Modeling emission scenarios in LOCSEE

ECRAN-TAIEX multi-beneficiary Workshop on contributions to the Global Climate Agreement II

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Dr. Elena Georgopoulou & Dr. Sebastian Mirasgedis

National Observatory of Athens (NOA)

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Structure of presentation

1. The modeling task in LOCSEE - Models' structure and results obtained

2. Measuring the co-benefits of energy efficiency

3. Concluding remarks

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1. The modeling task in LOCSEE - Models' structure and results obtained

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Modeling of low C policies in LOCSEE (I)

- LOCSEE (**www.locsee.eu**) aimed at strengthening the capacity and knowledge of public authorities and other institutions dealing with climate change in SEE countries, and at developing a systematic cross-sectoral approach for creation of low carbon policies in the SEE region.

- LOCSEE comprised 6 WPs:
  - WP1 (Transnational project and financial management)
  - WP2 (Communication activities)
  - WP3 (State-of-the-art analysis and good practice platform)
  - WP4 (Coordinated transfer of EU climate legislation)
  - WP5 (Capacity building for developing low carbon policies)
  - WP6 (Development of low carbon policy papers)

WP leader: National Observatory of Athens, contributor: Johanneum Research

Modeling of low C policies in LOCSEE (II)

- Case studies: Albania, Montenegro, FYROM, Serbia, Croatia
- Each of these countries (partners) selected a priority sector:
  - FYROM & Montenegro: Buildings
  - Albania & Croatia: Transport
  - Serbia: Solid waste
- Type of model was decided in each case on the basis of the availability of data required → bottom-up, spreadsheet-type
- Models developed are transparent and flexible
- Final outputs comprised a marginal GHG abatement cost curve (MAC) in each country – priority sector
- Co-benefits of mitigation measures also examined → social marginal abatement cost curve (SMAC), new jobs, impact on GDP

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1a. Buildings

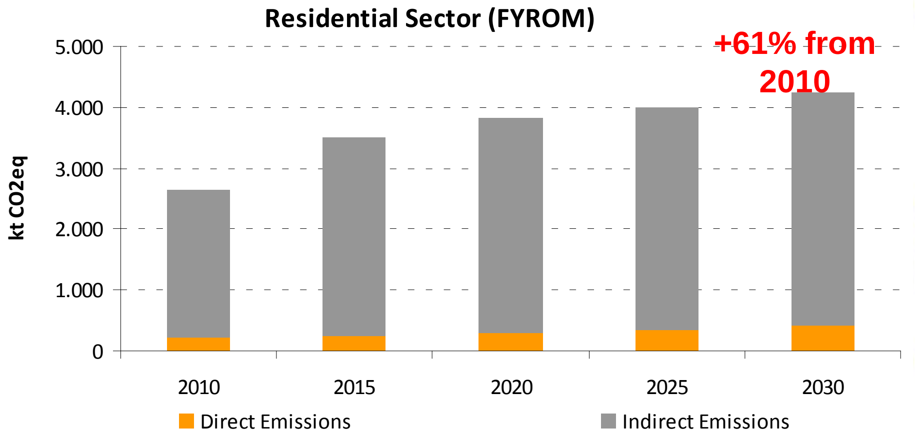
BUILDINGS – Model's structural characteristics (I)

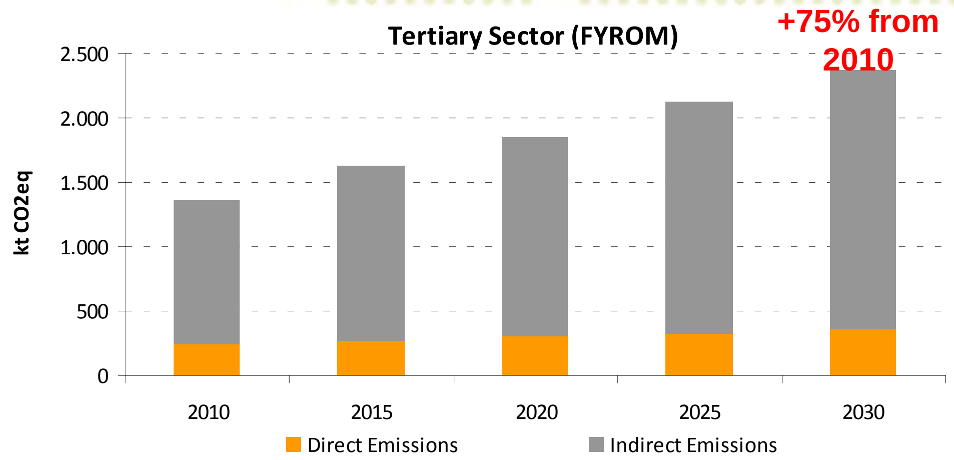
- **Energy consumption** is analyzed and **broken down** to specific activities (uses), technologies and energy sources related to GHG emissions
- Year 2010 is selected as the **base year** of the analysis
- Model results are **compared to Official Energy Balances** for 2006 and 2010 (assumptions modified aiming at convergence)
- **Projections** of future energy demand and consumption (Reference Scenario)
- Model consists of **two modules**:
  - Residential Sector Module
  - Tertiary Sector Module

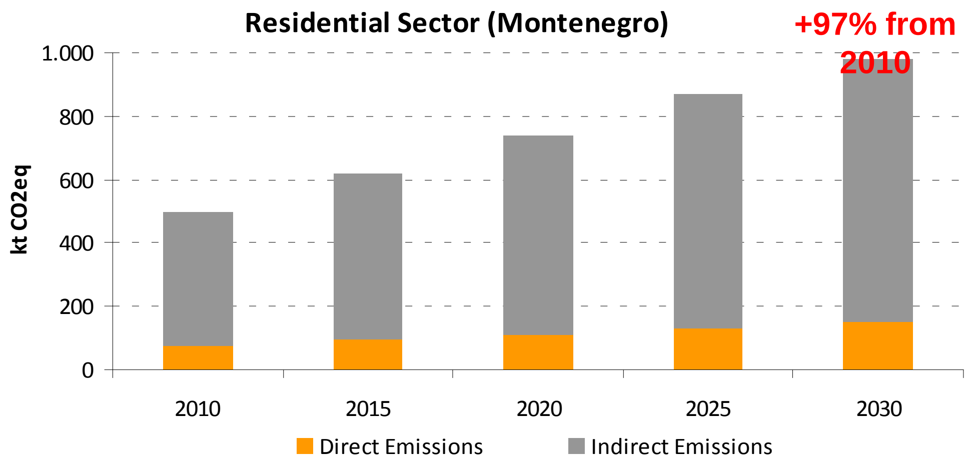
BUILDINGS – Model's structural characteristics (II)

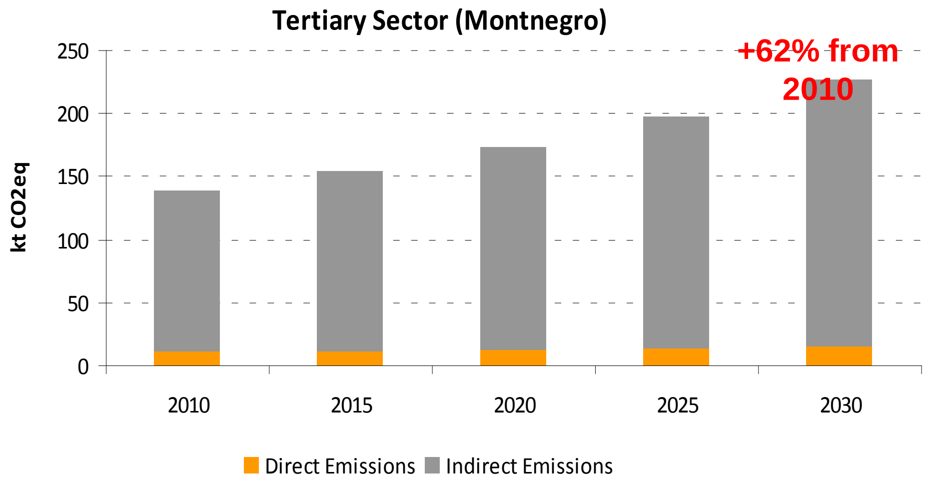
- **Building categories based** on:
  - Construction Period
  - Building type for Residential Sector (detached houses, high-rise buildings with multiple apartments, seasonal use)
  - Use for Tertiary sector (e.g. Schools/Educational, Hospitals, Hotels etc.)
- **Energy demand** of each category is simulated with **six end-uses**:
  - Space heating (central/individual heating systems in residential sector)
  - Hot water
  - Space cooling
  - Cooking
  - Lighting
  - Electrical Appliances (5 types)
- Energy demand for each end-use is calculated by applying methodologies which use typical meteorological data together with information and data from national statistics and studies, international sectoral studies and databases.

BUILDINGS – Reference scenario & GHG emissions









BUILDINGS – GHG mitigation measures examined

1. Use of double glazing with thermal breaks frames **(R,T)**
2. External wall thermal insulation **(R,T)**
3. Roof insulation **(R,T)**
4. Retrofitting of old diesel boilers **(R,T)**
5. Use of natural gas for central heating systems **(R,T)**
6. Installation of high efficiency air conditioning units **(R,T)**
7. Installation of solar collectors for hot water **(R,T)**
8. Promotion of energy efficient light bulbs **(R,T)**
9. Promotion of energy efficient household appliances **(R,T)**
10. Installation of thermostats and heating controllers in buildings with diesel central heating **(R)**
11. New energy efficient biomass stoves **(R)**
12. Installation of ceiling fans **(R)**
13. Installation of Building Management Systems **(T)**
14. Installation of heat pumps for space heating **(T)**

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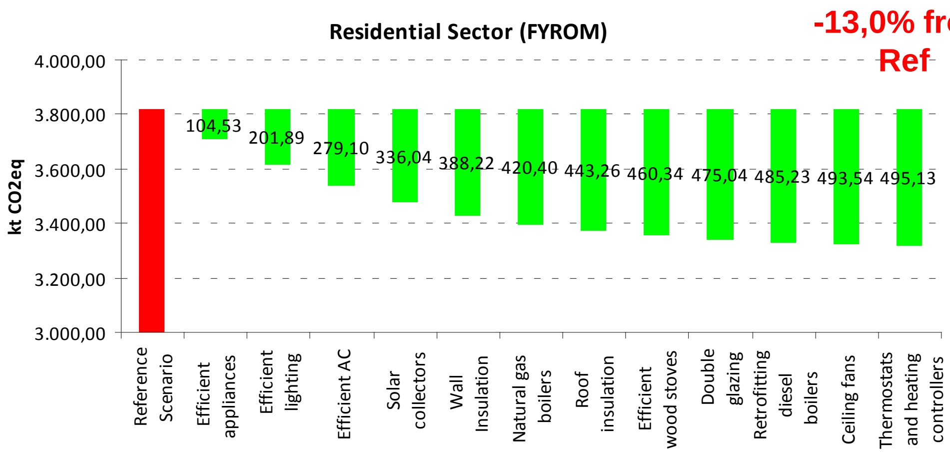
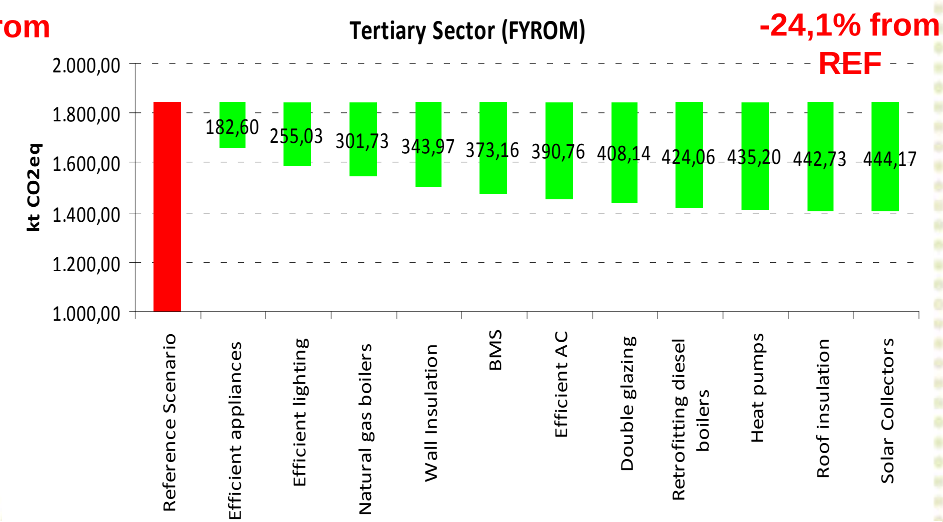
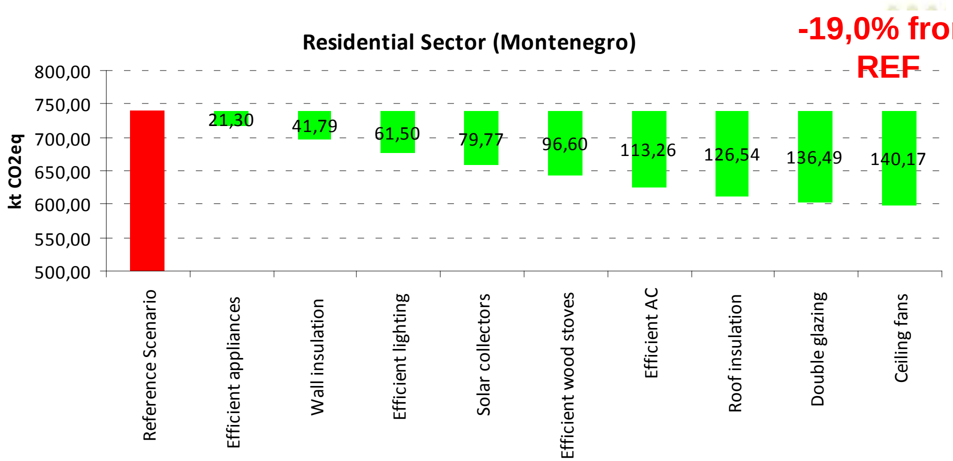
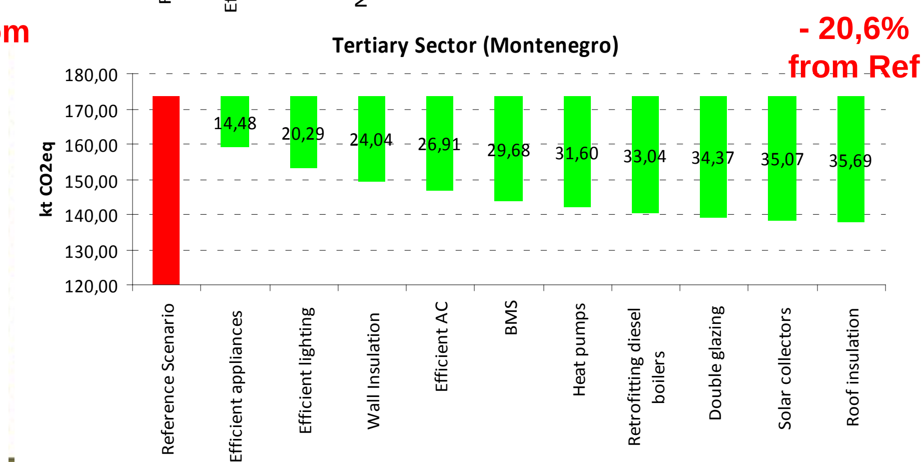
BUILDINGS – GHG Abatement Technical Potential in 2020

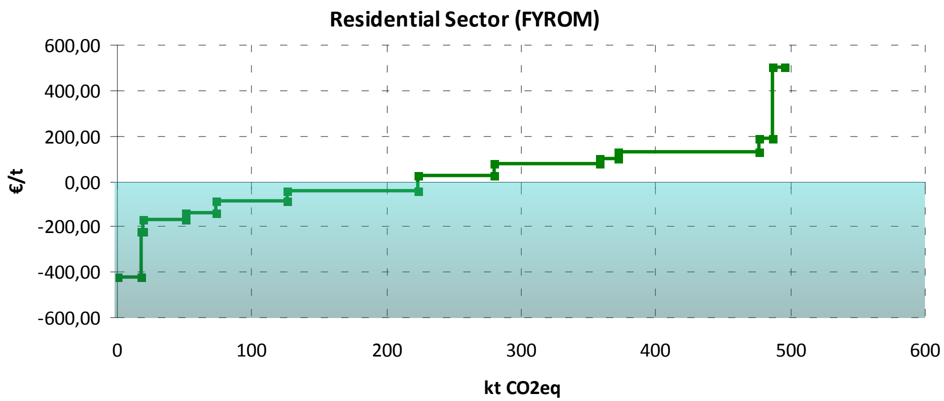




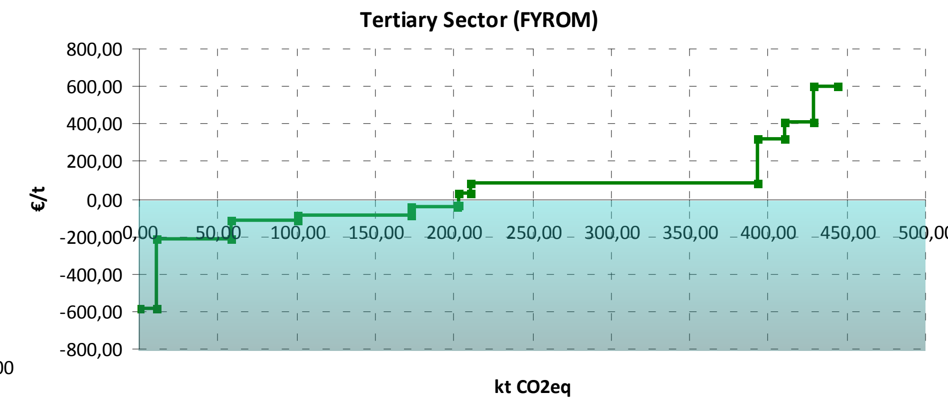




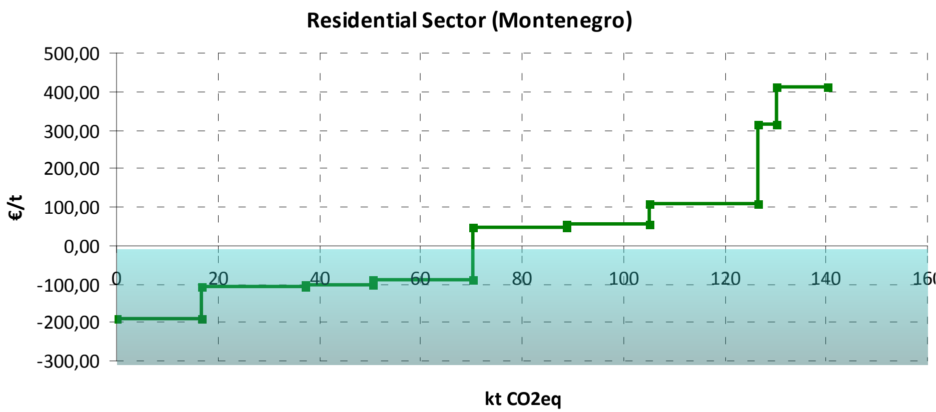
BUILDINGS – GHG Abatement Cost Curve



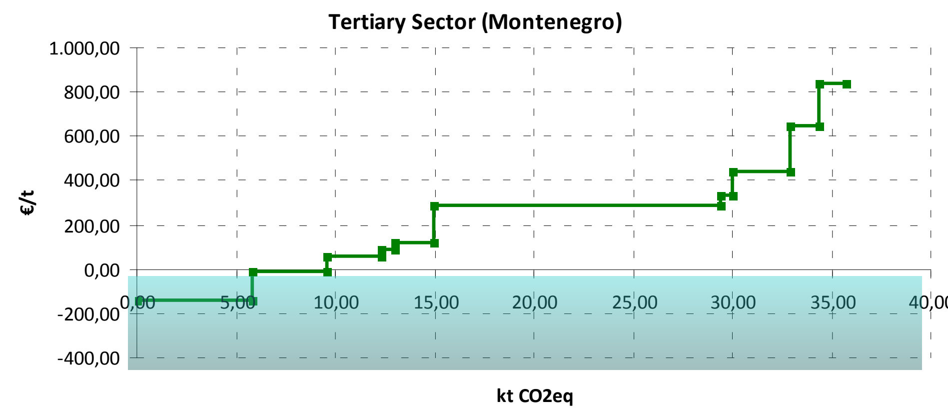
'win-'win': 45 % of total GHG mitigation potential



'win-'win': 46 % of total GHG mitigation potential



'win-'win': 50 % of total GHG mitigation potential



'win-'win': 27 % of total GHG mitigation potential

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1b. Transport

TRANSPORT – Model's structural characteristics

- **Base year:** 2010
- **Period of analysis:** 2010-2030
- **Input data:**
  - Vehicles stock disaggregated by type, fuel, capacity and technology
  - Mileage
  - Activity patterns, e.g modal shares
  - Additional requirements, e.g. average speed per vehicle category, passengers per vehicle etc.
  - Fuel characteristics, e.g NCV, density
- **Data sources:**
  - National Inventory reports
  - Energy Balances
  - Statistical agencies
  - National transport action plans
  - National or international sector studies
  - International organizations (e.g Eurostat, EEA)

TRANSPORT – Modeling steps

- **Step 1.** Total fuel consumption for the whole sector and for a specific year is calculated 'bottom-up' by taking into account the stock, fuel consumption and mileage per each type of vehicle:

$$FC = SFC \times Mileage \times \frac{Stock}{10^9} \qquad \text{(Eq-1)}$$

FC: fuel consumption, SFC: specific fuel consumption, Mileage: distance driven per car, Stock: number of cars

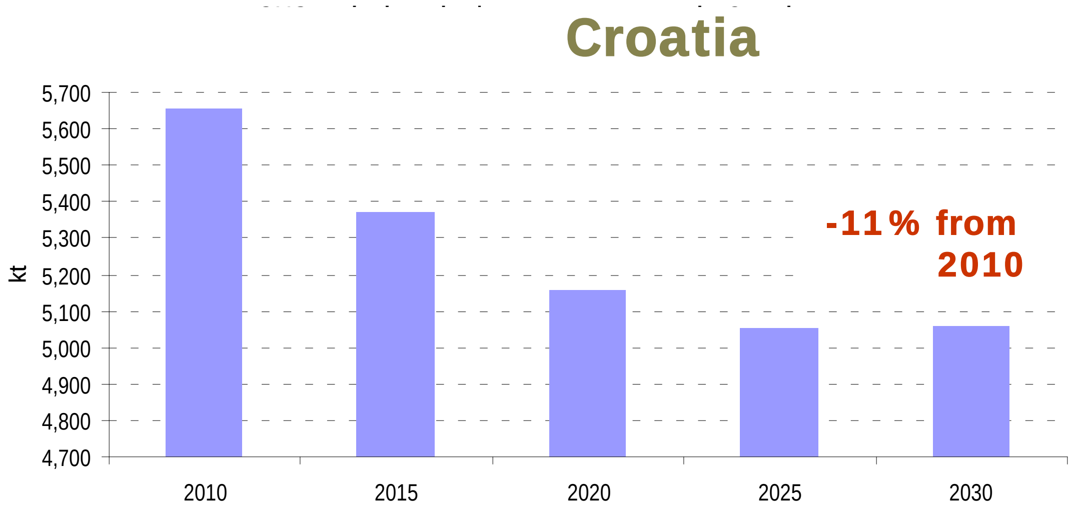
- **Step 2.** The calculated energy consumption is compared with the data provided in the relevant National Energy Balance. If necessary, modifications are made in order to minimize differences.

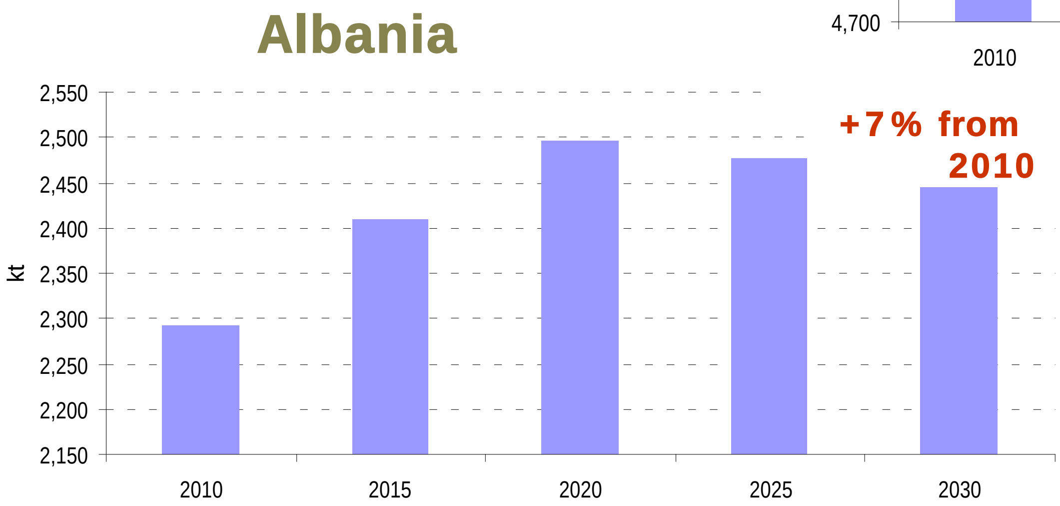
- **Step 3.** The model is applied to 2010-2030 and future energy consumption per vehicle type and fuel is calculated.

- **Step 4.** GHG emissions (CO_2, CH_4, N_2O) are calculated by taking into account the emission factor per gas and type of vehicle:

$$GHG = Stock \times Mileage \times \frac{EF_{GHG}}{10^9} \qquad \text{(Eq-2)}$$

TRANSPORT - Reference Scenario & GHG emissions





TRANSPORT – GHG Mitigation Measures examined

1. Renewal of gasoline passenger cars
2. Renewal of diesel passenger cars
3. Renewal of diesel LDV
4. Renewal of diesel HDV

$\}$ Faster, compared to the Reference Scenario, penetration rate of EURO 5 & 6 cars

5. Promotion of public transport
6. Use of hybrid passenger cars
7. Use of electric passenger cars
8. Eco-driving
9. Use of CNG busses
10. Increasing bus speed (traffic control, bus lanes)
11. Biodiesel penetration
    - Directive 2009/28/EE asks for a biofuels' share of 10% in the final consumption of the transport sector
    - Biodiesel is added to diesel
    - In case of Croatia, this measure is not applicable due to the fact that it has been already included in the Reference Scenario

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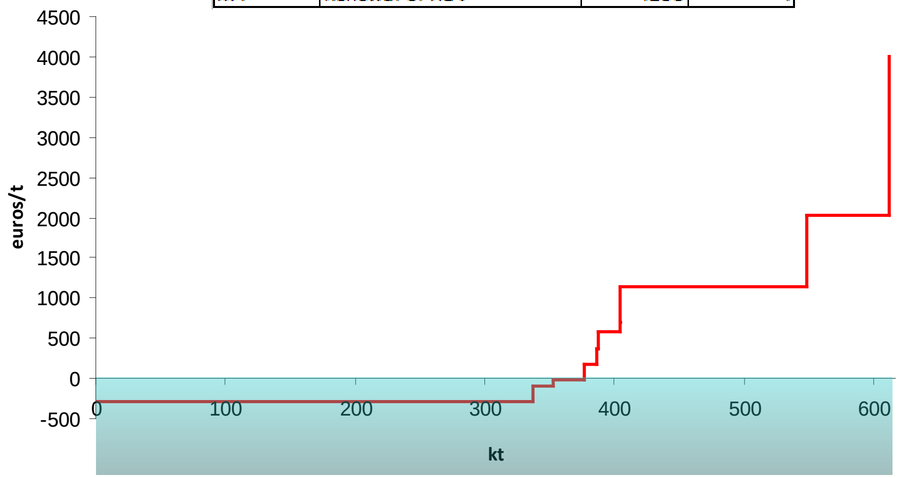
TRANSPORT - GHG Abatement Potential & Cost Curve

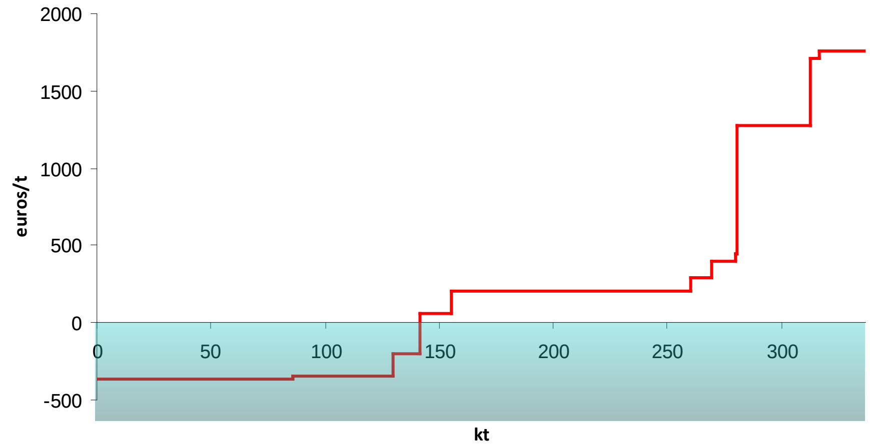
Croatia

		GHG abatement cost (€/t)	GHG emissions reduction (kt)
M5	Public transport	-288	338
M10	Increase bus speed	-96	16
M8	Eco-driving	-10	24
M6	Hybrid cars	178	9
M9	Penetration of CNG busses	375	1
M3	Renewal of LDV	590	17
M7	Electric cars penetration	688	1
M1	Renewal of gasoline PC	1147	144
M2	Renewal of diesel PC	2025	64
M4	Renewal of HDV	4230	4



Albania

		GHG abatement cost (€/t)	GHG emissions reduction (kt)
M5	Public transport	-365	86
M10	Increase bus speed	-345	44
M8	Eco-driving	-201	12
M9	Penetration of CNG busses	56	14
M11	Biodiesel penetration	209	105
M6	Hybrid cars	292	9
M3	Renewal of LDV	401	11
M7	Electric cars penetration	447	0
M1	Renewal of gasoline PC	1278	32
M4	Renewal of HDV	1707	4
M2	Renewal of diesel PC	1760	20



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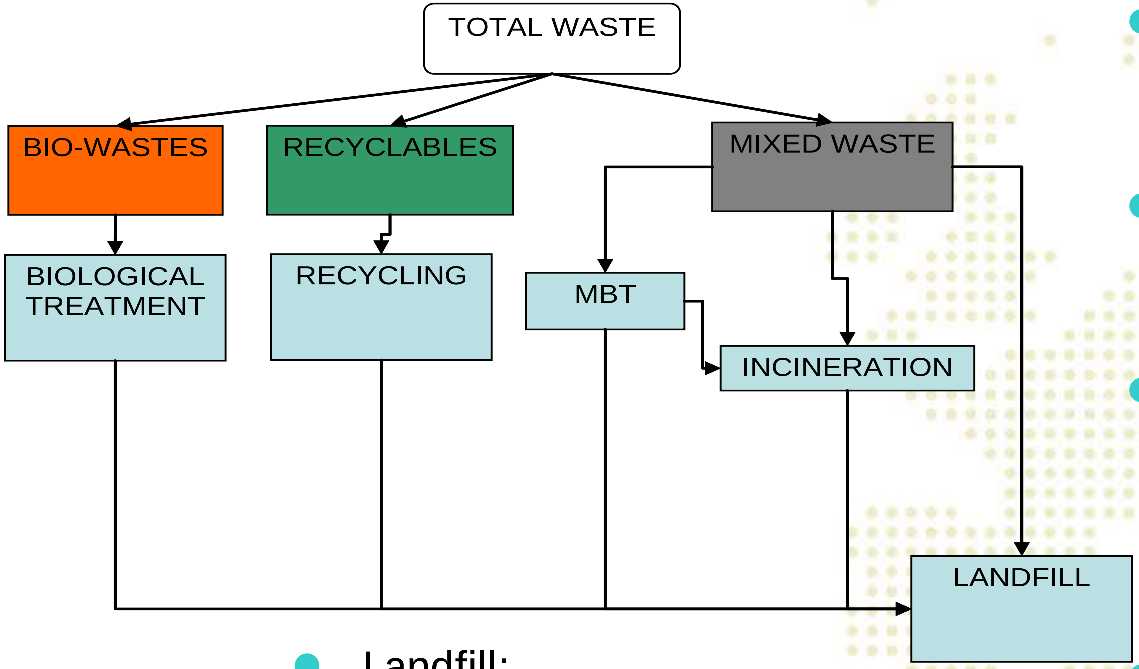
1c. Solid waste

WASTE – Model's structural characteristics

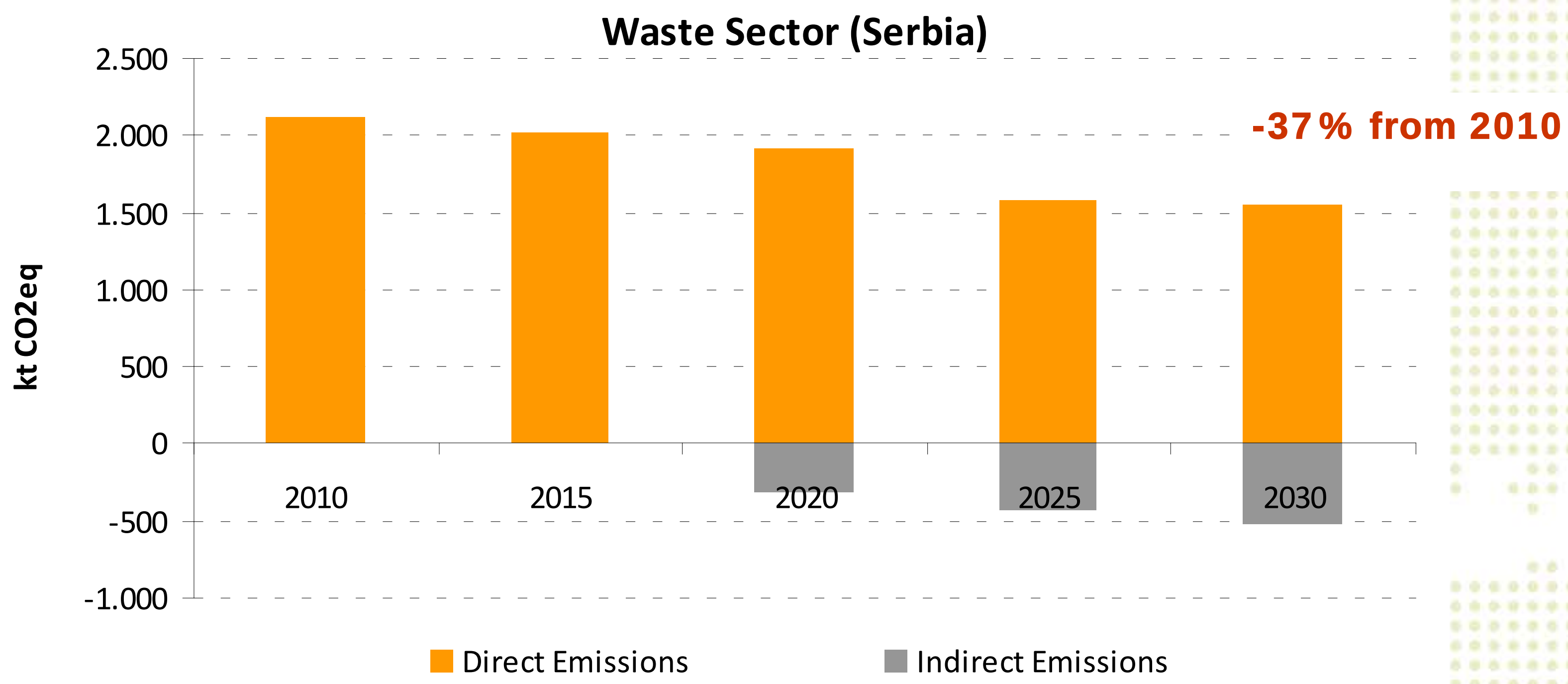
- Estimates GHG emissions generated from municipal solid waste treatment and disposal which are broken down to specific technologies and disposal options
- 2010 is selected as the base year and the model's results are compared with the National Communication and other official sources
- GHG emissions calculated annually include:
  - Process emissions from waste treatment and disposal (e.g. CO_2 emissions from the incineration of non-biodegradable part of wastes)
  - Emissions from fuel and electricity use
  - Avoided emissions due to electricity generated from Waste-to-Energy and Anaerobic Digestion facilities
- Process GHG emissions are calculated according to Tier 1 (for Incineration and Biological Treatment) and Tier 2 (for landfill) methods of the 2006 IPCC Guidelines
- GHG emissions are projected for the period 2010-2030

WASTE – Model's structural characteristics



- Biological Treatment:
  - Composting
  - Anaerobic Digestion
- Recycling:
  - At the source
  - Material Recovery Facilities
- Mechanical Biological Treatment:
  - Recovery of recyclables and biological treatment of organic fraction
  - Bio-drying
- Incineration in WtE facilities:
  - Mixed Wastes
  - RDF / SRF from MBT
- Landfill:
  - Unmanaged (deep/ shallow)
  - Managed
  - Managed semi-aerobic
  - Uncategorized

WASTE - Reference Scenario & GHG emissions



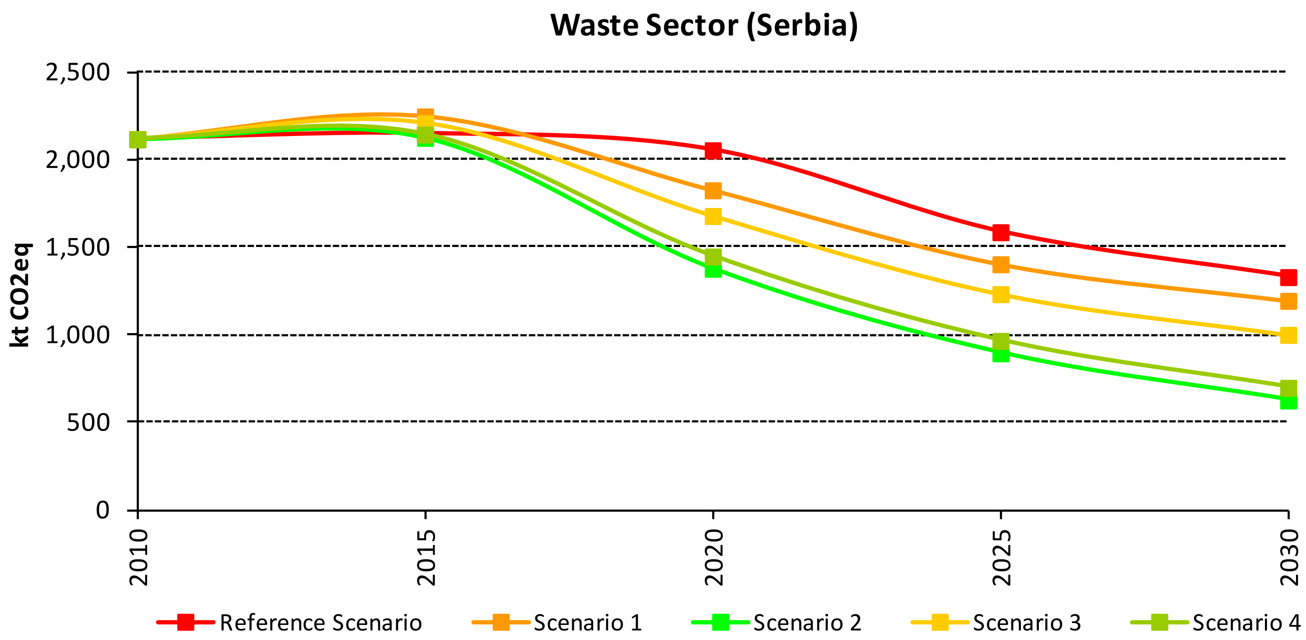
Direct Emissions: Process Emissions and Fuel Emissions

Indirect Emissions: Electricity (consumption and generation) emissions

WASTE - GHG Mitigation Measures examined

- **4 GHG Emissions abatement scenarios** were formulated
- In **all scenarios**:
  - Residuals are disposed at managed landfills with biogas collection and flaring
  - Increase of recycling
  - Separate collection of 20% of bio-wastes (followed by 50% composting and 50% anaerobic digestion).
- **Treatment** of the rest wastes (mixed):
  - S1: MBT-1 (Advanced sorting equipment, Production of RDF, Composting of the bio-stabilized organic fraction) and RDF incinerated in WtE facilities
  - S2: MBT-2 (Advanced sorting equipment, Production of RDF, AD of the bio-stabilized organic fraction) and RDF incinerated in WtE facilities
  - S3: Bio-drying and SRF incinerated in WtE facilities
  - S4: Incineration in WtE facilities

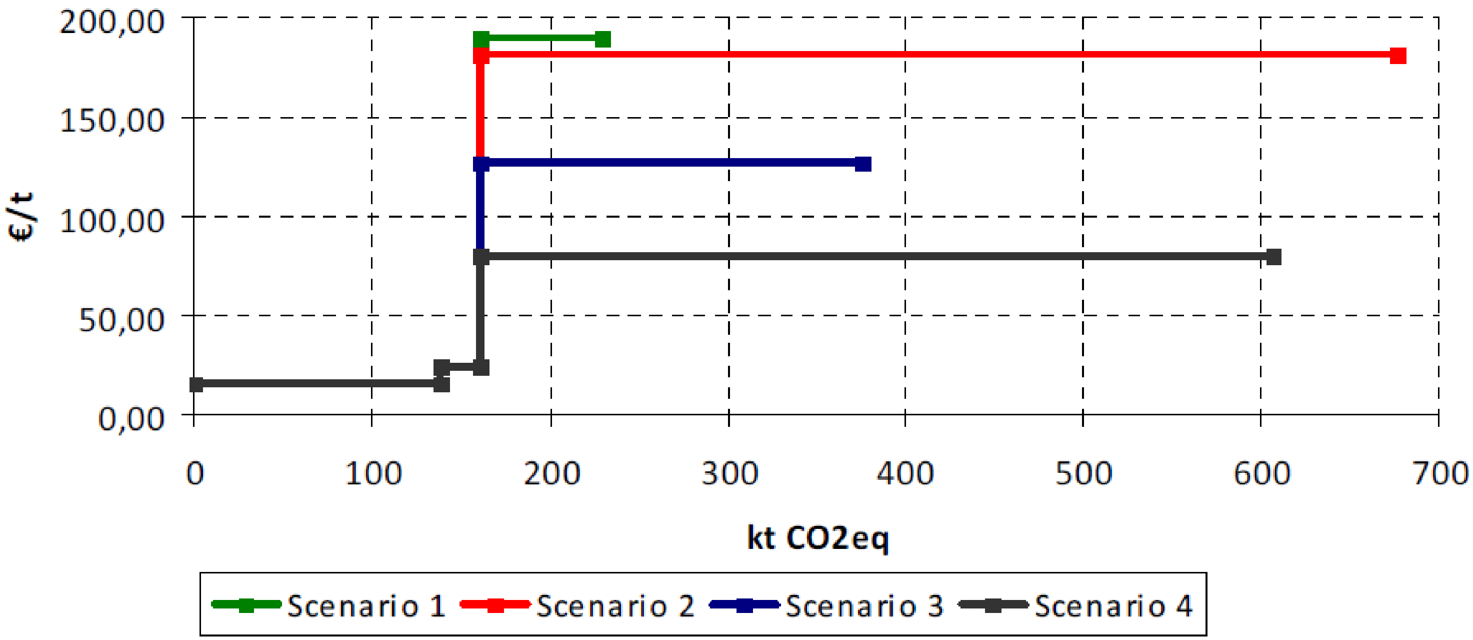
WASTE - GHG Abatement Technical Potential



GHG emissions reduction by 2020 compared to the Reference Scenario:

- **Scenario 1:** 228 kt CO2eq (-11.1%)
- **Scenario 2:** 676 kt CO2eq (-32.9%)
- **Scenario 3:** 375kt CO2eq (-18.3%)
- **Scenario 4:** 606 kt CO2eq (-29.5%)

WASTE - GHG Abatement Cost



S1: MBT-1 (Sorting, RDF, Composting, RDF incinerated in WtE facilities)

S2: MBT-2 (Sorting, RDF, AD, RDF incinerated in WtE facilities)

S3: Bio-drying and SRF incinerated in WtE facilities

S4: Incineration in WtE facilities

2. Measuring the co-benefits of energy efficiency

The concept

- EE investments can yield benefits beyond the value of saved energy.
- However these benefits are rarely included in CBA of EE and CC mitigation projects.
- Therefore, there is a need to quantify/monetize these **co-benefits**, to enable their introduction into a more realistic energy- and climate-related decision-making process.

Typology of co-benefits / 1a

Health effects	- Reduced mortality and morbidity effects due to the improved outdoor air quality and reduced noise - Reduced mortality and morbidity effects due to the improved indoor conditions - Health improvements associated with fuel poverty alleviation
Environmental effects	- Environmental benefits due to the reduced concentrations of air pollutants. - Increased vegetation in cities - Reduced water consumption - Construction and demolition waste reduction

Typology of co-benefits / 1b

Economic effects	- Macroeconomic effects (GDP, energy prices) - Job creation - Improved energy security - Improved productivity - Public budget impacts - Enhanced asset values of buildings - Lower need for energy subsidies
Social effects	- Fuel poverty alleviation - Road safety - Increased comfort (thermal comfort, reduced noise impacts) - Increased productive time in cities but also for women and children in developing countries

Typology of co-benefits /2

International	Macroeconomic effects (energy prices)
National	Macroeconomic effects (GDP), Job creation, Improved energy security, Public budget impacts
Sectoral	Improved productivity, Enhanced asset values of buildings, Lower need for energy subsidies, Improved energy security
Individual	Health benefits, Fuel poverty alleviation, Increased comfort, Increased productive time

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Typology of co-benefits: Buildings

Buildings	Effect on additional objectives/concerns			
	Economic	Social	Environmental	Other
Fuel switching, RES incorporation, green roofs, and other measures reducing GHG emissions intensity	↑ Energy security (m/h) ↑ Employment impact (m/m) ↑ Lower need for energy subsidies (l/l) ↑ Asset values of buildings (l/m)	Fuel poverty (residential) via ↓ Energy demand (m/h) ↑ Energy cost (l/m) ↓ Energy access (for higher energy cost) (l/m) ↑ Productive time for women/children (for replaced traditional cookstoves) (m/h)	Health impact in residential buildings via ↓ Outdoor air pollution (r/h) ↓ Indoor air pollution (in developing countries) (r/h) ↓ Fuel poverty (r/h) ↓ Ecosystem impact (less outdoor air pollution) (r/h) ↑ Urban biodiversity (for green roofs) (m/m)	Reduced Urban Heat Island (UHI) effect (l/m)
Retrofits of existing buildings (e.g., cool roof, passive solar, etc.) Exemplary new buildings Efficient equipment	↑ Energy security (m/h) ↑ Employment impact (m/m) ↑ Productivity (for commercial buildings) (m/h) ↑ Lower need for energy subsidies (l/l) ↑ Asset values of buildings (l/m) ↑ Disaster resilience (l/m)	↓ Fuel poverty (for retrofits and efficient equipment) (m/h) ↓ Energy access (higher cost for housing due to the investments needed) (l/m) ↑ Thermal comfort (for retrofits and exemplary new buildings) (m/h) ↑ Productive time for women and children (for replaced traditional cookstoves) (m/h)	Health impact via ↓ Outdoor air pollution (r/h) ↓ Indoor air pollution (for efficient cookstoves) (r/h) ↓ Improved indoor environmental conditions (m/h) ↓ Fuel poverty (r/h) ↓ Insufficient ventilation (m/m) ↓ Ecosystem impact (less outdoor air pollution) (r/h) ↓ Water consumption and sewage production (l/l)	Reduced UHI effect (for retrofits and new exemplary buildings) (l/m)
Behavioural changes reducing energy demand	↑ Energy security (m/h) ↑ Lower need for energy subsidies (l/l)		↓ Health impact via less outdoor air pollution (r/h) and improved indoor environmental conditions (m/h) ↓ Ecosystem impact (less outdoor air pollution) (r/h)	

Source:
IPCC AR5, 2014

Typology of co-benefits: Transport

Transport	Effect on additional objectives/concerns		
	Economic	**Social**	**Environmental**
Reduction of fuel carbon intensity: electricity, hydrogen (H_2), compressed natural gas (CNG), biofuels, and other fuels	↑ Energy security (diversification, reduced oil dependence and exposure to oil price volatility) **(m/m)** ↑ Technological spillovers (e.g., battery technologies for consumer electronics) **(l/l)**	Health impact via urban air pollution by ? CNG, biofuels: net effect unclear **(m/l)** ↓ Electricity, H_2: reducing most pollutants **(r/h)** ↑ Shift to diesel: potentially increasing pollution **(l/m)** ↓ Health impact via reduced noise (electricity and fuel cell LDVs) **(l/m)** ↓ Road safety (silent electric LDVs at low speed) **(l/l)**	Ecosystem impact of electricity and hydrogen via ↓ Urban air pollution **(m/m)** ↑ Material use (unsustainable resource mining) **(l/l)** ? Ecosystem impact of biofuels: *see AFOLU*
Reduction of energy intensity	↑ Energy security (reduced oil dependence and exposure to oil price volatility) **(m/m)**	↓ Health impact via reduced urban air pollution **(r/h)** ↑ Road safety (via increased crash-worthiness) **(m/m)**	↓ Ecosystem and biodiversity impact via reduced urban air pollution **(m/h)**
Compact urban form and improved transport infrastructure **Modal shift**	↑ Energy security (reduced oil dependence and exposure to oil price volatility) **(m/m)** ↑ Productivity (reduced urban congestion and travel times, affordable and accessible transport) **(m/h)** ? Employment opportunities in the public transport sector vs. car manufacturing **(l/m)**	Health impact for non-motorized modes via ↓ Increased physical activity **(r/h)** ↑ Potentially higher exposure to air pollution **(r/h)** ↓ Noise (modal shift and travel reduction) **(r/h)** ↑ Equitable mobility access to employment opportunities, particularly in developing countries **(r/h)** ↑ Road safety (via modal shift and/or infrastructure for pedestrians and cyclists) **(r/h)**	Ecosystem impact via ↓ Urban air pollution **(r/h)** ↓ Land-use competition **(m/m)**
Journey distance reduction and avoidance	↑ Energy security (reduced oil dependence and exposure to oil price volatility) **(r/h)** ↑ Productivity (reduced urban congestion, travel times, walking) **(r/h)**	↓ Health impact (for non-motorized transport modes) **(r/h)**	Ecosystem impact via ↓ Urban air pollution **(r/h)** ↑ New/shorter shipping routes **(r/h)** ↓ Land-use competition from transport infrastructure **(r/h)**

Source:
IPCC AR5, 2014

Analysis of co-benefits in LOCSEE

Co-benefits covered:

- Environmental and health benefits due to reduced outdoor air pollution and GHG emissions
- Employment
- Impact on GDP

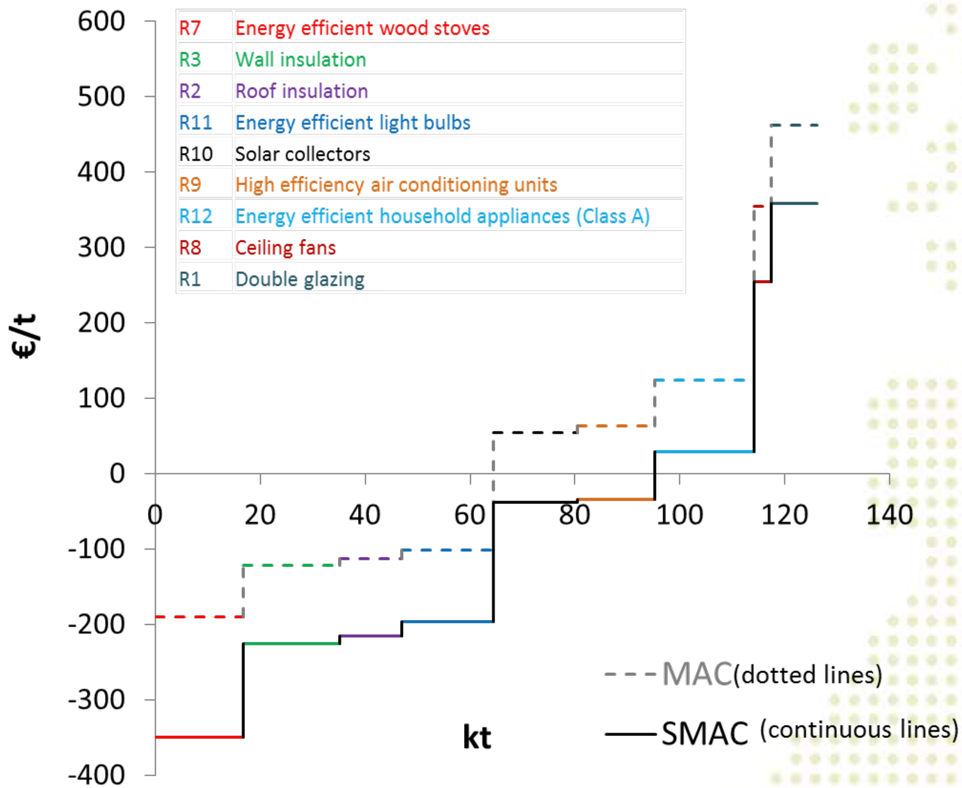
Methodological approaches:

- Quantification in physical terms and monetization only for environmental and health benefits
- Simplified methodologies [benefit transfer, multipliers]

The influence of environmental benefits

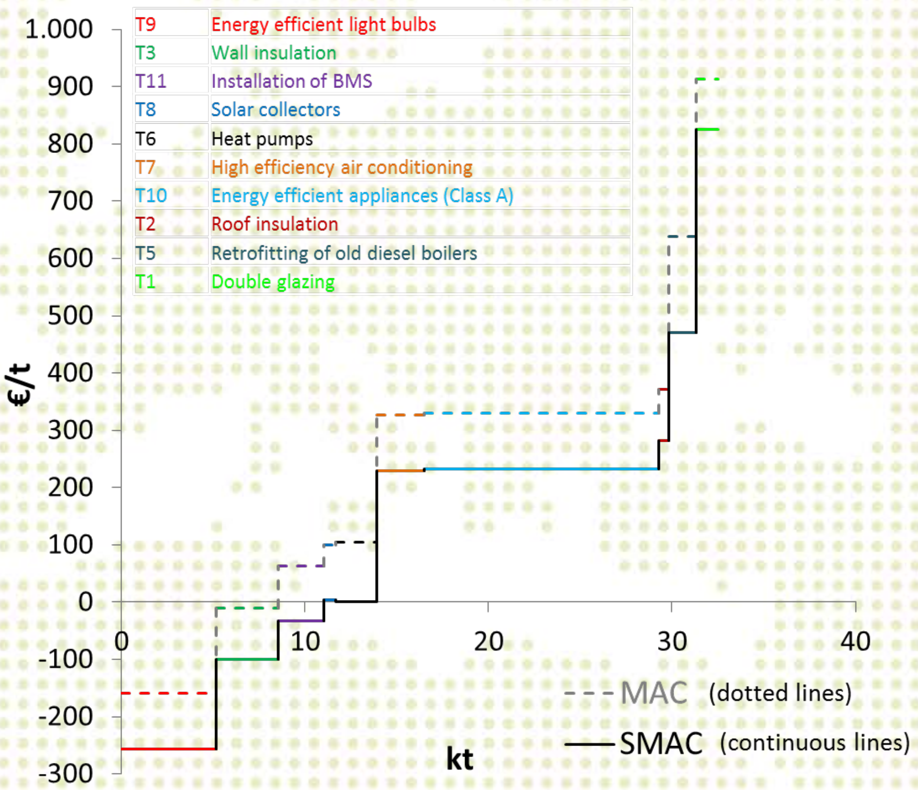
(S)MAC curve for proposed measures in the residential builidings sector Montenegro

((S)MAC - considering country specific modelling of electricity generation)

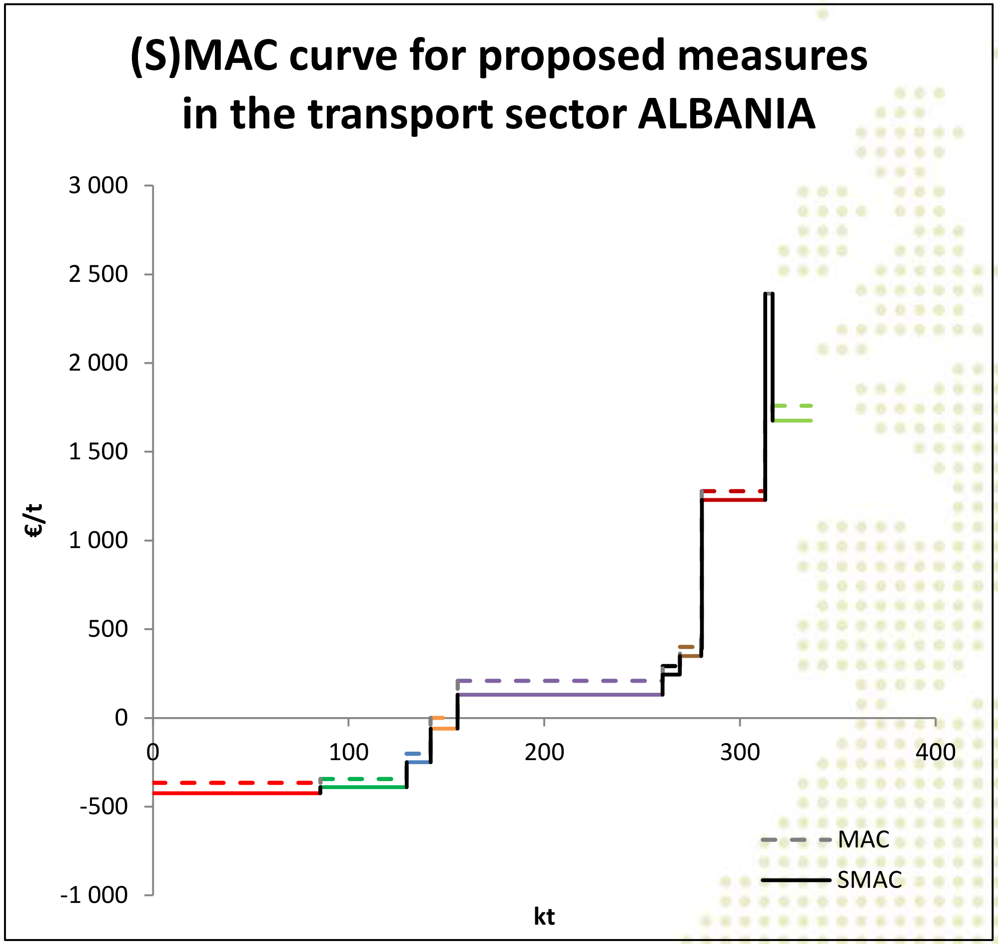


(S)MAC curve for proposed measures in the tertiary builidings sector Montenegro

((S)MAC) considering country specific modelling of electricity generation)



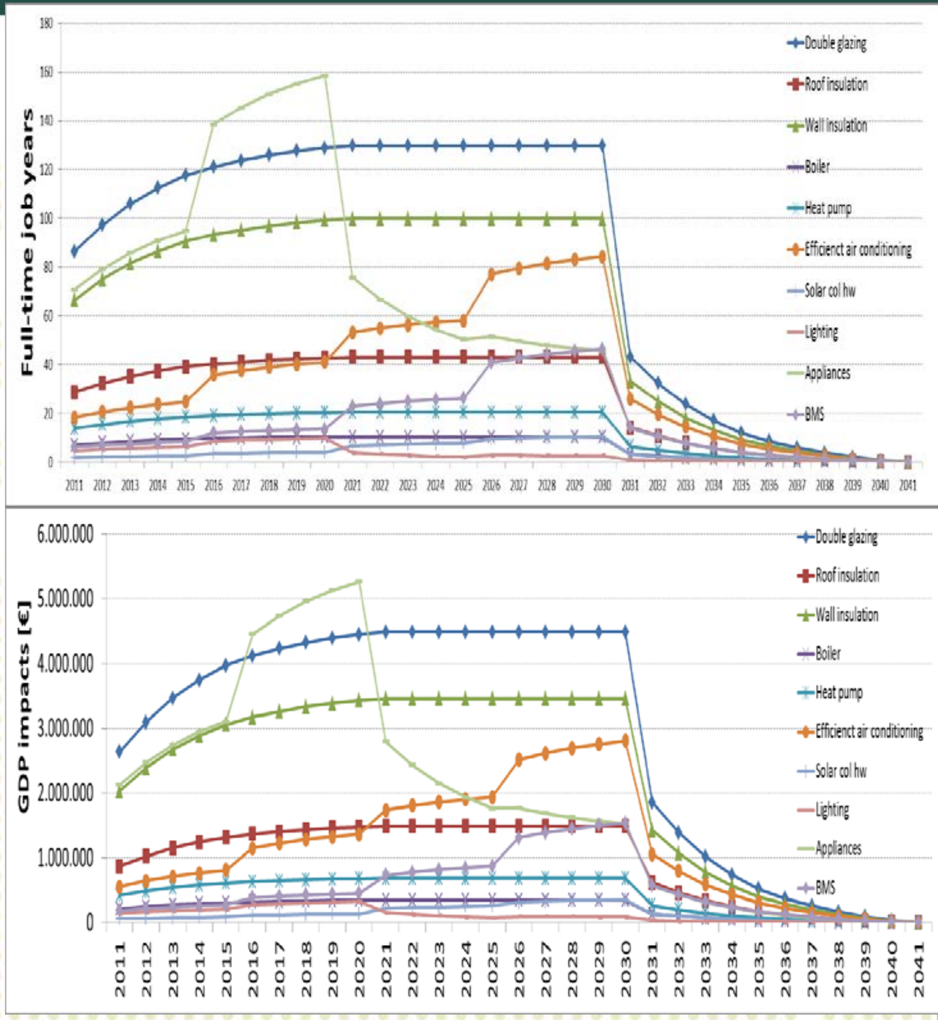
The influence of environmental benefits



M5	Public transport
M10	Increase bus speed
M8	Eco-driving
M9	Penetration of CNG busses
M11	Biodiesel penetration
M6	Hybrid cars
M3	Renewal of LDV
M7	Electric cars penetration
M1	Renewal of gasoline PC
M4	Renewal of HDV
M2	Renewal of diesel PC

Macro-economic impacts

- Effects associated with mitigation measures in tertiary buildings in Montenegro
- In total, nearly 10,000 full-time job-years will be created
- In total, all measures lead to positive domestic GDP impacts of € 330 mio. in the long run (compared to investment of around € 250 mio.).



EE & employment: examples from Greece

- Insulation of external walls and roofs in buildings constructed before 1980 (i.e. the year in which the 1st Thermal Insulation Regulation in Greece was put in effect)
- Installation of new window frames (double- or triple-glazed)
- Replacement of old diesel boilers for space heating by new ones using natural gas.

(Mirasgedis et al. 2014)

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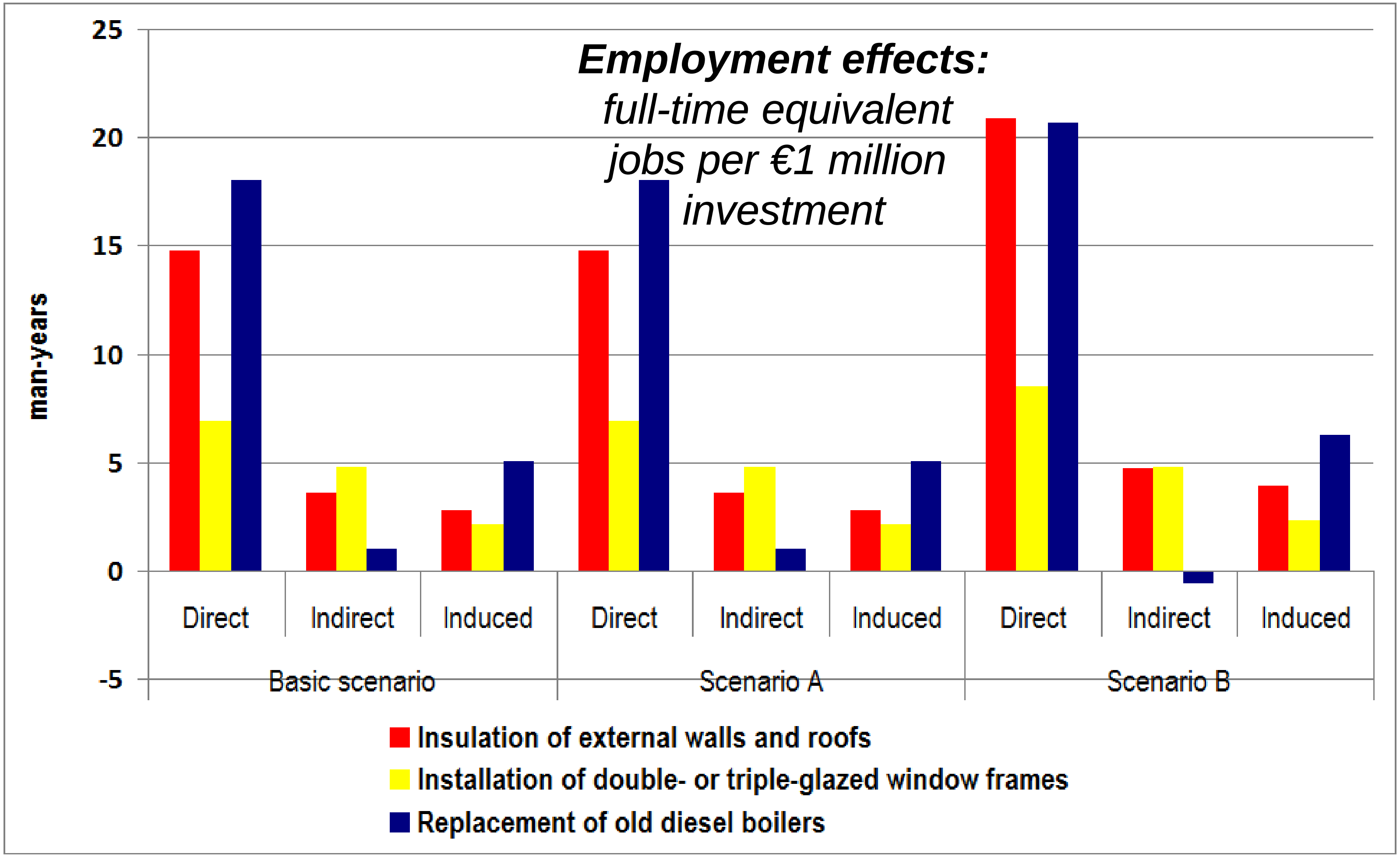
EE & employment: analytical modeling

- Construction and installation activities **[+]**
  - Temporary (pre-investment and implementation phases)
- Operation & maintenance activities **[+]**
  - Permanent (during the lifetime of the investment)
- Reduced activities in traditional economic sectors **[-]**
  - Permanent (during the lifetime of the investment)
- Increased consumption due to additional income available **[+]**
  - Permanent (after the payback period)

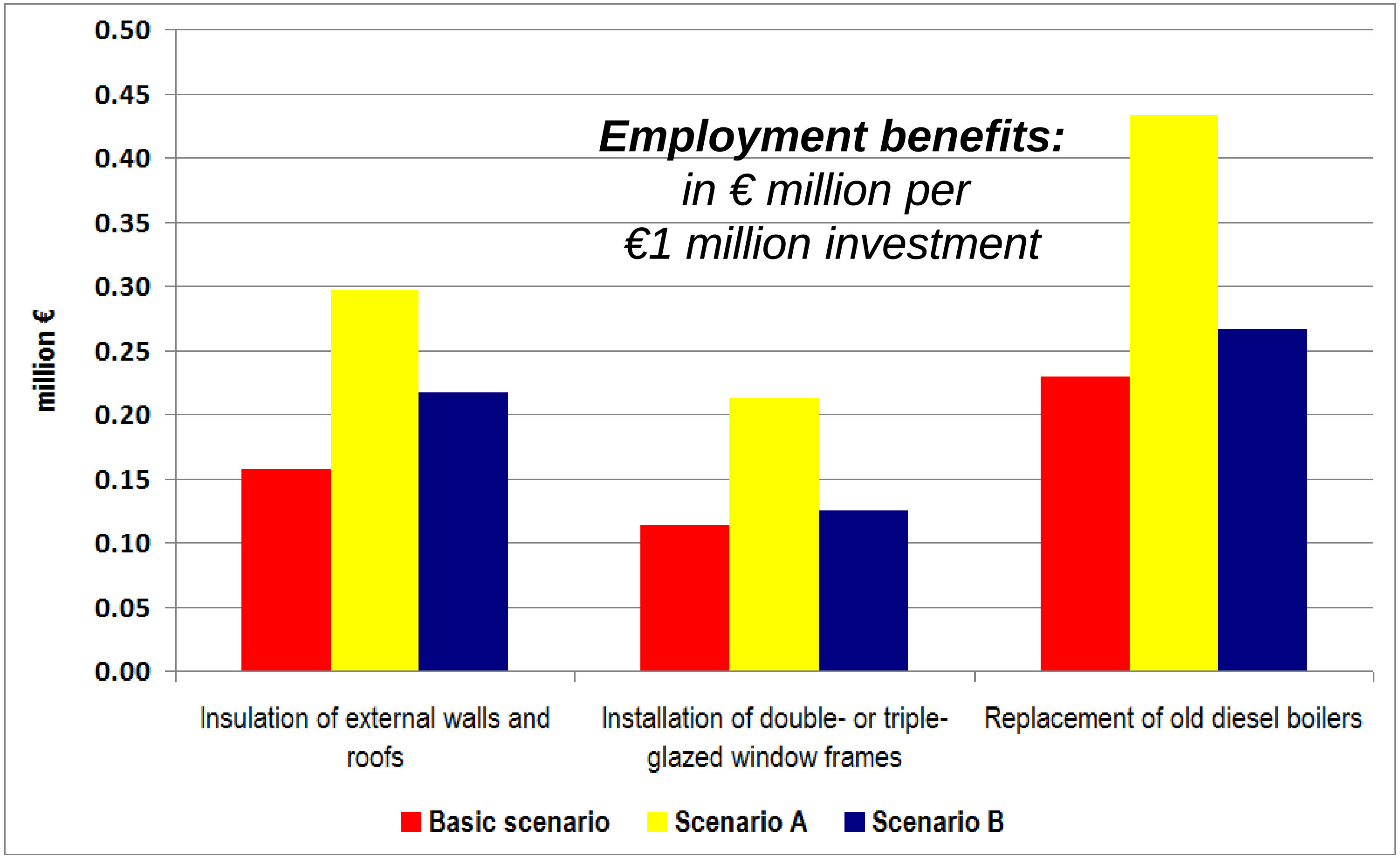
EE & employment: quantification

- Quantification in physical terms (positive or negative)
  - Input – Output analysis: direct/indirect/induced
- Calculation of the net present value of the estimated employment effects
- Monetization
  - Adjusted Earnings Gain Approach (Bartik 2012):
    - Probability the worker is drawn from the pool of previously unemployed people
    - Differences in income (wages in new and previous work, unemployment benefits)
    - Value of leisure time, stigma effects

EE & employment: examples from Greece



EE & employment: examples from Greece



Low Carbon South East Europe

3. Concluding remarks

Concluding remarks (I)

- **Critical factors:**
  - Availability of input data
  - Assumptions made in the Reference Scenario
  - Future evolution of EU legislation
  - Technological options considered
  - Future cost of technologies - Hidden costs
  - Rebound effect
  - Input from and interaction with policy makers
- **Challenges:**
  - Have a full understanding of input data utilized and assumptions made
  - Collect recent, reliable and detailed input data
  - Understand the sensitivity of models' results
  - Create capacity in public administration - Train personnel ('hands on')
  - Compare the outcomes of different models
  - Re-visit/ regularly update models being utilized

Concluding remarks (II)

- There seems to be a significant economically attractive GHG mitigation potential in the SEE countries examined, but hidden costs can greatly reduce this ‘optimism’
- A major barrier is also the initial (and often high) investment cost. Efficient financing of mitigation measures and complementary support policies are needed.
- In many cases, co-benefits of EE seem to exceed the energy cost savings or the investments required.
- While co-benefits are universal, their values are case- and site-specific. In the Balkans, co-benefits of EE seem to be higher in buildings than in transport sector.
- The methodologies and tools for their quantification exist and can be used for accelerating their inclusion in standard decision making tools.

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Thank you for your attention!

elenag@noa.gr , seba@noa.gr

National Observatory of Athens (NOA)