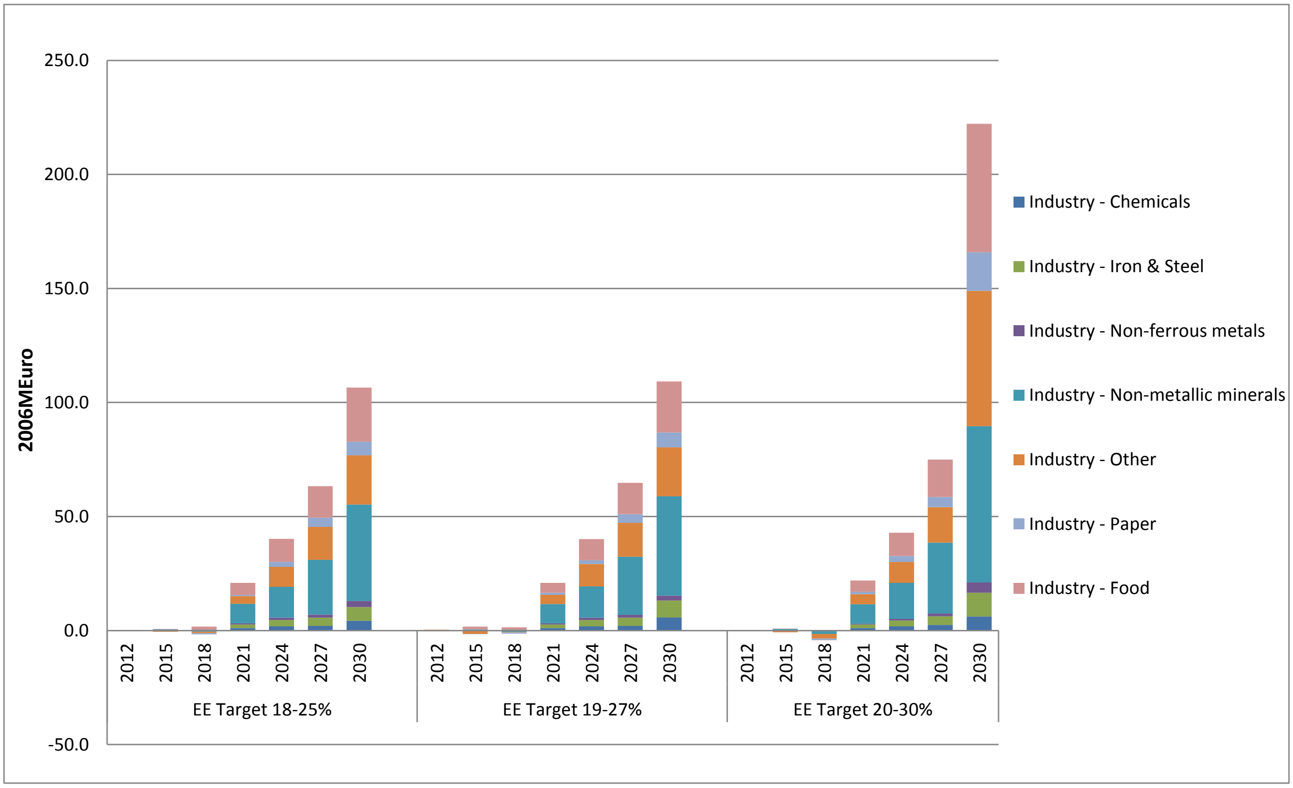



**Figure 37: Industrial Investment by Subsector – Difference from Reference Benchmark**

Table 19 shows that the investment per ktoe of energy saved is in general rather costly for all industry sub-sectors, with the most cost-effective efficiency investments occurring in the iron and steel, non-metallic minerals and chemical sub-sectors. It also indicates that unit costs increase only slightly across the scenarios.

**Table 19: Industrial Sector Investment per Energy Saved (MEUR/ktoe)**

| Energy Subsector | EE Target 18-25% | EE Target 19-27% | EE Target 20-30% |
|---|---|---|---|
| Chemicals | 1.22 | 1.21 | 1.28 |
| Food | 1.90 | 1.76 | 2.64 |
| Iron & Steel | 0.84 | 0.87 | 0.99 |
| Non-ferrous metals | 1.63 | 1.45 | 1.55 |
| Non-metallic minerals | 0.94 | 0.91 | 1.15 |
| Other | 1.64 | 1.70 | 2.46 |
| Paper | 1.32 | 1.30 | 2.14 |

### 7.1.6 Transport Sector Impacts

Figure 38 shows that achieving the EE target in the transportation sector primarily require reductions in final energy use for light duty vehicles, heavy trucks, with some contribution from buses and light commercial vehicles. It also shows that overall final energy use in 2030 is aggressively reduced in all cases, with dramatic reductions required in the EE Target 20-30% case.

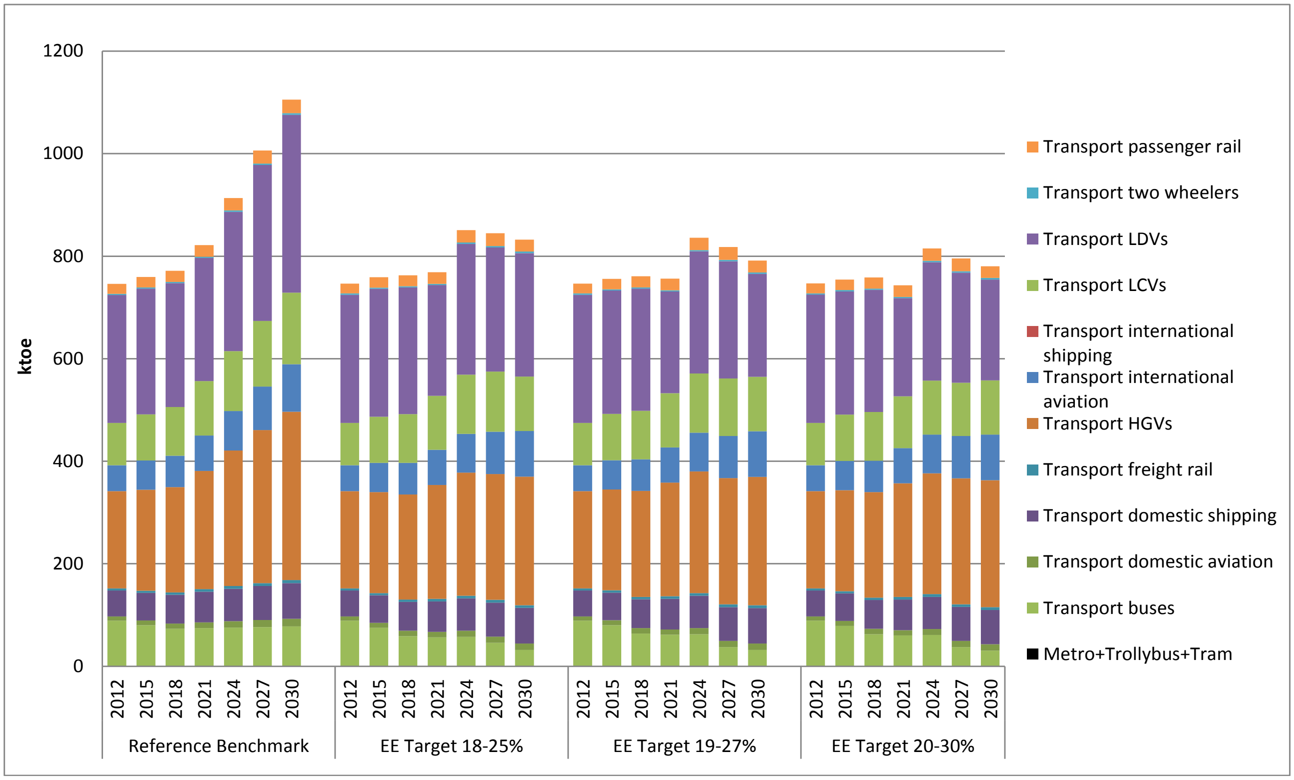



Figure 38: Transportation Energy use by Mode for Reference Benchmark and EE Target Scenarios

Figure 39 shows that the investment required to achieve the EE Target 18-25% and EE Target 19-27% cases are mainly for plug-in-hybrid light duty vehicles, hybrid heavy trucks, with electric buses coming in the later periods for the two more ambitious cases.

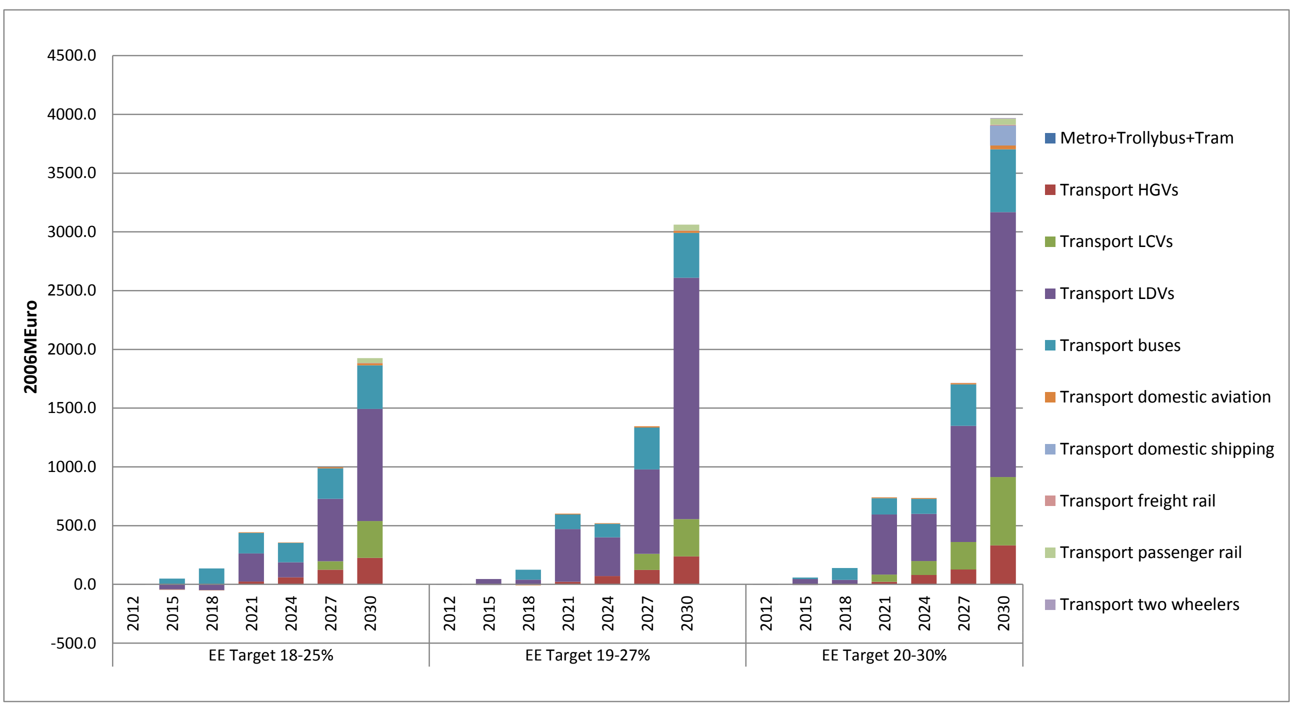



Figure 39: Transport Mode Investment – Difference from Reference Benchmark

Figure 40 and show that the investment per ktoe of energy saved increases about 9% from the EE Target 18-25% case to the EE Target 19-27% case, but then jumps another 95% in the EE Target 20-30% case compared to the EE Target 19-27% case. Light duty vehicles, light commercial vehicles and buses play a key role for all scenarios, with more light duty vehicle investment needed as well to meet the EE Target 19-27% case. For the EE Target 20-30% case more plug-in hybrid vehicles and electricity buses, push up the cost per unit energy saved.

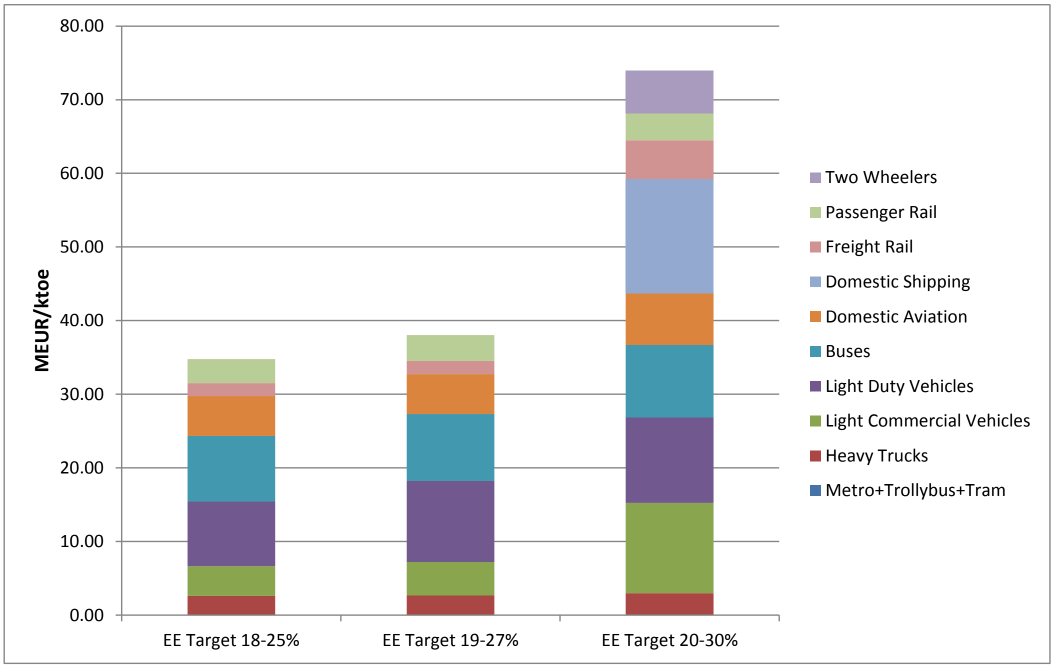



**Figure 40: Transport Mode Investment per unit Energy Saved**

**Table 20: Transportation Sector Investment per Energy Saved (MEUR/ktoe)**

| Energy Service | EE Target 18=25% | EE Target 19-27% | EE Target 20-30% |
|---|---|---|---|
| Heavy Trucks | 2.62 | 2.68 | 3.00 |
| Light Commercial Vehicles | 4.04 | 4.54 | 12.25 |
| Light Duty Vehicles | 8.78 | 11.01 | 11.61 |
| Buses | 8.92 | 9.09 | 9.85 |
| Domestic Aviation | 5.40 | 5.44 | 7.02 |
| Domestic Shipping | 0.00 | 0.00 | 15.51 |
| Freight Rail | 1.78 | 1.78 | 5.26 |
| Passenger Rail | 3.24 | 3.51 | 3.65 |
| Two Wheelers | 0.00 | 0.00 | 5.82 |

## 7.2 EE Target Scenario Details - Bosnia-Herzegovina

This section provides a country-specific understanding of the impacts of the EE Target levels for Bosnia-Herzegovina. The section examines the changes in Final Energy Consumption (FEC) and the related changes in end-use device purchases by sector and end-use application, industry subsector or transport mode. This section first provides the overall results for Bosnia-Herzegovina by fuel type and demand sector and then examines the results for each sector in detail. No specific results for the Supplier Obligation scenario are provided because the measures implemented are the same as those identified as most relevant to this scenario.

### 7.2.1 System Cost Impacts

Figure 41 shows that the total discounted system cost increases by 1.1% over the Reference Benchmark case for the EE Target 18-25% case of 18% in 2025 and 25% in 2030. In the EE Target 19-27% case, the incremental cost goes to 1.9%, while turning to more costly measures, and the EE Target 20-30% case results in jump of 3.6% based on the need to resort to even more costly efficiency measures, as will be discussed.

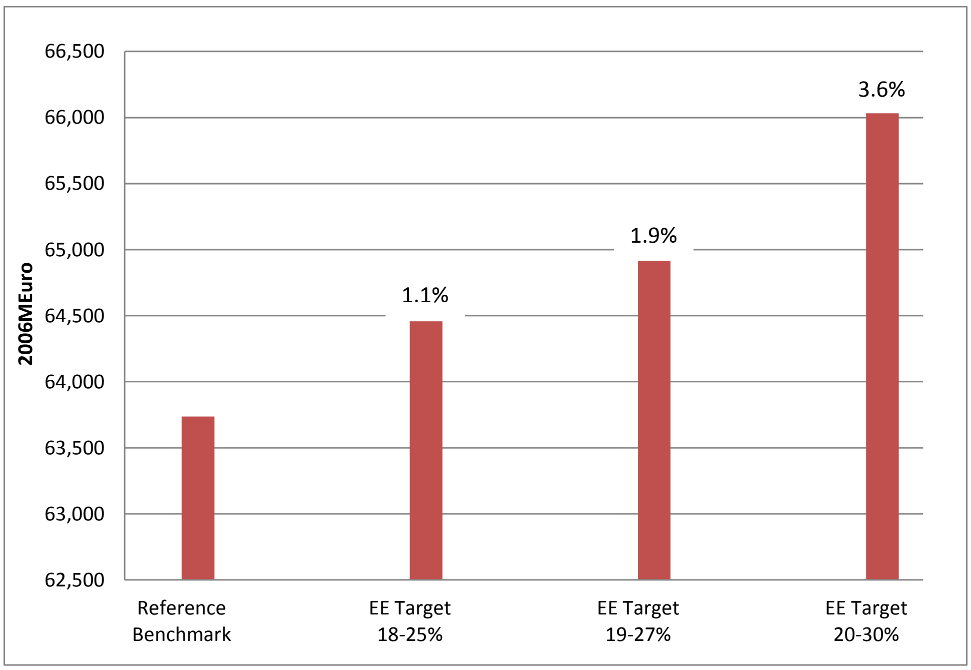



**Figure 41: Bosnia-Herzegovina Total System Cost for Reference Benchmark and EE Target Scenarios**

In the sections that follow the trends for some key aspects of the national energy system evolution over the 20-year planning horizon are shown for these EE target scenarios against the Reference Benchmark.

### 7.2.2 Reductions in Final Energy Consumption

Figure 42 shows final energy consumption by fuel type, and illustrates that the major savings are achieved through reductions in the use of biomass, along with coal, gasoline and diesel. There are also small increases in electricity and natural gas consumption, particularly in the later periods. The figure also illustrates that significant reductions are required in the 2021 to 2030 periods in all cases. It also shows that the reductions are similar in each of the scenarios.

Figure 43 shows that these energy savings come primarily from reductions in residential sector as a result of improvements in space conditioning arising from a move to more efficient devices and improved building shells. The sections that follow provide more details on a sectoral basis.

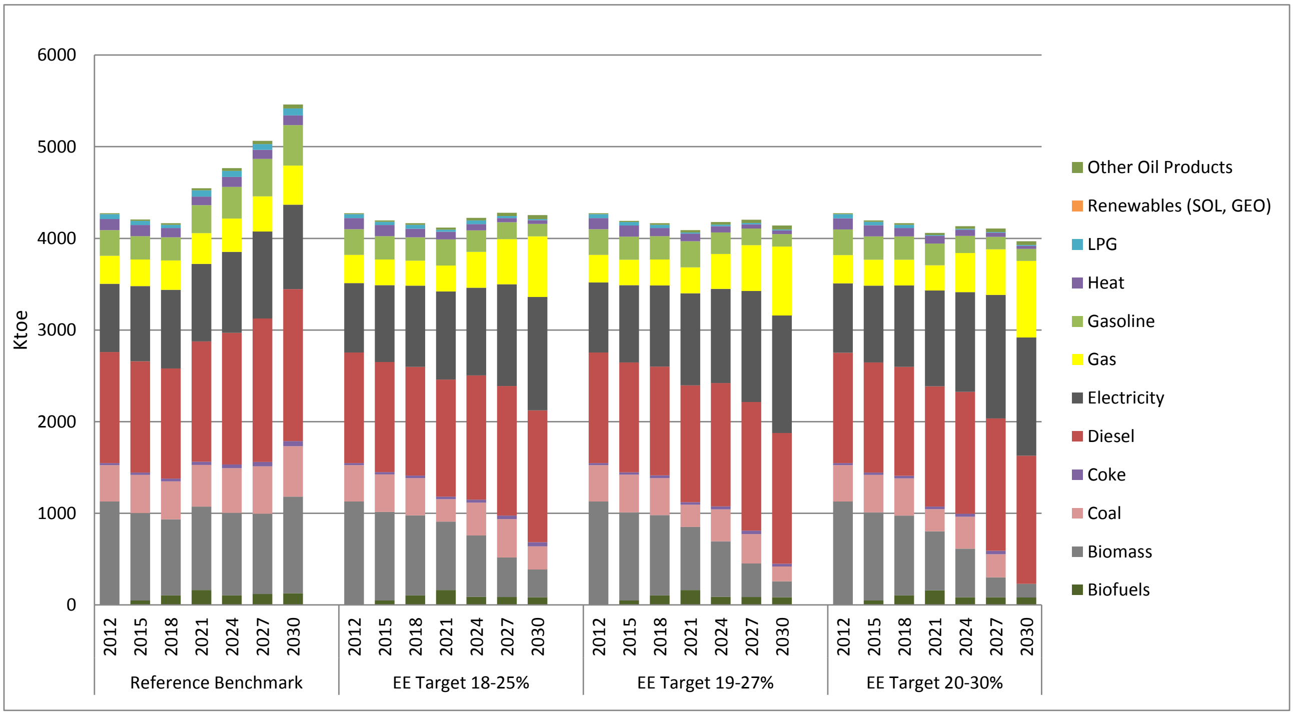



**Figure 42: Final Energy by Fuel Type for Reference Benchmark and EE Target Scenarios**

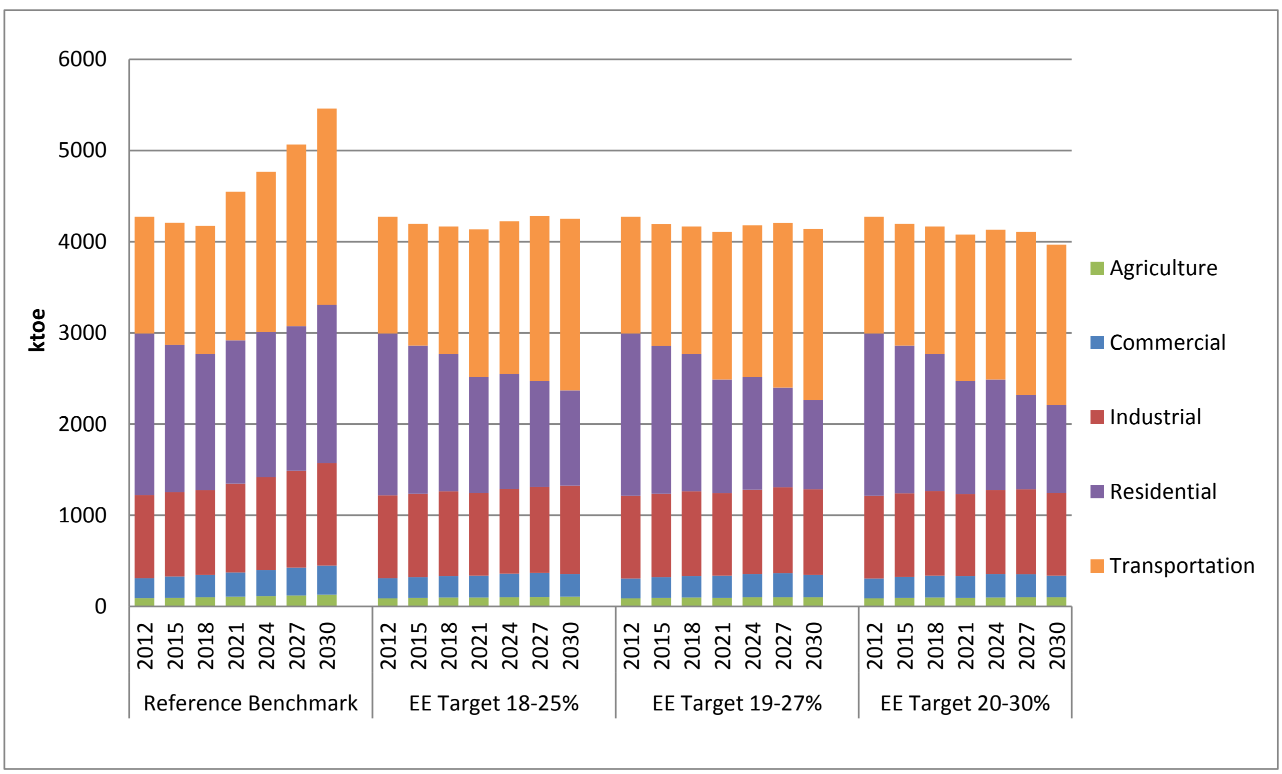



**Figure 43: Final Energy by Sector for Reference Benchmark and EE Target Scenarios**

### 7.2.3 Residential Sector Impacts

Figure 44 shows that achieving the EE targets in the residential sector requires significant reductions in final energy use for space heating with some savings for water heating – lighting changes little as most lighting options are implemented in the Reference Benchmark case. It also shows that final energy use changes only slightly between the three target cases. Figure 45 shows that the investment needed to achieve the increased savings in all the cases requires significant increases in the areas of space conditioning (heating and cooling) along with insulation, with contribution from other appliances necessary in 2030, particularly for the EE Target 20-30% case, pointing to the need for appliance standards and perhaps targeted rebate programs. Note that part of the increased expenditure in heating devices is for heat pumps and insulation, which serve both the heating and cooling demands.

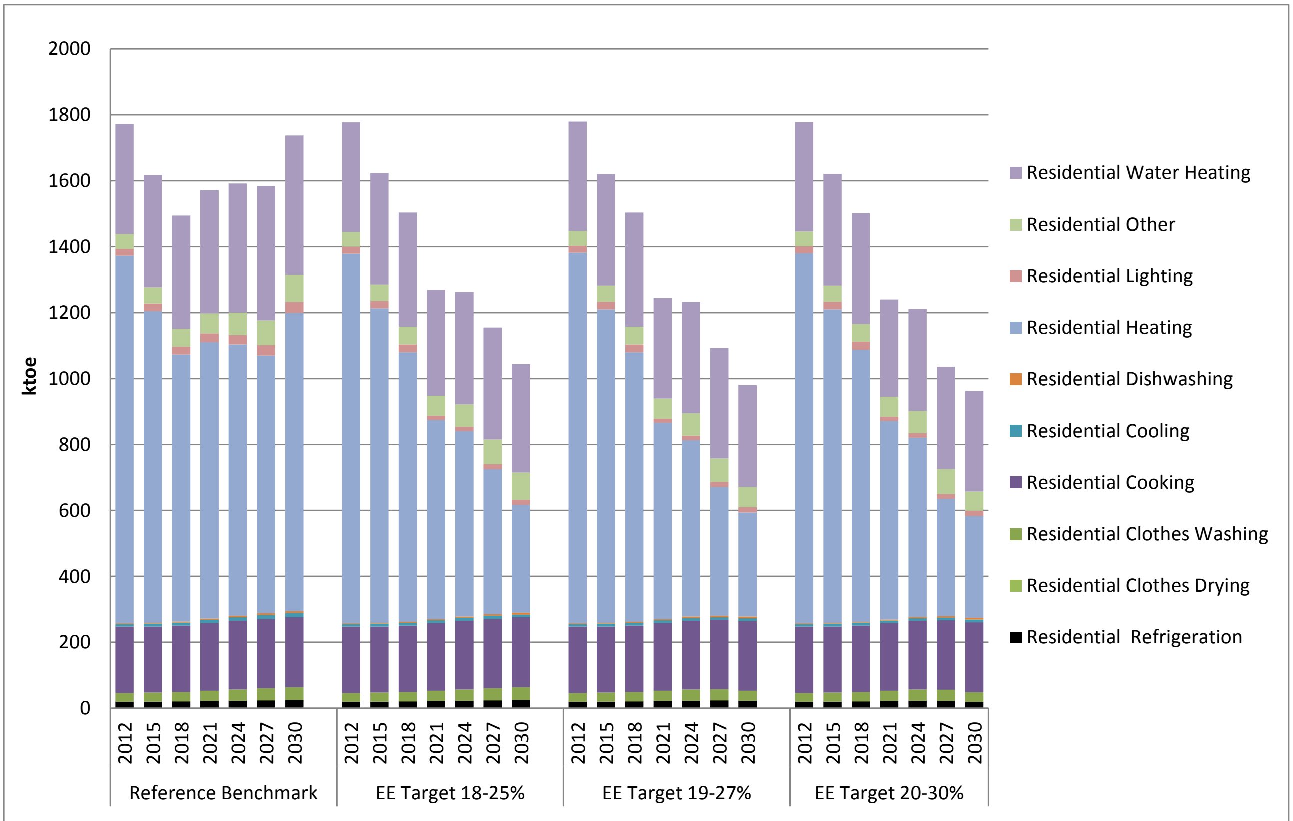



**Figure 44: Residential Energy use by Application for Reference Benchmark and EE Target Scenarios**

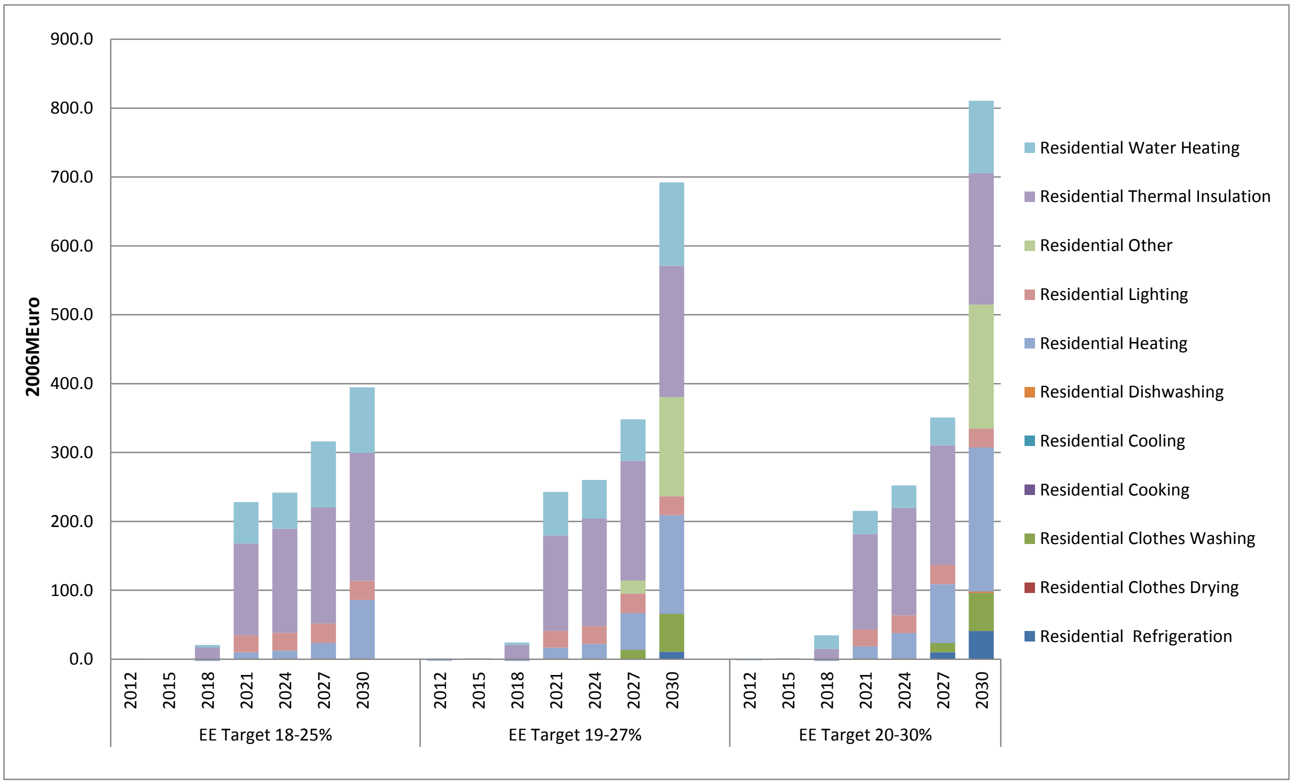



**Figure 45: Residential Investment by Application - Difference from Reference Benchmark**

Figure 46 shows that the investment per ktoe of energy saved more than doubles to meet the EE Target 19-27% case, and doubles again from there to reach the EE Target 20-30% case as low use devices such as dishwashers and clothes dryers with higher costs save only a relatively small amount of energy.

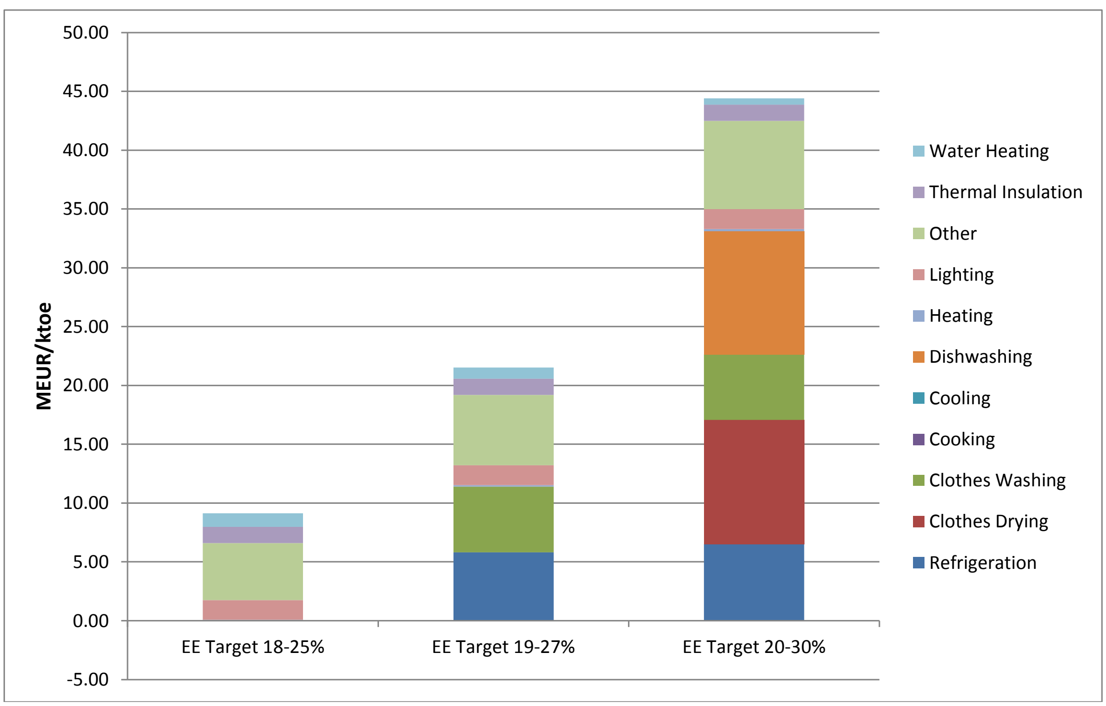



**Figure 46: Residential Device Investment per unit Energy Saved**

Table 21 presents the change in expenditure divided by the change in energy saved from the Reference Benchmark as a measure of cost-effectiveness of actions for each energy service. It shows that high efficiency space cooling and heating are extremely important, with water heaters and thermal insulation following as the most cost-effective measures to pursue in the residential sector. Note that investments in thermal insulation reduce heating and cooling demands, and that the negative values for cooling result because the Reference scenario already uses relatively efficient cooling devices, and the investments in building insulation allows a slightly lower investment in cooling devices. Heat pump technology and the value of residential building insulation are clearly priority areas for incentives as identified from these results.

**Table 21: Residential Investment per unit Energy Saved (MEUR/ktoe)**

| Energy Service | EE Target 18-25% | EE Target 19-27% | EE Target 20-30% |
|---|---|---|---|
| Refrigeration | 0.00 | 5.82 | 6.52 |
| Clothes Drying | 0.00 | 0.00 | 10.54 |
| Clothes Washing | 0.00 | 5.58 | 5.58 |
| Cooling | -0.04 | -0.04 | -0.02 |
| Dishwashing | 0.00 | 0.00 | 10.47 |
| Heating | 0.08 | 0.13 | 0.19 |
| Lighting | 1.68 | 1.68 | 1.68 |
| Other | 4.85 | 5.98 | 7.51 |
| Thermal Insulation | 1.37 | 1.38 | 1.38 |
| Water Heating | 1.15 | 0.96 | 0.53 |

### 7.2.4 Commercial Sector Impacts

Figure 47 shows that achieving the EE targets in the commercial sector requires significant reductions in final energy use for space heating and space cooling, along with lighting. It also shows that final energy use changes only slightly between the three target cases, with some additional savings in space cooling in the final period, particularly in the most stringent reduction scenario.

Figure 48 shows that the investments required to achieve the savings in the EE Target 18-25% and EE Target 19-27% cases require similar shifts to more efficient space heating and commercial building retrofits along with lighting, with the 19-27 target requiring additional investments in new efficient space cooling equipment in the last period, and that reaching the EE Target 20-30% level requires a massive increase in investment in new efficient cooling equipment in last period. In all scenarios the increase in building insulation and move to heat pumps lowers the expenditure for cooling equipment some in the 2021-2027 timeframe.

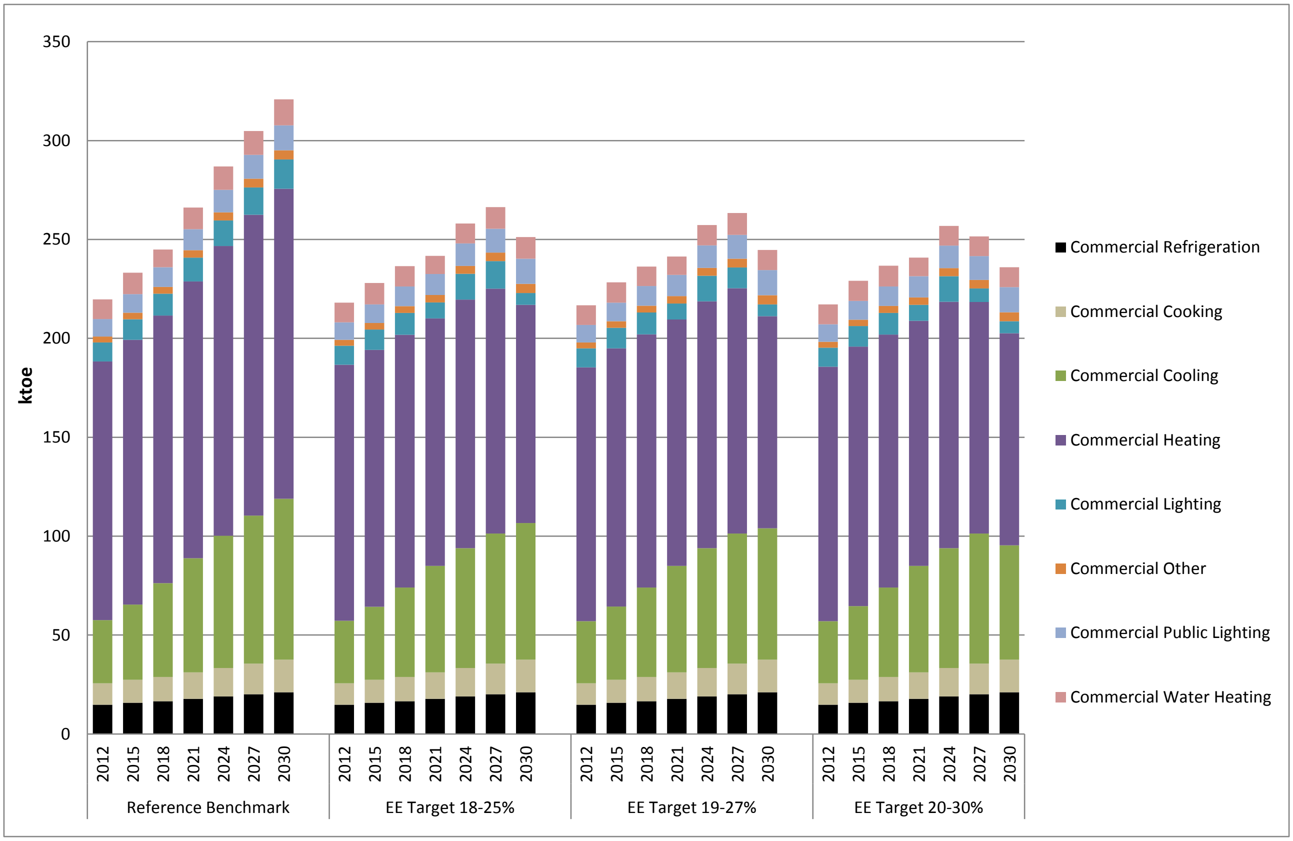



**Figure 47: Commercial Energy use by Application for Reference Benchmark and EE Target Scenarios**

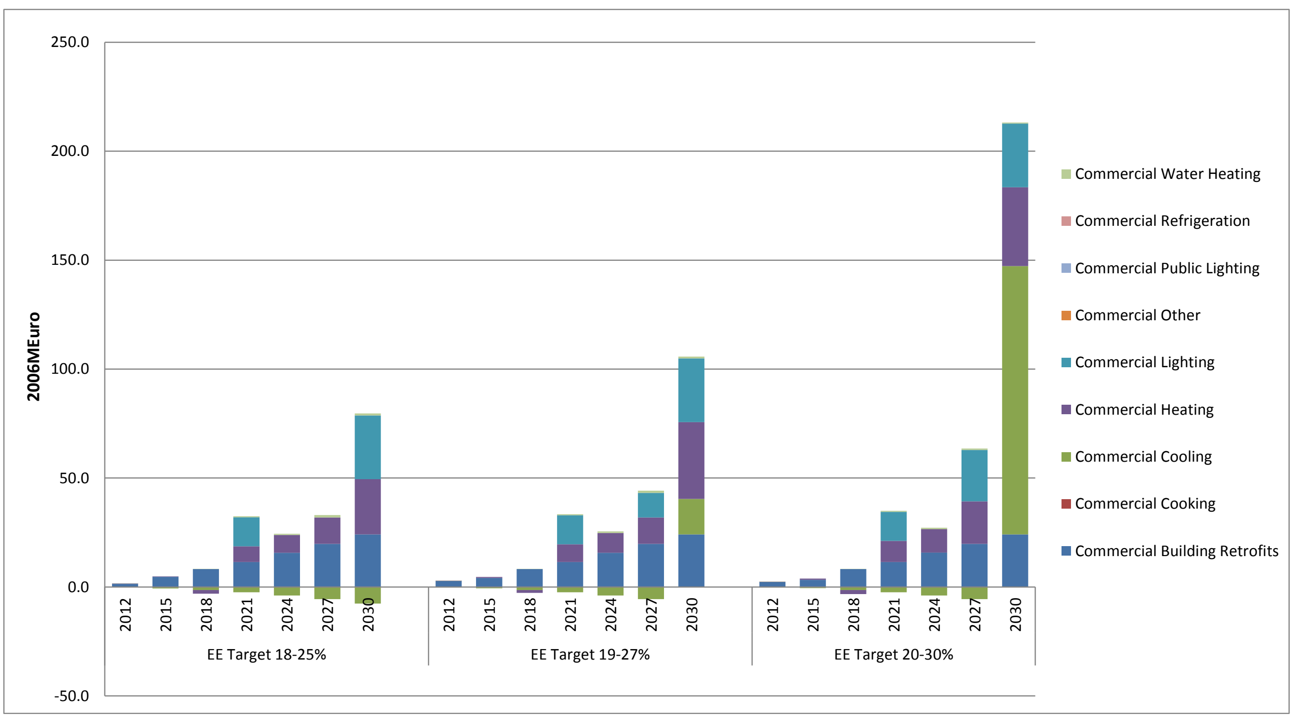



**Figure 48: Commercial Investment by Application – Difference for Reference Benchmark**

Table 22 shows that space conditioning (heating and cooling) and building retrofits are the most cost-effective types of investments, where the latter leads to savings in space heating and cooling device investments in this sector. Water heating is also cost-effective though demand for hot water in the sector is small so the impact is minor. Note that the building retrofits facilitate some reductions in cooling device investments in the EE Target 18-25% and EE Target 19-27% cases. Commercial scale heat-pump technologies and commercial building retrofits, along with the lighting improvements, are highlighted by these results for incentive programs.

**Table 22: Commercial Sector Investment per unit Energy Saved (MEUR/ktoe)**

| Energy Service | EE Target 18-25% | EE Target 19-27% | EE Target 20-30% |
|---|---|---|---|
| Building Retrofits | 0.51 | 0.51 | 0.51 |
| Cooling | -0.62 | -0.19 | 0.85 |
| Heating | 0.46 | 0.52 | 0.59 |
| Lighting | 3.37 | 3.37 | 3.37 |
| Water Heating | 0.49 | 0.53 | 0.29 |

### 7.2.5 Industry Sector Impacts

Figure 49 shows that achieving the EE target in the industrial sector requires significant reductions in final energy use from all sectors, other than Chemicals (which is a very small industry in Bosnia- Herzegovina). It also shows that final energy use in the industrial sector changes only slightly between the three target cases, with incremental additional savings needed in the final two periods for the more ambitious reduction cases.

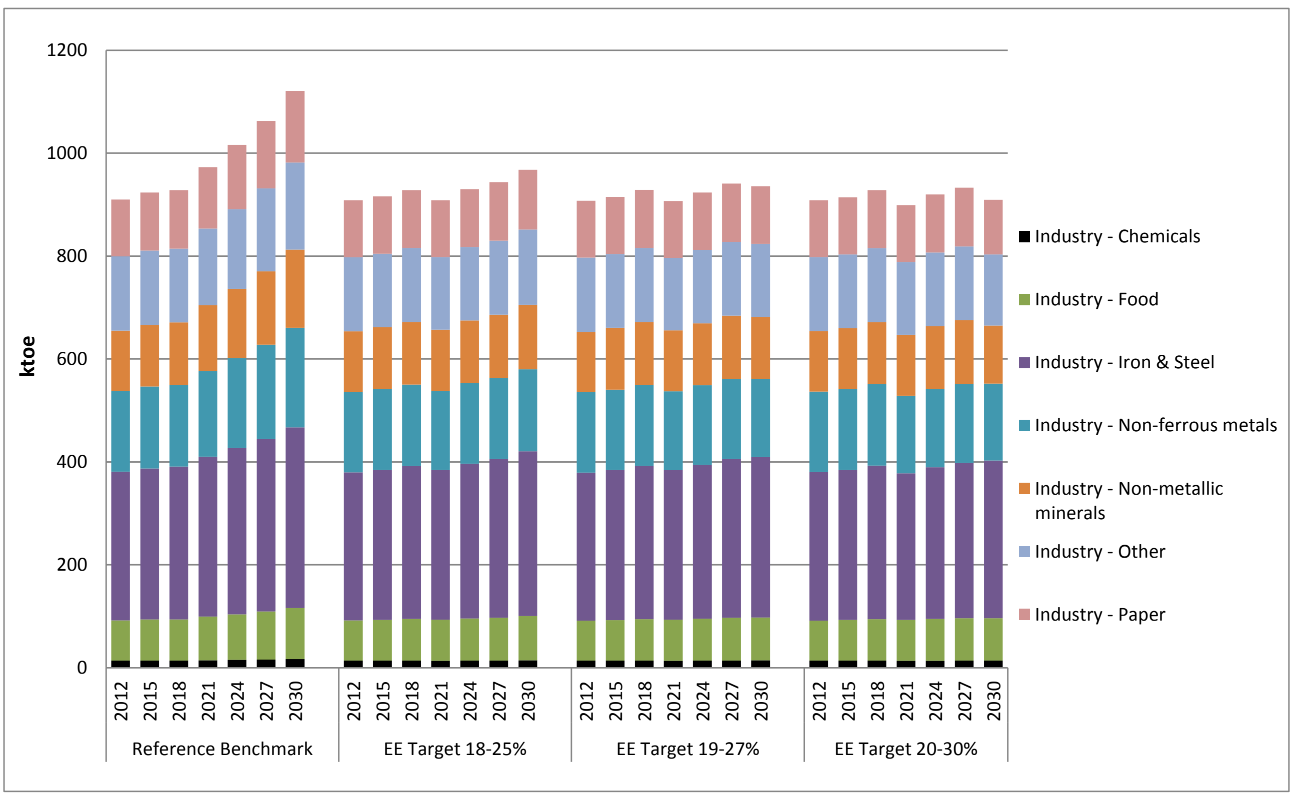



**Figure 49: Industrial Energy use by Application for Reference Benchmark and EE Target Scenarios**

Figure 50 shows that the investment required to achieve the EE target increases significantly in the 2030 period in the two more aggressive cases, with a doubling in expenditure needed to achieve the 2030 level in each of the cases compared to that in the earlier periods when the EE targets come into effect.

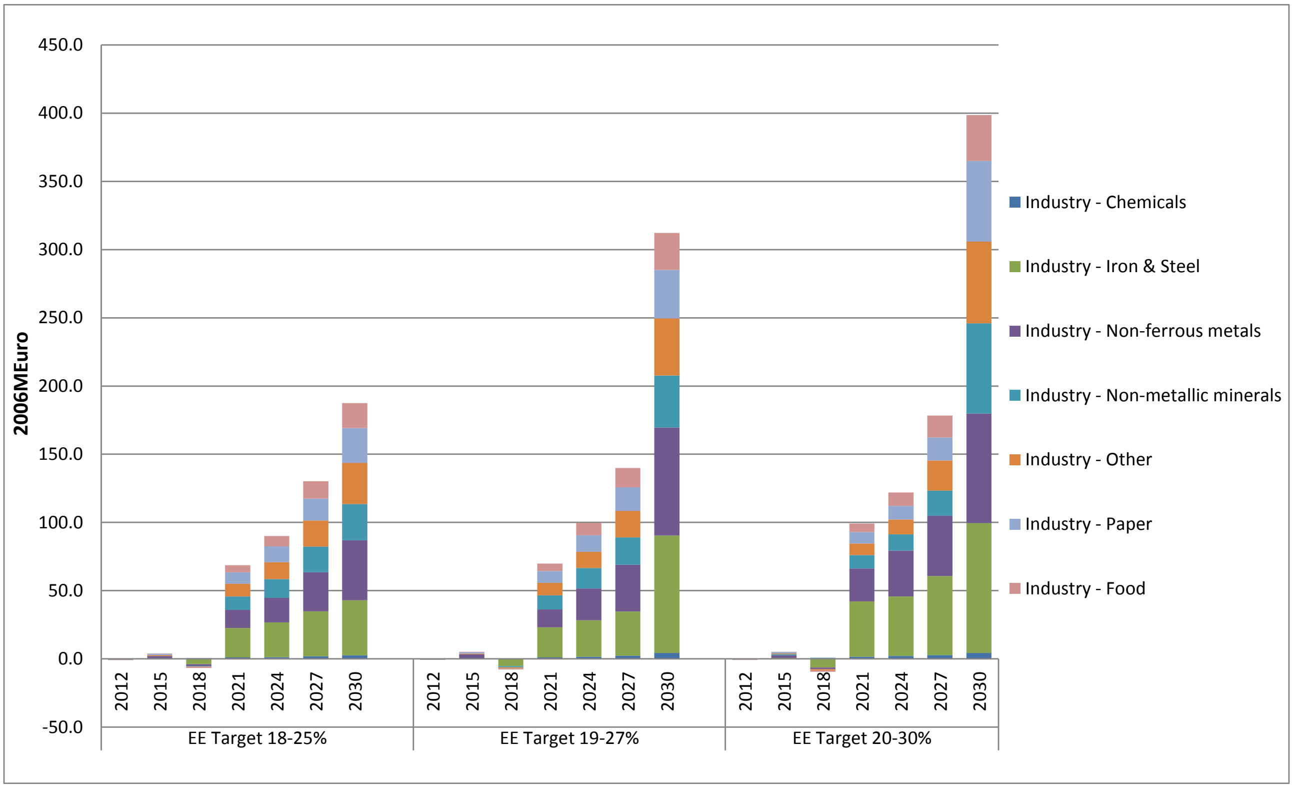



**Figure 50: Industrial Investment by Subsector – Difference from Reference Benchmark**

Table 23 shows that the investment per ktoe of energy saved is in a cost-effective range for all industry sub-sectors, with the most cost-effective efficiency investments occurring in the pulp and paper and non-metallic minerals sub-sectors. It also indicates that and that unit costs increase similarly across all scenarios.

**Table 23: Industrial Sector Investment per Energy Saved (MEUR/ktoe)**

| Energy Subsector | EE Target 18-25% | EE Target 19-27% | EE Target 20-30% |
|---|---|---|---|
| Chemicals | 1.18 | 1.37 | 1.54 |
| Food | 1.20 | 1.34 | 1.47 |
| Iron & Steel | 1.18 | 1.39 | 1.74 |
| Non-ferrous metals | 1.12 | 1.33 | 1.57 |
| Non-metallic minerals | 1.03 | 1.10 | 1.19 |
| Other | 1.14 | 1.19 | 1.29 |
| Paper | 0.98 | 1.04 | 1.14 |

### 7.2.6 Transport Sector Impacts

Figure 51 shows that achieving the EE target in the transportation sector primarily requires reductions in final energy use for heavy trucks and light duty vehicles, with some contribution from buses. It also shows that overall final energy use in 2030 is aggressively reduced in all cases, with dramatic reductions required in the EE Target 20-30% case.

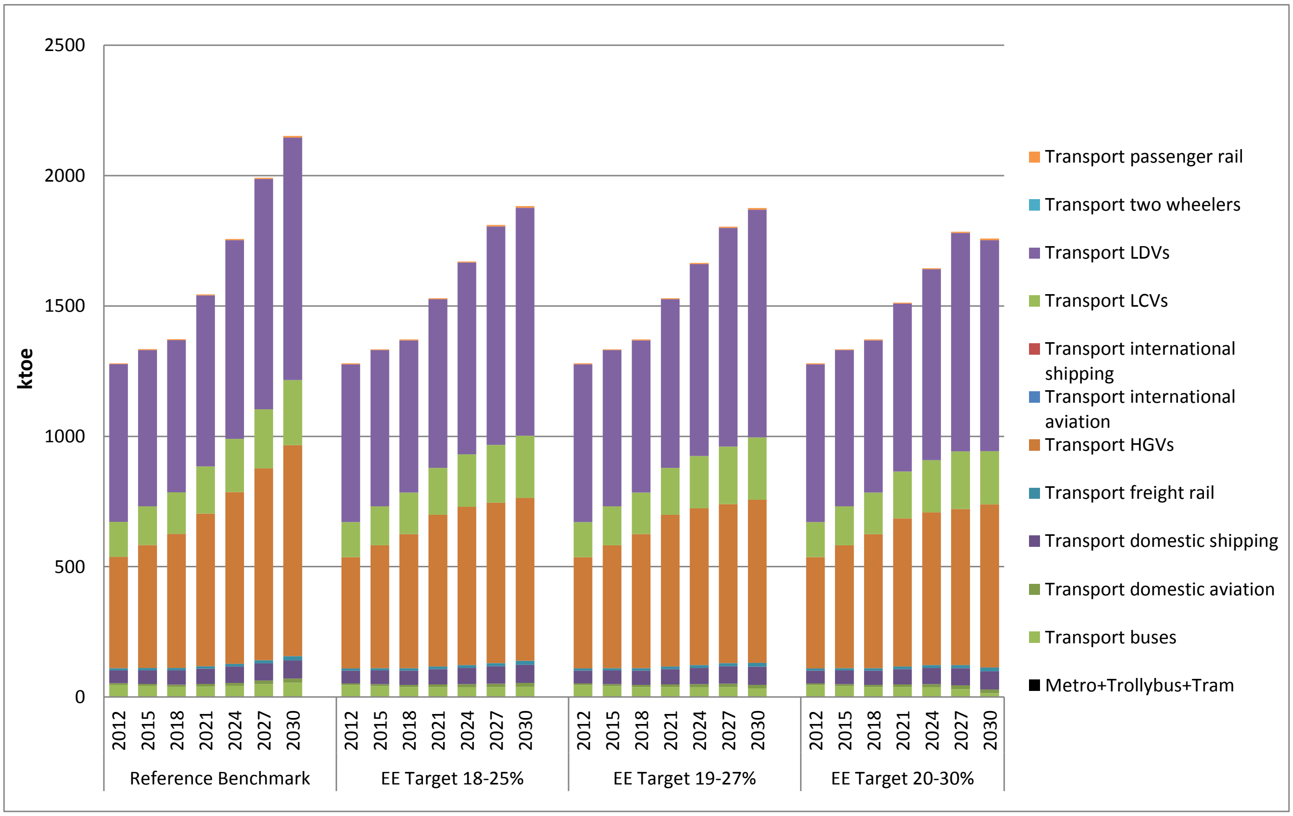



**Figure 51: Transportation Energy use by Mode for Reference Benchmark and EE Target Scenarios**

Figure 52 shows that the investment required to achieve the EE Target 18-25% and EE Target 19-27% cases are mainly for hybrid heavy trucks and CNG LDVs, with electric buses coming in the later periods for the two more ambitious cases, along with plug-in hybrid cars and diesel hybrid commercial vehicles in the last period in order to achieve the EE Target 20-30%.

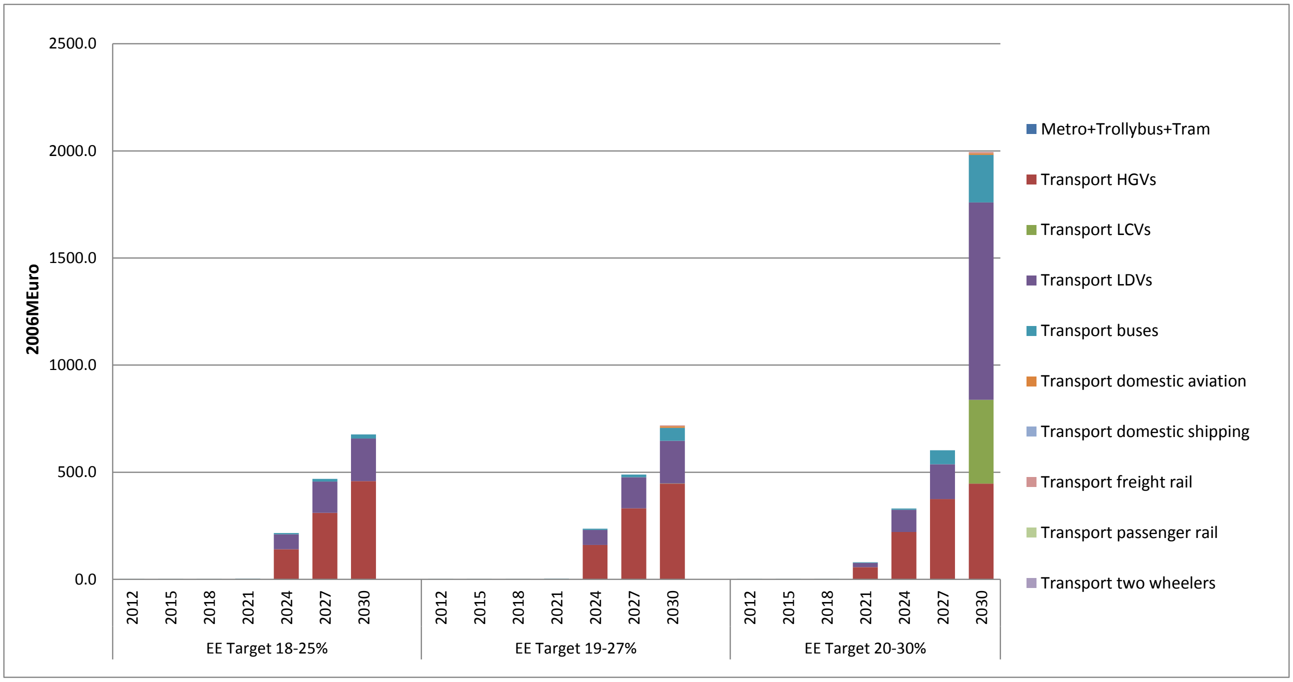



**Figure 52: Transport Mode Investment – Difference from Reference Benchmark**

Figure 53 and show that the investment per ktoe of energy saved increases about 25% from the EE Target 18-25% case to the EE Target 19-27% case, but then jumps another 75% in the EE Target 20-30% case compared to the EE Target 19-27% case. Heavy trucks, LDVs and buses play a key role for all scenarios, with aviation and rail improvements needed as well to meet the more aggressive targets. For the EE Target 20-30% case plug-in hybrid vehicles and electricity buses, along diesel hybrid commercial vehicles, push up the cost per unit energy saved.

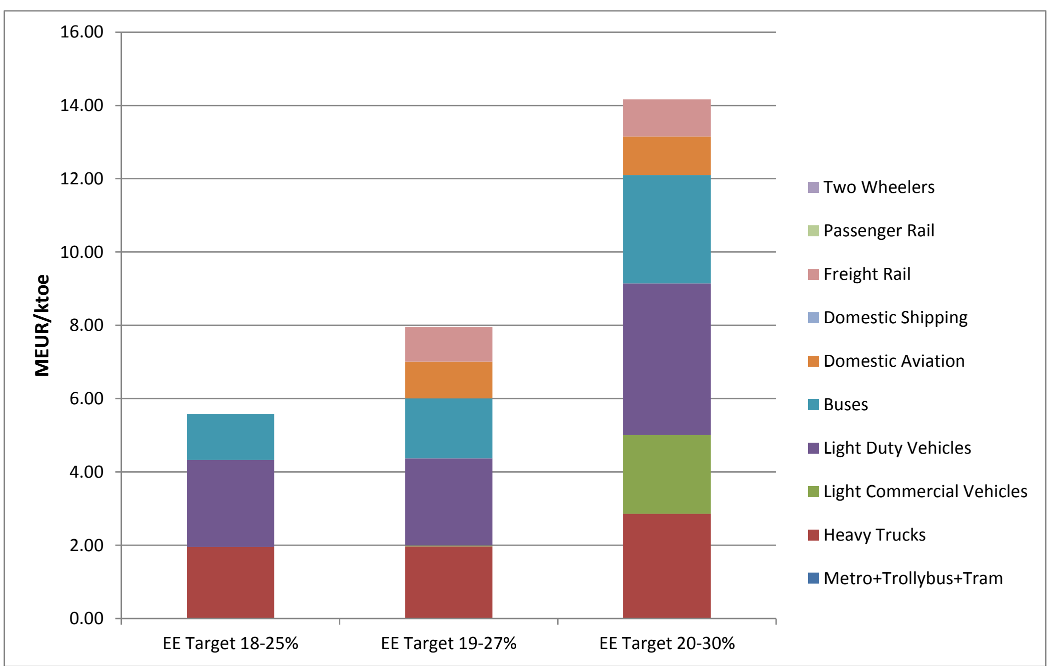



**Figure 53: Transport Mode Investment per unit Energy Saved**

**Table 24: Transportation Sector Investment per Energy Saved (MEUR/ktoe)**

| Energy Service | EE Target 20-25 | EE Target 20-27 | EE Target 20-30% |
|---|---|---|---|
| Heavy Trucks | 1.95 | 1.97 | 2.86 |
| Light Commercial Vehicles | 0.00 | 0.03 | 2.15 |
| Light Duty Vehicles | 2.38 | 2.38 | 4.13 |
| Buses | 1.25 | 1.63 | 2.96 |
| Domestic Aviation | 1.04 | 2.06 | 3.60 |
| Freight Rail | 0.00 | 0.94 | 1.01 |

## 7.3 EE Target Scenario Details – FYR Macedonia

This section provides a country-specific understanding of the impacts of the EE Target levels for the Republic of Macedonia. The section examines the changes in Final Energy Consumption (FEC) and the related changes in end-use device purchases by sector and end-use application, industry subsector or transport mode. This section first provides the overall results for Macedonia by fuel type and demand sector and then examines the results for each sector in detail. No specific results for the Supplier Obligation scenario are provided because the measures implemented are the same as those identified as most relevant to this scenario.

### 7.3.1 System Cost Impacts

Figure 54 shows that the total discounted system cost increases by 1.8% over the Reference Benchmark case for the EE Target 18-25% case of 18% in 2025 and 25% in 2030. In the EE Target 19-27% case, the incremental cost goes to 3%, while turning to more costly measures, and the EE Target 20-30% case results in jump of 7% based on the need to resort to even more costly efficiency measures, as will be discussed.

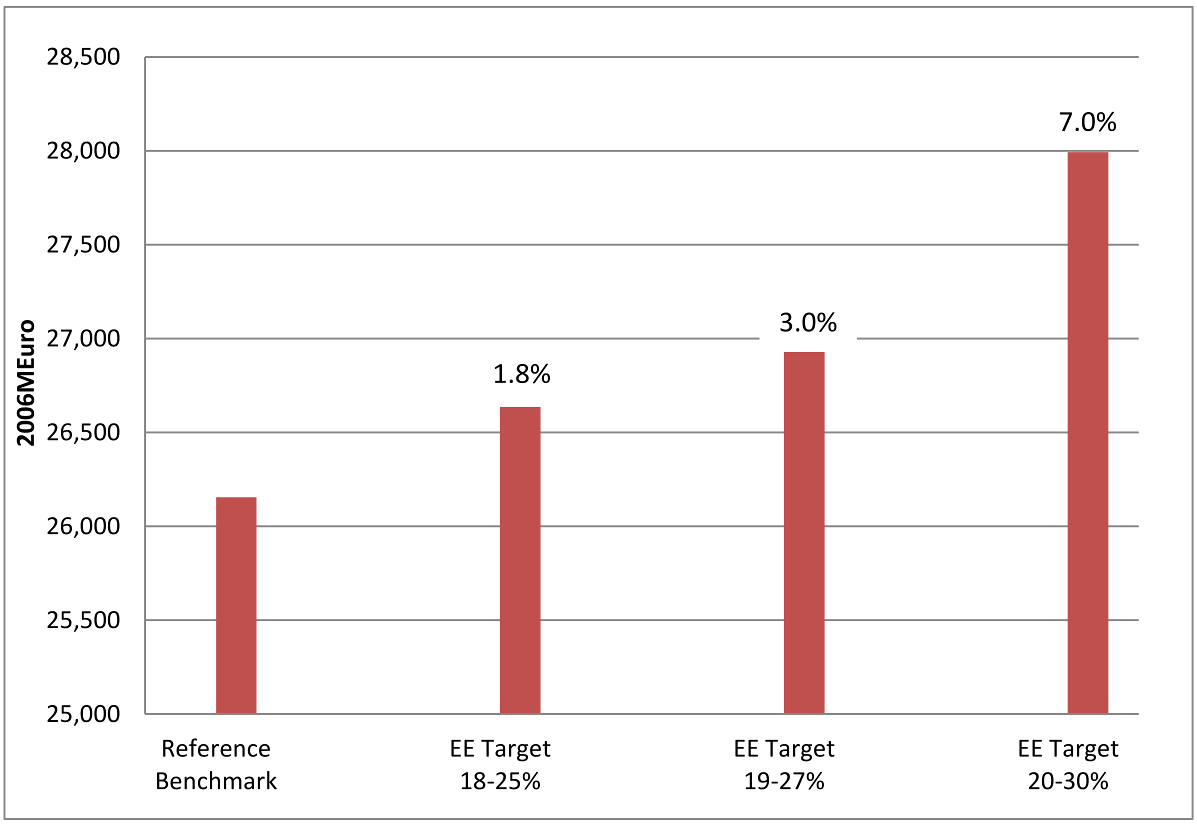



**Figure 54: Macedonia Total System Cost for Reference Benchmark and EE Target Scenarios**

In the sections that follow the trends for some key aspects of the national energy system evolution over the 20-year planning horizon are shown for these EE target scenarios against the Reference Benchmark.

### 7.3.2 Reductions in Final Energy Consumption

Figure 55 shows final energy consumption by fuel type, and illustrates that the major savings are achieved through reductions in the use of biomass, along with coal, gasoline and diesel. There are also small increases in natural gas consumption, particularly in the later periods. The figure also illustrates that significant reductions are required in the 2021 to 2030 periods in all cases, but that to meet the proposed

20-30 target, additional reductions are needed in 2027 and 2030 compared to the 18-25 target. Figure 56 shows that these energy savings come primarily from reductions in residential sector as a result of improvements in space conditioning arising from a move to more efficient devices and improved building shells. The sections that follow provide more details on a sectoral basis.

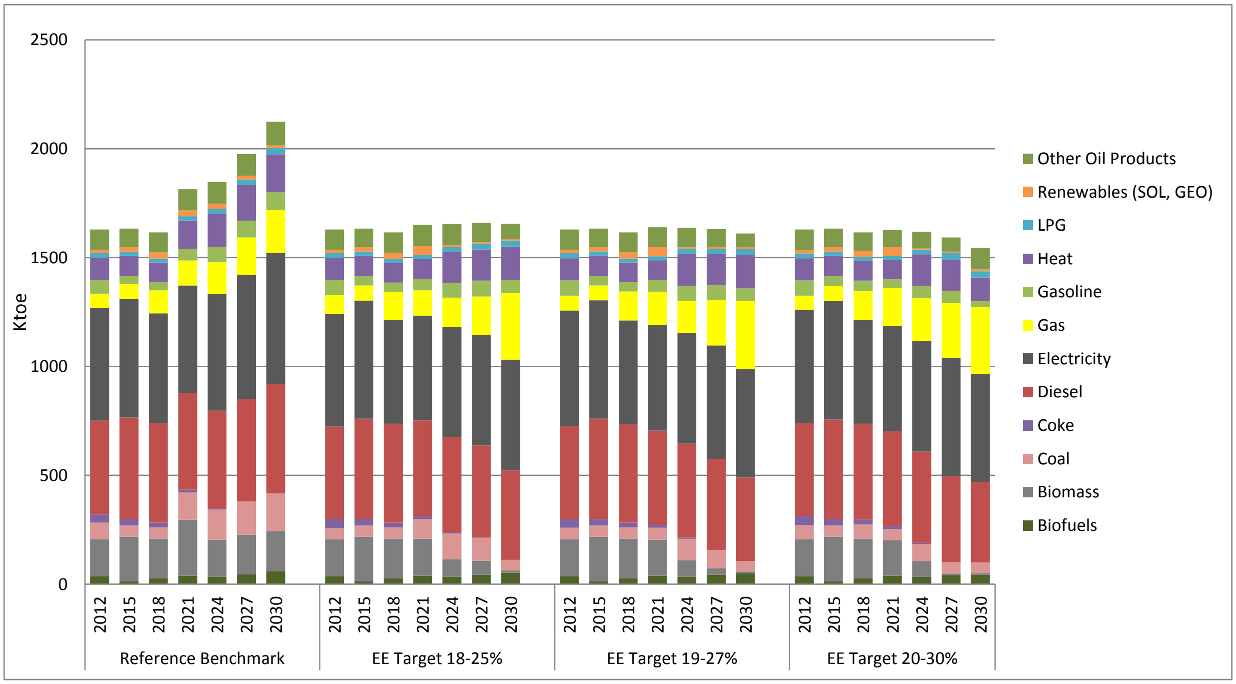



**Figure 55: Final Energy by Fuel Type for Reference Benchmark and EE Target Scenarios**

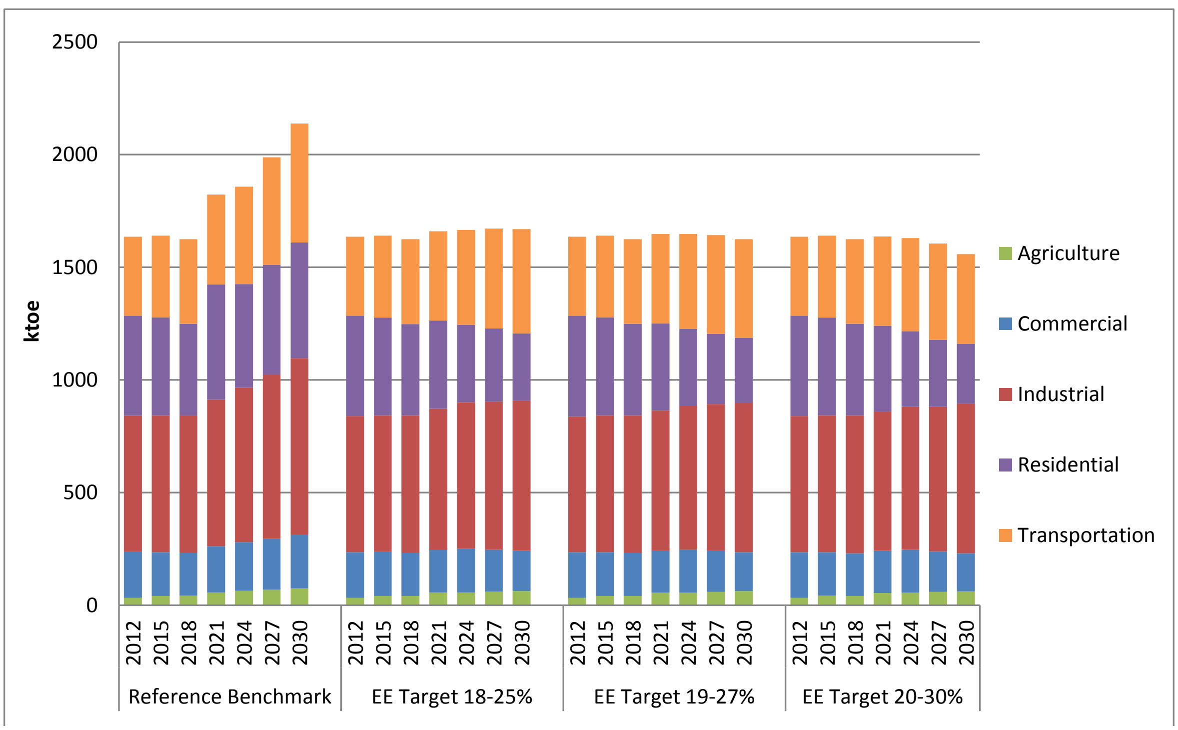



**Figure 56: Final Energy by Sector for Reference Benchmark and EE Target Scenarios**

### 7.3.3 Residential Sector Impacts

Figure 57 shows that achieving the EE targets in the residential sector requires significant reductions in final energy use for space heating with some savings for water heating. Lighting changes little as most lighting options are implemented in the Reference Benchmark case. The figure also shows that final energy use changes only slightly between the three target cases, with some additional savings in space cooling and refrigeration needed to reach the most stringent target. Figure 58 shows that the investment needed to achieve the increased savings in all the cases requires significant increases in the areas of space conditioning (heating and cooling) along with insulation, with contribution from other appliances necessary in 2030, particularly for the EE Target 20-30% case. This result points to the need for appliance standards and perhaps targeted rebate programs. Note that part of the increased expenditure in heating devices is for heat pumps and insulation, which serve both the heating and cooling demands.

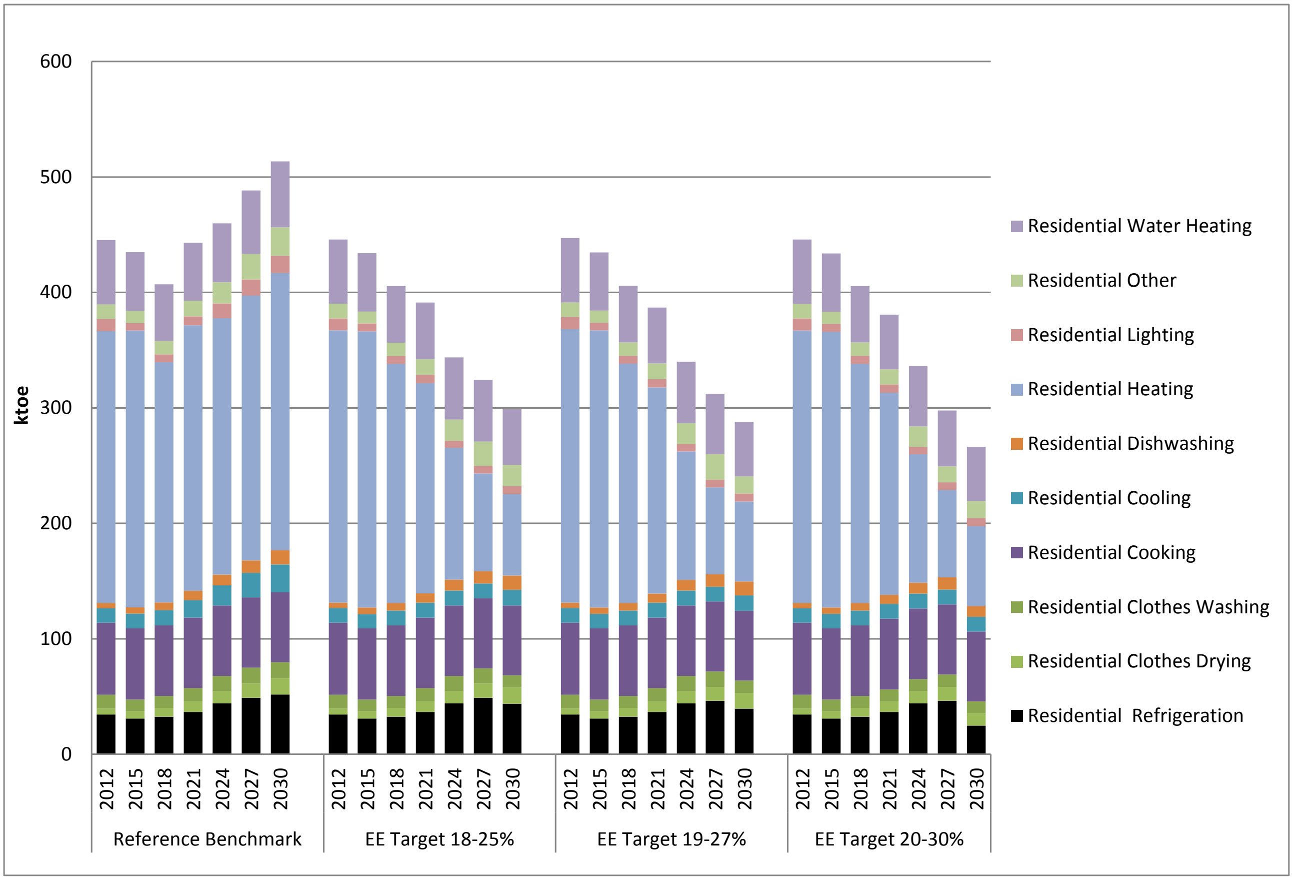



**Figure 57: Residential Energy use by Application for Reference Benchmark and EE Target Scenarios**

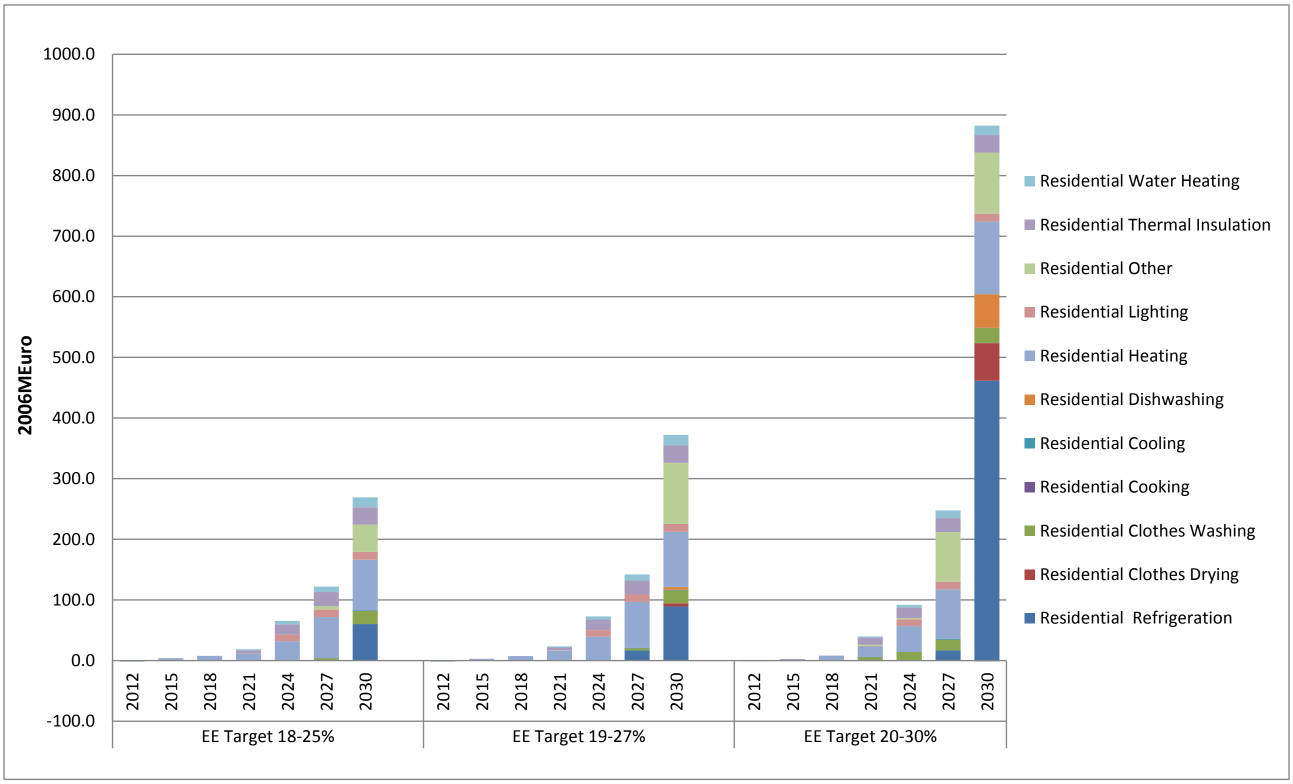



**Figure 58: Residential Investment by Application - Difference from Reference Benchmark**

Figure 59 shows that the investment per ktoe of energy saved more than doubles to meet the EE Target 19-27% case, and increases by 39% from there to reach the EE Target 20-30% case. Much of the new investment is needed in low use devices such as dishwashers and clothes dryers with higher costs and relatively small energy savings.

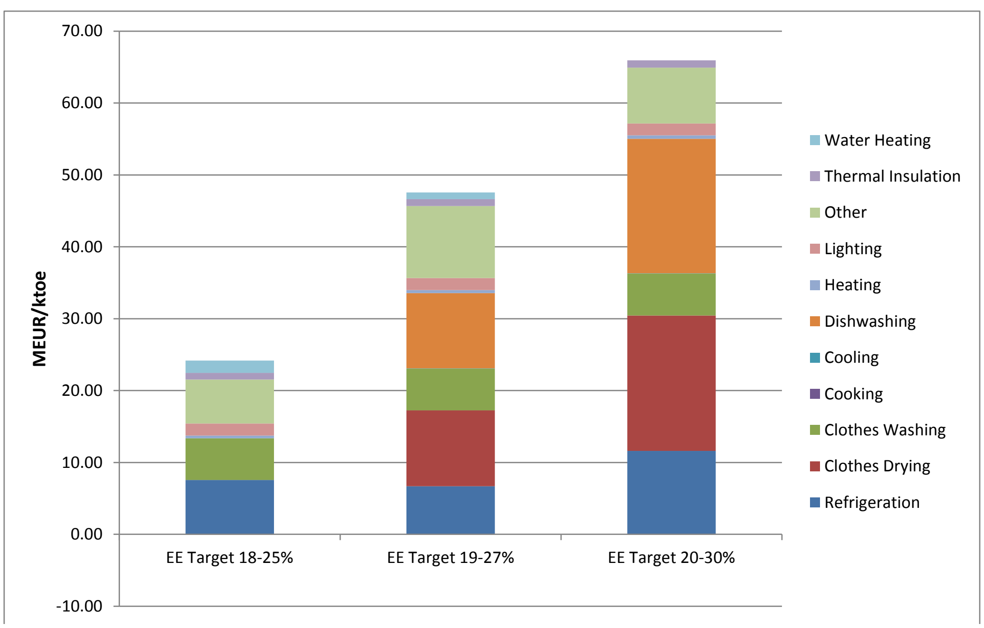



**Figure 59: Residential Device Investment per unit Energy Saved**

Table 25 presents the change in expenditure divided by the change in energy saved from the Reference Benchmark as a measure of cost-effectiveness of actions for each energy service. It shows that high efficiency space cooling and heating are extremely important, with water heaters and thermal insulation following as the most cost-effective measures to pursue in the residential sector. Note that investments in thermal insulation reduce heating and cooling demands and the investments in building insulation allows a slightly lower investment in cooling devices. Heat pump technology and the value of residential building insulation are clearly priority areas for incentives as identified from these results.

**Table 25: Residential Investment per unit Energy Saved (MEUR/ktoe)**

| Energy Service | EE Target 18-25% | EE Target 19-27% | EE Target 20-30% |
|---|---|---|---|
| Refrigeration | 7.55 | 6.70 | 11.60 |
| Clothes Drying | 0.00 | 10.54 | 18.83 |
| Clothes Washing | 5.81 | 5.81 | 5.86 |
| Cooling | 0.01 | 0.04 | 0.04 |
| Dishwashing | 0.00 | 10.47 | 18.70 |
| Heating | 0.37 | 0.42 | 0.48 |
| Lighting | 1.66 | 1.66 | 1.66 |
| Other | 6.12 | 10.03 | 7.74 |
| Thermal Insulation | 0.95 | 0.95 | 1.03 |
| Water Heating | 1.69 | 0.92 | -0.04 |

### 7.3.4 Commercial Sector Impacts

Figure 60 shows that achieving the EE targets in the commercial sector requires significant reductions in final energy use for space heating and space cooling, along with lighting. It also shows that final energy use changes only slightly between the three target cases, with some additional savings in space cooling in the final period, particularly in the most stringent reduction case.

Figure 61 shows that the investments required to achieve the savings in the EE Target 18-25% and EE Target 19-27% cases require similar shifts to more efficient space heating and commercial building retrofits along with lighting, with the 19-27 target requiring additional investments in new efficient space cooling equipment in the last period. Reaching the EE Target 20-30% level requires a massive increase in investment in new efficient cooling equipment in last period. In all scenarios the increase in building insulation and move to heat pumps lowers somewhat the expenditure for cooling equipment in the 2021-2027 timeframe.

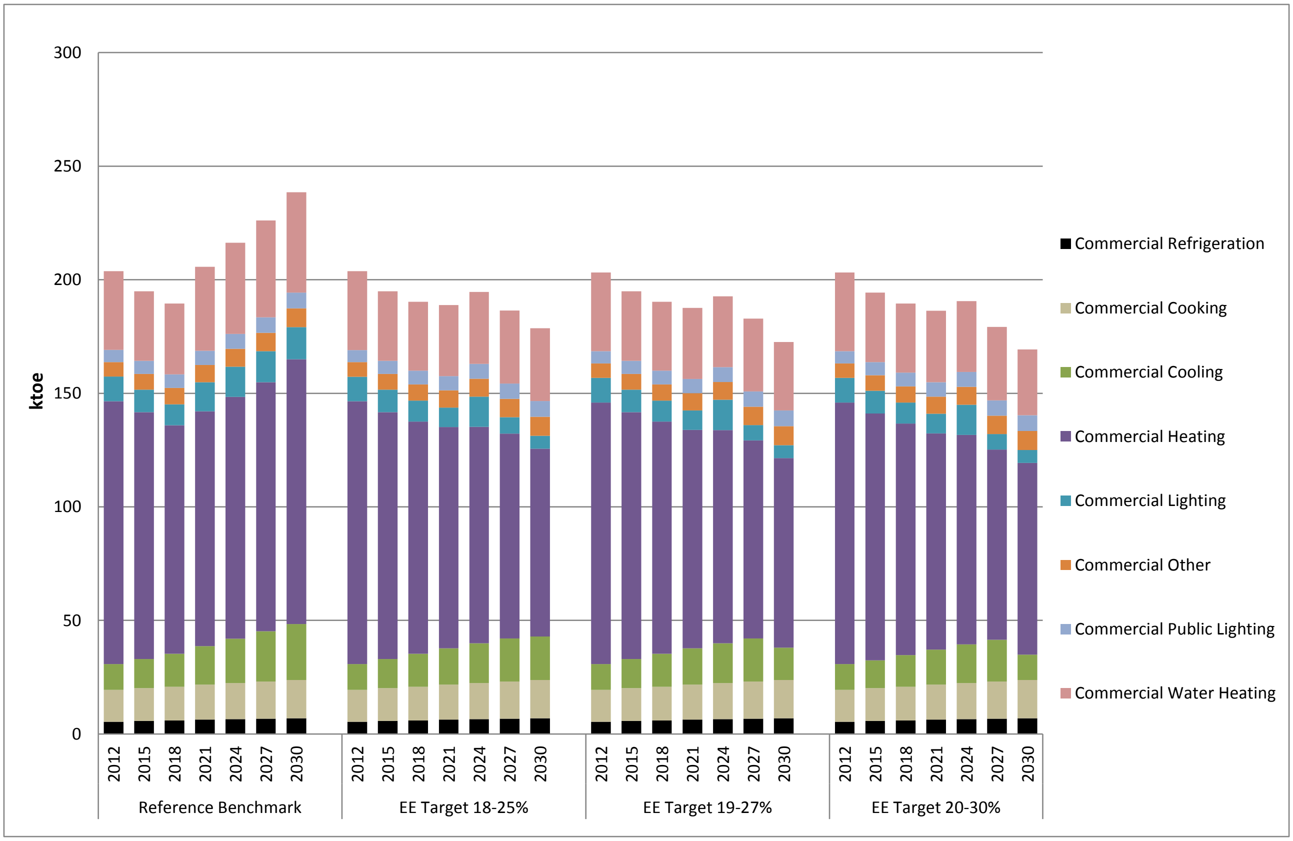



**Figure 60: Commercial Energy use by Application for Reference Benchmark and EE Target Scenarios**

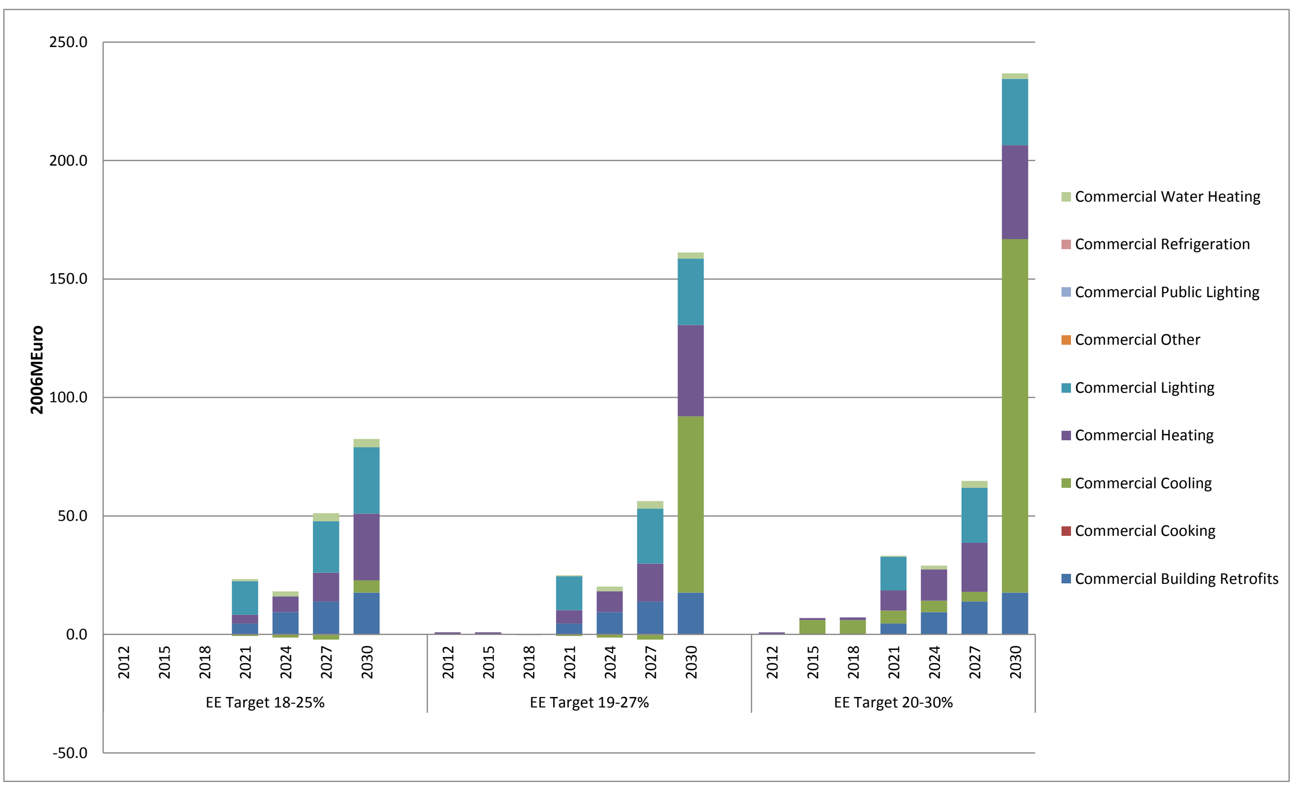



**Figure 61: Commercial Investment by Application – Difference for Reference Benchmark**

Table 26 shows that water heating is the most cost-effective types of investments. Space conditioning (heating and cooling) and building retrofits are also cost-effective, where the latter leads to savings in space heating and cooling device investments in this sector. Note that the building retrofits facilitate some reductions in cooling device investments in the EE Target 18-25% and EE Target 19-27% cases. Commercial scale heat-pump technologies and commercial building retrofits, along with the lighting improvements, are highlighted by these results for incentive programs.

**Table 26: Commercial Sector Investment per unit Energy Saved (MEUR/ktoe)**

| Energy Service | EE Target 18-25% | EE Target 19-27% | EE Target 20-30% |
|---|---|---|---|
| Building Retrofits | 0.69 | 0.69 | 0.69 |
| Cooling | -0.23 | 1.33 | 4.43 |
| Heating | 0.66 | 0.84 | 1.00 |
| Lighting | 3.37 | 3.37 | 3.37 |
| Water Heating | 0.25 | 0.19 | 0.17 |

### 7.3.5 Industry Sector Impacts

Figure 62 shows that achieving the EE target in the industrial sector requires significant reductions in final energy use from the iron and steel and non-metallic minerals subsectors. It also shows that final energy use in the industrial sector changes only slightly between the three target cases, with incremental additional savings needed in the final two periods for the more ambitious reduction cases.

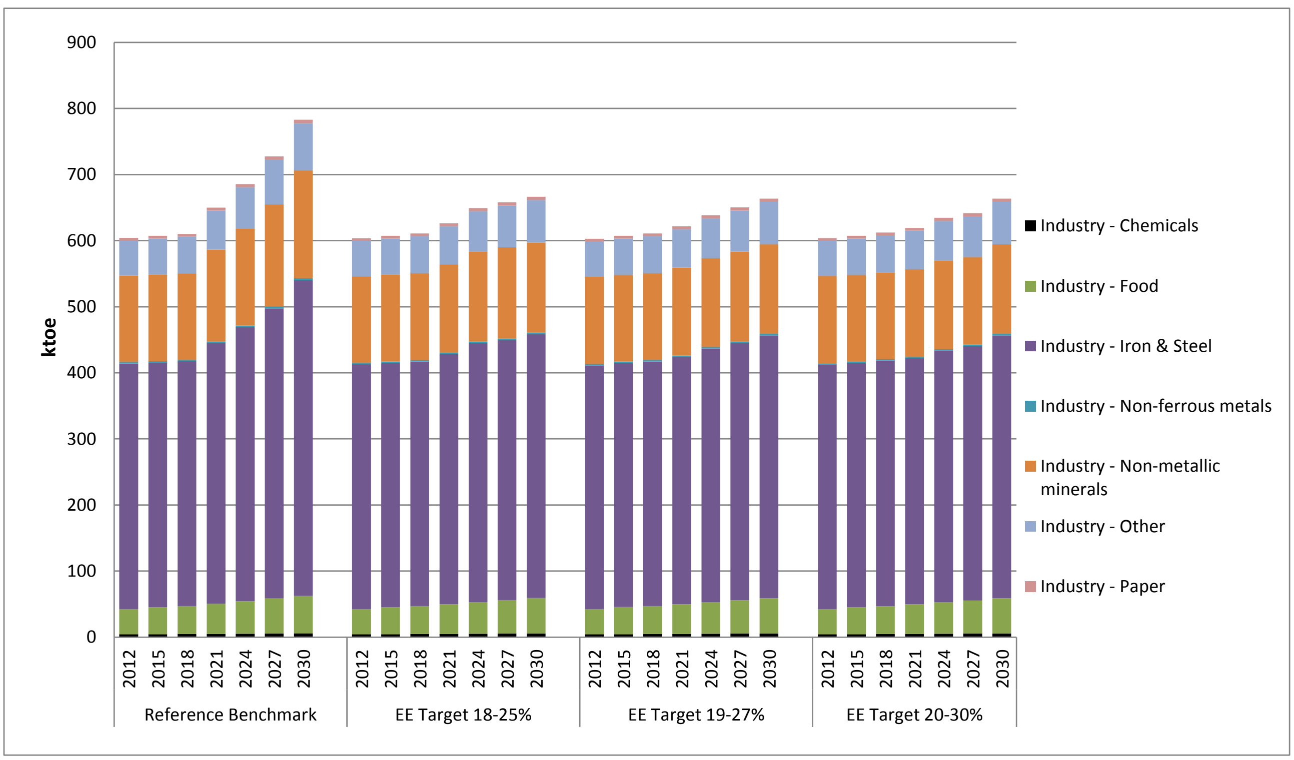



**Figure 62: Industrial Energy use by Application for Reference Benchmark and EE Target Scenarios**

Figure 63 shows that the investment required to achieve the EE target increases significantly in the 2030 period in all of the EE target cases, with a doubling in expenditure needed to achieve the 2030 level in the

EE Target 18-25% and EE Target 19-27% cases and 40% higher investment in EE Target 20-30% case compared to the earlier periods.

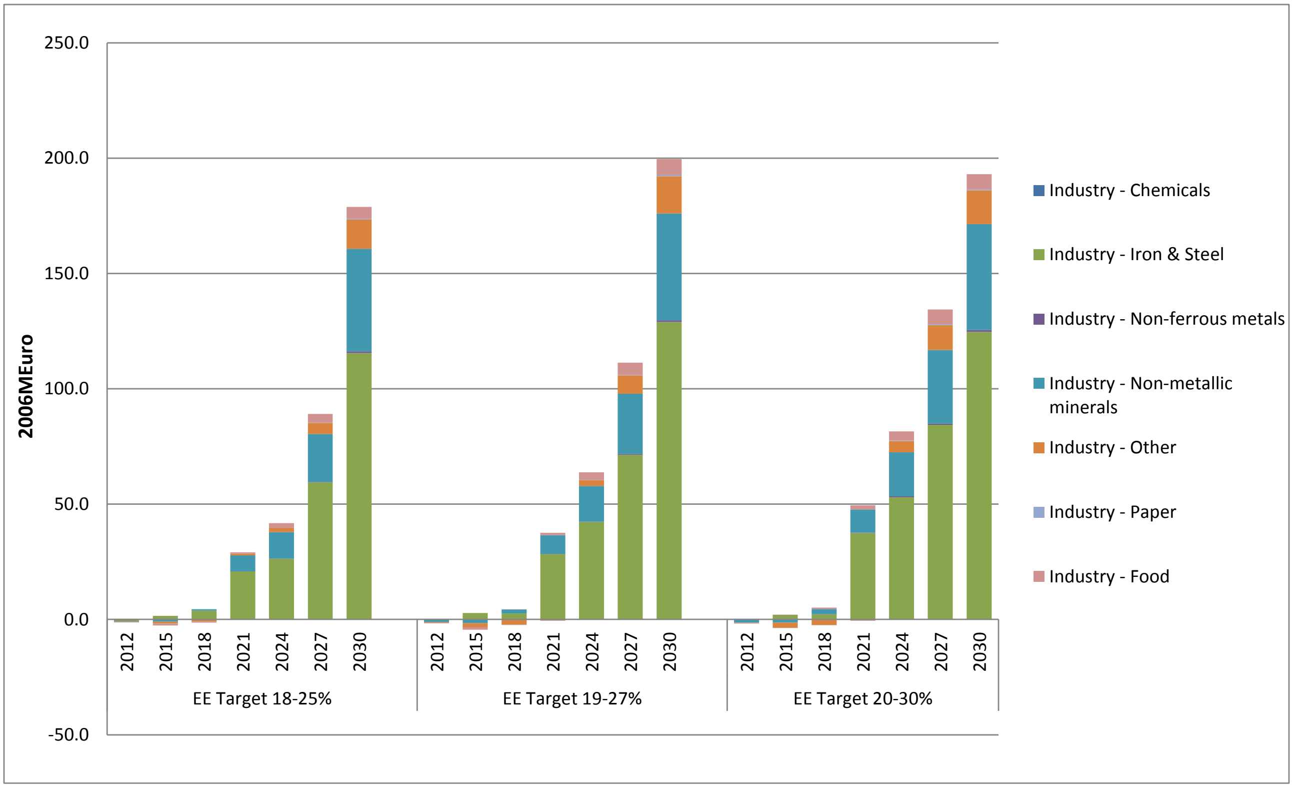



**Figure 63: Industrial Investment by Subsector – Difference from Reference Benchmark**

Table 27 shows that the investment per ktoe of energy saved is in a cost-effective range for all industry sub-sectors, with the most cost-effective efficiency investments occurring in the pulp and paper, non-metallic minerals and iron & steel sub-sectors. It also indicates that unit costs increase similarly for all scenarios.

**Table 27: Industrial Sector Investment per Energy Saved (MEUR/ktoe)**

| Energy Subsector | EE Target 18-25% | EE Target 19-27% | EE Target 20-30% |
|---|---|---|---|
| Chemicals | 1.43 | 1.66 | 1.66 |
| Food | 1.40 | 1.85 | 2.12 |
| Iron & Steel | 1.30 | 1.45 | 1.59 |
| Non-ferrous metals | 1.16 | 1.29 | 2.10 |
| Non-metallic minerals | 1.32 | 1.43 | 1.56 |
| Other | 1.16 | 1.06 | 1.26 |
| Paper | 0.59 | 1.22 | 0.81 |

### 7.3.6 Transport Sector Impacts

Figure 64 shows that achieving the EE target in the transportation sector primarily require reductions in final energy use for heavy trucks and light duty vehicles, with some contribution from buses and light commercial vehicles. It also shows that overall final energy use in 2030 is aggressively reduced in all cases, with dramatic reductions required in the EE Target 20-30% case.

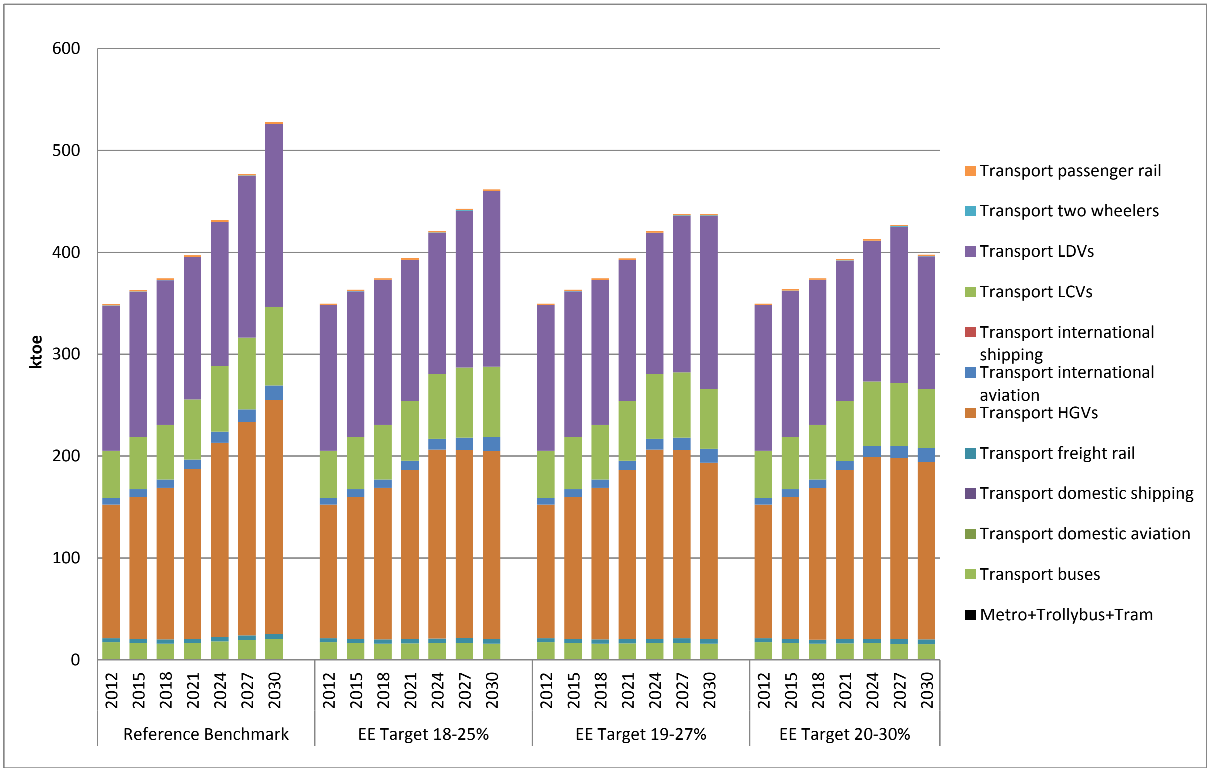



**Figure 64: Transportation Energy use by Mode for Reference Benchmark and EE Target Scenarios**

Figure 65 shows that the investment required to achieve the EE Target 18-25% and EE Target 19-27% cases are mainly for hybrid heavy trucks and light commercial vehicles, with electric buses coming in the later periods for the two more ambitious cases, along with plug-in hybrid LDV in the last period in order to achieve the EE Target 20-30%.

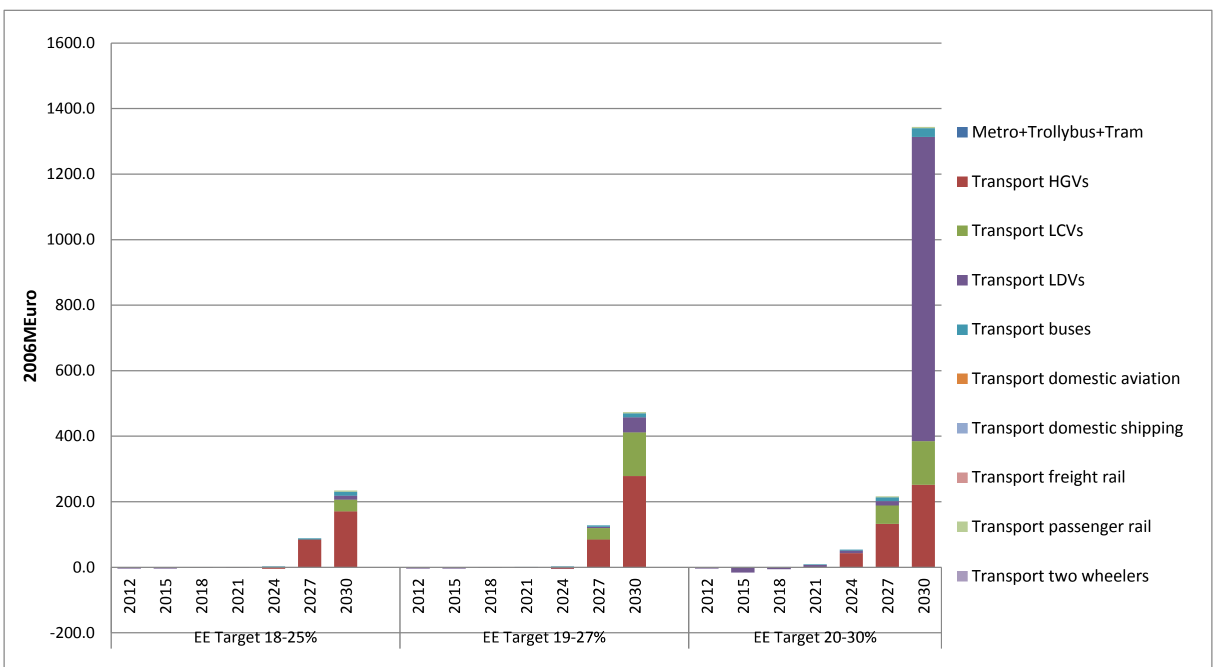



**Figure 65: Transport Mode Investment – Difference from Reference Benchmark**

Figure 66 and show that the investment per ktoe of energy saved increases about 26% from the EE Target 18-25% case to the EE Target 19-27% case, but then jumps another 53% in the EE Target 20-30% case compared to the EE Target 19-27% case. Passenger rail, heavy trucks, light commercial vehicles and buses play a key role for all scenarios, with additional investments in light duty vehicles needed as well to meet the more aggressive targets. For the EE Target 20-30% case plug-in hybrid vehicles and electricity buses, push up the cost per unit energy saved.

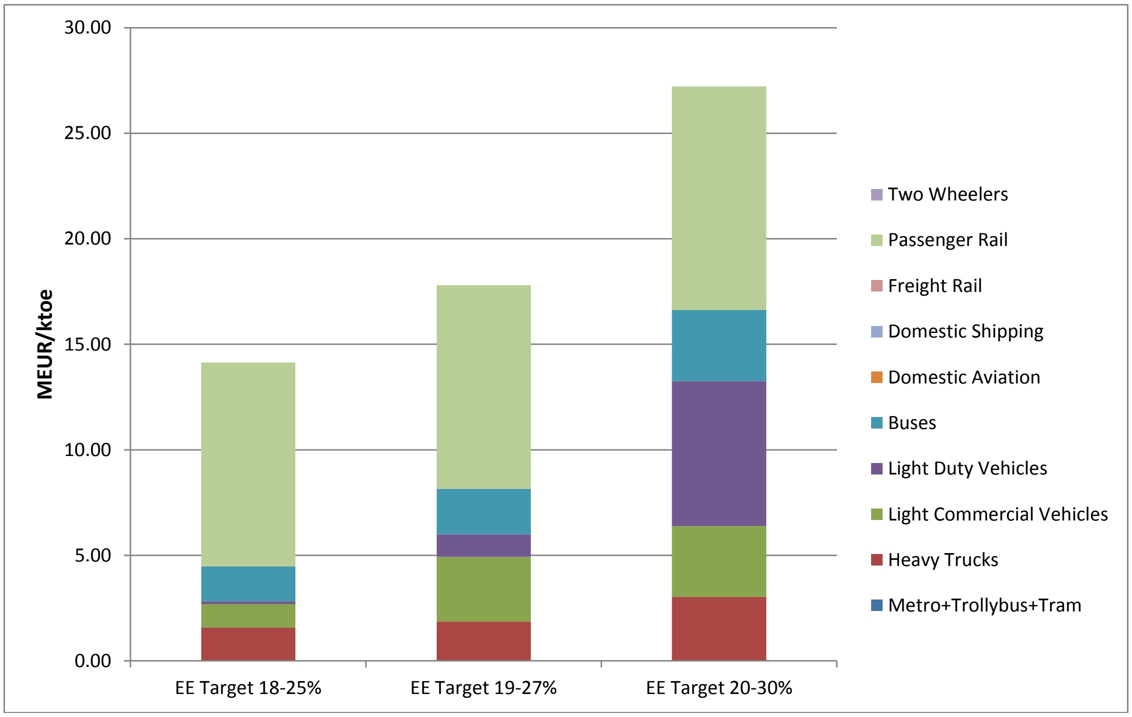



**Figure 66: Transport Mode Investment per unit Energy Saved**

**Table 28: Transportation Sector Investment per Energy Saved (MEUR/ktoe)**

| Energy Service | EE Target 20-25 | EE Target 20-27 | EE Target 20-30% |
|---|---|---|---|
| Heavy Trucks | 1.58 | 1.86 | 3.04 |
| Light Commercial Vehicles | 1.12 | 3.07 | 3.35 |
| Light Duty Vehicles | 0.13 | 1.06 | 6.86 |
| Buses | 1.65 | 2.15 | 3.38 |
| Passenger Rail | 9.66 | 9.66 | 10.59 |

## 7.4 Investment Costs for Kosovo* and Montenegro

### 7.4.1 Development of Kosovo and Montenegro Models

As Kosovo* and Montenegro did not participate in the USAID project[11] that developed the initial national models comprising EC-TIMES, these models were developed recently from available data. While there is reasonably good data available on energy supply, imports/exports, the power sector, and aggregate final energy consumption, there is little available on details of energy use within the various demand sectors - which is where the RESMD Planning Teams provided important insight as to the situation in each country. Therefore, final energy-only models were established for Kosovo* and Montenegro with sector level fuel consumption by type.

There is no complete energy balance for Kosovo*, although the Statistical Agency of Kosovo* provides an energy balance that has details for electricity generation and consumption, but presents coal production and oil imports in aggregate only. Other reports, such as the Kosovo* Energy Efficiency Action Plan (KEEAP), do provide useful details on consumption, and the REDP MARKAL-Kosovo* model prepared by the Ministry of Energy and Mining under the USAID REDP project [12] supplemented assumptions where necessary. A detailed energy balance for Montenegro is produced by the Statistical Office of Montenegro.

These models follow the same Reference Energy System network depiction employed for the rest of the Energy Community national models to ensure consistency between the EC-TIMES regions. For each of the main demand sectors there are fuel consumption processes that are seeded with the initial year fuel shares and guided over time according to the EnC RES-TF data call information to reflect expectations on any anticipated changes in the fuel mix over time as provided by the country experts to the ECS. These externally imposed drivers of the energy requirements for these countries may be easily adjusted to reflect differing views of the evolution of their energy demand.

### 7.4.2 Development of Demand Sector Investment Costs for Kosovo* and Montenegro

The EE targets scenarios for Kosovo* and Montenegro were implemented, as in the other country models, as a required reduction in final energy consumption. However, because there are no demand sector technologies in these two models, the required investment in high efficiency demand devices and conservation measures is not calculated directly. Instead, a proxy investment cost per unit of energy saved was calculated from the results of the other countries, and those proxy costs were applied at the sector level to the final energy reductions from the Kosovo* and Montenegro runs to estimate the required level of investment. For each sector, agriculture, commercial, industry, residential and transport, the incremental investment in demand devices and conservation measures over the period from 2012 to 2030 was divided by the savings in final energy consumption for each EE target scenario, to get a proxy sector investment cost in million Euro per ktoe. This cost was averaged, by sector and scenario, over the other Western Balkans countries and applied to the final energy saved by sector for Kosovo* and Montenegro to get an investment cost for each scenario, as shown in Table 29.

[11] The USAID Regional Energy Security and Market Development Project was carried out by International Resources Group between 2008 and 2012.

[12] The USAID Regional Energy Development Project was carried out by International Resources Group between 2005 and 2007.

**Table 29: Demand Sector Investment Cost per Energy Reduced for Kosovo* and Montenegro**

| Scenario | Million Euro per ktoe | | | |
|---|---|---|---|---|
| | Commercial | Industrial | Residential | Transport |
| EE Target 20-30% | 0.979 | 1.068 | 1.564 | 3.534 |
| EE Target 19-27% | 0.806 | 0.988 | 1.063 | 2.491 |
| EE Target 18-25% | 0.724 | 0.926 | 0.866 | 2.116 |
| ASUP 1.5% | 0.560 | 0.629 | 0.396 | -0.075 |
| ASUP 1-1.5% | 0.492 | 0.688 | 0.354 | -0.086 |

### 7.4.3 Energy Efficiency Investment Costs

For Kosovo* and Montenegro, the final energy reductions are specified as a percentage reduction required in each sector, and the model decides on technology and fuel choices that allow the EE Target reductions to be most cost-effectively met. Figure 67 shows the resulting change in final energy use by fuel type for Kosovo*, and Figure 68 shows the change in final energy use for Montenegro.

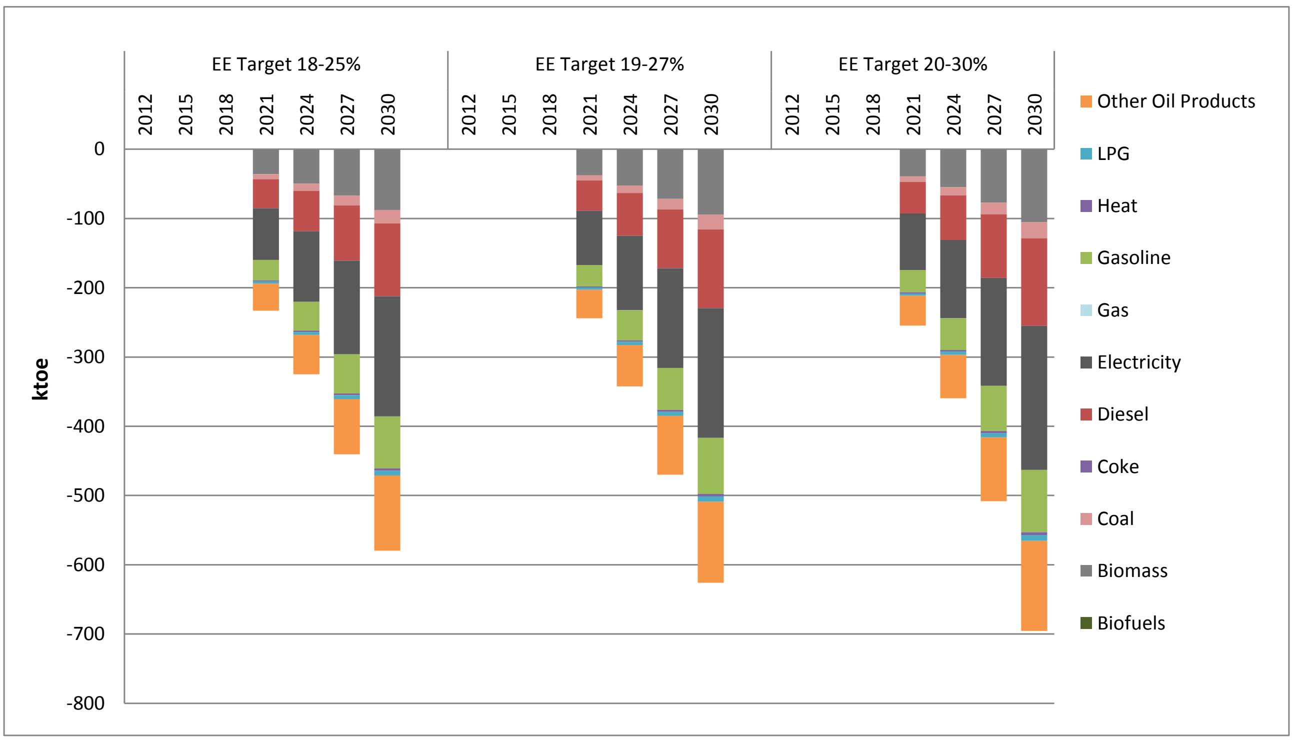



**Figure 67: Change in Final Energy Use by Fuel Type for EE Target Scenarios vs Reference Benchmark – Kosovo***

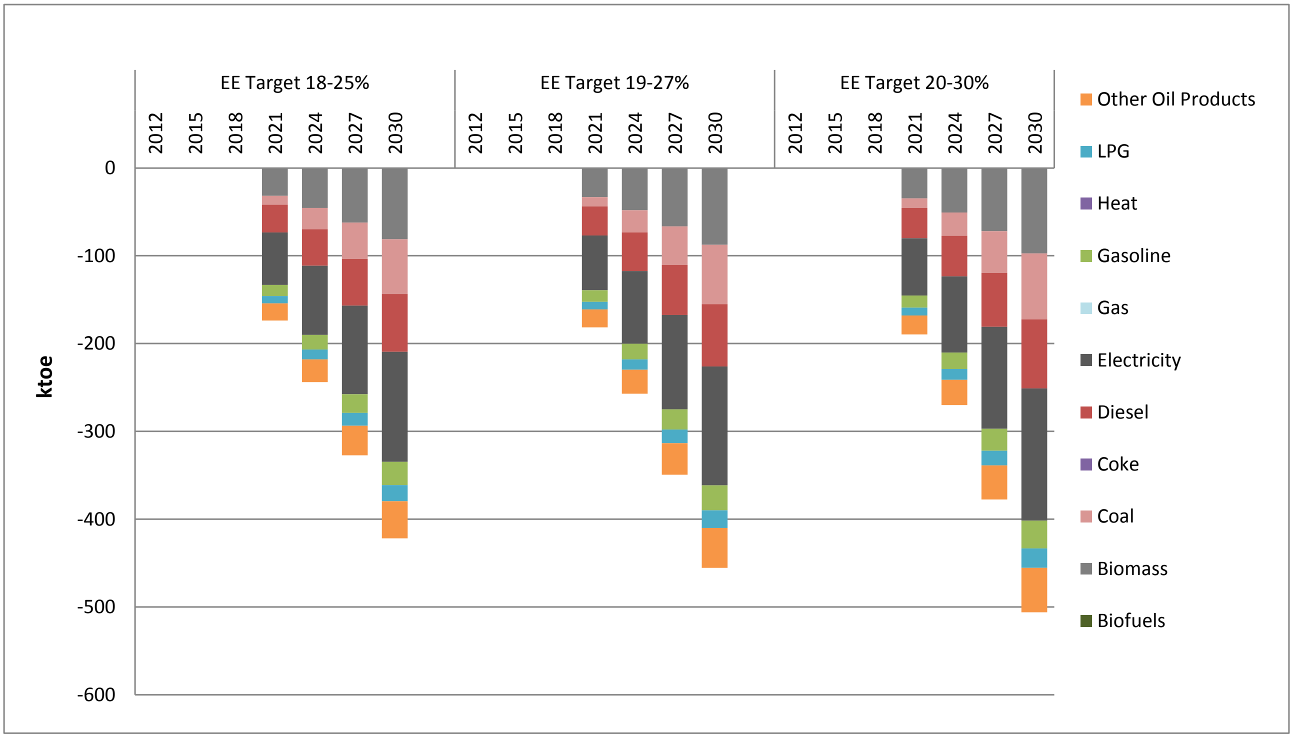



**Figure 68: Change in Final Energy Use by Fuel Type for EE Target Scenarios vs Reference Benchmark – Montenegro**

Using the final energy reductions, such as those shown in Figure 67 and Figure 68, the proxy investment costs in Table 29, the total discounted investments for Kosovo* and Montenegro were calculated and used to increment the total energy system value from EC-TIMES to get comparable values to the other CPs. Table 30 provides these incremental discounted investment costs.

**Table 30: Discounted Investment Costs for Kosovo* and Montenegro**

| Scenario | Million Euro (Discounted Present Value) | |
|---|---|---|
| | Kosovo* | Montenegro |
| EE Target 20-30% | 3305 | 2358 |
| EE Target 19-27% | 2316 | 1655 |
| EE Target 18-25% | 1890 | 1351 |
| ASUP 1.5 | 323 | 248 |
| ASUP 1-1.5 | 225 | 180 |

## 7.5 EE Target Scenario Details - Moldova

This section provides a country-specific understanding of the impacts of the EE Target levels for the Republic of Moldova. The section examines the changes in Final Energy Consumption (FEC) and the related changes in end-use device purchases by sector and end-use application, industry subsector or transport mode. This section first provides the overall results for Serbia by fuel type and demand sector and then examines the results for each sector in detail. No specific results for the Supplier Obligation scenario are provided because the measures implemented are the same as those identified as most relevant to this scenario.

### 7.5.1 System Cost Impacts

Figure 69 shows that the total discounted system cost increases by 3.8% over the Reference Benchmark case for the EE Target 18-25% case of 18% in 2025 and 25% in 2030. In the EE Target 19-27% case, the incremental cost goes to 5.9%, while turning to more costly measures, and the EE Target 20-30% case results in jump of 9.0% based on the need to resort to even more costly efficiency measures, as will be discussed.

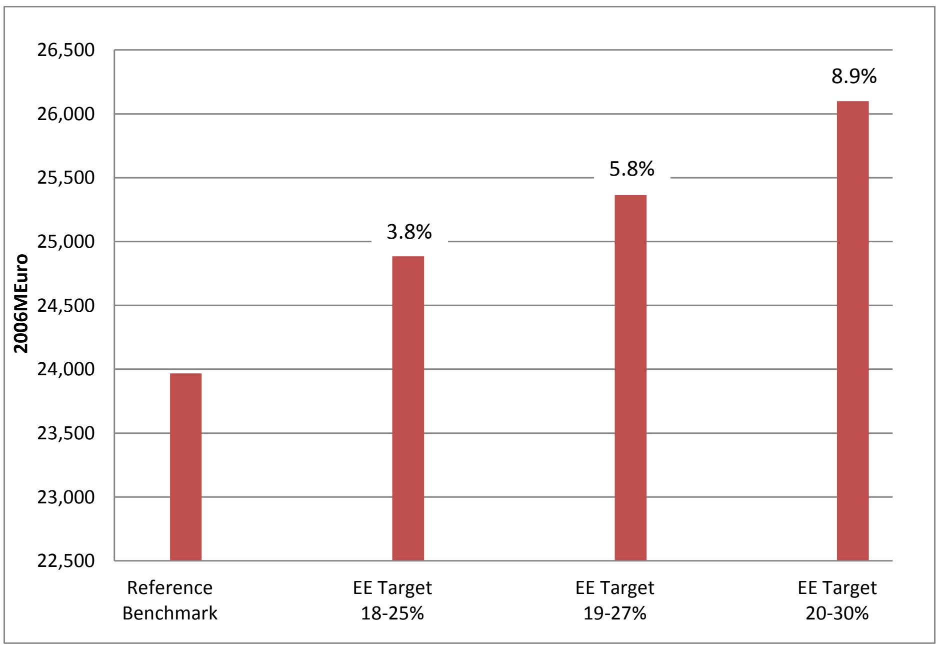



**Figure 69: Moldova Total System Cost for Reference Benchmark and EE Target Scenarios**

In the sections that follow the trends for some key aspects of the national energy system evolution over the 20-year planning horizon are shown for these EE target scenarios against the Reference Benchmark.

### 7.5.2 Reductions in Final Energy Consumption

Figure 70 shows final energy consumption by fuel type, and illustrates that the major savings are achieved through reductions in the use of biomass and coal, along with gasoline and district heat. There are also small increases in electricity, LPG and diesel consumption in some periods. The figure also illustrates that significant reductions are required in the 2021 and 2030 periods in all cases, but that to meet the proposed 20-30 target, additional reductions are needed in 2027 and 2030 compared to the 18-25 target case. Figure 71 shows that these energy savings come primarily from reductions in the transportation sector as a result of vehicle improvements needed to meet the more stringent target level. The sections that follow provide more details on a sectoral basis.

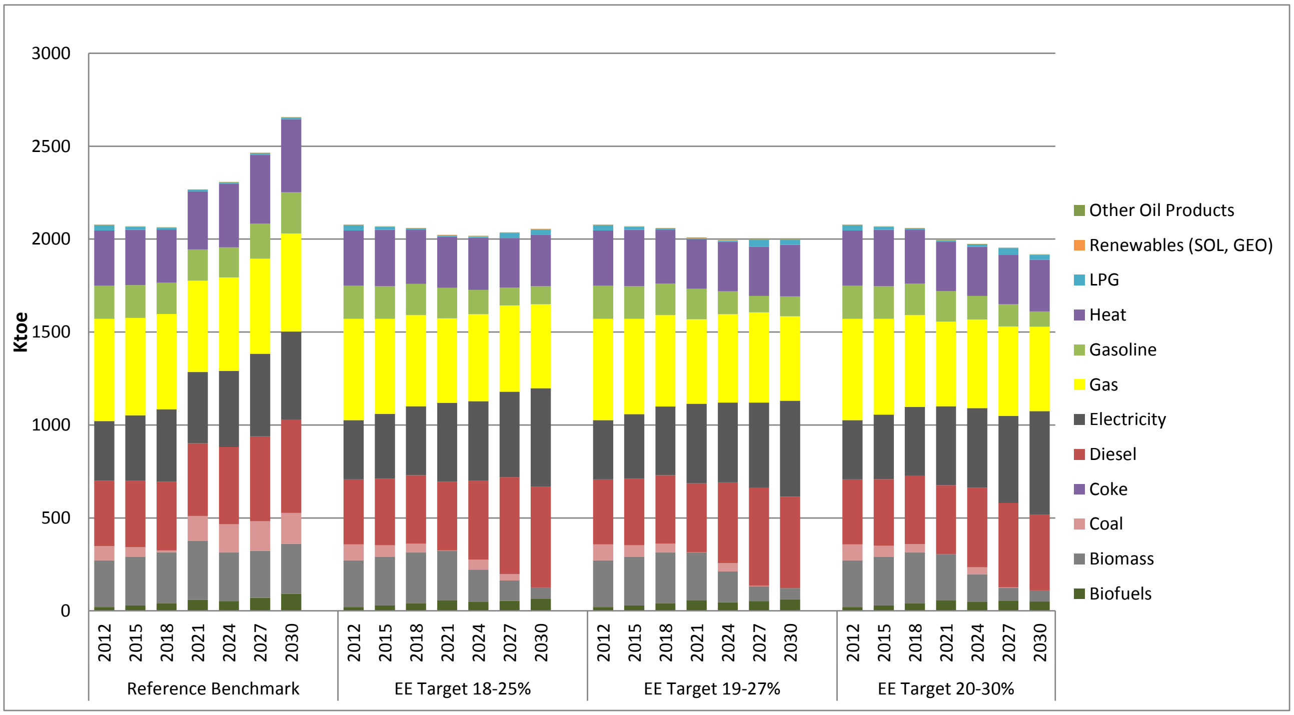



**Figure 70: Final Energy by Fuel Type for Reference Benchmark and EE Target Scenarios**

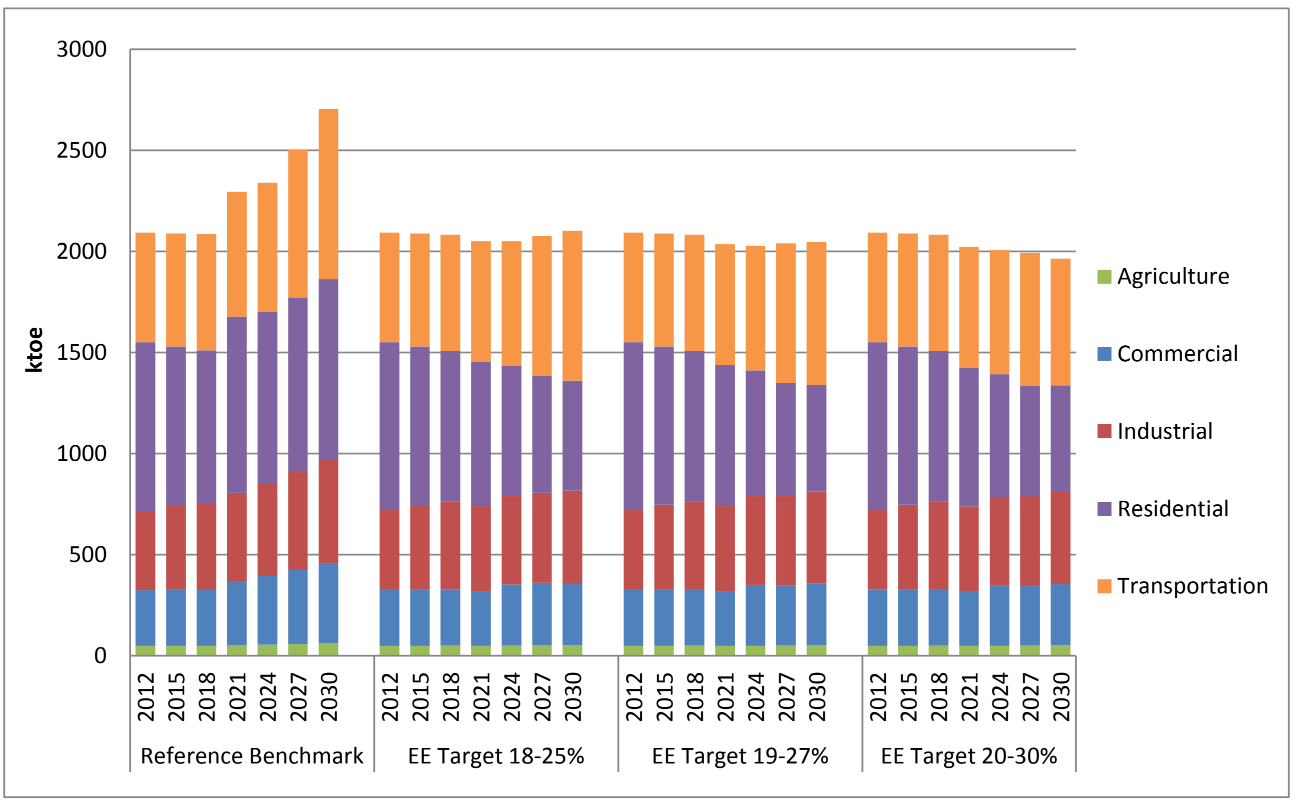



**Figure 71: Final Energy by Sector for Reference Benchmark and EE Target Scenarios**

### 7.5.3 Residential Sector Impacts

Figure 72 shows that achieving the EE targets in the residential sector requires significant reductions in final energy use for space heating and building insulation, as well as small incremental reductions in water heating. It also shows that final energy use changes only slightly between the three target cases, indicating that actions to reduce consumption for space heating are a robust cost-effective option.

Figure 73 shows that the investment needed to achieve the increased savings in all the cases requires significant increases in the areas of space conditioning (heating and cooling) along with building shell improvements, and Other (largely electrical appliances) in 2030, particularly for the EE Target 19-27% and EE Target 20-30% cases. This points to the need for appliance standards and perhaps targeted rebate programs. Note that part of the increased expenditure in heating devices is for heat pumps, which serve both the heating and cooling demands.

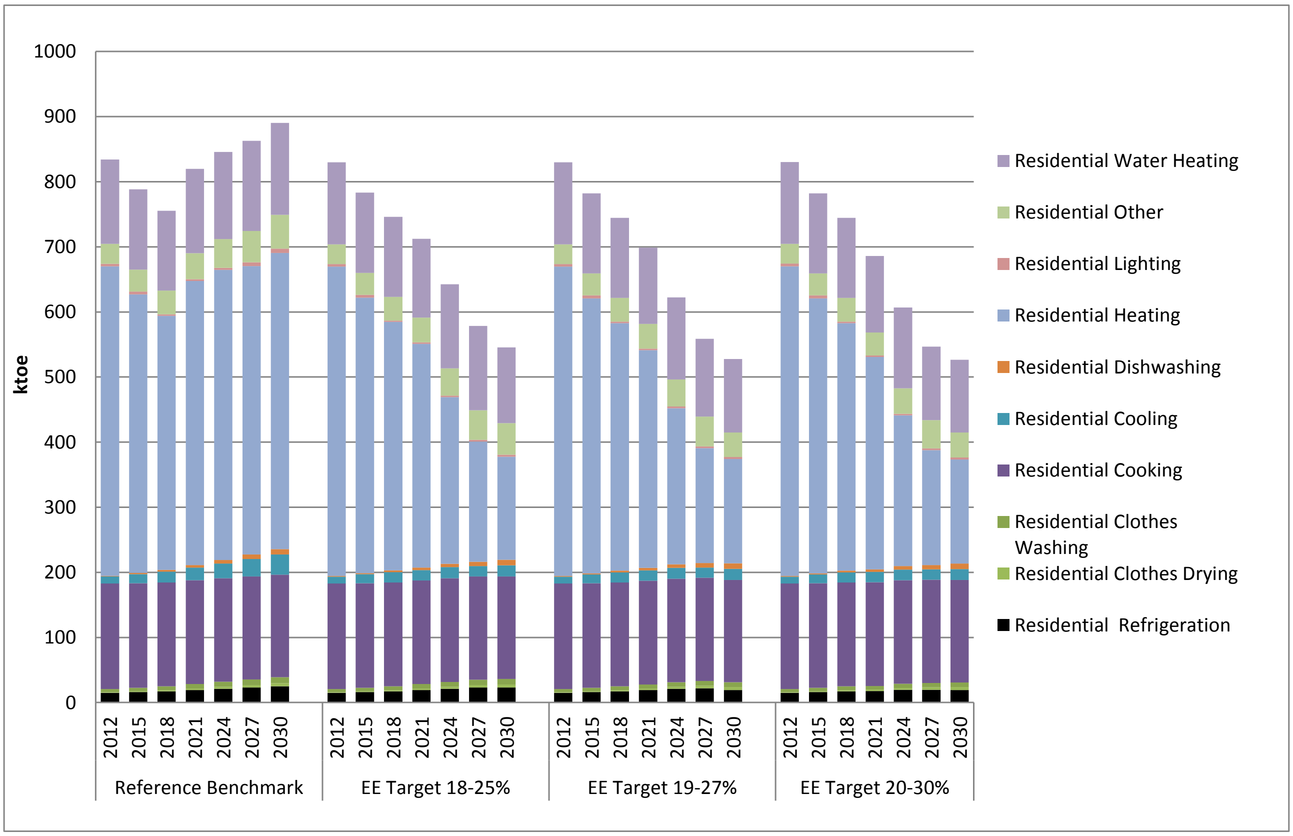



**Figure 72: Residential Energy use by Application for Reference Benchmark and EE Target Scenarios**

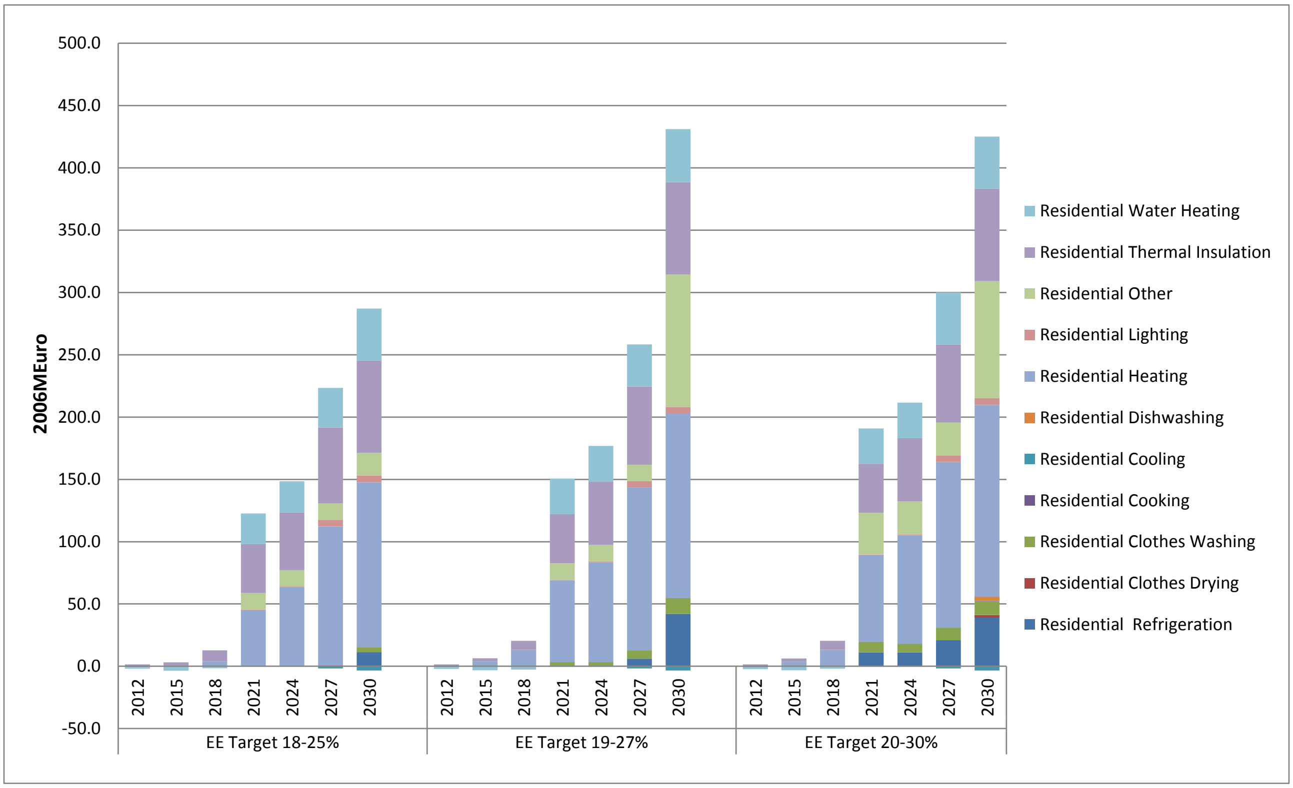



**Figure 73: Residential Investment by Application - Difference from Reference Benchmark**

Figure 74 shows that the investment per ktoe of energy saved increases by almost 50% in the EE Target 20-30% case, driven by the need to dramatic improve the efficiency of clothes drying and dishwashing, because all the more cost-effective options are already implemented at the 19-27 target level.

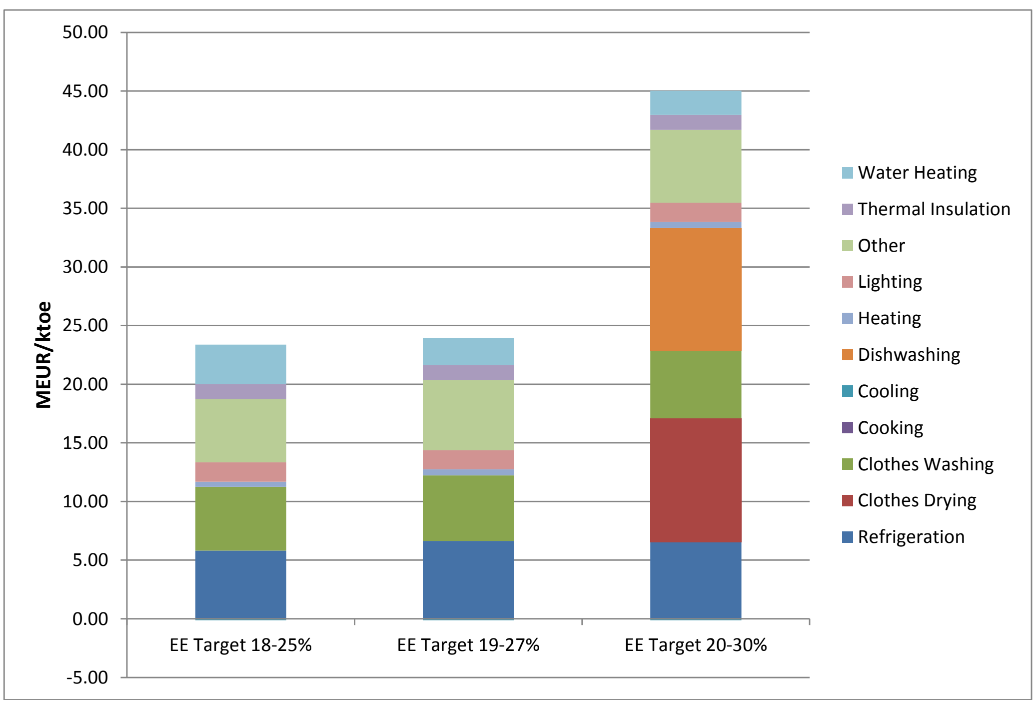



**Figure 74: Residential Device Investment per unit Energy Saved**

Table 31 presents the change in expenditure divided by the change in energy saved from the Reference Benchmark as a measure of the cost-effectiveness of actions for each energy service. It shows that high efficiency space heating and cooling are extremely important, with thermal insulation following as the most cost-effective measures to pursue in the residential sector. Note that investments in thermal insulation reduce heating and cooling demands, and that the negative values for cooling result because the Reference scenario already uses relatively efficient cooling devices, and the investments in building insulation allows a slightly lower investment in cooling devices. Heat pump technology and the value of residential building insulation are clearly priority areas for incentives as identified from these results.

**Table 31: Residential Investment per unit Energy Saved (MEUR/ktoe)**

| Energy Service | EE Target 18-25% | EE Target 19-27% | EE Target 20-30% |
|---|---|---|---|
| Refrigeration | 5.82 | 6.73 | 6.54 |
| Clothes Drying | 0.00 | 0.00 | 10.54 |
| Clothes Washing | 5.48 | 5.77 | 5.77 |
| Cooling | -0.13 | -0.13 | -0.13 |
| Dishwashing | 0.00 | 0.00 | 10.47 |
| Heating | 0.42 | 0.50 | 0.50 |
| Lighting | 1.65 | 1.65 | 1.65 |
| Other | 5.39 | 5.97 | 6.19 |
| Thermal Insulation | 1.28 | 1.28 | 1.28 |
| Water Heating | 3.48 | 2.14 | 2.07 |

### 7.5.4 Commercial Sector Impacts

Figure 75 shows that achieving the EE targets in the commercial sector requires significant reductions in final energy use for space heating, along with some minor savings in water heating and lighting. It also shows that final energy use changes only slightly between the three target cases, with some additional savings in space cooling in the final period.

Figure 76 shows that the investments required to achieve the necessary savings are similar in all three EE cases, with investments in efficient space heating, lighting and commercial building retrofits key, but with additional investments in new efficient space cooling equipment required to meet the EE Target 20-30%.

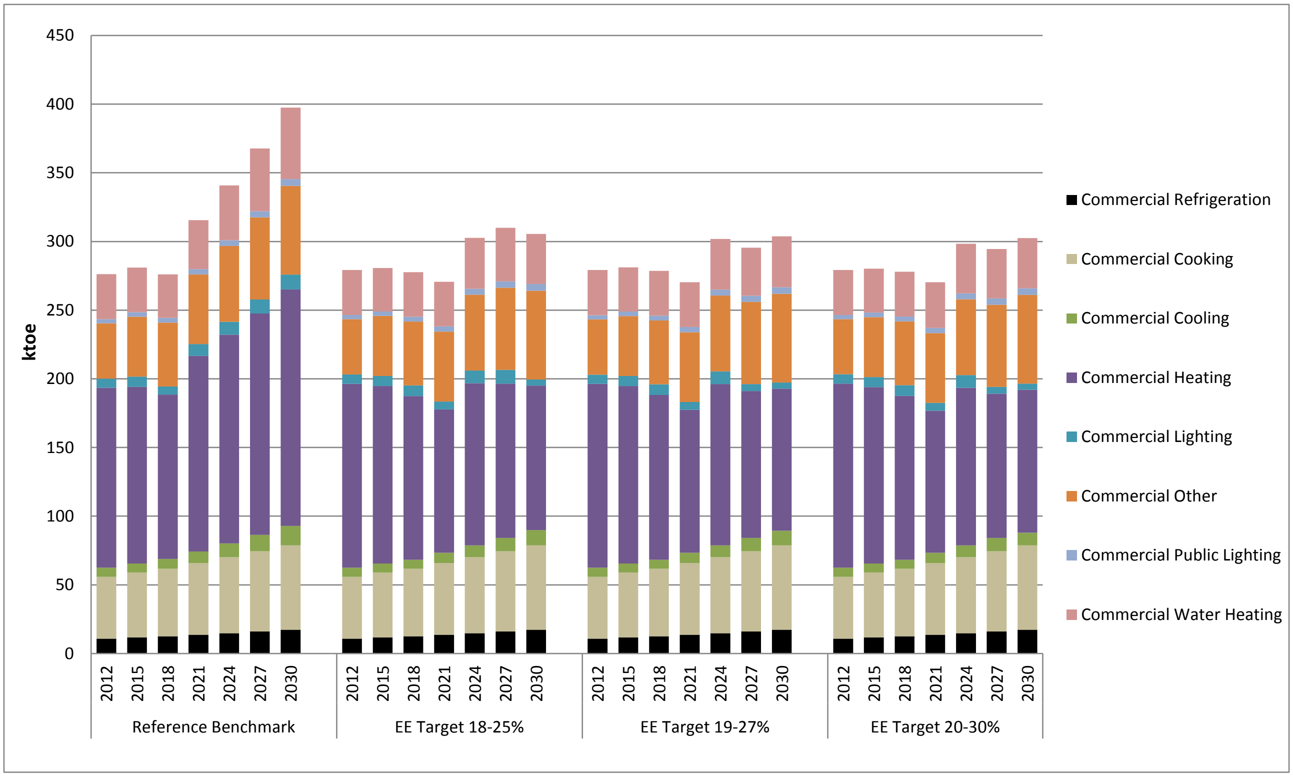



Figure 75: Commercial Energy use by Application for Reference Benchmark and EE Target Scenarios

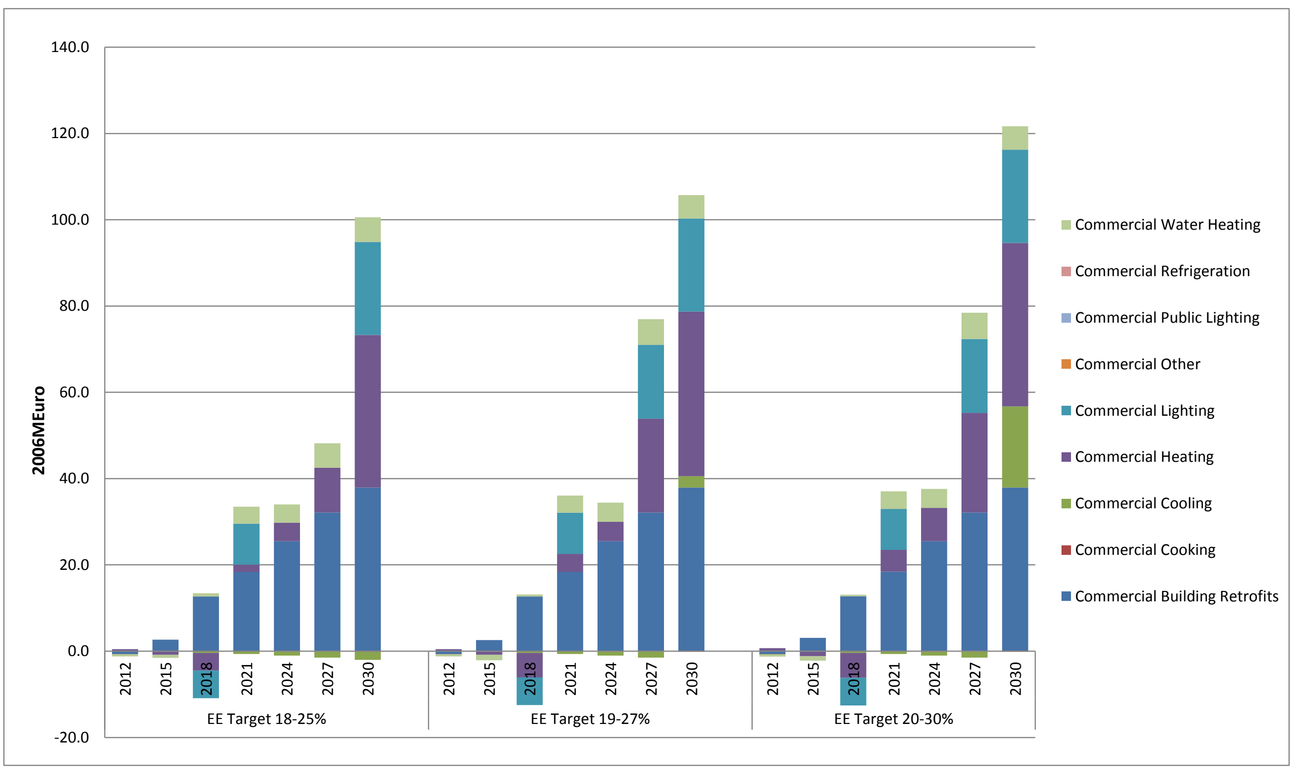



Figure 76: Commercial Investment by Application – Difference for Reference Benchmark

Table 32 shows that space conditioning (heating and cooling) and building retrofits are the most cost-effective types of investments, where the latter leads to savings in space heating and cooling device investments in this sector. Water heating is also cost-effective. Note that the building retrofits facilitate some reductions in cooling device investments in the EE Target 18-25% and EE Target 19-27% cases, but incremental investments in cooling are needed in the more stringent case. Overall, the unit investment cost for all the cases are similar. Commercial scale heat-pump technologies and commercial building retrofits, along with the lighting improvements, are highlighted by these results for incentive programs.

**Table 32: Commercial Sector Investment per unit Energy Saved (MEUR/ktoe)**

| Energy Service | EE Target 18-25% | EE Target 19-27% | EE Target 20-30% |
|---|---|---|---|
| Building Retrofits | 1.08 | 1.08 | 1.08 |
| Cooling | -0.62 | -0.28 | 0.50 |
| Heating | 0.23 | 0.32 | 0.33 |
| Lighting | 3.37 | 3.37 | 3.37 |
| Water Heating | 0.95 | 0.87 | 0.88 |

### 7.5.5 Industry Sector Impacts

Figure 77 shows that achieving the EE target in the industrial sector requires significant reductions in final energy use for the food and non-metallic minerals subsectors, along with actions required for Other industries. It also shows that final energy use in the industrial sector changes only slightly between the three target cases.

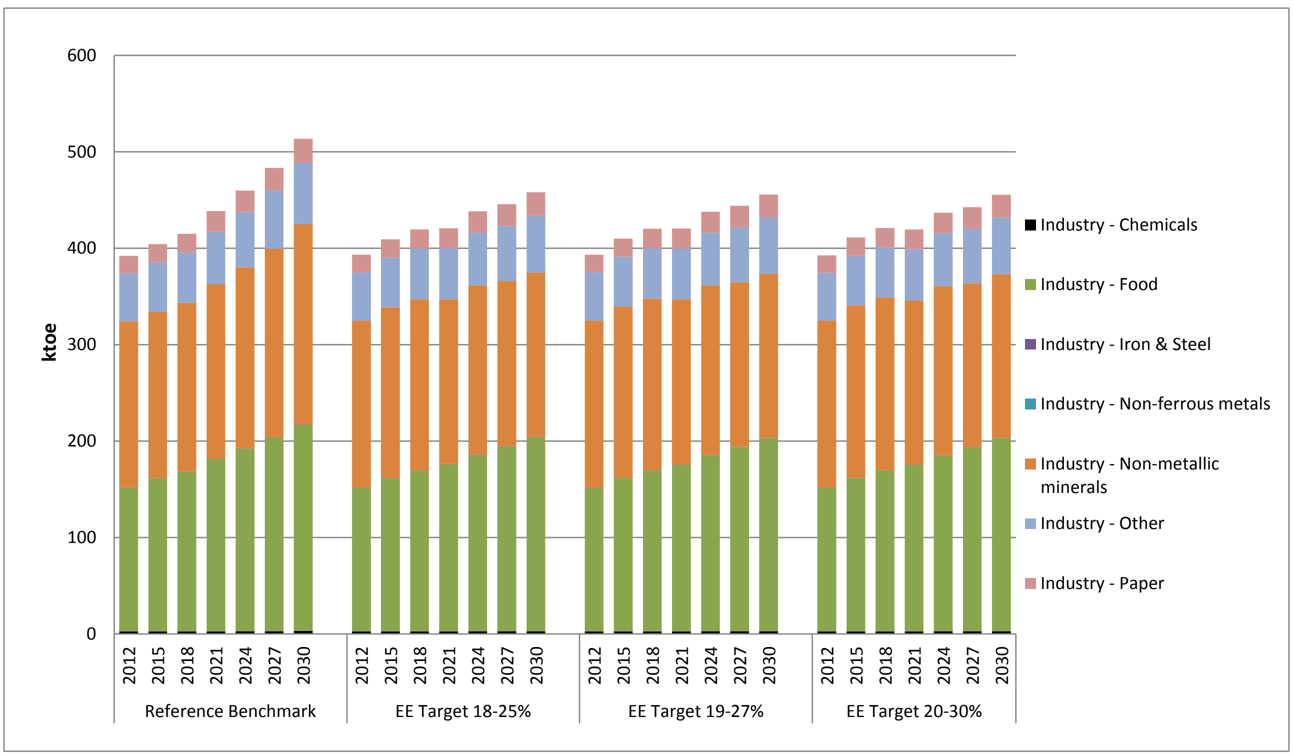



**Figure 77: Industrial Energy use by Application for Reference Benchmark and EE Target Scenarios**

Figure 78 shows that the investment required to achieve the EE target increases significantly in the 2030 period in all three cases, with a doubling in expenditure needed to achieve the 2030 level in each of the cases compared to that in the earlier periods when the EE targets come into effect. In the EE Target 20-

30% case, earlier action is required in 2021, 2024 and 2027 which damps the 2030 period increase slightly compared to the less stringent EE Target 19-27% case.

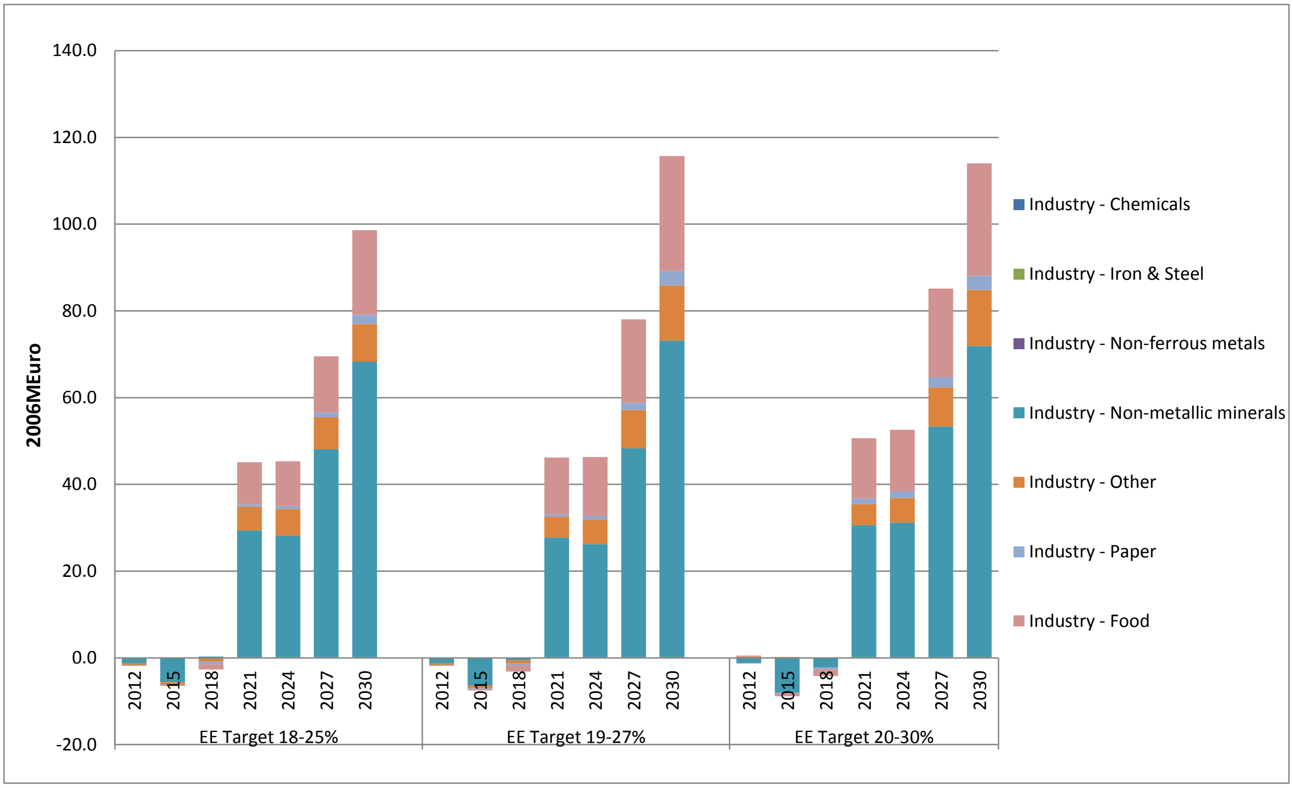



**Figure 78: Industrial Investment by Subsector – Difference from Reference Benchmark**

Table 33 shows that the investment per ktoe of energy saved is in a cost-effective range for all industry sub-sectors, with the most cost-effective efficiency investments occurring in the chemicals and food sub-sectors. It also indicates that and that unit costs increase for the more aggressive scenarios.

**Table 33: Industrial Sector Investment per Energy Saved (MEUR/ktoe)**

| Energy Subsector | EE Target 18-25% | EE Target 19-27% | EE Target 20-30% |
|---|---|---|---|
| Chemicals | 1.14 | 1.14 | 1.14 |
| Food | 1.63 | 2.01 | 2.07 |
| Iron & Steel | 3.16 | 3.24 | 3.24 |
| Non-metallic minerals | 2.24 | 2.29 | 2.30 |
| Other | 2.48 | 2.73 | 2.65 |
| Paper | 1.43 | 2.32 | 2.31 |

### 7.5.6 Transport Sector Impacts

Figure 79 shows that achieving the EE target in the transportation sector primarily requires reductions in final energy use for light duty vehicles, heavy trucks and buses. It also shows that overall final energy use in 2027 and 2030 is aggressively reduced in all cases, with dramatic reductions required in the EE Target 20-30% case.

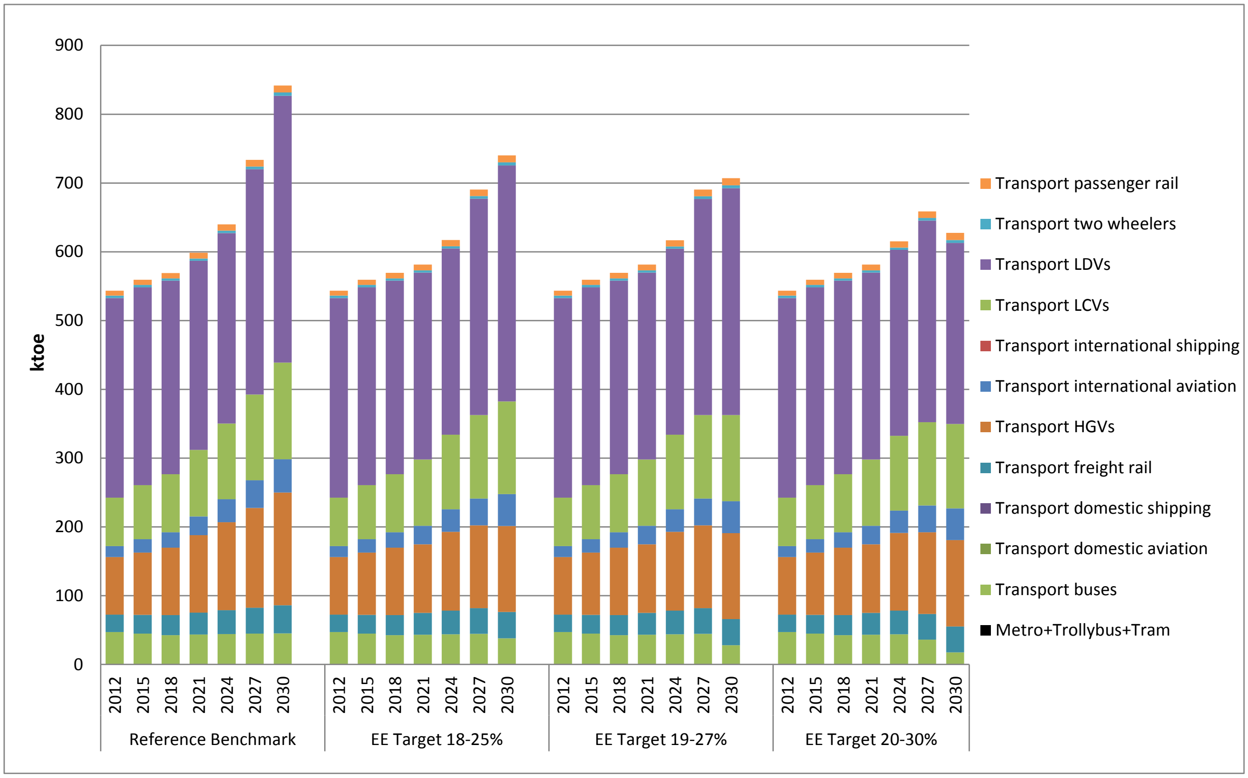



**Figure 79: Transportation Energy use by Mode for Reference Benchmark and EE Target Scenarios**

Figure 80 shows that the investment required to achieve the increased savings in 2030 requires significant increases for diesel hybrid light duty vehicles and heavy trucks, mostly in 2030, while for EE Target 19-27% and EE Target 20-30% cases electric buses and plug-in light duty vehicles are turned to as well causing a dramatic spike in that final period particular for the more stringent scenario.

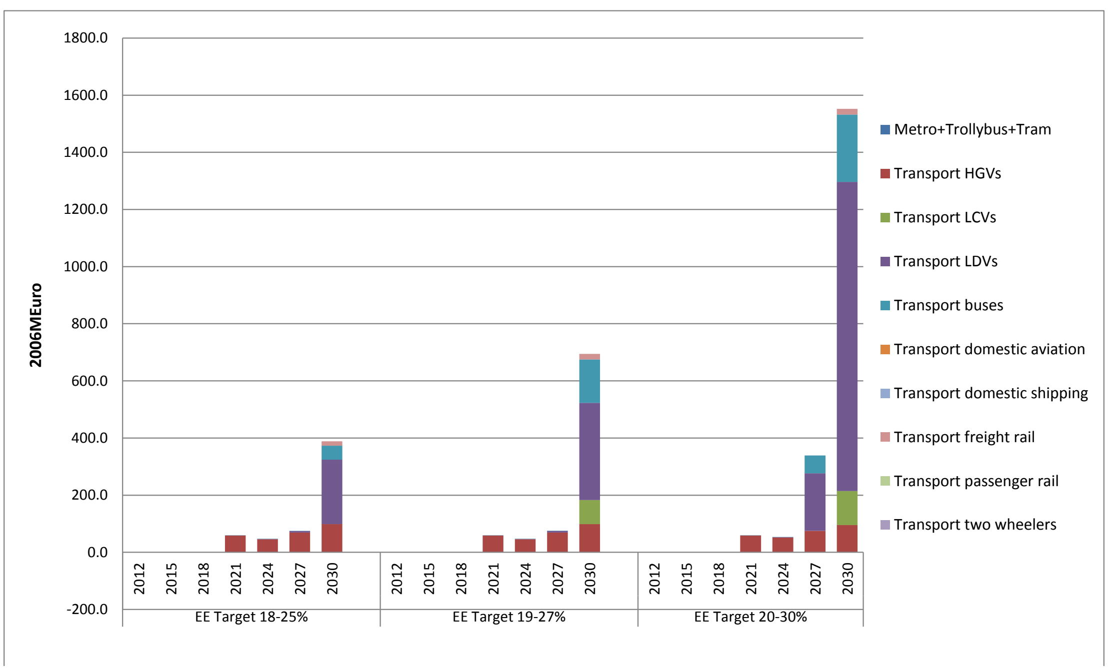



**Figure 80: Transport Mode Investment – Difference from Reference Benchmark**

Figure 81 and show that the investment per ktoe of energy saved increases by 25% in the EE Target 19-27% case compared to the EE Target 18-25% case and increases another 32% in the EE Target 20-30% case compared to the EE Target 19-27% case. While light commercial vehicles and freight rail are the most cost-effective investments in transport they are rather minor demands, so the LDV investments are the most important in terms of achieving the required energy savings.

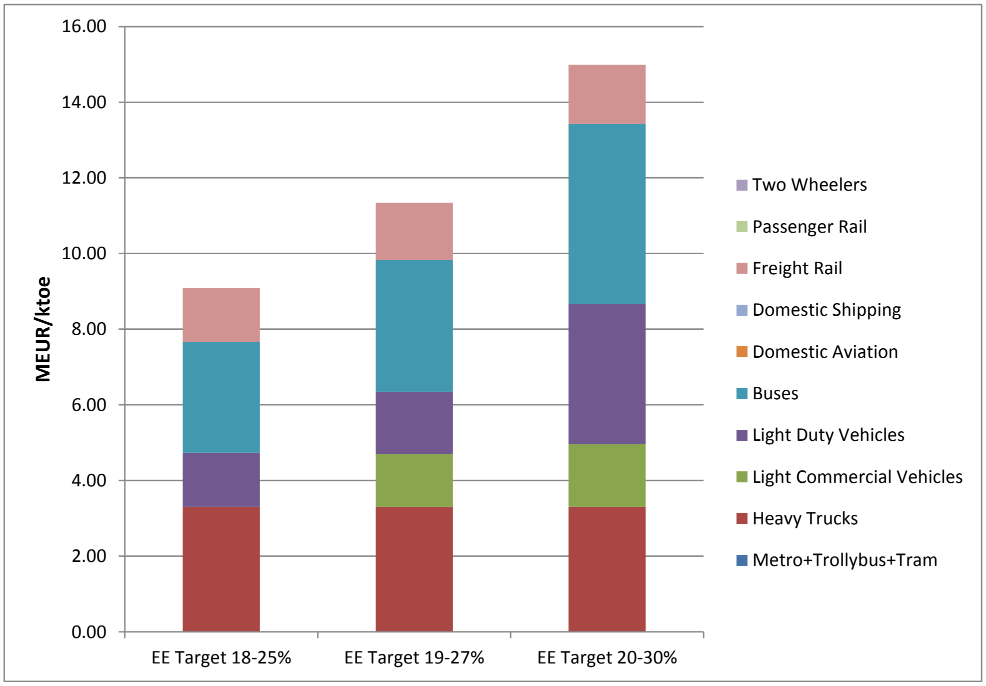



**Figure 81: Transport Mode Investment per unit Energy Saved**

**Table 34: Transportation Sector Investment per Energy Saved (MEUR/ktoe)**

| Energy Service | EE Target 18-25% | EE Target 19-27% | EE Target 20-30% |
|---|---|---|---|
| Heavy Trucks | 3.31 | 3.31 | 3.30 |
| Light Commercial Vehicles | 0.00 | 1.40 | 1.66 |
| Light Duty Vehicles | 1.42 | 1.64 | 3.70 |
| Buses | 2.93 | 3.48 | 4.77 |
| Freight Rail | 1.43 | 1.52 | 1.56 |

## 7.6 EE Target Scenario Details - Serbia

This section provides a country-specific understanding of the impacts of the EE Target levels for the Republic of Serbia. The section examines the changes in Final Energy Consumption (FEC) and the related changes in end-use device purchases by sector and end-use application, industry subsector or transport mode. This section first provides the overall results for Serbia by fuel type and demand sector and then examines the results for each sector in detail. No specific results for the Supplier Obligation scenario are provided because the measures implemented are the same as those identified as most relevant to this scenario.

### 7.6.1 System Cost Impacts

Figure 82 shows that the total discounted system cost increases by 4% over the Reference Benchmark case for the EE Target 18-25% case of 18% in 2025 and 25% in 2030. In the EE Target 19-27% case, the incremental cost goes to 5.6%, while turning to more costly measures, and the EE Target 20-30% case results in jump of 9.4% based on the need to resort to even more costly efficiency measures, as will be discussed.

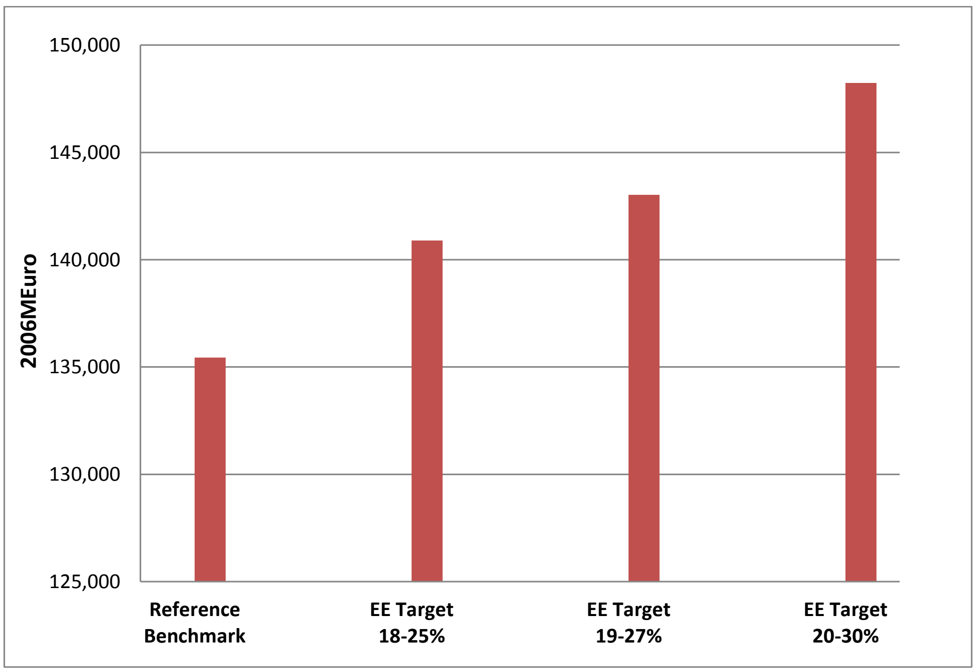



**Figure 82: Serbia Total System Cost for Reference Benchmark and EE Target Scenarios**

In the sections that follow the trends for some key aspects of the national energy system evolution over the 20-year planning horizon are shown for these EE target scenarios against the Reference Benchmark.

### 7.6.2 Reductions in Final Energy Consumption

Figure 83 shows final energy consumption by fuel type, and illustrates that the major savings are achieved through reductions in the use of coal, biomass and diesel. There are also small increases in electricity and natural gas consumption in some periods. The figure also illustrates that significant reductions are required in the 2021 and 2030 periods in all cases, but that to meet the proposed 20-30 target, additional reductions are needed in 2027 and 2030 compared to the 18-25 target. Figure 84 shows that these energy savings come primarily from reductions in diesel and gasoline to the transport sector as a result of a move to hybrid-electric and plug-in hybrid vehicles. The sections that follow provide more details on a sectoral basis.

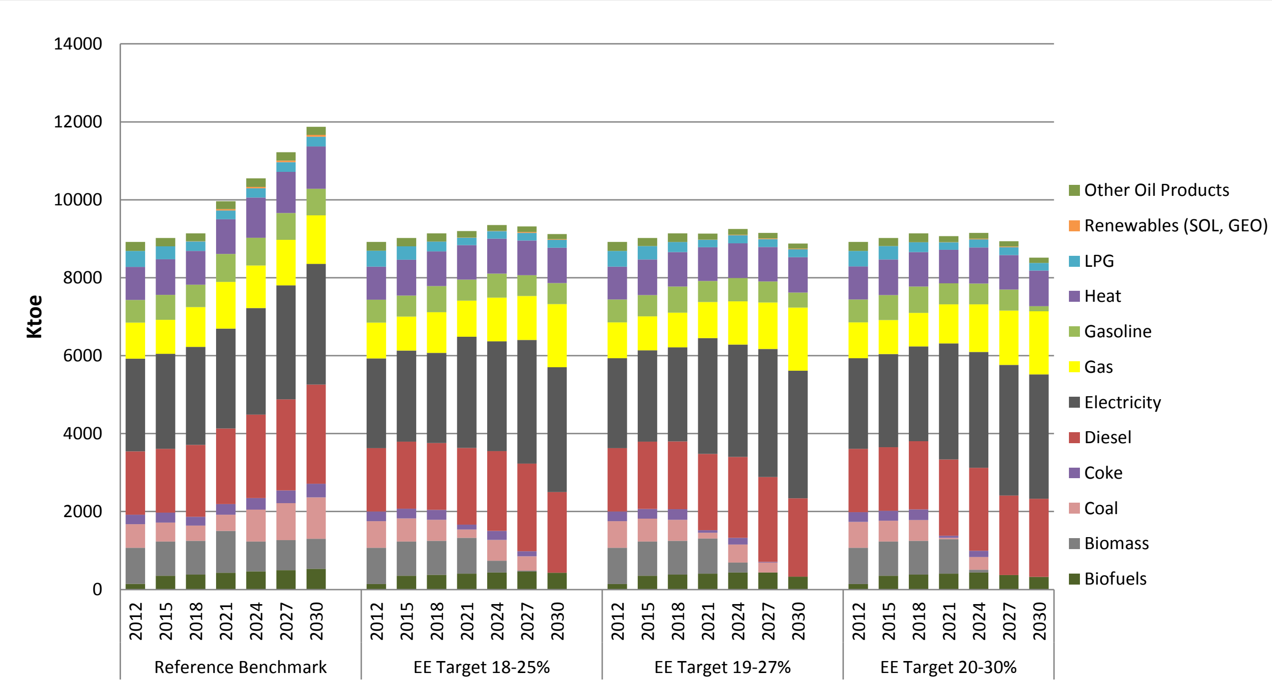



**Figure 83: Final Energy by Fuel Type for Reference Benchmark and EE Target Scenarios**

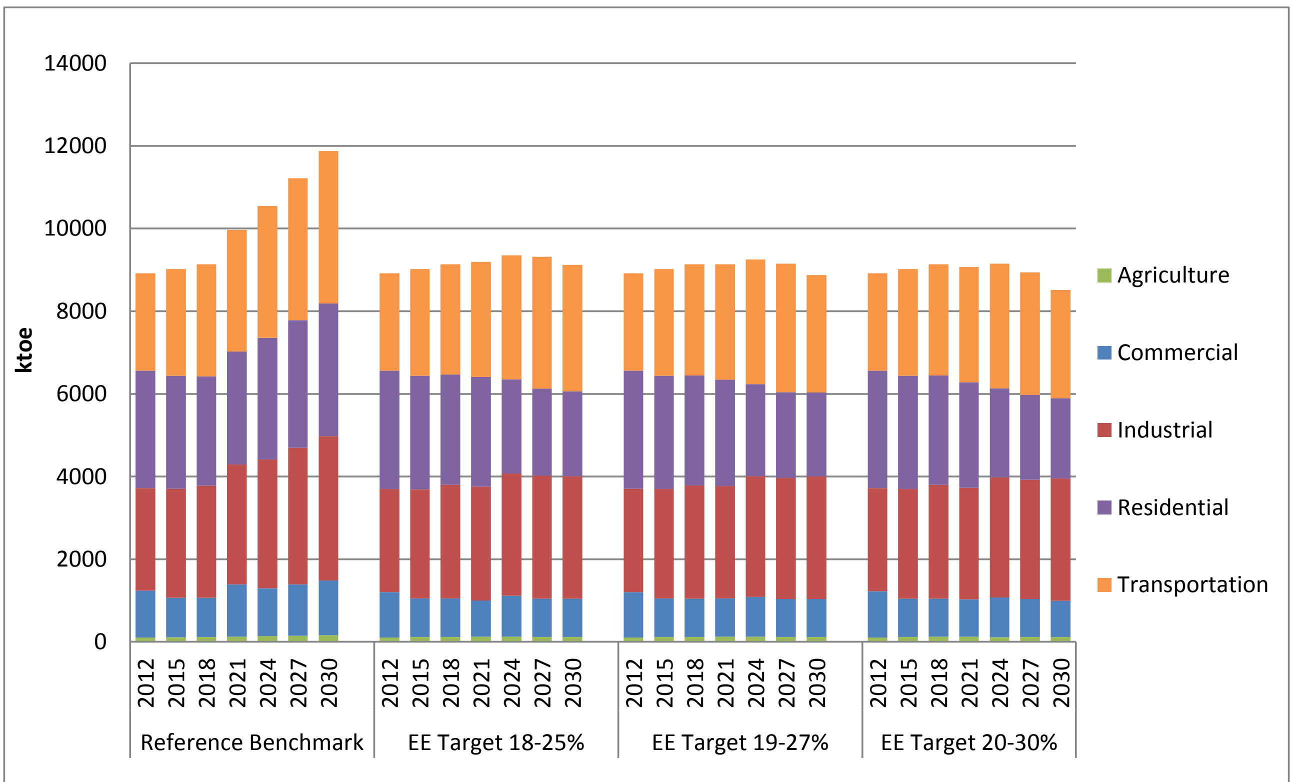



**Figure 84: Final Energy by Sector for Reference Benchmark and EE Target Scenarios**

### 7.6.3 Residential Sector Impacts

Figure 85 shows that achieving the EE targets in the residential sector requires significant reductions in final energy use for space heating and water heating with small incremental reductions in lighting – as most lighting options are implemented in the Reference Benchmark case. It also shows that final energy use changes only slightly between the three target cases, with some additional savings in space heating as well as refrigeration and other appliances. Figure 86 shows that the investment needed to achieve the increased savings in all the cases requires significant increases in the areas of space conditioning, refrigeration and other (largely electrical appliances) in 2030, particularly for the EE Target 20-30% case, pointing to the need for appliance standards and perhaps targeted rebate programs. Note that part of the increased expenditure in heating devices is for heat pumps, which serve both the heating and cooling demands.

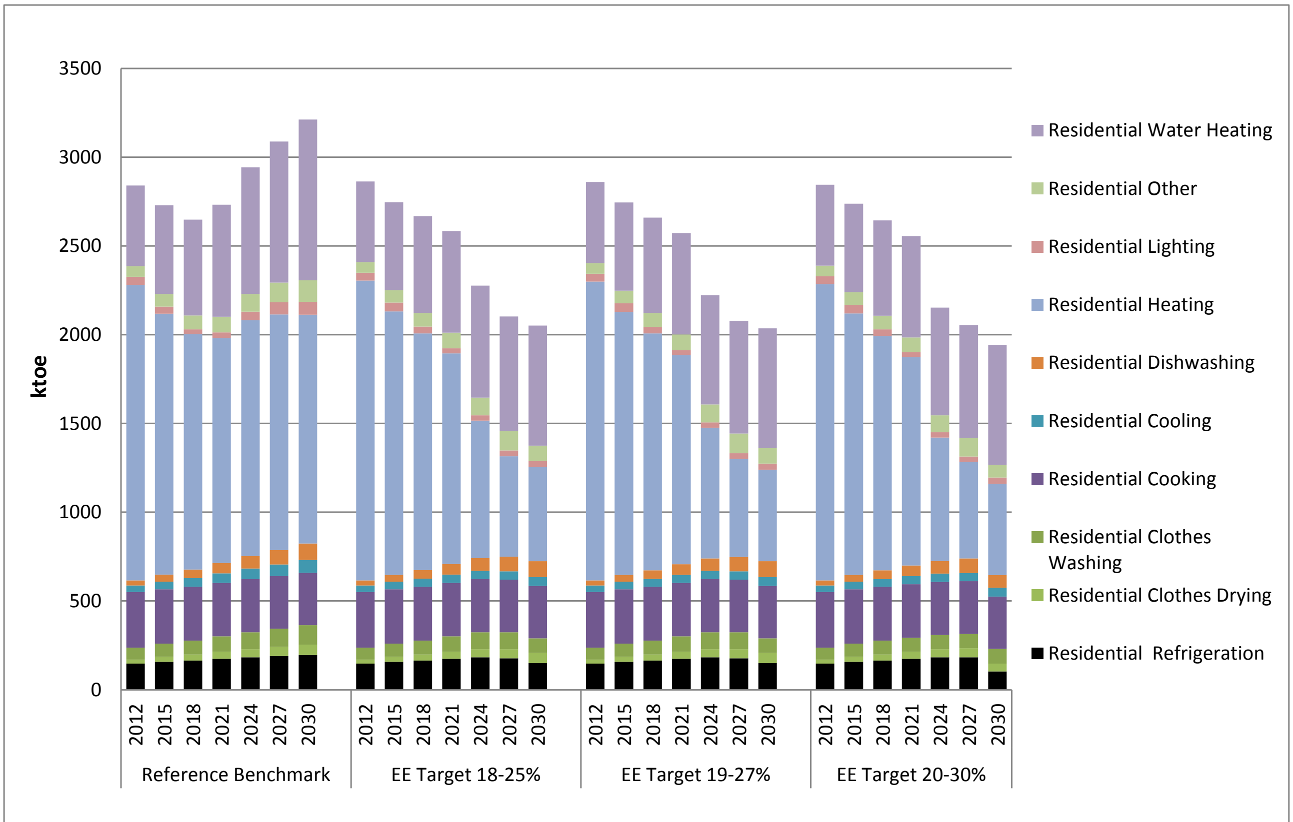



**Figure 85: Residential Energy use by Application for Reference Benchmark and EE Target Scenarios**

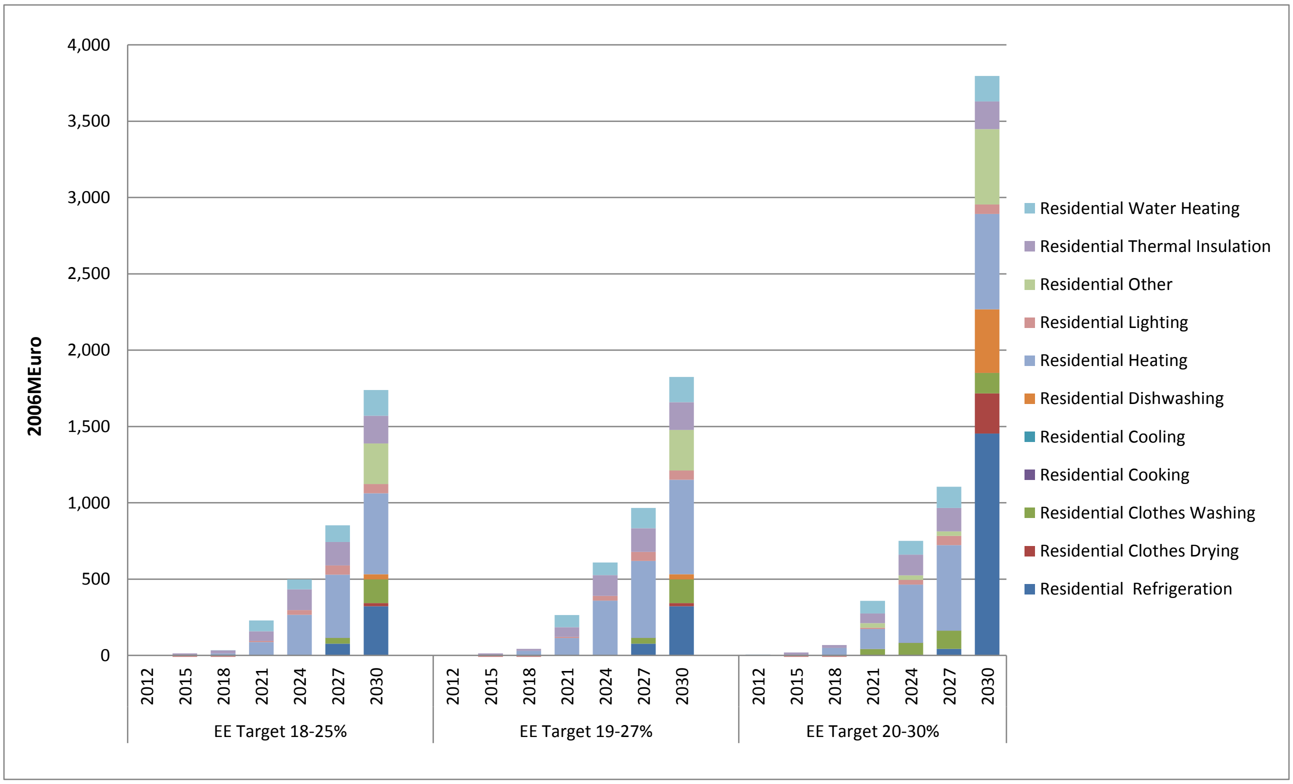



**Figure 86: Residential Investment by Application - Difference from Reference Benchmark**

Figure 87 shows that the investment per ktoe of energy saved increases by almost 50% in the EE Target 20-30% case.

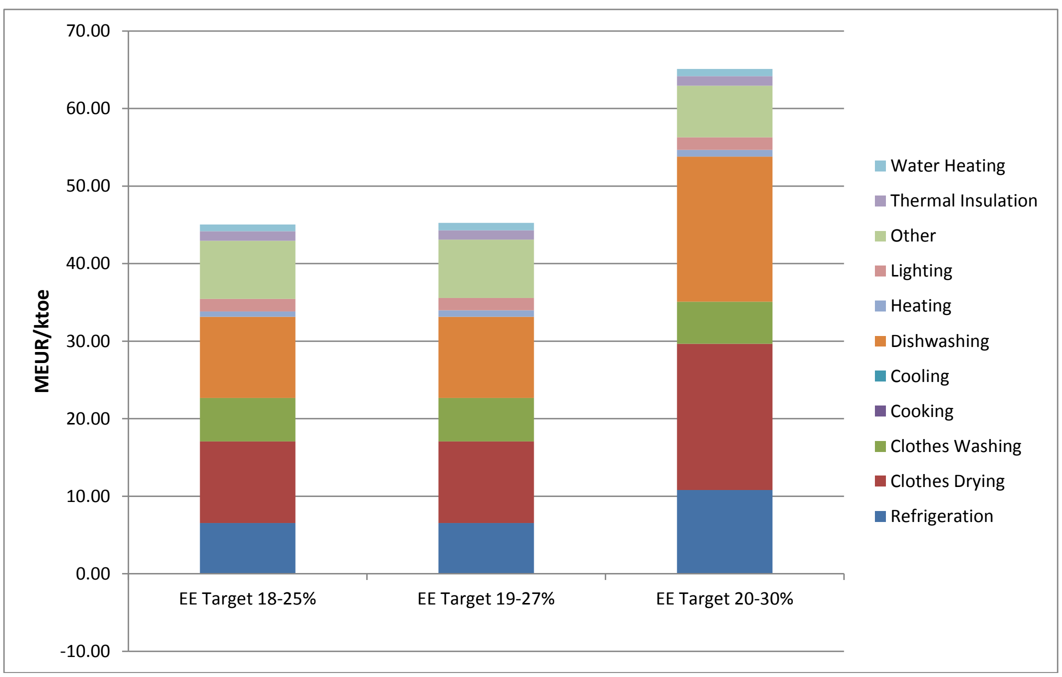



**Figure 87: Residential Device Investment per unit Energy Saved**

Table 35 presents the change in expenditure divided by the change in energy saved from the Reference Benchmark as a measure of the cost-effectiveness of actions for each energy service. It shows that high efficiency space heating and cooling are extremely important, with water heaters and thermal insulation following as the most cost-effective measures to pursue in the residential sector. Note that investments in thermal insulation reduce heating and cooling demands, and that the negative values for cooling result because the Reference scenario already uses relatively efficient cooling devices, and the investments in building insulation allows a slightly lower investment in cooling devices. Heat pump technology and the value of residential building insulation are clearly priority areas for incentives as identified from these results.

**Table 35: Residential Investment per unit Energy Saved (MEUR/ktoe)**

| Energy Service | EE Target 18-25% | EE Target 19-27% | EE Target 20-30% |
|---|---|---|---|
| Refrigeration | 6.52 | 6.52 | 10.81 |
| Clothes Drying | 10.54 | 10.54 | 18.85 |
| Clothes Washing | 5.59 | 5.59 | 5.42 |
| Cooling | -0.02 | -0.03 | -0.03 |
| Dishwashing | 10.47 | 10.47 | 18.70 |
| Heating | 0.71 | 0.84 | 0.89 |
| Lighting | 1.60 | 1.60 | 1.60 |
| Other | 7.51 | 7.51 | 6.65 |
| Thermal Insulation | 1.22 | 1.22 | 1.22 |
| Water Heating | 0.87 | 0.94 | 0.95 |

### 7.6.4 Commercial Sector Impacts

Figure 88 shows that achieving the EE targets in the commercial sector requires significant reductions in final energy use for space heating, lighting and space cooling. The drop in 2015 lighting is due to the rapid elimination of incandescent light bulbs. It also shows that final energy use changes only slightly between the three target cases, with mostly some additional savings in space cooling in the final period.

Figure 89 shows that the investments required to achieve the savings in the EE Target 18-25% and EE Target 19-27% cases require similar investments in efficient space heating, lighting and commercial building retrofits, but that the 19-27% target requires additional investments in new efficient space cooling equipment, and that reaching the EE Target 20-30% level requires a factor of four increase in investment in new efficient cooling equipment.

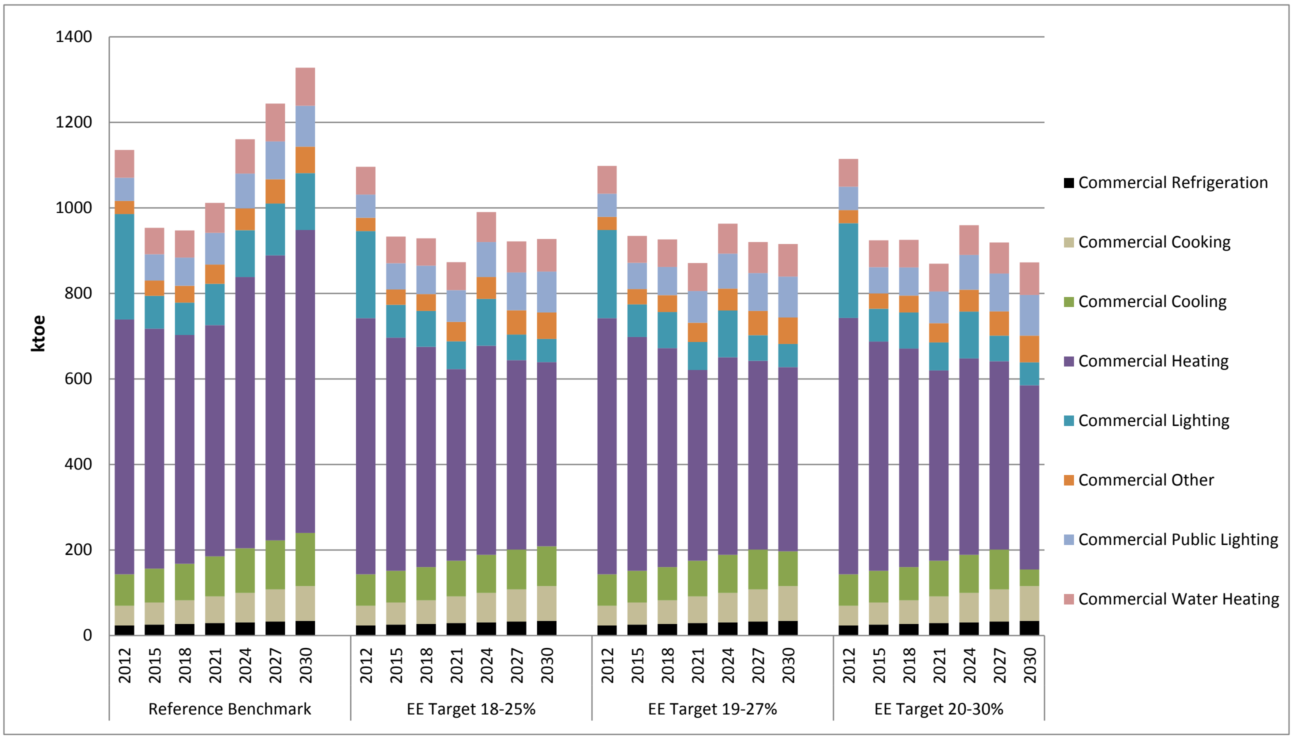



**Figure 88: Commercial Energy use by Application for Reference Benchmark and EE Target Scenarios**

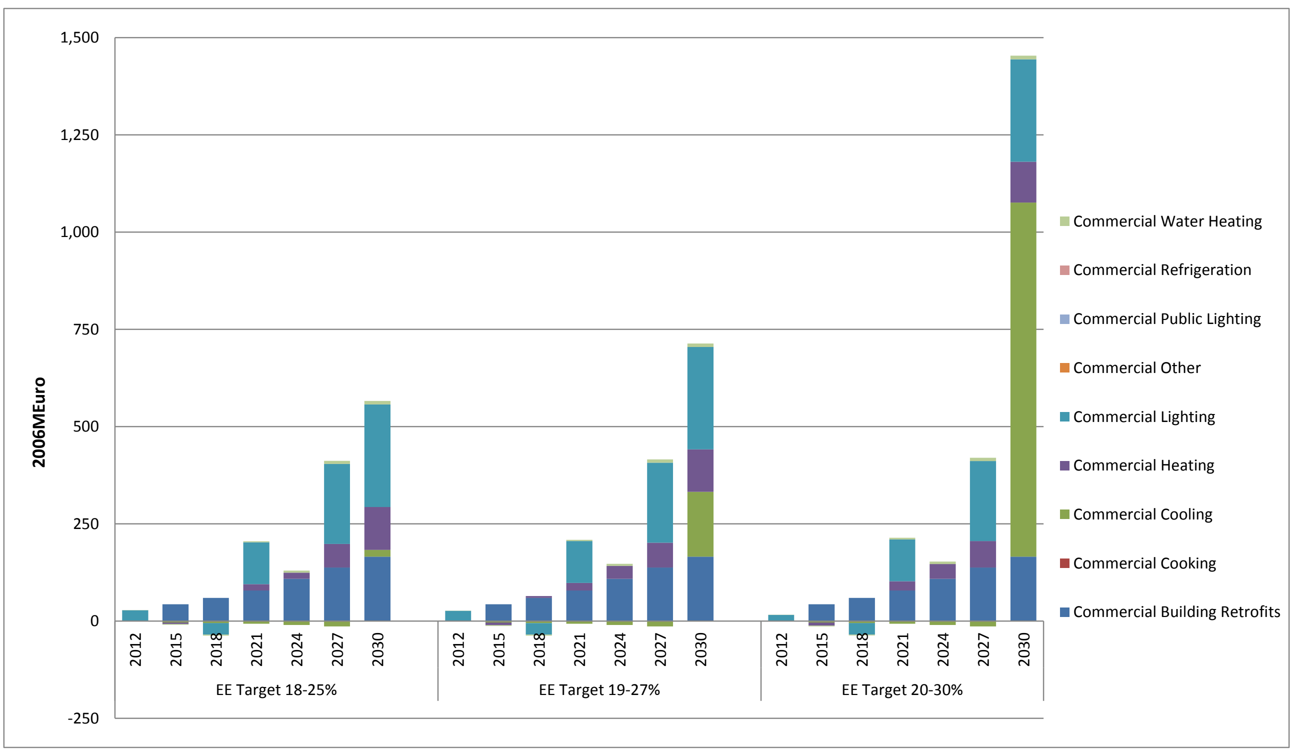



**Figure 89: Commercial Investment by Application – Difference for Reference Benchmark**

Table 36 shows that space heating and building retrofits are the most cost-effective types of investments, where the latter leads to savings in space heating and cooling device investments in this sector. Water heating and lighting are also cost-effective investments. Note that the building retrofits facilitate some reductions in cooling device investments in the EE Target 18-25% case, but that incremental investments are needed in the other two cases, with the unit cost increasing by a factor of 4 between the EE Target 19-27% and EE Target 20-30% cases. Overall, the unit investment cost for the EE Target20-30% case is 32% higher than in the 18-25% target case. Commercial scale heat-pump technologies and commercial building retrofits, along with the lighting improvements are highlighted by these results for incentive programs.

**Table 36: Commercial Sector Investment per unit Energy Saved (MEUR/ktoe)**

| Energy Service | EE Target 18-25% | EE Target 19-27% | EE Target 20-30% |
|---|---|---|---|
| Building Retrofits | 0.89 | 0.89 | 0.89 |
| Cooling | -0.32 | 0.51 | 2.20 |
| Heating | 0.24 | 0.27 | 0.29 |
| Lighting | 3.37 | 3.37 | 3.37 |
| Water Heating | 0.56 | 0.58 | 0.65 |

### 7.6.5 Industry Sector Impacts

Figure 90 shows that achieving the EE target in the industrial sector requires significant reductions in final energy use for non-metallic minerals, iron and steel, food processing and non-ferrous metals subsectors. It also shows that final energy use in the industrial sector changes only slightly between the three target cases, with some additional savings mostly in iron and steel and non-metallic minerals in the final two periods.

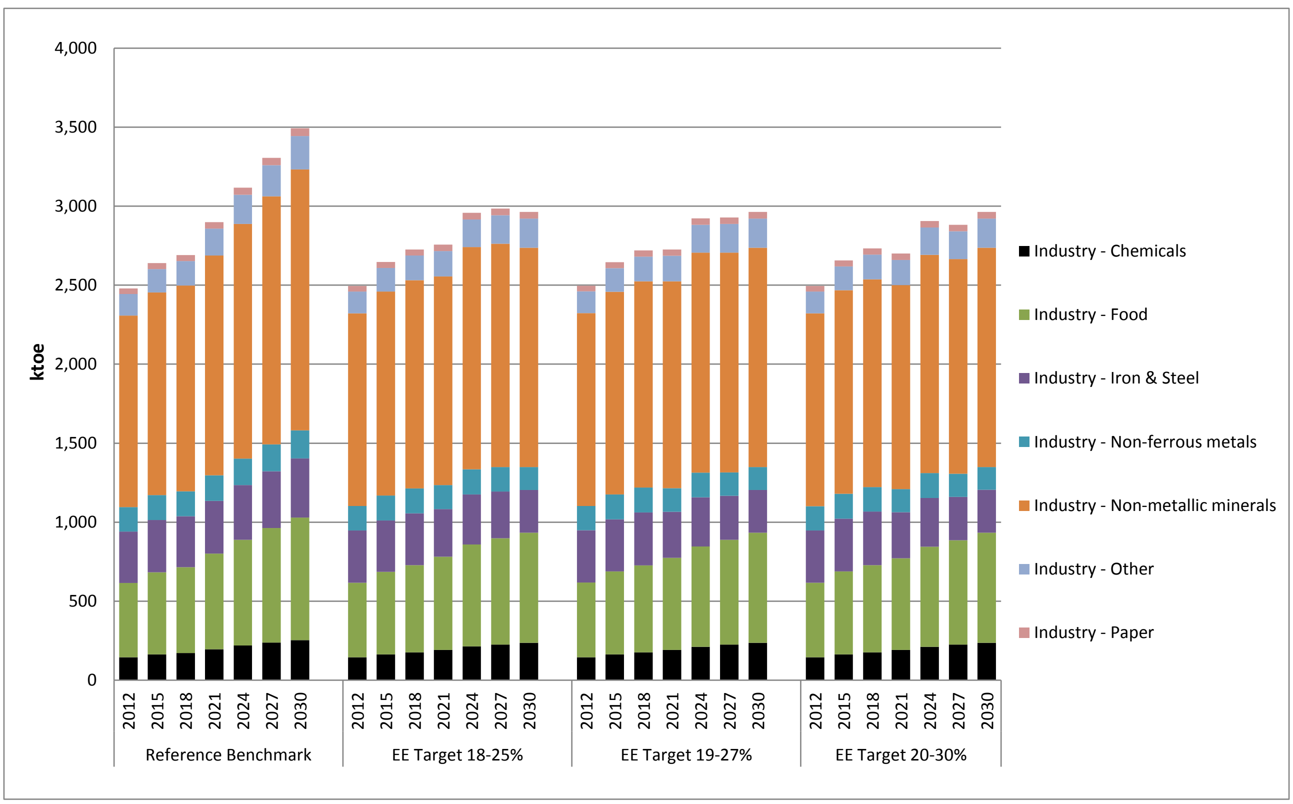



**Figure 90: Industrial Energy use by Application for Reference Benchmark and EE Target Scenarios**

Figure 91 shows that the investment required to achieve the EE target increases significantly in the 2030 period in all three cases, with over a 100% increase to achieve the 2030 level in the EE Target 18-25% and EE Target 19-27% cases. In the EE Target 20-30% case, earlier action is required in 2021, 2024 and 2027 which damps the 2030 period increase somewhat.

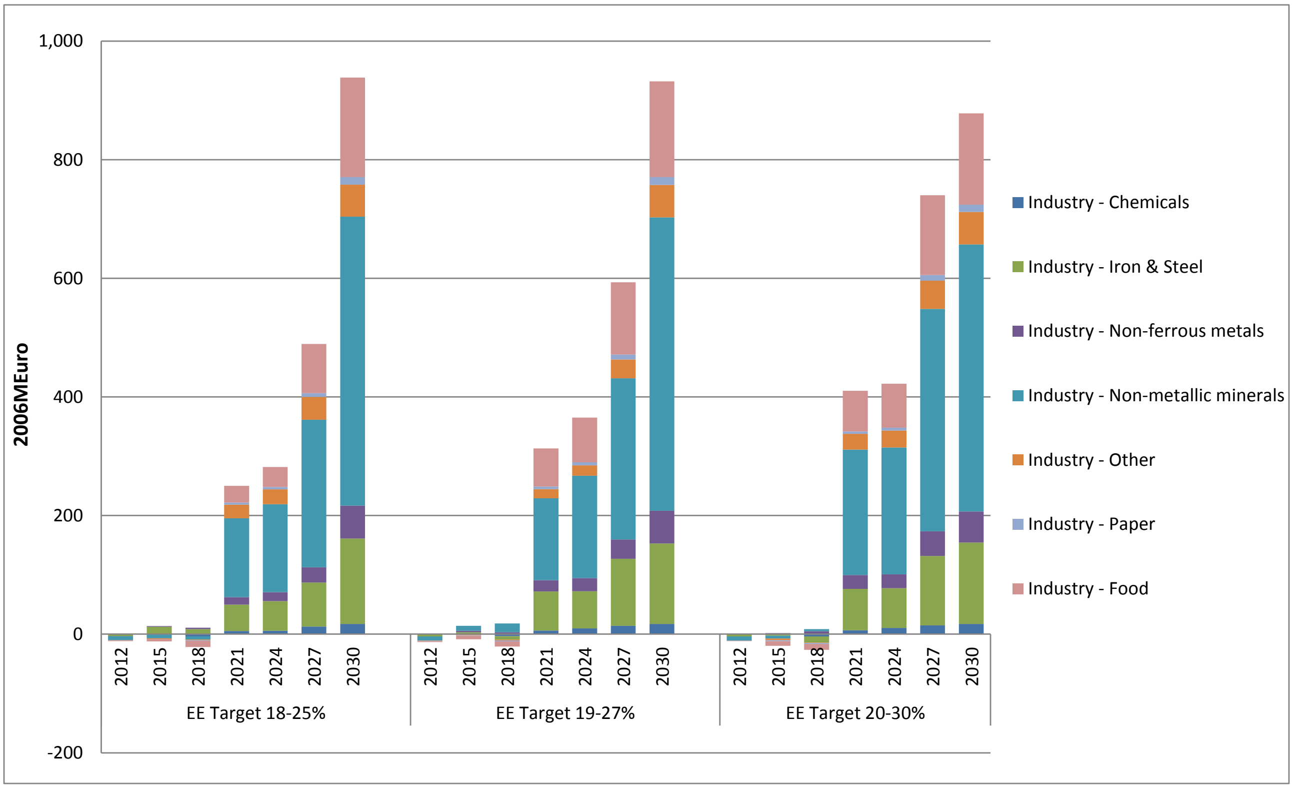



**Figure 91: Industrial Investment by Subsector – Difference from Reference Benchmark**

Table 37 shows that the investment per ktoe of energy saved is in a cost-effective range for all industry sub-sectors, with the most cost-effective efficiency investments occurring in the chemicals and iron and steel sub-sectors. It also indicates that and that unit costs increase similarly across all scenarios.

**Table 37: Industrial Sector Investment per Energy Saved (MEUR/ktoe)**

| Energy Subsector | EE Target 18-25% | EE Target 19-27% | EE Target 20-30% |
|---|---|---|---|
| Chemicals | 1.12 | 1.16 | 1.21 |
| Food | 2.06 | 2.27 | 2.10 |
| Iron & Steel | 1.14 | 1.25 | 1.39 |
| Non-ferrous metals | 1.44 | 1.60 | 1.71 |
| Non-metallic minerals | 1.70 | 1.63 | 1.77 |
| Other | 1.87 | 2.34 | 2.17 |
| Paper | 1.83 | 1.71 | 1.98 |

### 7.6.6 Transport Sector Impacts

Figure 92 shows that achieving the EE target in the transportation sector primarily requires reductions in final energy use for light duty vehicles, heavy trucks and light commercial trucks. It also shows that overall final energy use in 2030 is aggressively reduced in all cases, with dramatic reductions required in both the EE Target 19-27% and EE Target 20-30% cases.

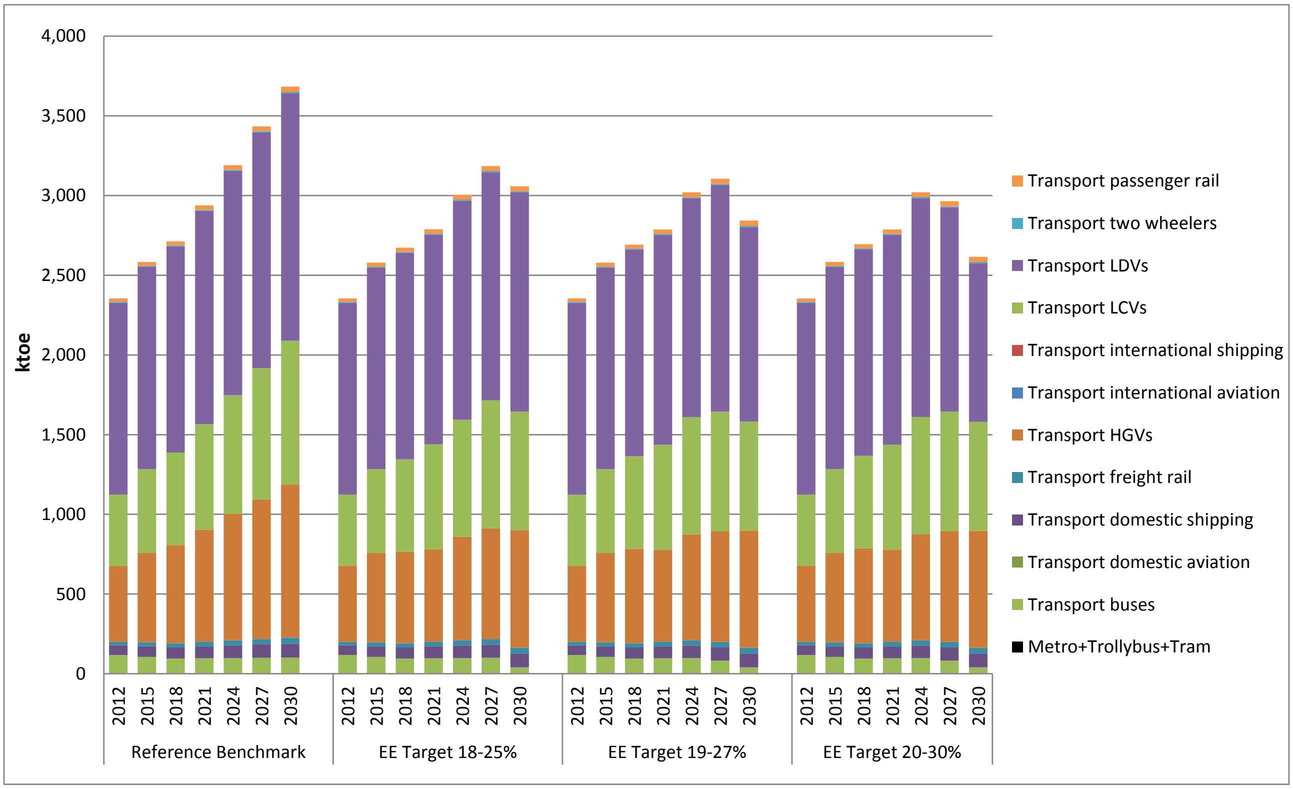



**Figure 92: Transportation Energy use by Mode for Reference Benchmark and EE Target Scenarios**

Figure 93 shows that the investment required to achieve the increased savings in 2030 requires significant increases for plug-in hybrid LDVs and hybrid and light commercial trucks, mostly in 2030, but also in 2027 for the EE Target 19027 and EE Target 20-30% cases.

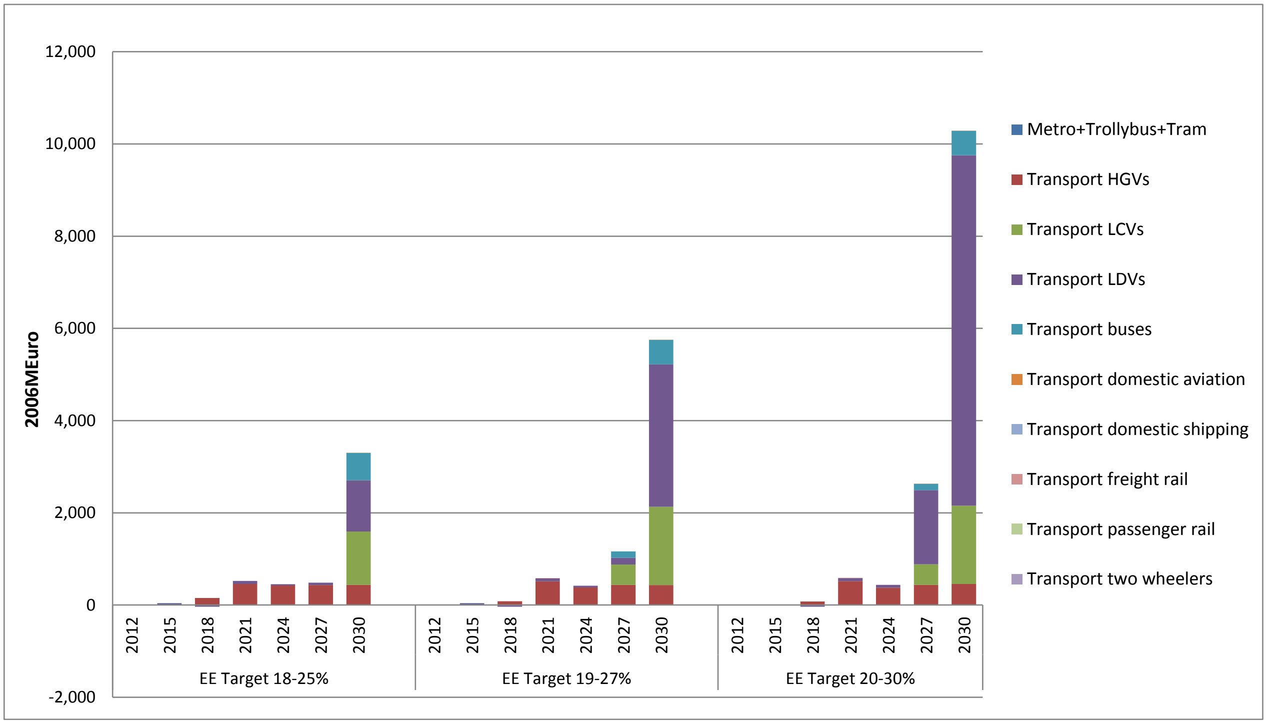



**Figure 93: Transport Mode Investment – Difference from Reference Benchmark**

Figure 94 and show that the investment per ktoe of energy saved increases by 13% in the EE Target 19-27% case compared to the EE Target 18-25% case and increases another 21% in the EE Target 20-30% case compared to the EE Target 19-27% case. Light commercial vehicles, light duty vehicles, heavy trucks and domestic aviation are the transport modes/devices that provide the most cost-effective efficiency investments.

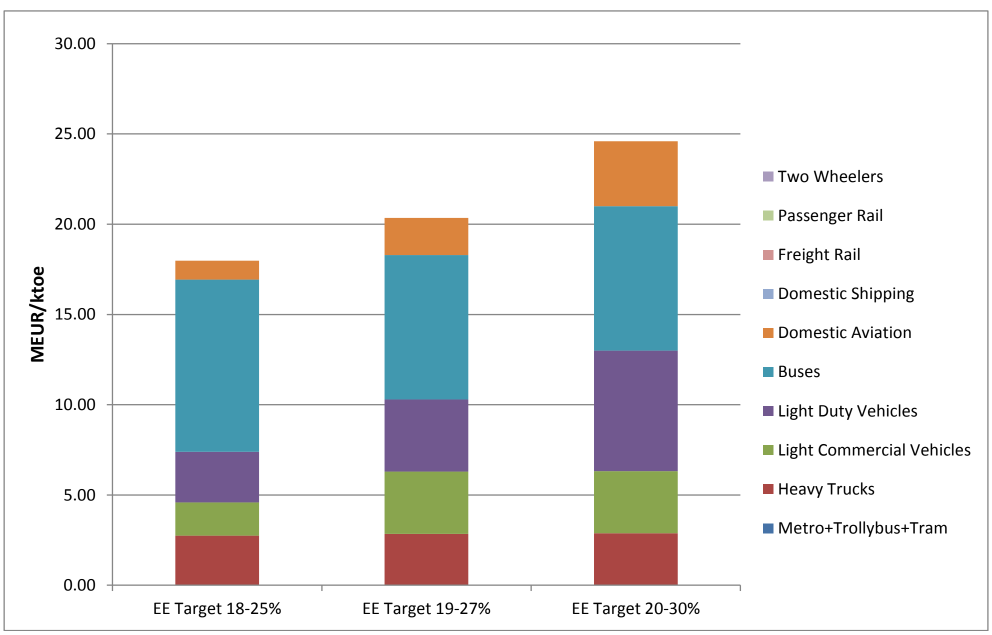



**Figure 94: Transport Mode Investment per unit Energy Saved**

**Table 38: Transportation Sector Investment per Energy Saved (MEUR/ktoe)**

| Energy Service | EE Target 18-25% | EE Target 19-27% | EE Target 20-30% |
|---|---|---|---|
| Heavy Trucks | 2.74 | 2.84 | 2.88 |
| Light Commercial Vehicles | 1.84 | 3.45 | 3.45 |
| Light Duty Vehicles | 2.81 | 4.00 | 6.68 |
| Buses | 9.54 | 7.99 | 7.99 |
| Domestic Aviation | 1.04 | 2.06 | 3.60 |

## 7.7 EE Target Scenario Details – Ukraine

This section provides a country-specific understanding of the impacts of the EE Target levels for Ukraine. The section examines the changes in Final Energy Consumption (FEC) and the related changes in end-use device purchases by sector and end-use application, industry subsector or transport mode. This section first provides the overall results for Ukraine by fuel type and demand sector and then examines the results for each sector in detail. No specific results for the Supplier Obligation scenario are provided because the measures implemented are the same as those identified as most relevant to this scenario.

Unfortunately, due to the turmoil in the Ukraine since early this year the UNAS-IEF team was not able to make desired improvements in their model for this EE assessment. In particular, the current TIMES-Ukraine model includes an overly ambitious view of the uptake of new efficient demand technologies, and building shell improvements in the commercial/public and residential sectors, resulting in lower energy consumption growth than would be the base under "business-as-usual" assumptions and thereby higher incremental costs (since the more cost-effective measure have already substantially penetrated in the Reference) than might otherwise be the case. In addition, a number of demand technology updates and additional new options for building retrofitting introduced to the SECC models were not able to be included in the Ukraine version. However, while this likely resulting in higher overall costs for the EE targets, the observations made are expected to change substantively as the results are taken compared with the Reference scenario.

### 7.7.1 System Cost Impacts

Figure 95 shows that the total discounted system cost increases by 8.1% over the Reference Benchmark case for the EE Target case of 18% in 2025 and 25% in 2030 (the EE Target 18-25% case). This somewhat steep initial jump in system cost is because many of the most cost-effective efficiency measures are taken up in the Reference Benchmark scenario, forcing the need to move to more costly options to meet the target. If the 2030 target is increased to 27%, the incremental cost goes to 10.2%, while turning to more costly measures results, and jumps to 16.1% for the case of a 30% target on 2030.

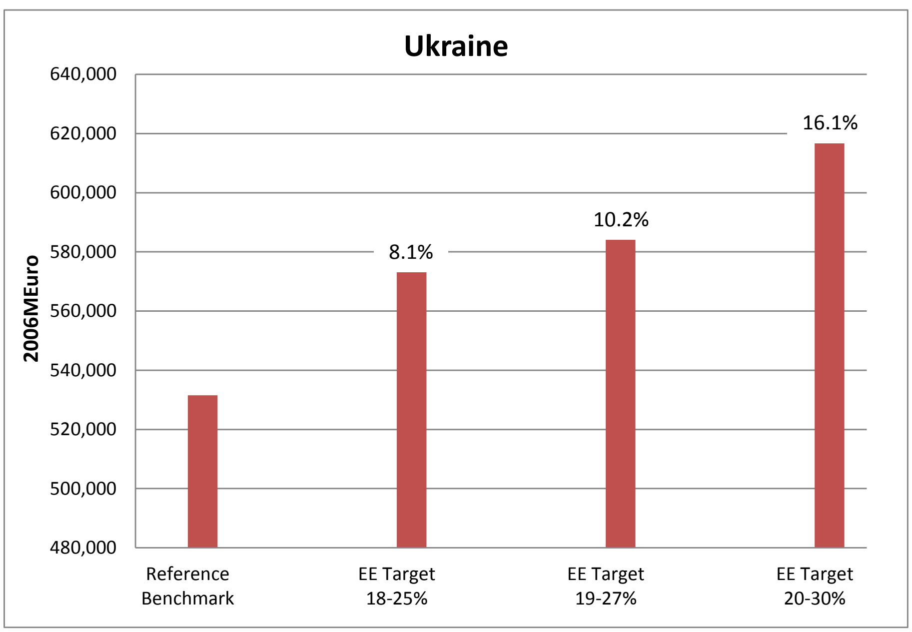



**Figure 95: Ukraine Total System Cost for Reference Benchmark and EE Target Scenarios**

In the sections that follow the trends for some key aspects of the national energy system evolution over the 20-year planning horizon are shown for these EE target scenarios against the Reference Benchmark.

### 7.7.2 Reductions in Final Energy Consumption

Figure 96 shows the change in total final energy consumption by fuel type and by sector from the Reference Benchmark, and illustrates the significant reductions required to meet the proposed targets compared with not continuing the current energy efficiency improvement in place now till 2018 as reflected in the Reference scenario. The most notable change in the fuel mix is the significant drop in gas consumption across most all sectors, whereas electricity use increases due to technology-based fuel switching. The largest reduction in gas consumption are seen in the Residential sector (8 bcm) in and Industry (almost 6 bcm) by 2030.

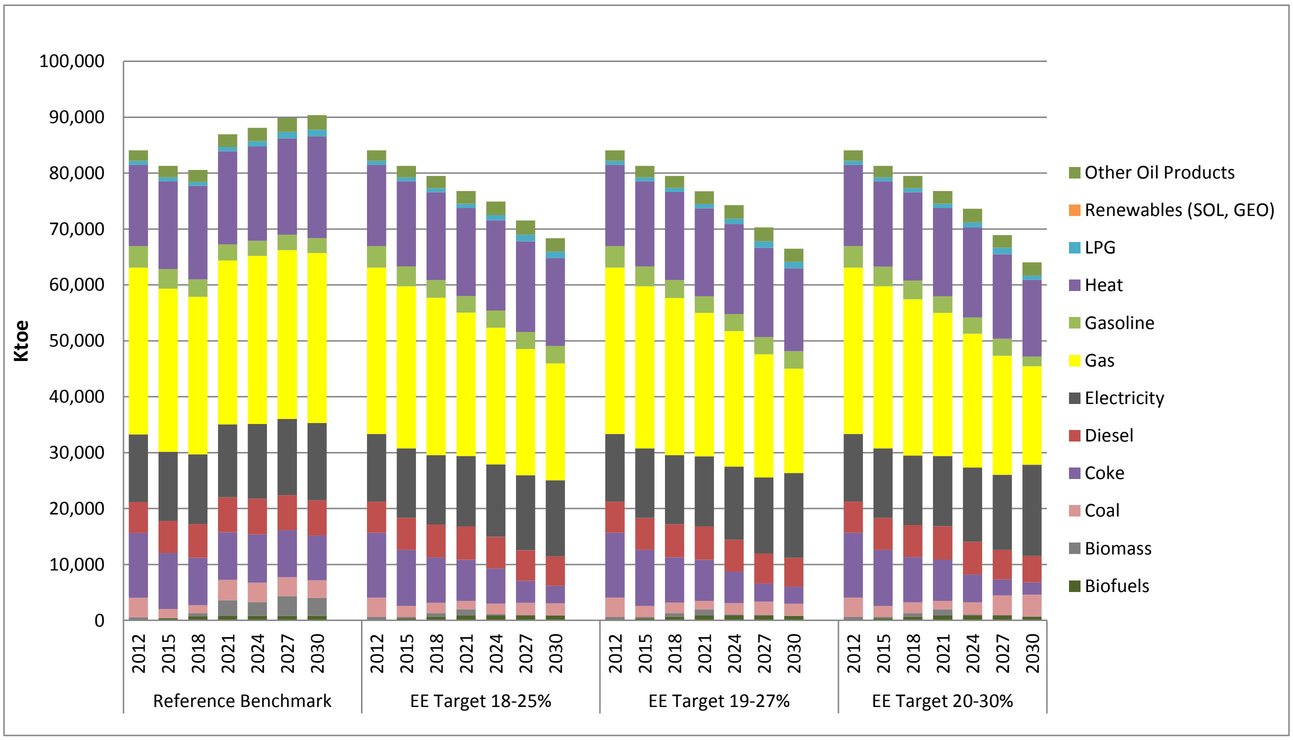



Figure 96: Final Energy Consumption for Reference Benchmark and EE Target Scenarios

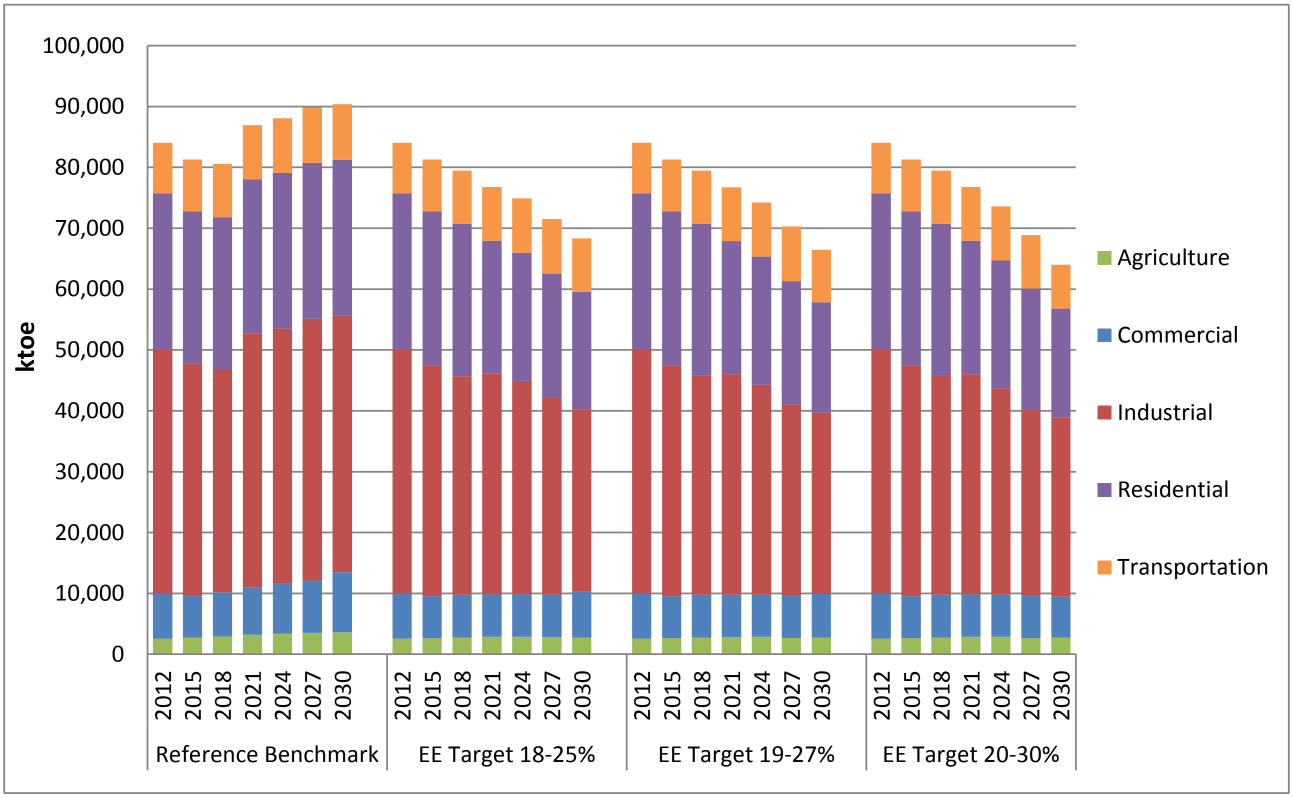



**Figure 97: Final Energy by Fuel Type for Reference Benchmark and EE Target Scenarios**

### 7.7.3 Residential Sector Impacts

Figure 98 shows that achieving the EE targets in the residential sector requires significant reductions in final energy use primairly for space heating, with building insulation and water heating also contributing. This confirms the fact that the potential of energy efficiency in the residential sector on space and water heating demands is still considerable and economically attractive, as till now the lowest energy prices in Europe hardly stimulated the implementation of energy efficiency projects. It also shows that final energy use changes proportionaly between the three target cases, with reductions in the sector by 24% to 30% in 2030 across the scenario. The difference in the purchase of new devices needed to achieve the increased savings in the EE Target 19-27% and EE Target 20-30% cases requiring significant increase in number of improved space and water heating devices, as well as clothes washers.

As shown on Figure 99, achieving the EE Target 18-25% scenario does not overly burden the sector. However, this is not the case in the later periods for the more stringent scenarios, where investments in 2030 need to nearly double for EE Target 19-27% and more than double for the EE Target 20-30% cases.

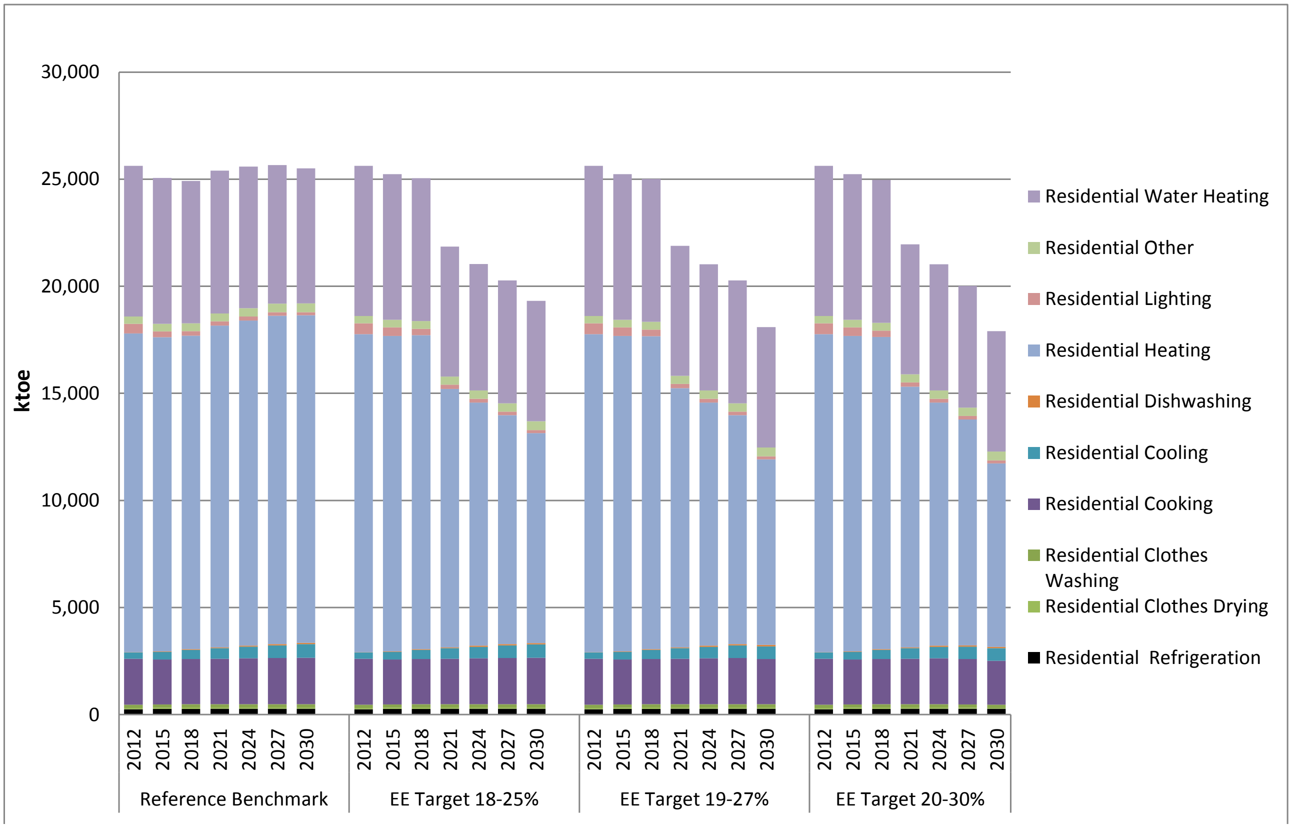



**Figure 98: Residential Energy use by Application for Reference Benchmark and EE Target Scenarios**

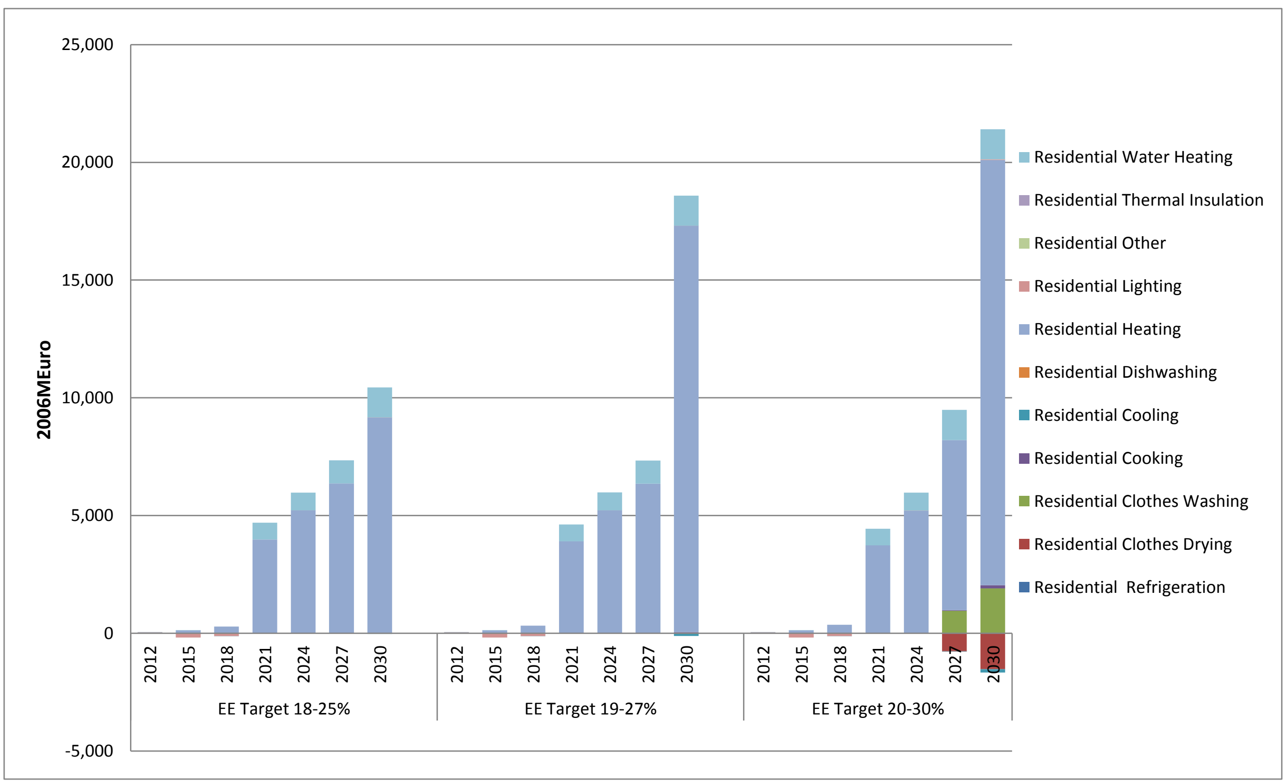



**Figure 99: Residential Investment by Application - Difference from the Reference Benchmark**

While the biggest energy savings comes from more efficient space and water heating appliances, they are not enough to achieve the EE Target 20-30%.  Improved clothes washers and some improvements in cooking are needed as well. Figure 100 shows that the investment per ktoe of energy saved raises dramatically in the EE Target 20-30% scenario as additional more expensive measures should be applied. Table 39 presents the change in expenditure divided by the change in energy saved from the Reference Benchmark as a measure of how cost-effective actions are in each demand service. It shows that high efficiency water heaters, space heating, lighting, cooking and clothes washing/ drying are the most cost-effective measures to pursue in the residential sector.

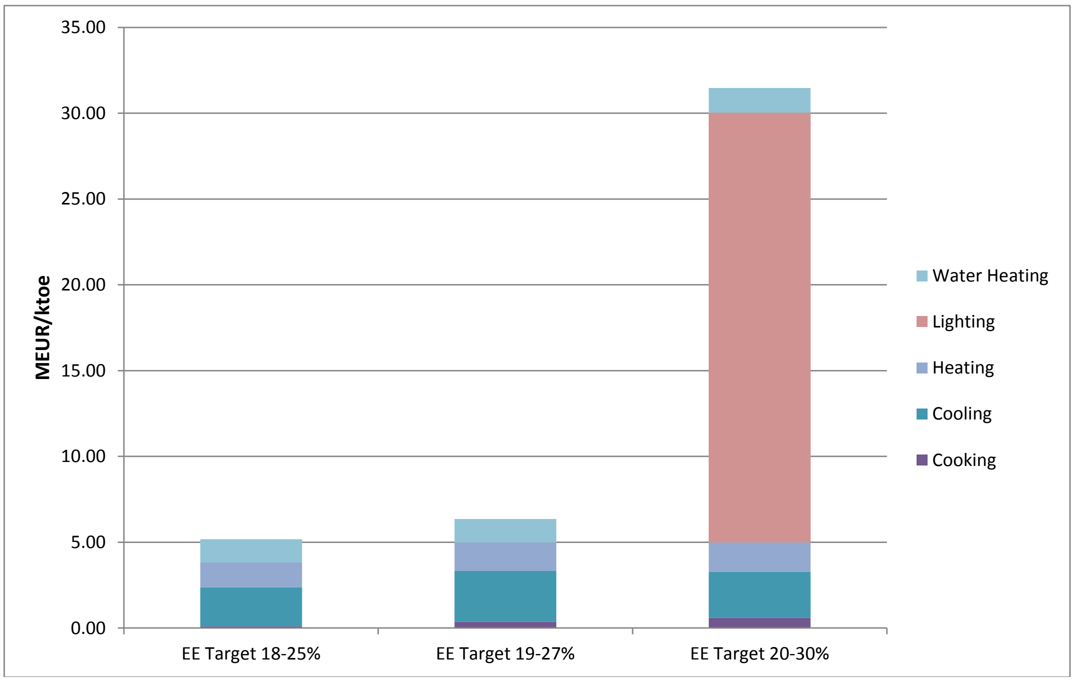


Figure 100: Residential Device Investment per Energy Saved

Table 39: Residential Investment per Energy Saved (MEUR/ktoe)

| Energy subsector | EE Target 18-25% | EE Target 19-27% | EE Target 20-30% |
|---|---|---|---|
| Cooking | 0.10 | 0.37 | 0.60 |
| Cooling | 2.27 | 2.45 | 2.67 |
| Heating | 1.44 | 1.67 | 1.72 |
| Lighting | 0.00 | 0.00 | 25.04 |
| Water Heating | 1.37 | 1.38 | 1.46 |

### 7.7.4 Commercial Sector Impacts

The situation in the Commercial sector is similar to the Residential, as commercial and public institutions are mostly using old obsolete buildings. Figure 101 shows that achieving the EE targets in the Commercial sector requires significant reductions in final energy use first of all for space and water heating along with space cooling. There is also an increase in the use of more efficient lighting. The structure of final energy consumption remains relatively consistent the three EE target cases, and with additional savings needed mostly in space heating in the final period, where energy used for heating under the most aggressive reduction case reduces by 50% comparing to the Reference scenario.

Figure 35 shows that achieving the EE Target 18-25% scenario does not overly burden the sector. However, this is not the case in the later periods for the more stringent scenarios, where the investments required to achieve the savings will force companies to increase their investments in more efficient appliances 3 to 5 fold respectively compared to the Reference scenario by 2030. Most of the investment are for the purchase of efficient space and water heating appliances, and also in lighting technologies in all scenarios, with contributions coming from Other (improved appliances, e.g., computers) needed in the more stringent cases. The absence of the commercial building retrofit options seen is the other CPs is because this data update was not able to be implemented in the Ukraine model.

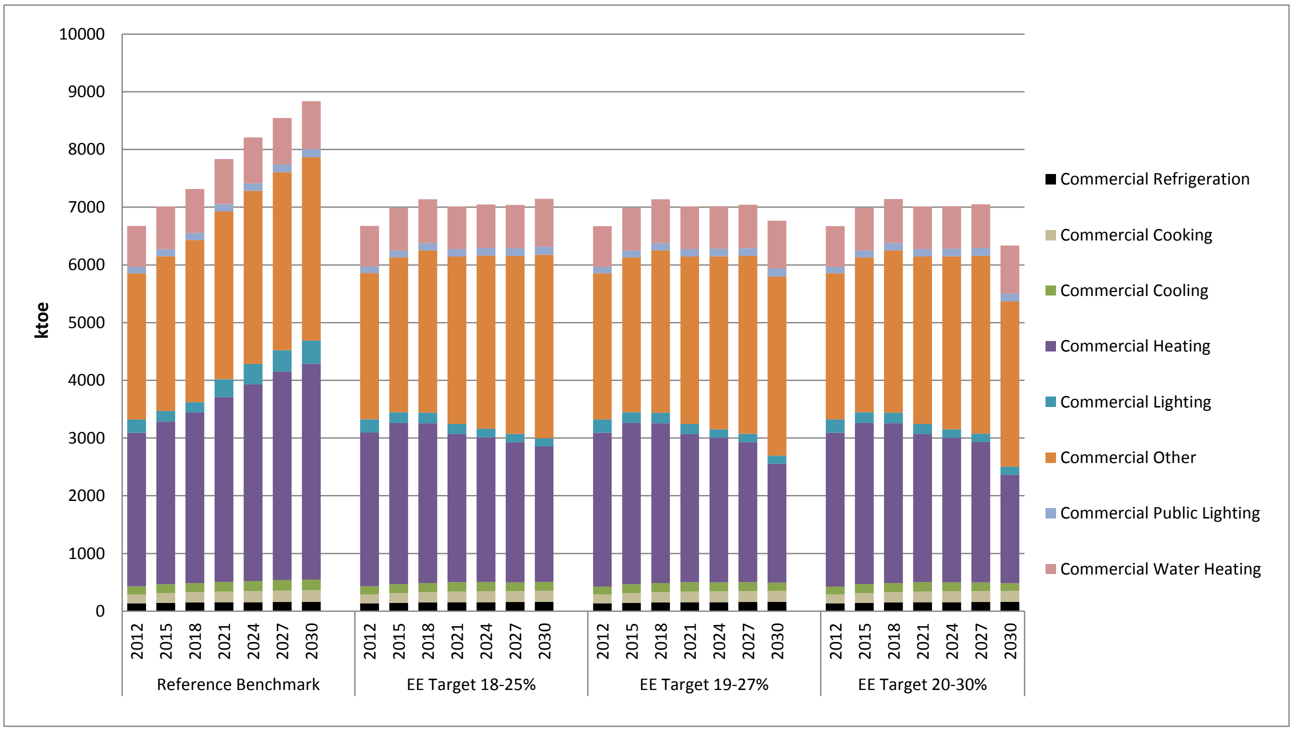



**Figure 101: Commercial Energy use by Application for Reference Benchmark and EE Target Scenarios**

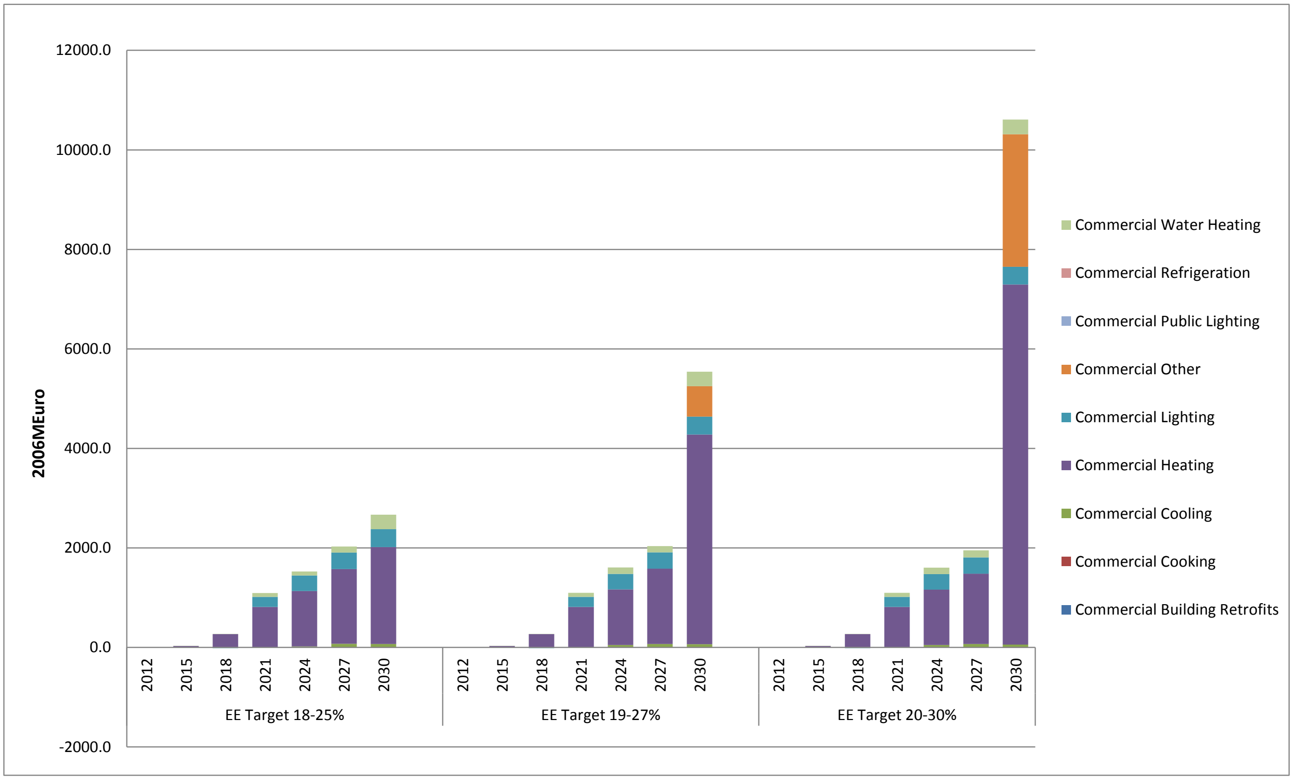



**Figure 102: Commercial Investment by Application for Reference Benchmark and EE Target Scenarios**

Table 40 shows that space heating and lightening technologies are the most cost-effective types of investments in this sector. Cooling and water heating equipment are also attractive.

**Table 40: Commercial Sector Investment per Energy Saved (MEUR/ktoe)**

| Energy subsector | EE Target 1820-25 | EE Target 19-27% | EE Target 20-30% |
|---|---|---|---|
| Cooling | 2.20 | 1.89 | 1.66 |
| Heating | 1.31 | 1.72 | 2.27 |
| Lighting | 1.45 | 1.45 | 1.45 |
| Other | 0.00 | 7.65 | 8.29 |
| Water Heating | 4.08 | 3.95 | 4.17 |

### 7.7.5 Industry Sector Impacts

Figure 103 shows that to achieve the EE targets, the reductions in industrial final energy use are spread proportionally across all sub-sectors, resulting in sectoral consumption falling below the 2012 level. Considering that metallurgy and non-ferrous metals production requires over 50% of sectoral energy use, their share in the reduction is dominant. This figure also shows that final energy use in the industrial sector changes only slightly between the three target cases. It is interesting to note that as the pressure builds in 2030 to achieve the EE Target 20-30% there is actually a slight increase in energy used in the Industrial sector, as additional efforts are made in the Residential and Commercial sector to meet the overall target instead.

This is reinforced by Figure 104 which shows that the 2030 cost of achieving the EE targets does not change as much for Industry as for the Residential and Commercial sectors. However, the required investment increases from the 2027 to the 2030 period by 98% under the EE Target 18-25% case, 103% under the EE Target 27 case and 132% under the EE Target 20-30% case – with the large investment required from Other industries. For the entire modeling horizon the cumulative increase of industrial investments is 28%, 37% and 54% respectively.

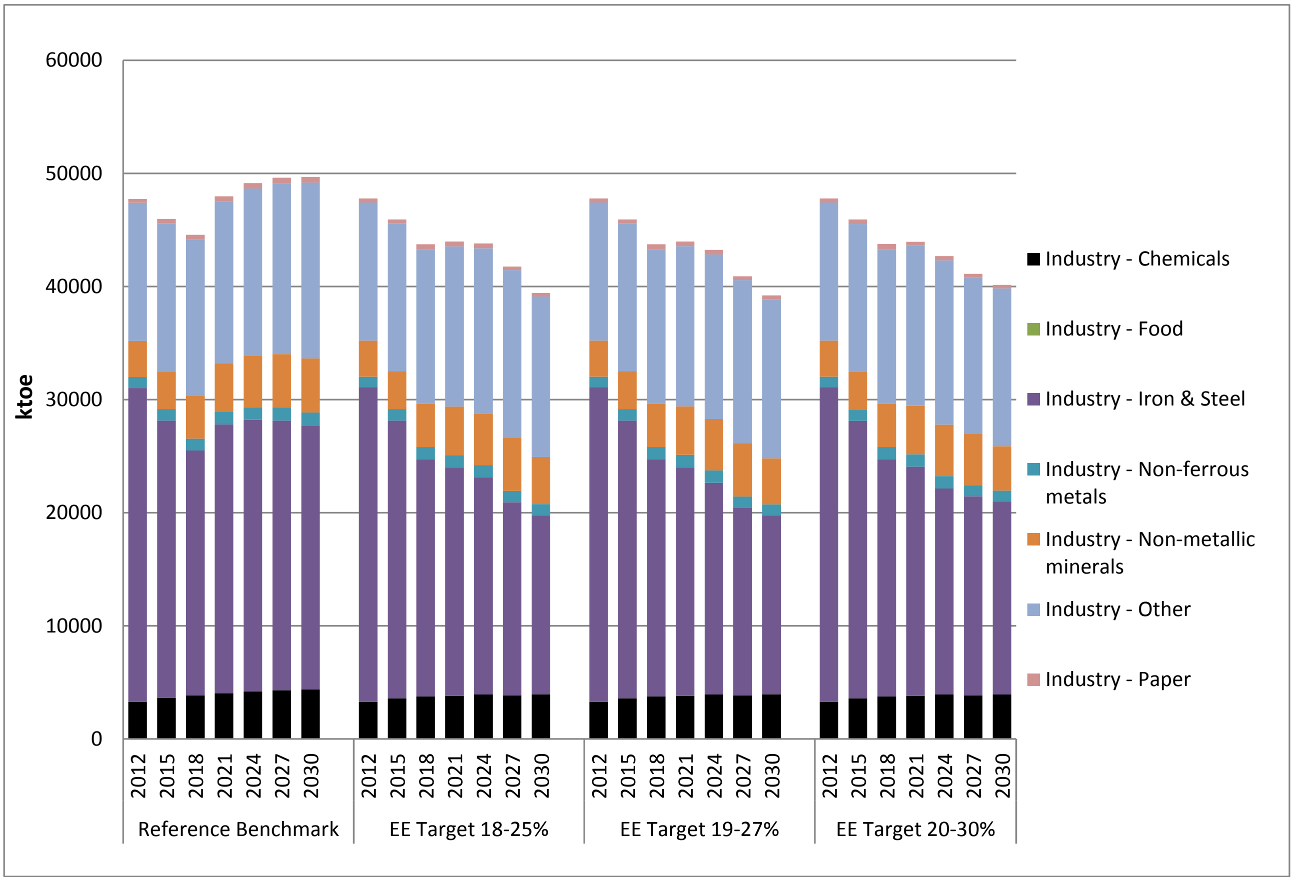



**Figure 103: Industrial Energy use by Application for Reference Benchmark and EE Target Scenarios**

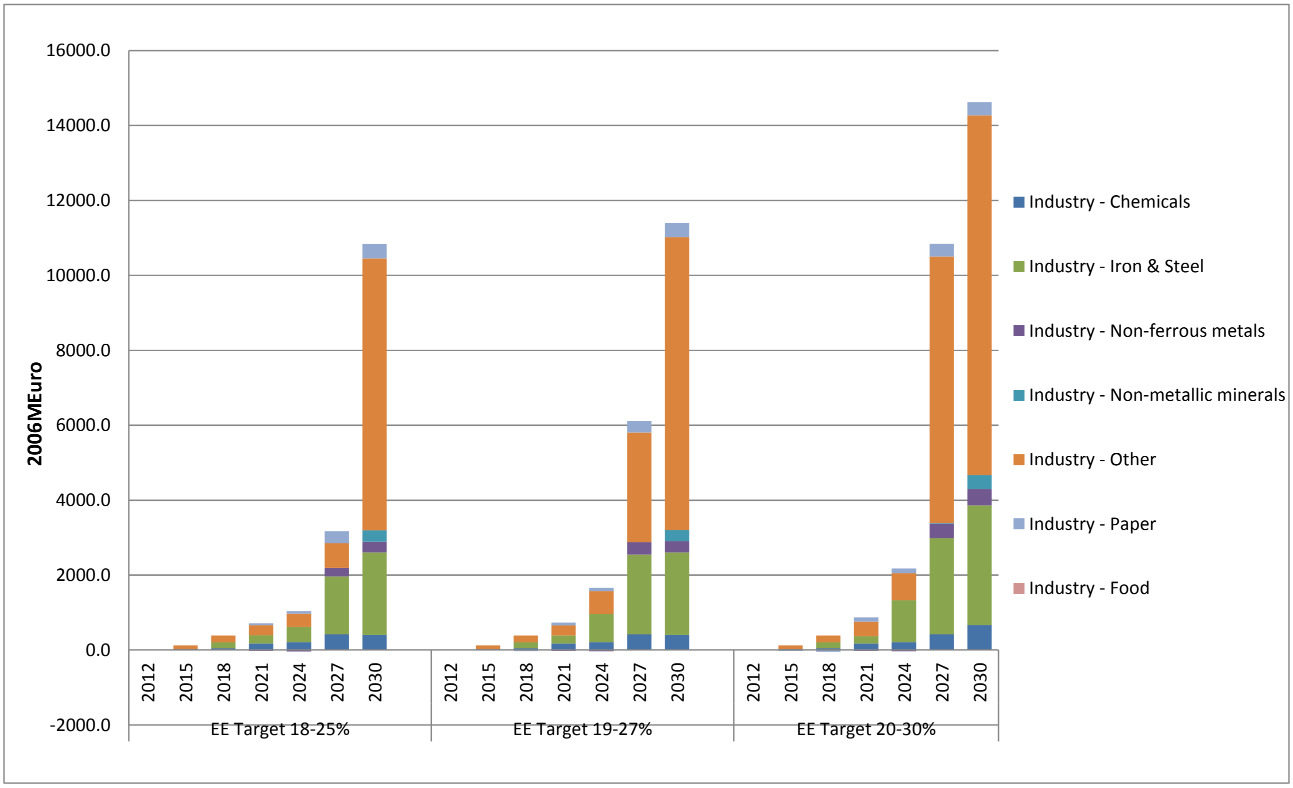



**Figure 104: Industrial Investment – Difference from Reference Benchmark**

Figure 105 shows that the investment per ktoe of energy saved in Industry does not differ significantly – increasing by €300,000 per 1% growth of the reduction target. As shown in Table 41 the biggest industrial consumers - iron & steel, chemicals, non-ferrous metals and non-metallic minerals production are the sub-sectors that provide the most cost-effective efficiency investments.

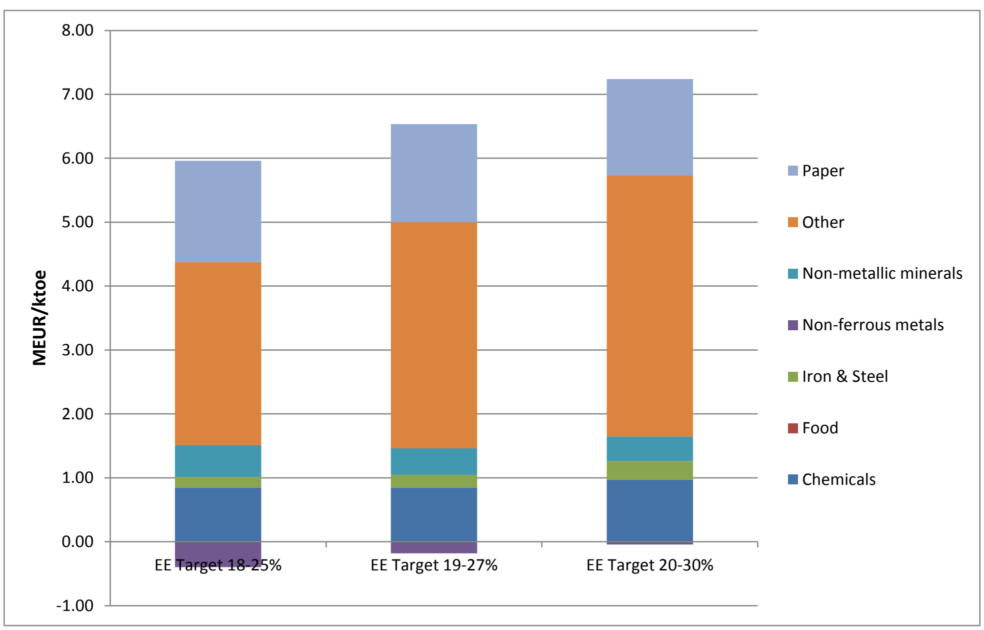



**Figure 105: Industrial Investment per Energy Saved**

**Table 41: Industrial Sector Investment per Energy Saved (MEUR/ktoe)**

| Energy subsector | EE Target 18-25% | EE Target 19-27% | EE Target 20-30% |
|---|---|---|---|
| Chemicals | 0.8 | 0.8 | 1.0 |
| Iron & Steel | 0.2 | 0.2 | 0.3 |
| Non-ferrous metals | 1.2 | 1.4 | 1.7 |
| Non-metallic minerals | 0.5 | 0.4 | 0.4 |
| Other | 4.2 | 4.5 | 5.1 |
| Paper | 1.8 | 1.7 | 1.7 |

### 7.7.6 Transport Sector Impacts

Figure 106 shows that achieving the EE targets in the transportation sector requires reductions in final energy use for heavy trucks and light vehicles in particular, along with buses and trains. It also shows that final energy use in 2030 is reduced slightly in the EE Target 19-27% case and more dramatically in the EE Target 20-30% case compared with the EE Target 18-25% case.

Figure 107 shows that the investment required to achieve the increased savings in the EE Target 20-30% case requires significant increases for plug-in electric and hybrid LDVs, and more efficiency diesel and gasoline trucks as well as biofuel trucks.

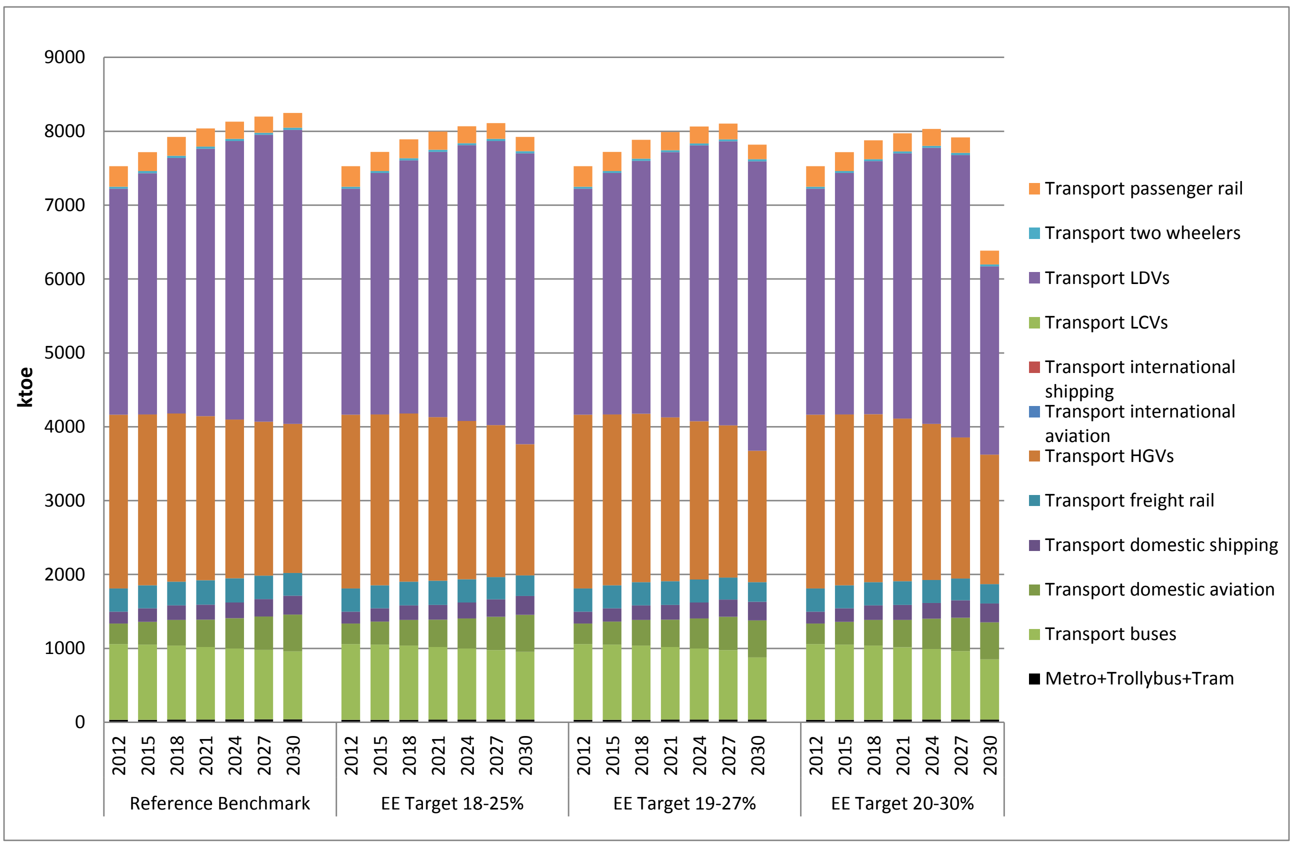



**Figure 106: Transportation Energy use by Application for Reference Benchmark and EE Target Scenarios**

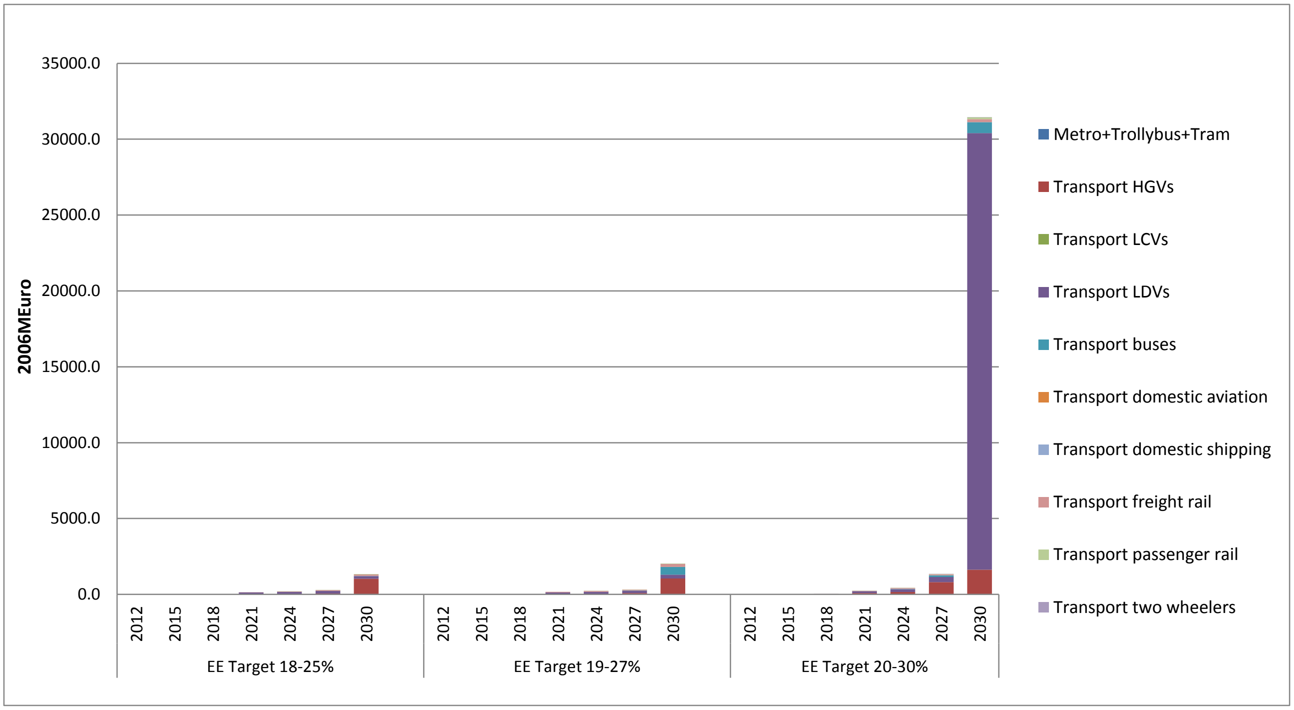



**Figure 107: Transport Device Investment – Difference from the Reference Benchmark**

Figure 108 shows that the investment per ktoe of energy saved increases by 30% when moving from the EE Target 18-25% to EE Target 19-27% cases, while to reach the EE Target 20-30% goal results in a unit investment increase 2.3 times higher. Freight and passenger rail, metro, trolleybus, tram, and also trucks are the transport modes/devices that provide the most cost-effective efficiency investments.

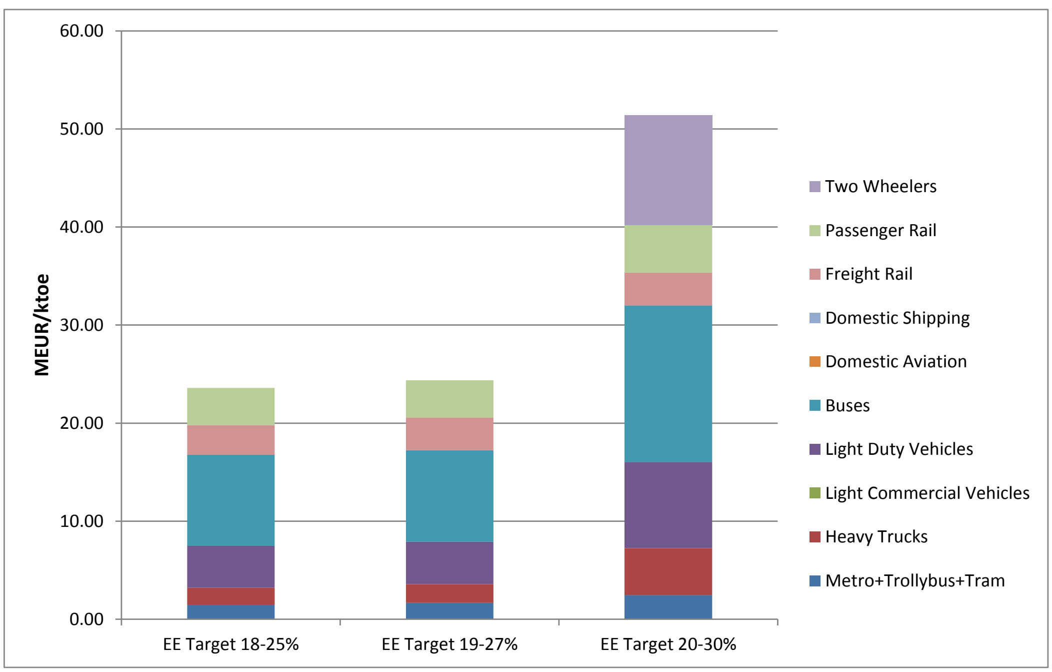



**Figure 108: Transport Device Investment per Energy Saved**