The Abdus Salam International Centre for Theoretical Physics

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Joint ICTP-IAEA Workshop on Sustainable Energy Development: Pathways and Strategies after Rio+20

1 - 5 October 2012

STRATEGIES FOR SUSTAINABLE ENERGY DEVELOPMENT AND CLIMATE CHANGE IN CUBA

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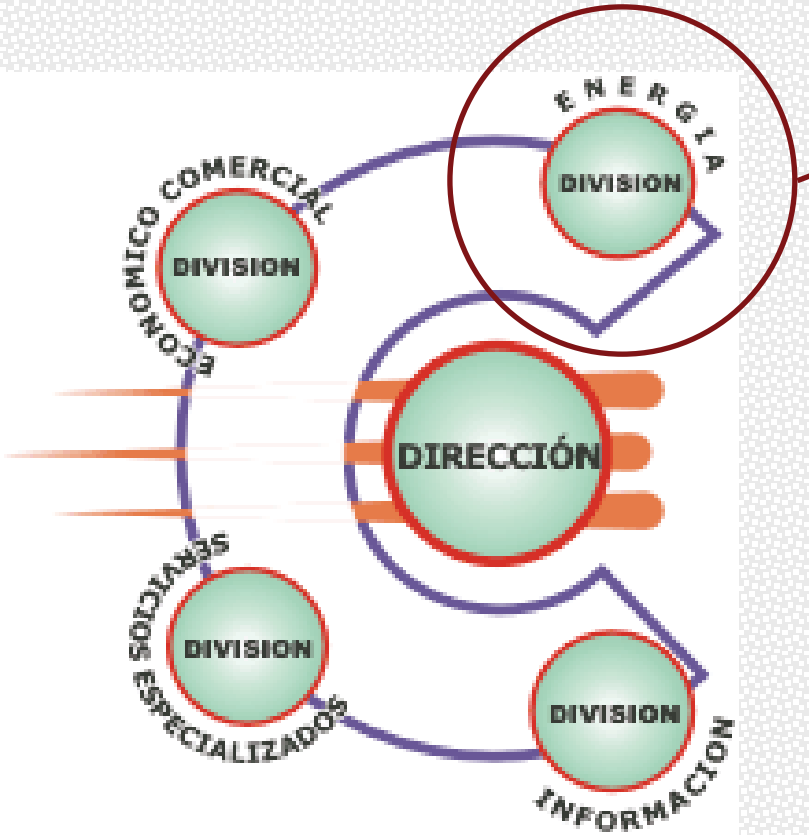
ICTP, Miramare - Trieste, Italy

"STRATEGIES FOR SUSTAINABLE ENERGY DEVELOPMENT AND CLIMATE CHANGE IN CUBA"

CUBAENERGIA

Information Management and Energy Development Center



División de Energía

- Environmental Impacts
- Energy Planning
- Renewal Energies

www.cubaenergia.cu

Background Information

- Surface extension: 109 866 km^2
- Total population (2010) 11.24 million
- GDP (2010) 64 328.2 M CUP

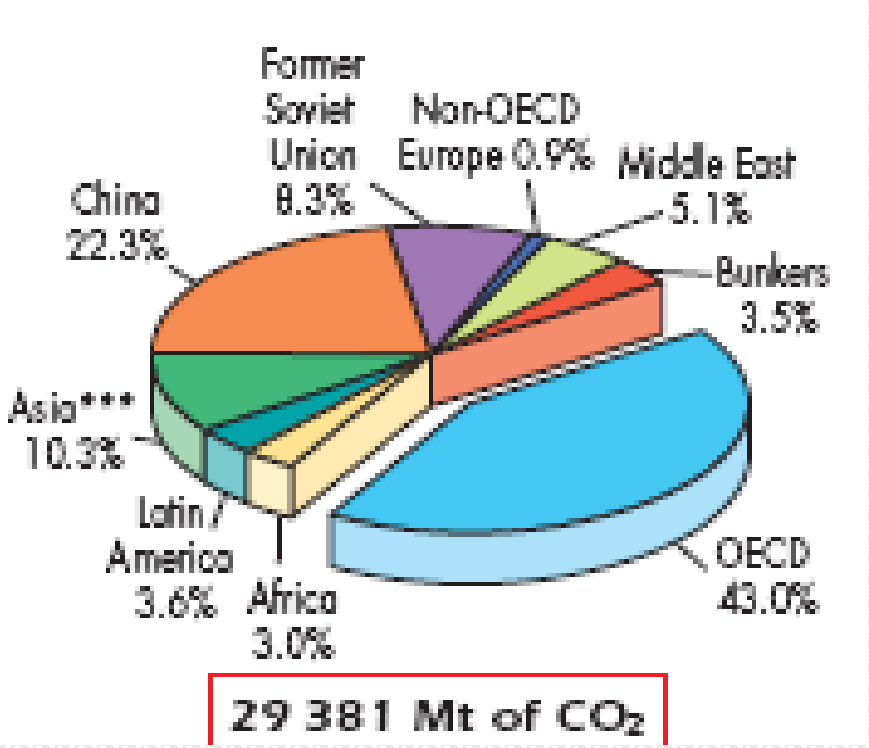
Source: ONE,2010

GHG Emissions

CO_2 emissions from fuel combustion

Region/ Country/ Economy	CO_2 emissions (Mt of CO_2)
World	29 381
OECD	12 630
Middle East	1 492
Former Soviet Union	2 426
Non-OECD Europe	269
China	6 550
Asia	3 023
Latin America	1 068
Africa	890

Source: Key World Energy Statistics 2010

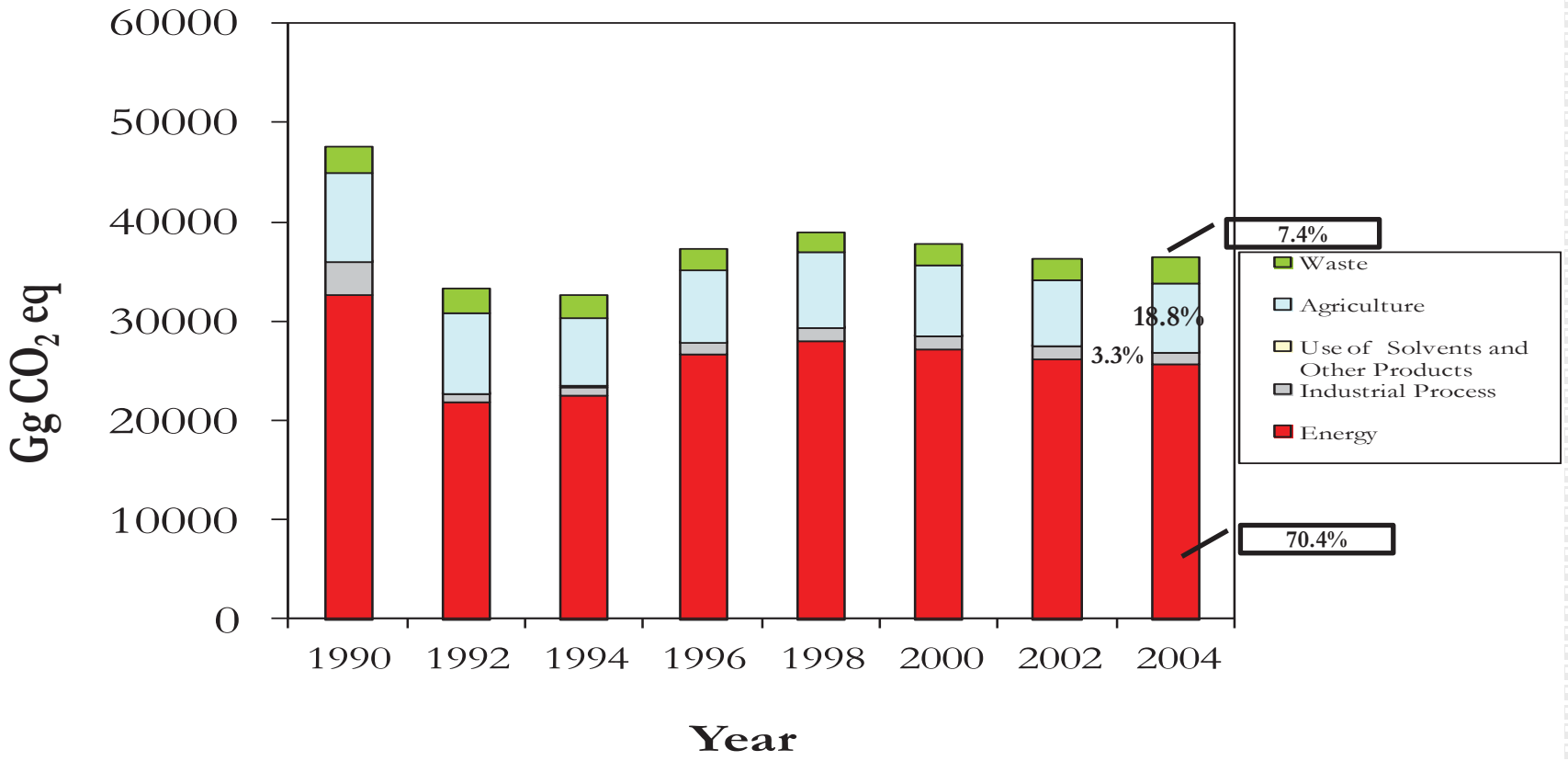


Cuba: 30.51 Mt CO_2

2.85 % of the Latin America

0.1 % of the World

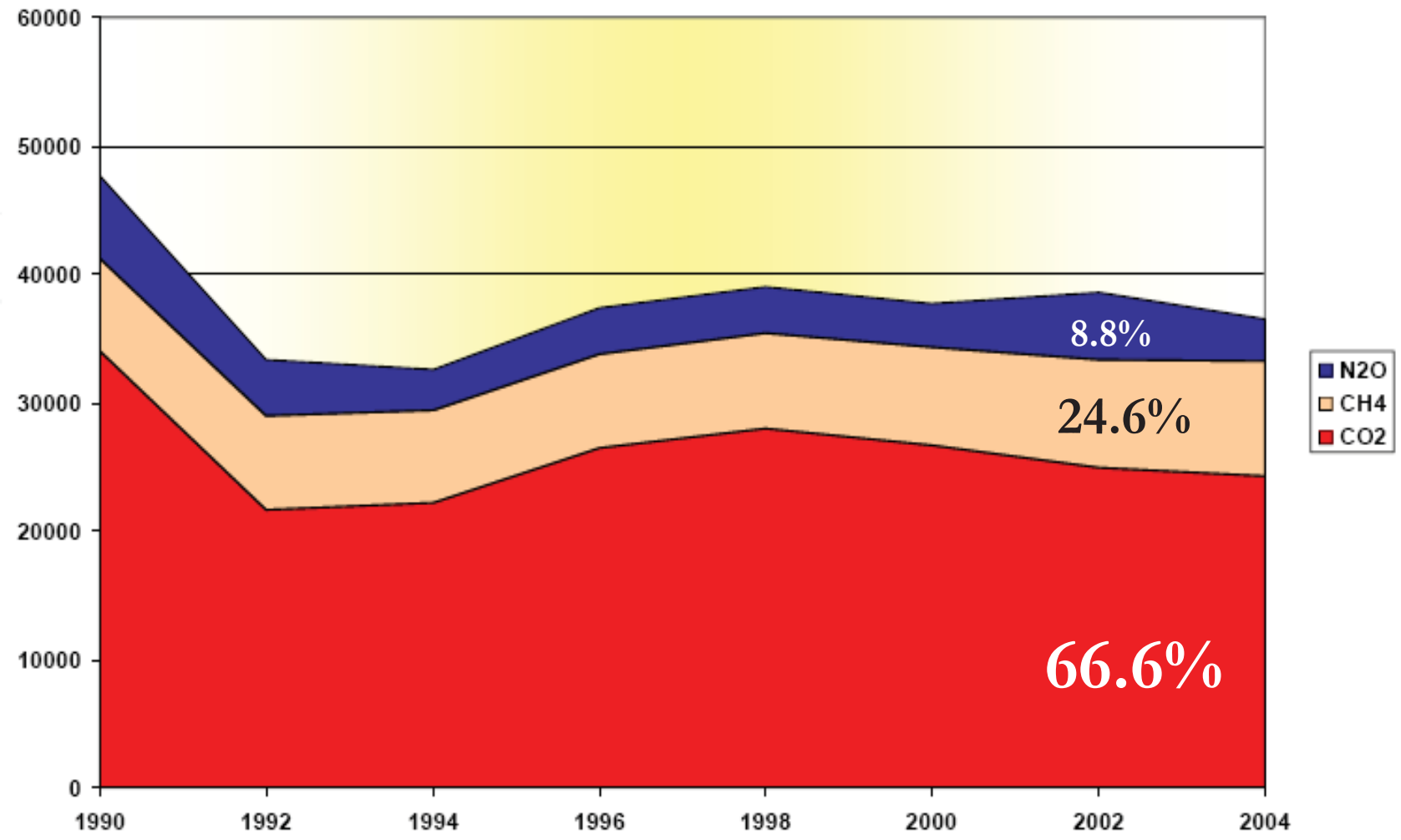
Gross Emissions by Sector (Gg CO_2 eq)



Emissions were 23.6% lower than 1990

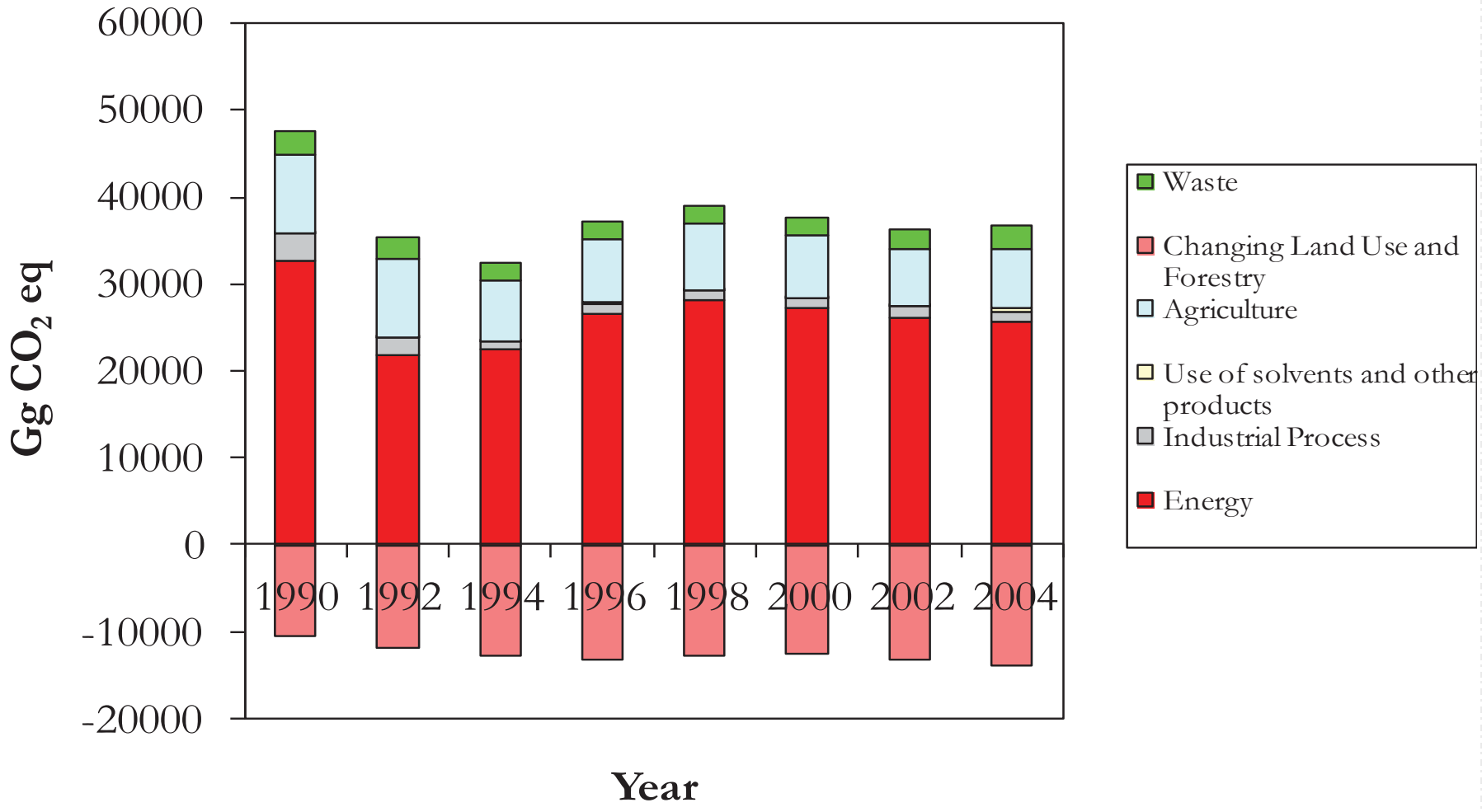
Source: López et al, 2009

Gross Emissions
(Gg CO_2 eq)



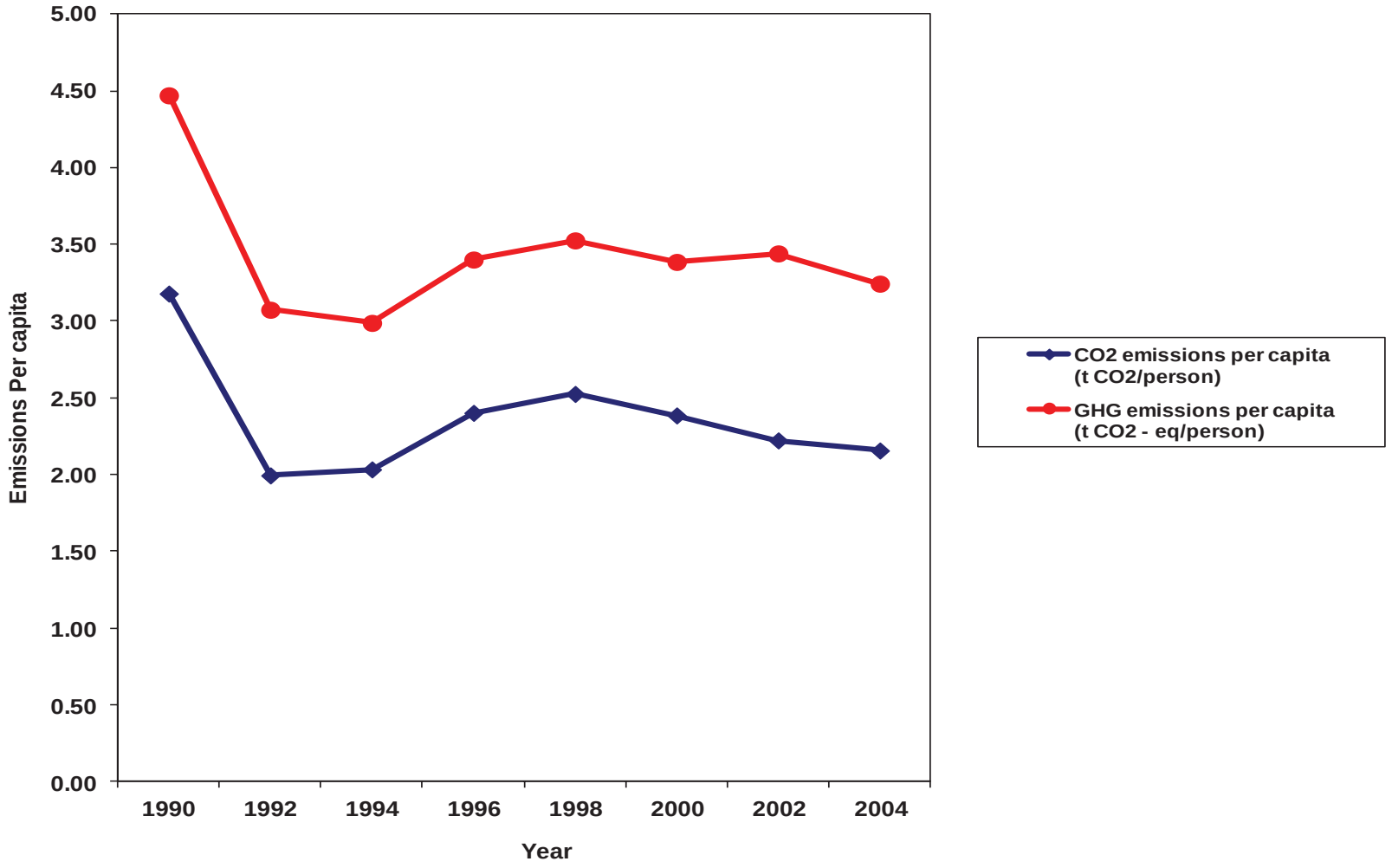
Source: López et al, 2009

Net Emissions by Sectors
(Gg CO_2 eq)



Source: López et al, 2009

Emissions Per Capita



Source: López et al, 2009

Energy sector 2004:

- *95 % of the Gross Emissions of CO_2*
- *99 % of the Emissions of SO_2 and NOx*

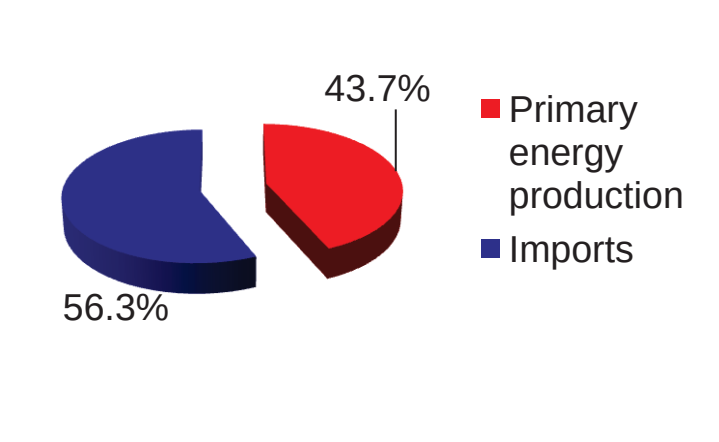
Electricity Generation 2004:

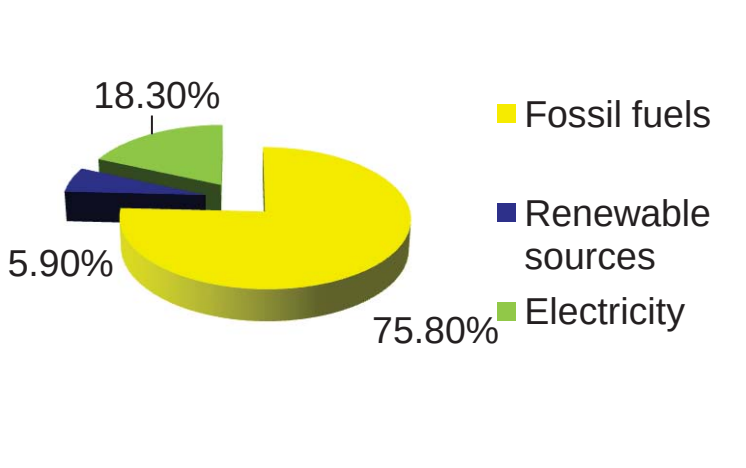
48 % of the Gross Emissions of CO_2 (11.9 Mton CO_2)

Energy

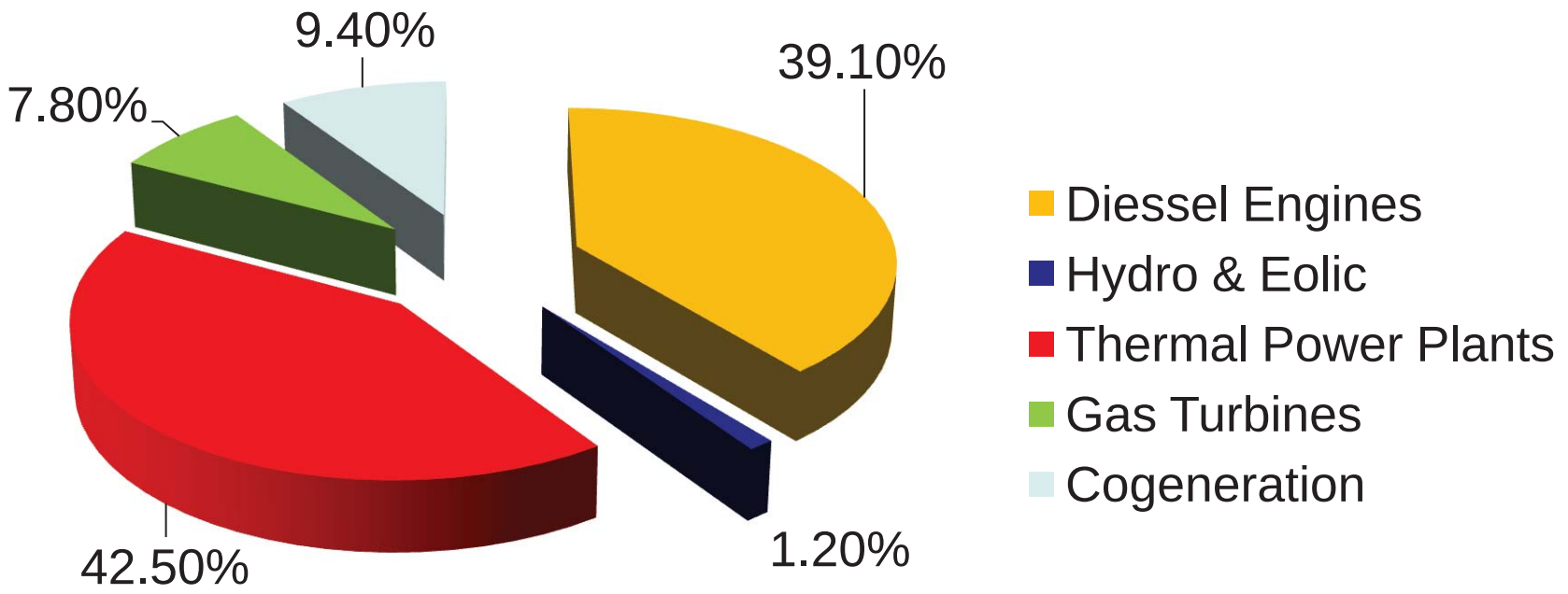
Total primary energy (TPES) supply and final energy use

TPES (Mtoe)	**11.8**
Primary energy production	5.1
Imports	6.6
Final energy use (Mtoe)	**6.5**
Fossil fuels	4.9
Renewable sources	0.4
Electricity	1.2

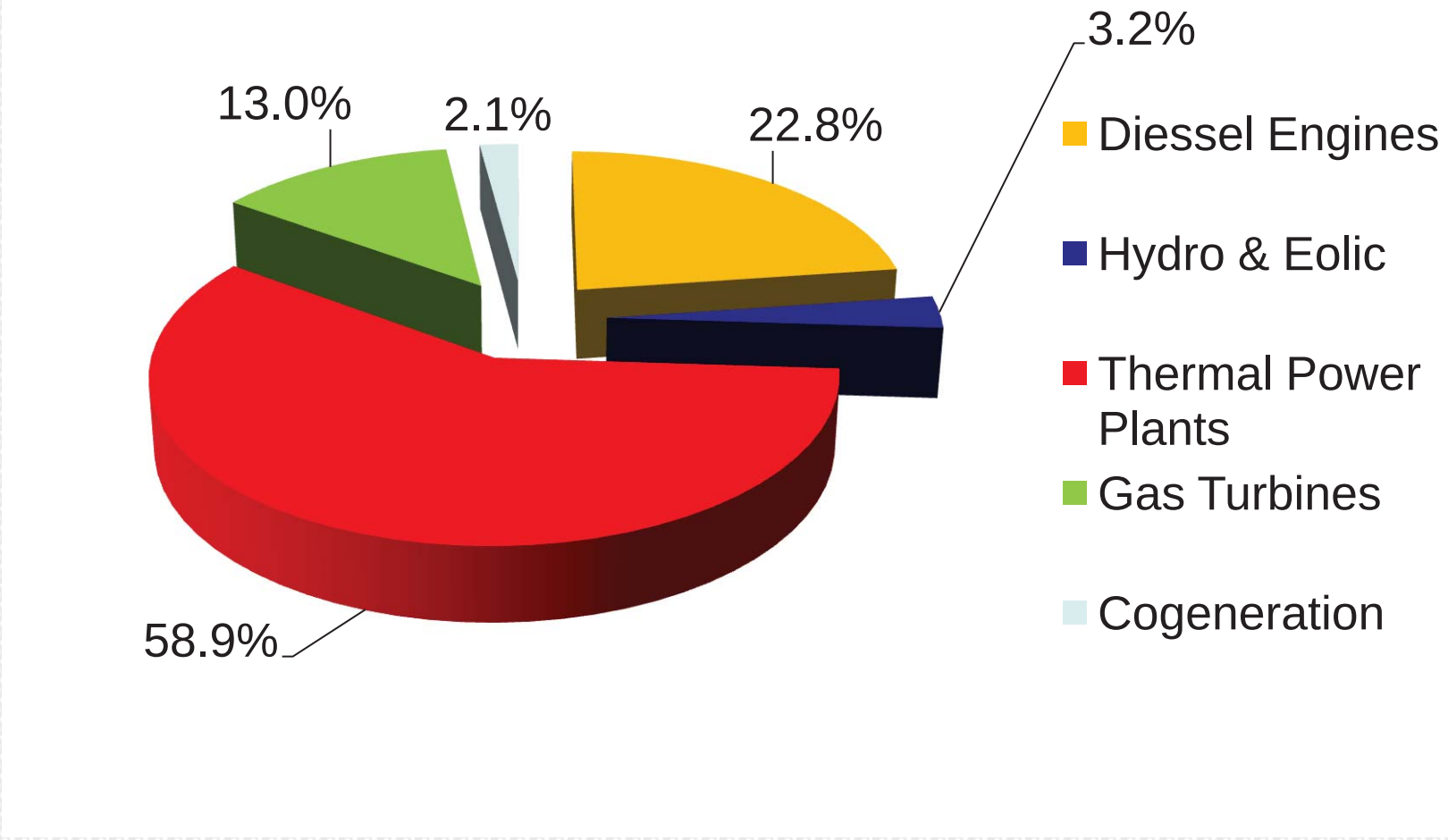




Total electricity installed capacity 2010: 5852.6 MW



Total electricity generation : 17395.5 GWh



Energy Policies and Projections

Major Energy Transformation

Frequent interruptions in oil-fired power plants, together with the impact of hurricanes on high-voltage transmission lines, caused an energy crisis in Cuba in the period 2004-2005. To overcome the situation, the Cuban Government launched an initiative called the ***Energy Revolution***. Its main goals are to **guarantee economic development (reduce the energy vulnerability).**

Major Energy Transformation: aspects of this strategy

- To accelerate the introduction of renewable energy technologies **(16%, 2020?)**.
- Distributed Generation (DG) of electricity.
- Changing over inefficient appliances.
- Since 2005, were installed 3,072 MW of new power in diesel and fuel oil generators synchronized to the National Electric System in all the provinces of the country under a DG scheme. Installation of 701 MW of emergency backup generator sets.

Generation sets impact

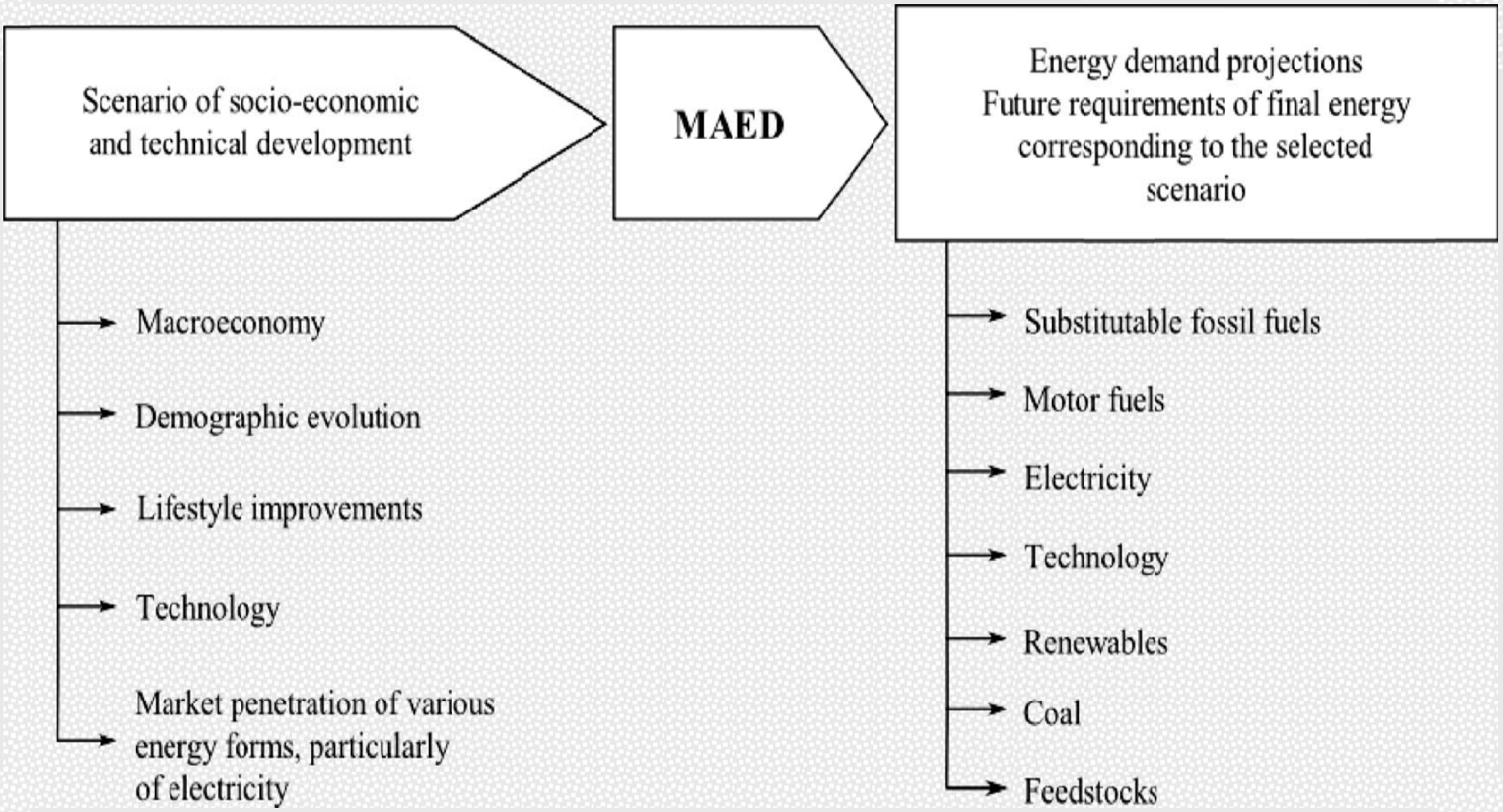
In spite of the positive impacts for Distributed Generation of the Diesel and Fuel Oil generation sets, its operation has bring a negative impact on the population due the emissions of local air pollutant (SO_2 and NOx). Currently its use have limited to the hours of high electricity demand, mainly for those located closer to human settlements.

Future supply scenarios

- In the frame of the IAEA RESEARCH CO-ORDINATE PROGRAM: "Greenhouse Gas Mitigation Strategies and Energy Options", using the IAEA tools, MAED and MESSAGE, a set of demand and supply scenarios were developed (reference and mitigation).
- These scenarios take into account the country's energy policy.

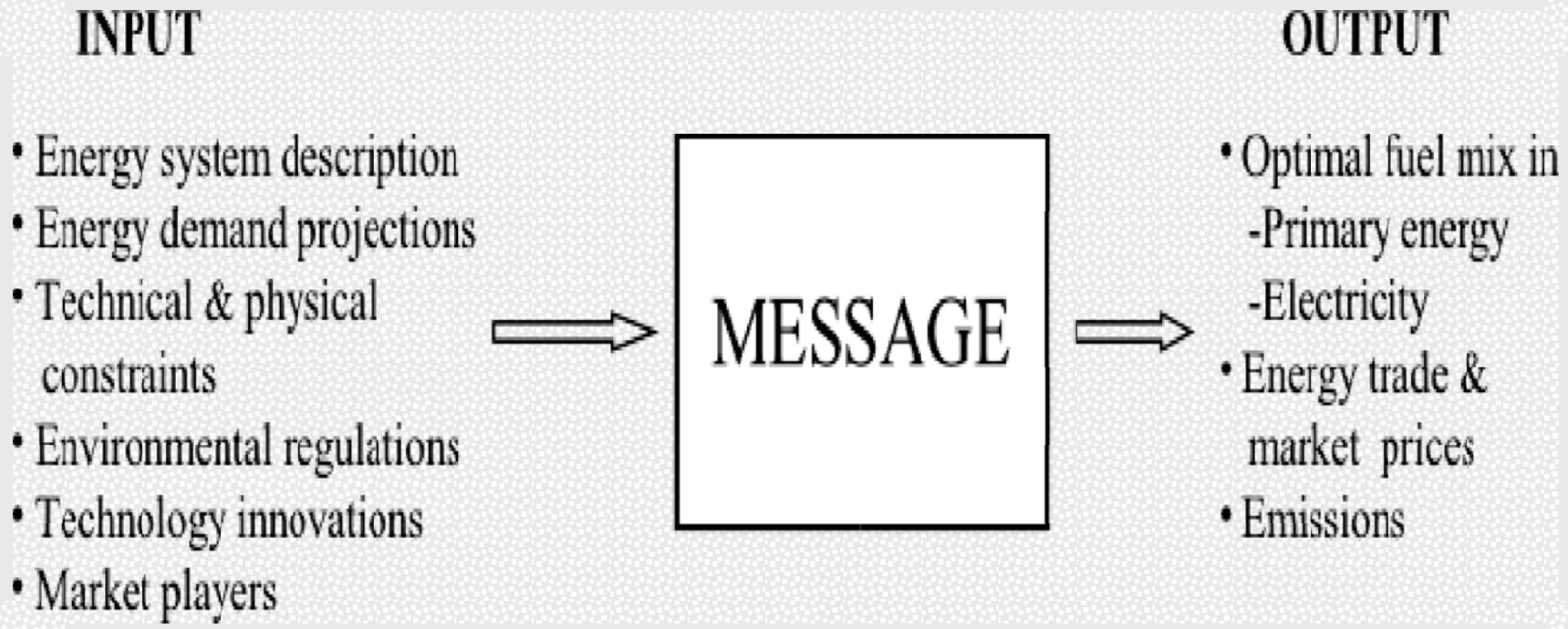
MAED

Model for the Analysis of Energy Demand



MESSAGE

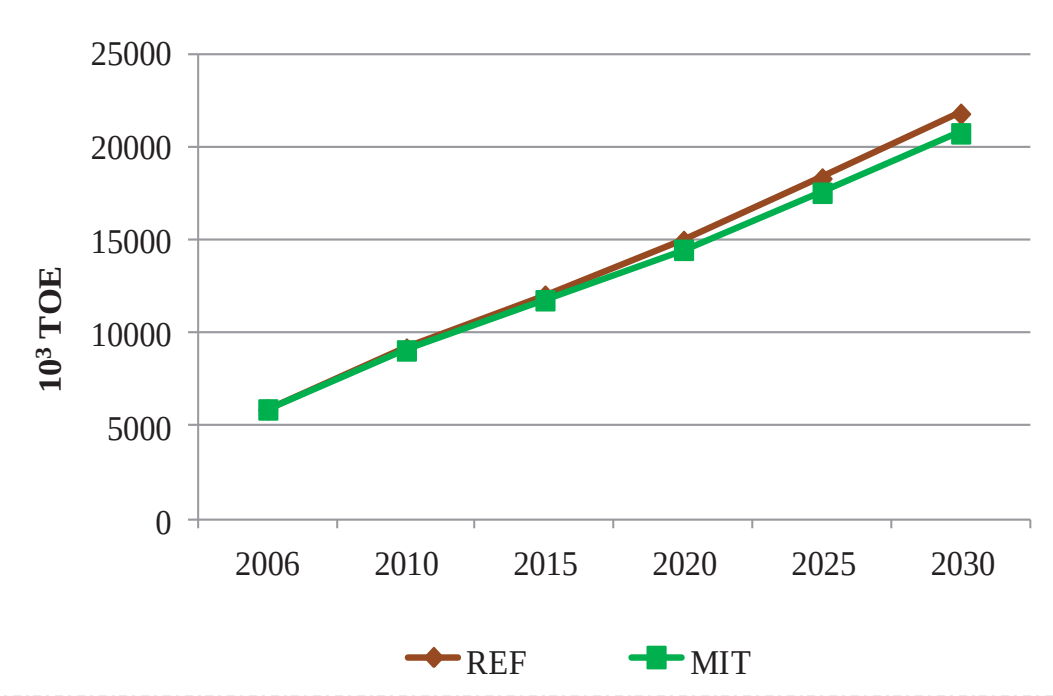
***M**odel for **E**nergy **S**upply **S**ystem **A**lternatives and their **G**eneral **E**nvironmental impacts*



Main approaches for scenarios

- Increase of Energy efficiency.
- Increment in the renewable energies participation.
- Increment in the use of natural gas for electricity generation incorporating more efficient technologies.
- Introduction of Nuclear Energy.

Energy Demand Projection

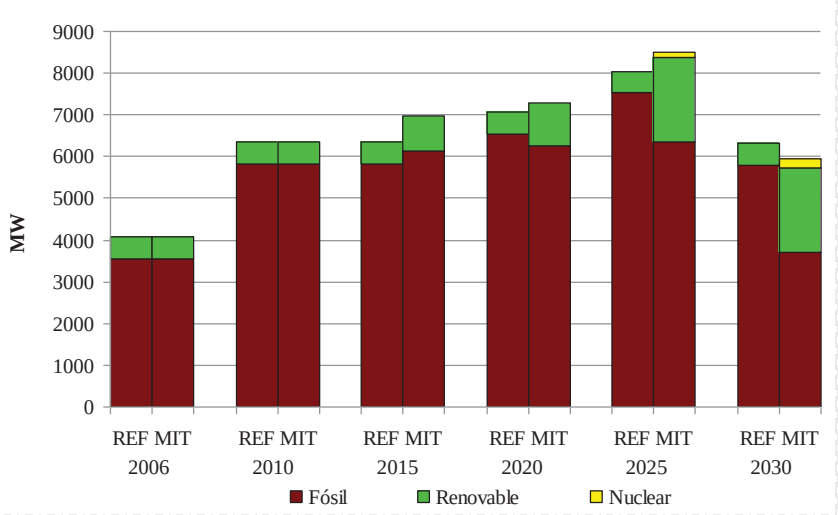


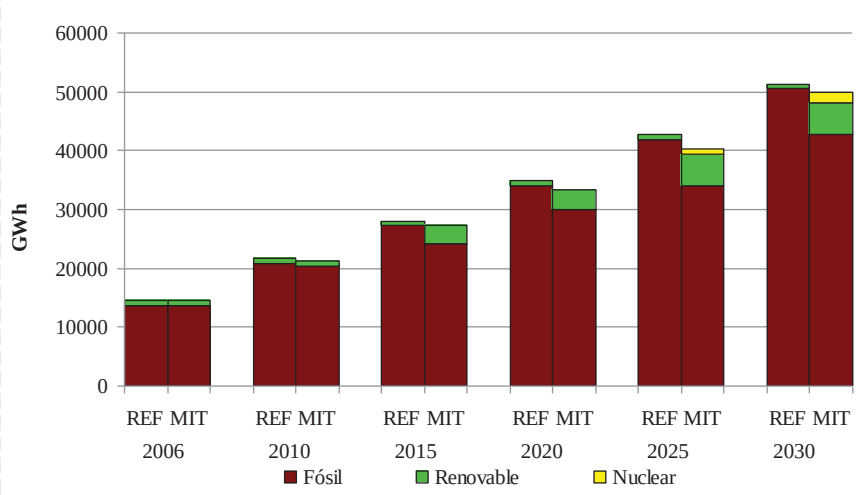
Mitigation Scenario has a lower demand (4%) due:

- use of solar energy for thermal purposes
- substitution of fossil fuels by electricity in cooking
- Lower energy intensity in the industrial sector

2.821 $MtCO_2$ avoided

Installed Capacity and Generation





Electricity Installed Capacity

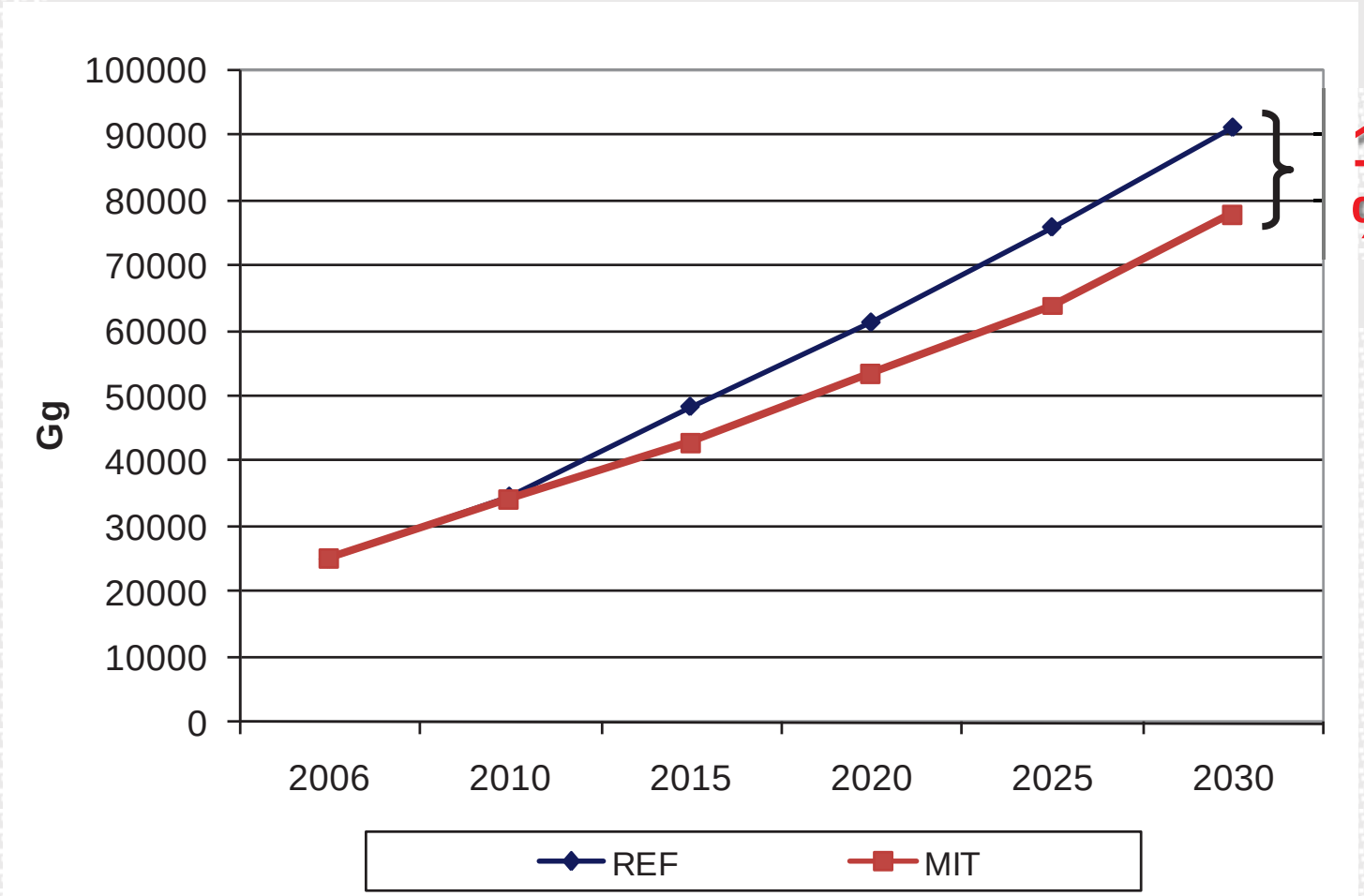
- **Higher participation of the renewal energy sources**
- Increment in the use of wind energy and hydro
- Increment in the use of biomass for electricity production
- **Introduction of the Nuclear Energy**

Electricity Generation

Fossil fuel participation will decrease from 97% in the Reference Scenario to 81% in the Mitigation Scenario

Total GHG Emissions

GHG emissions will increase by 2030, 3.6 times the values of Base Year



Latest energy projection (2010-2040)

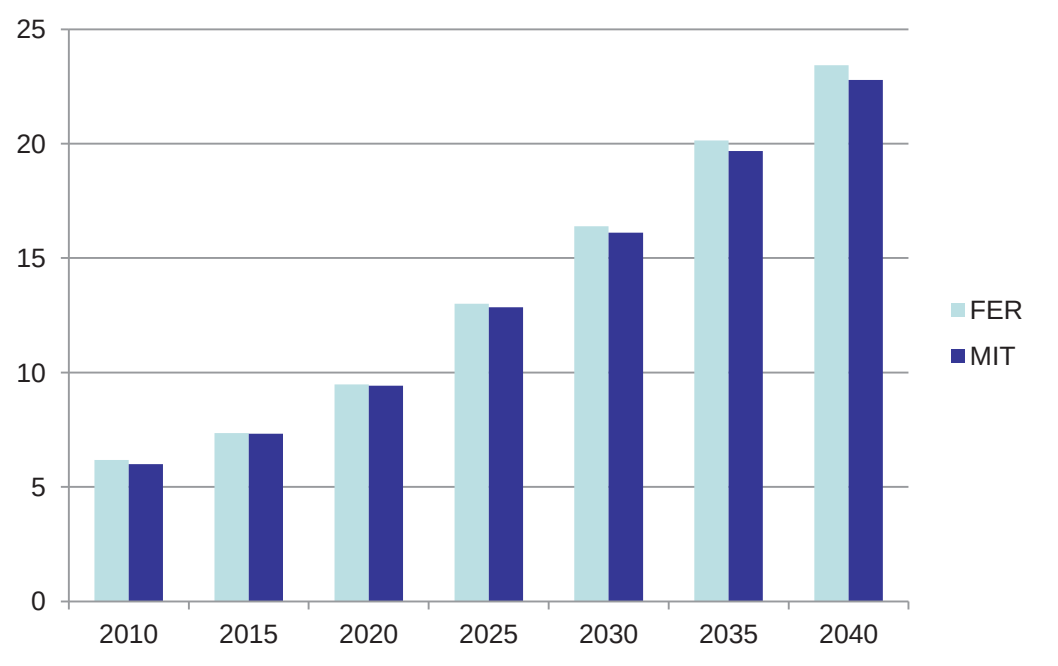
In the frame of the project "CARBONO 2012"

Mitigation options in energy demand

- Penetration solar energy for heating purposes,
- Use of biogas for cooking,
- Reducing energy intensity,
- Replacing diesel by CNG in transport,
- Introduction of electric passenger transport,
- Increase the transportation by rail,
- Increase in the use of biomass (bagasse and forestry),
- Use of ethanol and biodiesel.

Source: Perez. D, et al 2012

Final Energy Demand, Mtoe



- Demand grows at 3.6% annual
- Decrease in the MIT scenario of 1.6 Mtoe, avoiding 15.1 million tones CO_2

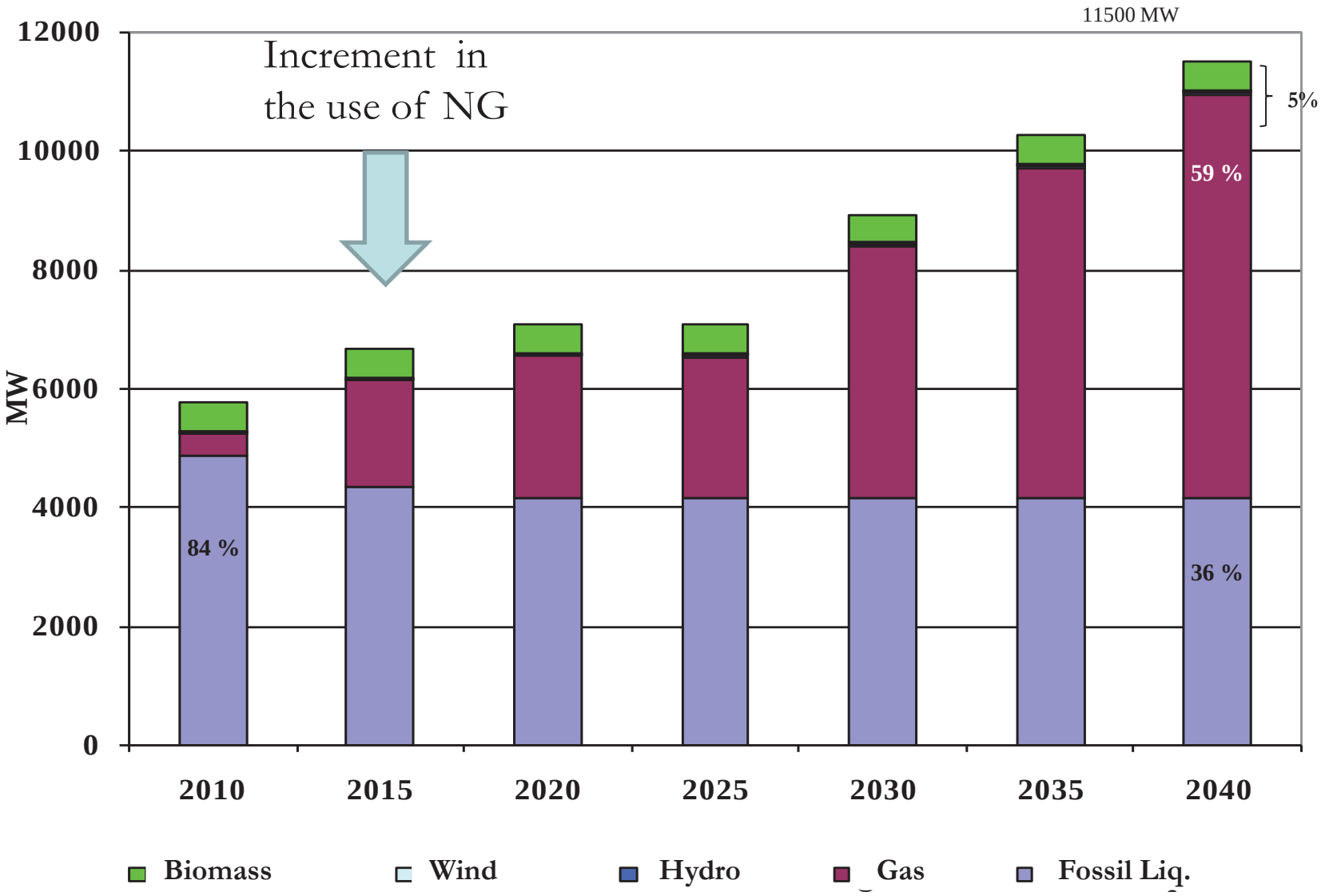
Source: Perez. D, et al 2012

Main mitigation options evaluated

- Using NG in the existing PP (2015),
- Increase of NG in combined cycle,
- Installed Steam Turbine in sugar mill,
- Integrated gasification combined cycle using forest biomass.
- Increased hydropower,
- Increased wind power,
- Solar photovoltaic grid connected,
- Using biogas in gas turbines.

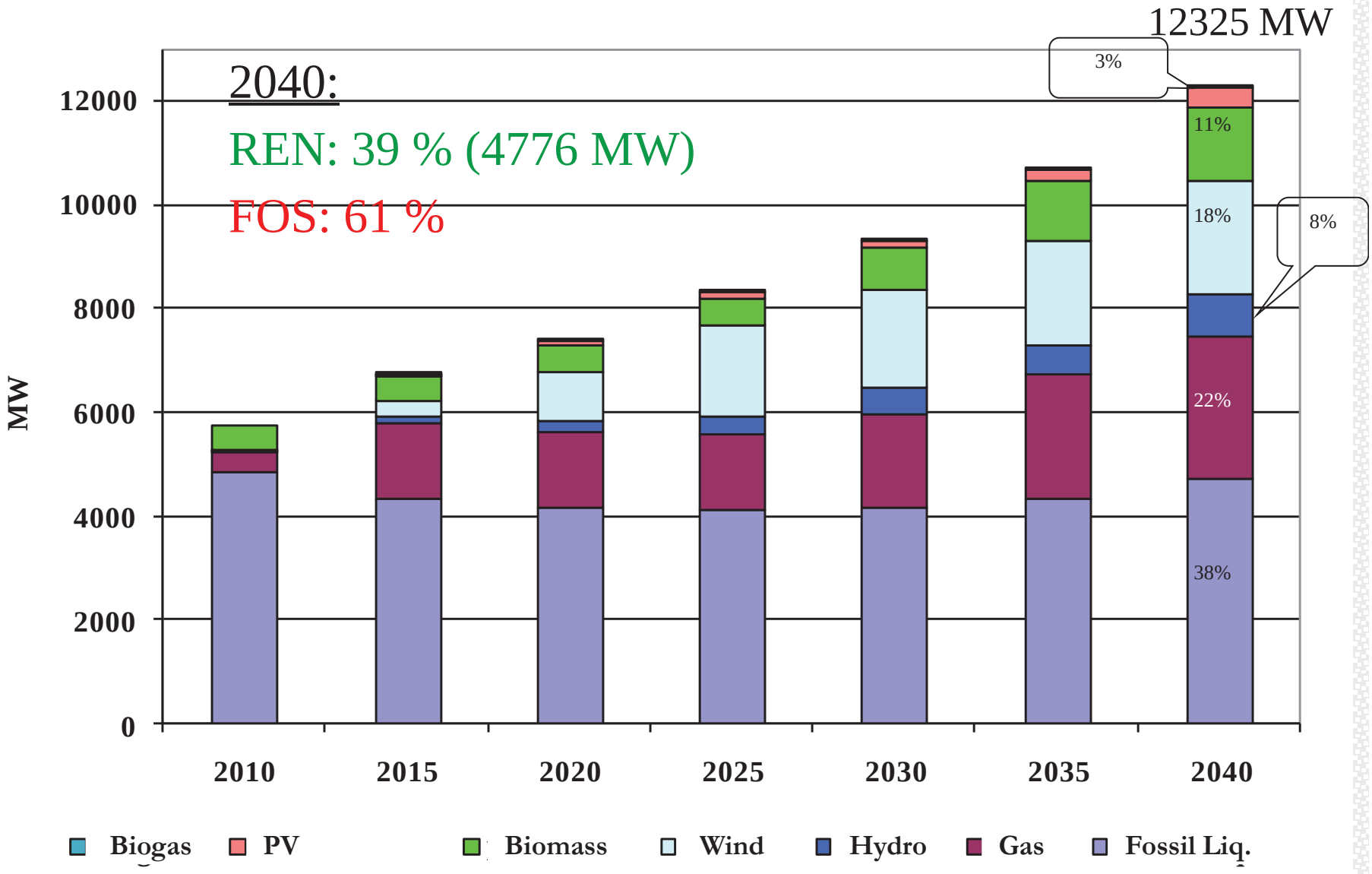
Source: Perez. D, et al 2012

Electricity Installed Capacity REF scenario



Source: Perez. D, et al 2012

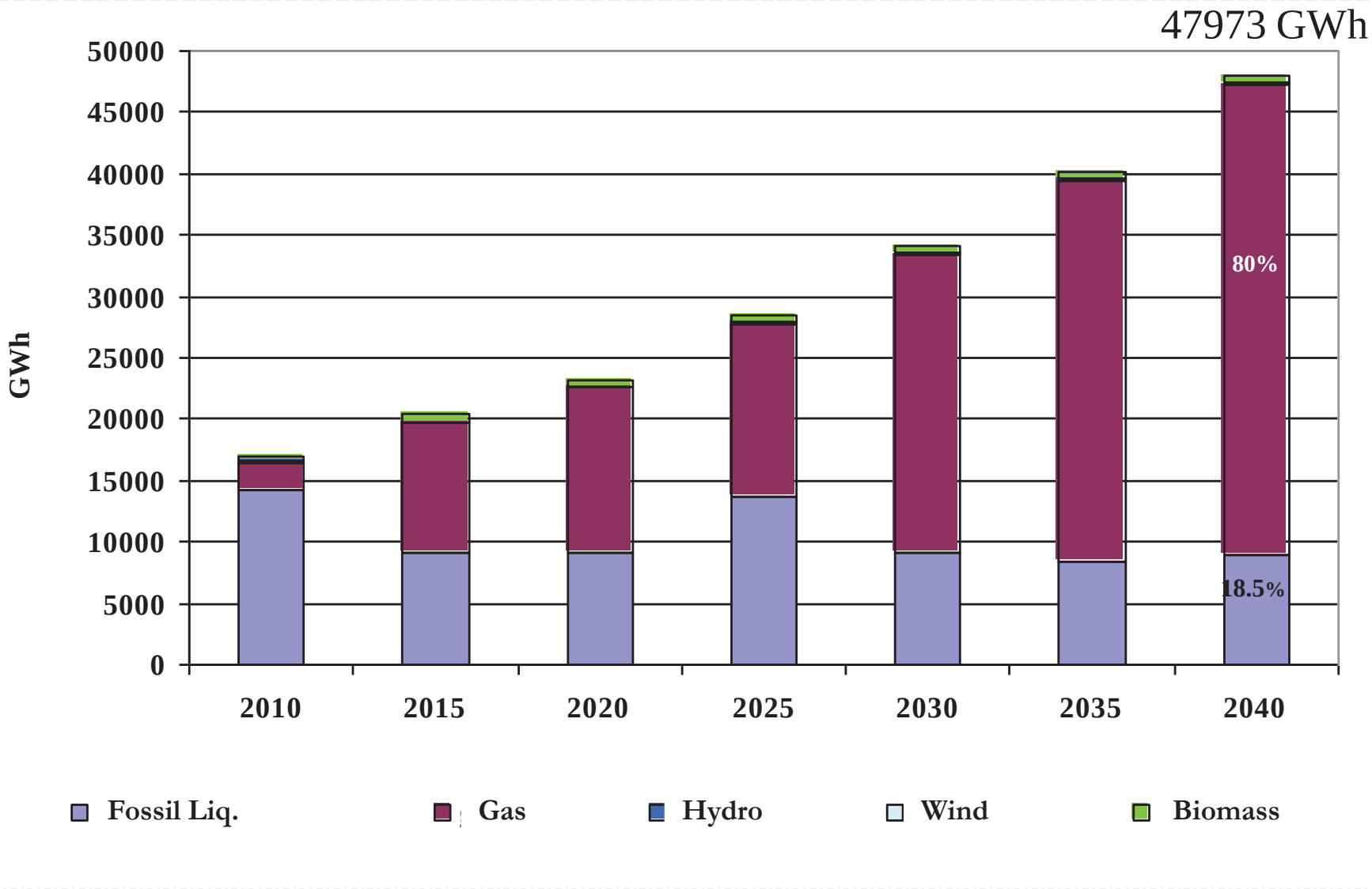
Electricity Installed Capacity MIT scenario



In 2040 3817 MW additional would be needed to meet the total demand

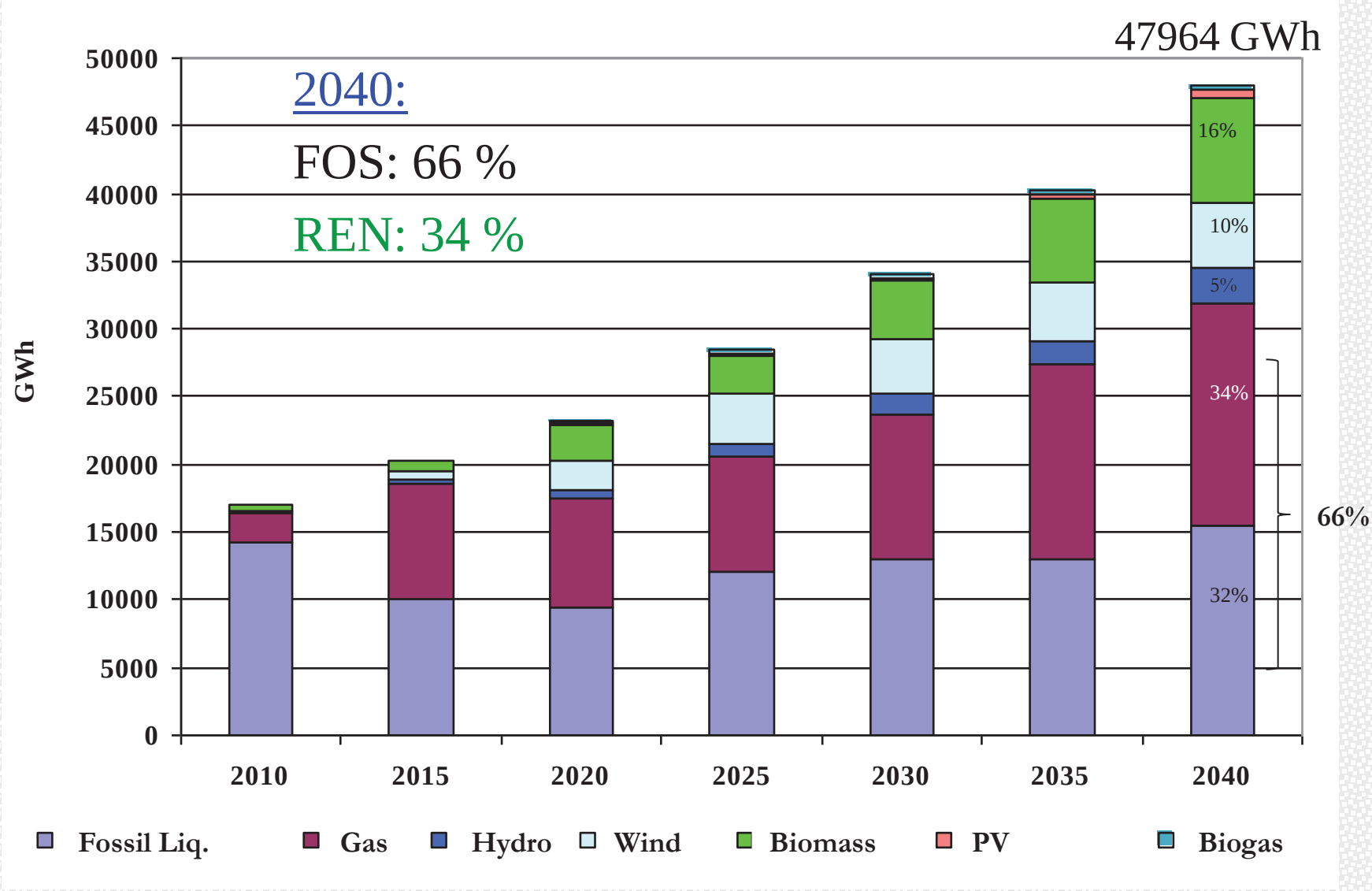
Source: Perez. D, et al 2012

Electricity Generation REF scenario



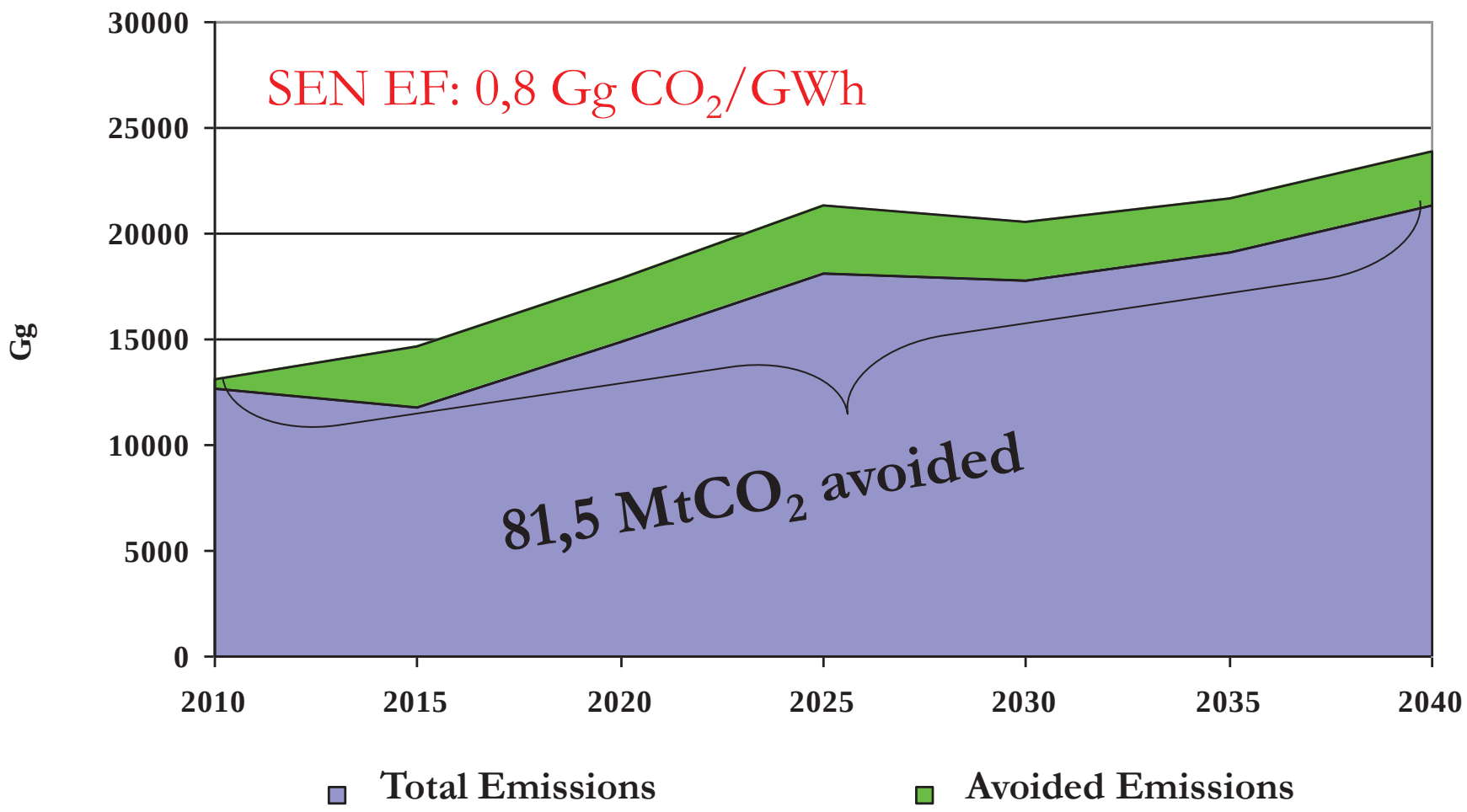
Source: Perez. D, et al 2012

Electricity Generation MIT scenario



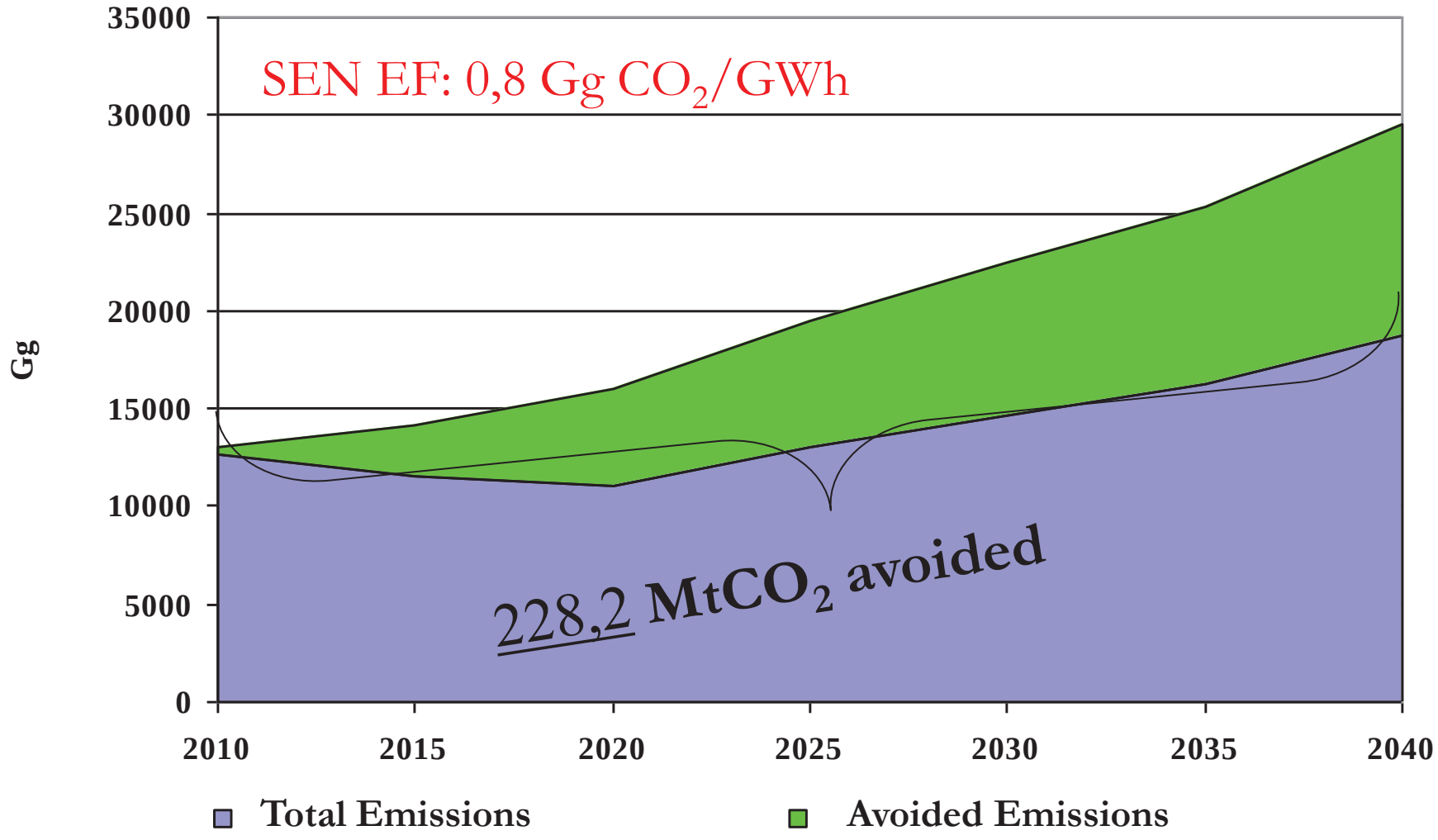
Source: Perez. D, et al 2012

Avoided CO_2 emissions REF scenario



Source: Perez. D, et al 2012

Avoided CO_2 emissions MIT scenario



Source: Perez. D, et al 2012

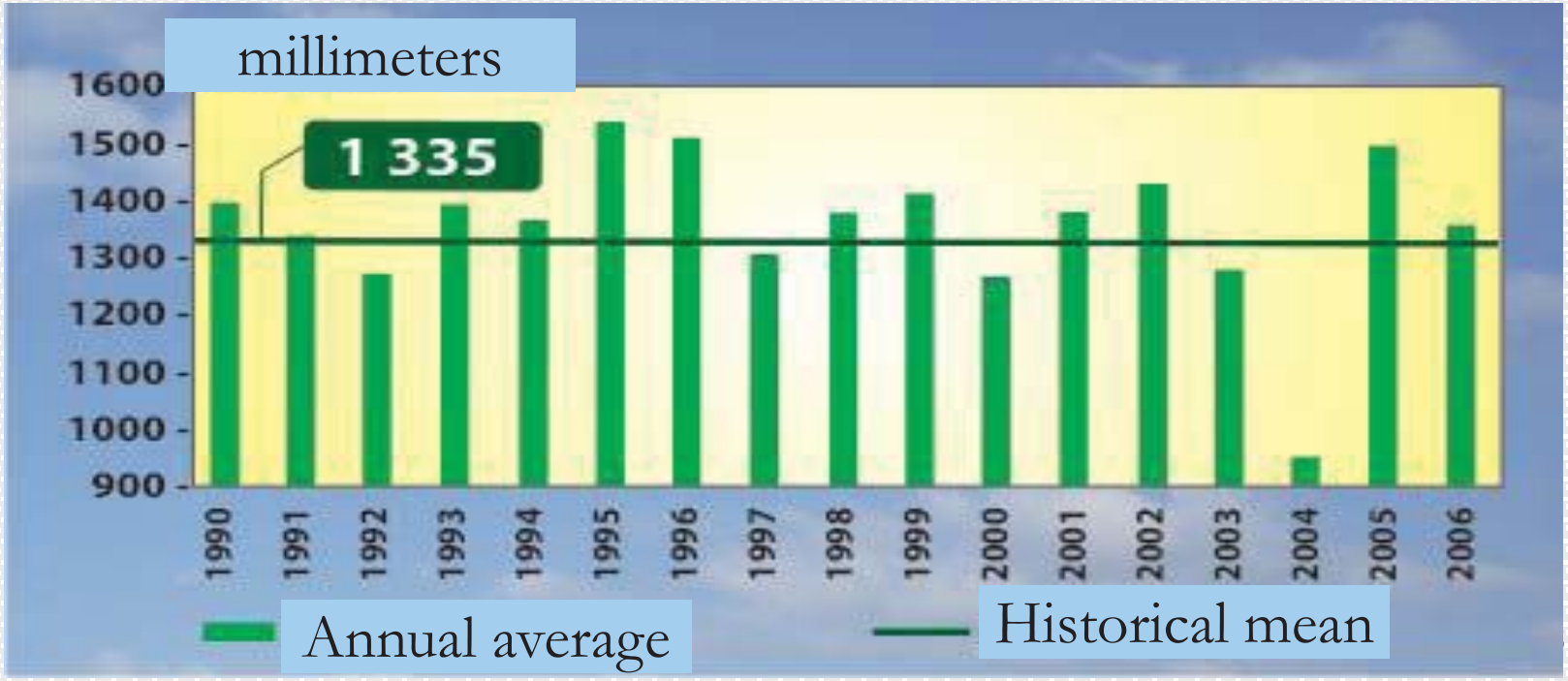
Climate Change Projection

Temperature

- Annual and seasonal ocean surface and island air temperatures have increased by 0.6 to 1.0°C since 1910.
- The percentage of days having very warm maximum temperatures has increased considerably since the 1950s, while the percentage of days with cold temperatures has decreased.

Precipitation

In the Caribbean, the maximum number of consecutive dry days is decreasing and the number of heavy rainfall events is increasing.



Sea level

- On average, a mean relative sea-level rise of 1mm/yr during the 20th century.
- Preliminary analysis foresee the lost of the 6% of the coastal area by 2050 in Cuba.

Tropical cyclones

- Tropical cyclones: risk by strong winds, severe rains and coastal storm surges.
- It is expected with the increment in the sea surface temperatures, favorable conditions for the formation of vigorous tropical hurricanes.

Climate Variations in the Caribbean Region

Climatic variables	Climatic scenario
Temperature	Increment from 0,8 ^{0}C to 2,5 ^{0}C in 2050 and from 0,9 ^{0}C to 4 ^{0}C in 2080
Precipitation	Variation Range from -36.3% to 34.2% in 2050 and from -49,3% to 28,9% in 2080
Sea level rise	Increment of 35 cm during the century
Extreme events	Increment of the frequency from 5% to 10% during the century

- Persistent increment of events climatic extreme as tropical hurricanes.
- Increment of the rains in 10%
- Increment in the number of serial dry days

Source: IPCC, 2007 and CEPAL 2010

Climate Change and Extreme events:

Vulnerability of Energy systems in Cuba

Extreme events affect the entire economical sector, include of energy sector. Depending on the kind event an energy source can be more affected than another.

- Damages in the energy facilities due tropical hurricanes.
- Reduction of hydropower generation potentials and biomass production due the droughts,
- Reduction of the power production efficiency due the temperature increment,
- Damages on the oil production facilities by the increment of the sea level, etc.

MIT scenario	Biogas	PV	Hydro	Biomass	Wind	Gas	Liquid fossil
Installed Capacity (MW)	45	410	843	1378	2100	2748	4721

Hurricanes trajectory in the 2008 season

Hurricanes damages to the transmission and distribution electricity net

Integrated assessment

Integrated assessment is an interdisciplinary process that combines, interprets, and communicates knowledge from diverse scientific disciplines in an effort to investigate and understand causal relationships within and between complicated systems. There is a current development on methods and tools to improve the assessments. However, the current energy models are lack of comprehensive analysis. Efforts are underway in Cuba for the use of IAMs 1) to assess the economic impact of climate change and, 2) to improve energy supply projections based on the climate change adaptation from a CLEW approach.

CLEW (climate, land, energy and water) interaction approach

Premises

- *"Most water, energy and land-use planning, decision and policy making occurs in separate and disconnected institutional entities. Likewise, the analytical tools used to support decision-making are equally fragmented, though undertaken routinely" (Rogner H-H, CSD 17, 2009).*
- *What is needed is an integrated analysis tool that includes Climate, Land, and Energy and Water (CLEW) aspects in a manner that is accessible and useful to analysts and planners in developing countries.*

Project Objective

Review, test and apply prototype methodologies to analyze Climate-Land-Energy-Water (CLEW) interrelations in Cuba

Conclusions and Remarks

- ✓ Energy sector will continue dominate by fossil fuels
- ✓ The consideration of mitigation options on the demand side, will allow a reduction in the final energy use of 1.6 million toe, equivalent to avoid 15.1 million tones CO_2.
- ✓ On the supply side renewable energy in 2040 cover the 39% of the installed capacity and 33% of electricity generation in MIT scenario, avoiding 228,2 Mt CO_2.

Conclusions and Remarks

- ✓ Cuba for its island status should focus their efforts on climate change adaptation. It is expected some climate variation in the Caribbean area that will affect the entire economical sector.
- ✓ For adaptation to climate change is important to know the behavior of the climate impacts in the energy sector to foresee futures changes. A correct policy will consider an energy mix that allows the minimum of affectations to the energy supply.
- ✓ IAMs are needed to improve the energy planning analysis take into account the effects of climate change and its interactions with other resources that usually are evaluated in isolated way.

Thank you