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PACT OF ISLANDS

# ISLAND SUSTAINABLE ENERGY ACTION PLAN

## *ISLAND OF CRETE*

**November 2011**

# *Executive summary*

## Objectives – Targets – Fields of action

The **Region of Crete** and its **Regional Energy Agency (REAC)** by participating in the ''**Pact of Islands''** sets the ambitious long-term vision of transforming Crete into a energy sustainable ecosystem. Managing the energy cycle, from production to consumption, through a sustainable approach, can be a major contribution into reaching this goal. The ''**Island Sustainable Energy Action Plan''** (**ISEAP)** is considered a fundamental instrument to materialize this vision into the following years.

On the energy production side the exploitation of the abundant, locally available, renewable energy sources (RES), respecting the ecosystem's potentials, will serve as the main target of the ISEAP. Therefore the implementation of wind parks and photovoltaic parks will be the main actions regarding the electricity production from RES.

The **electrical interconnection** with mainland Greece is also expected within the following years which can provide even greater possibilities of turning Crete into a 100% RES island.

As a mid-term approach for reducing CO2 emissions and maximizing RES production, **natural gas** will gradually replace fuel oil in the conventional power stations. Moreover high efficiency electricity solar thermal, biomass and hybrid stations, with controllable operation, will substitute base load coming from the conventional power stations.

On the **demand side** a wide range of **Demand Side Management (DSM**) actions will be promoted and implemented by the Region of Crete-Regional Energy Agency of Crete in order to increase rational energy use, energy efficiency and energy savings. The maximum possible involvement of the stakeholders, the energy users and the citizens will be aimed in order to reassure their effectiveness.

In the framework of ''**Pact of Islands''** the Region of Crete committed into going further than national targets for $CO_2$ emissions reduction and RES penetration and become a ''good-to-best practice'' example for the rest of the country and for the other Mediterranean islands. Crete is lucky to have a wide range of RES high potential, making the island an ideal area to promote sustainable development based on RES combined also with substantial actions in increasing energy efficiency and energy saving.

The Region of Crete by submitting the following ''**Island Sustainable Energy Action Plan** (ISEAP)'' sets clear targets towards energy sustainability.

Specifically, the main two targets set are:

1. **25% reduction of $CO_2$ emissions in comparison to 2005**
2. **36% participation of RES into electricity production**

## Coordination structure

The coordination of the ISEAP will be taken over by the **Region of Crete-Regional Energy Agency of Crete** and the Regional Council will serve as the main decision making body. The Regional Energy Agency of Crete will function as the permanent technical consultant of the Region and of the Local Authorities and of the other public and private related structures and organizations. Work groups within the Region's mechanisms will be formulated to ensure the successful **implementation** and **monitoring** of the ISEAP, whereas a wide range of external collaborations will support the progress of several tasks.

## Budget – Financing

The cost for the ISEAP implementation and monitoring is expected to rise up to 850.000€.

Several financing mechanisms are available in assisting the materialization of the ISEAP. Indicatively the following are mentioned:

1) Regional/Municipal budgets

2) National Funds and programs

3) European Investment Bank funds

4) European programs and initiatives

5) Bank Loans

3) NSRF (National Strategic Reference Framework)

4) Private investments

# *Contents*

# *Figures*

# *Tables*

# 1 CONTEXT

## 1.1 Geography and territory

Crete is the biggest island of Greece and the 5th biggest island of the Mediterranean Sea. It lies at the southern part of the Aegean Sea.

The island has an elongated shape, it spans 260km from east to west, is 60km at its widest point, and narrows to as little as 12km (close to Ierapetra). Crete covers an area of 8,336km$^2$, with a coastline of 1,046km; to the north, it broaches the Sea of Crete; to the south, the Libyan Sea; in the west, the Myrtoan Sea, and towards the east the Karpathion Sea. The closest distance to the Greek mainland is 95km between Cape Maleas (mainland) and Cape Spathi (Crete).

The distance from Athens to Chania (the closest big city of Crete) is approxiamtely 175km. The Aegean islands surrounding Crete are on the northwest Antikythira and Kythira, on the north the Cycladic complex with Santorini and Anafi the closest islands, on the east and northeast Kasos, Karpathos and Rhodes from the Dodecanese complex and finally on the south the small island of Gavdos.

There is a frequent connection between the main ports of Crete (Heraklio, Chania, Rethymno and Agios Nikolaos) and Pireus (the port of Athens) and many islands of the Southern Aegean Sea. There are two international airports operating in the island in Heraklion (Nikos Kazantzakis) and in Chania (Ioannis Daskalogiannis) while a smaller one located in Sitia (East Crete) will soon be operational. The island is connected with most of the airports in Greece, Cyprus and many other European countries, with regular or frequent charter flights.

Crete has an intensive mountainous character with three mountain groups ranging from west to east Lefka Ori (White mountains - 2453m), Idi Range (Psiloritis – 2456m), Dikti Mountains (Lassithiotika Ori – 2148,), also other lower altitude mountains are spread around the island. The mountainous areas cover the 41% of the island whereas the semi-mountainous and flat areas the 26% and 33% resperctively.

One of the principal features of the Cretan landscape is the many ravines which cut through the island from north to south. Most of them start in the mountainous zone and end near the sea. Their role in preserving the rare flora and fauna of the island is enormous, because they are the only regions that remain far - removed from all human activity. The best known, both for its size and its beauty, is the Gorge of Samaria.

Another characteristic of the land in Crete is the numerous plateaux which are generally located in the middle zone of the mountains and which act as rain water collectors in the winter. Several of these plateaux are fertile and densely populated. Others are used only for grazing. Unquestionably, the most beautiful and impressive of these is the Lassithi plateau, which is surrounded by the peaks of Dikti and lies at a height of approximately 900 m.

There are no large plains in Crete but between the mountain complexes are several small, fertile tracts, and there are some others at certain coastal locations on the north side of the island, mainly at the back of bays. The biggest plain is Messara at the South west of Heraklion Prefecture.

There are no important rivers in Crete. Most of them would be better characterized as dry stream beds because in the summer they have little or no water.

The land use in Crete according to the Corine 2000 project is mainly divided between agricultural (71.5%) and forest and semi-natural areas (27.1%). The water and artificial surfaces cover just a minor part of Crete's land (0.034% and 1.35% respectively).

## 1.2 Demography

Crete is the most populous island of Greece. On the census of 2001 the population of the island was 601159 inhabitants. The territorial distribution of the population was:

- Urban: 42.5%
- Suburban: 12.5%
- Rural: 45%

Also the region of Crete has shown one of the highest (after region of South Aegean) population growth rates in Greece.

| Year | Population | Growth rate |
|---|---|---|
| 1971 | 455035 | - |
| 1981 | 483608 | 6% |
| 1991 | 536805 | 11% |
| 2001 | 601159 | 12% |
| 2011 (est.) | 655232 | 9% |
| 2020 (est.) | 720755 | 10% |

**Table 1.1.Population evolution (source: EL.STAT)**

The population division among the prefectures of Crete is shown in the following table:

| Prefecture | 2001 | | 2011 (est.) |
|---|---|---|---|
| Heraklion | 294312 | 48.95% | 320735 |
| Lassithi | 75903 | 12.63% | 82756 |
| Rethymnon | 81781 | 13.60% | 89112 |
| Chania | 149163 | 24.82% | 162629 |

**Table 1.2. Population per prefecture (source: EL.STAT)**

According to the 2001 census the six (6) most populous cities of Crete are:

1. Heraklion: 130914 (Heraklion prefecture)
2. Chania: 53373 (Chania prefecture)
3. Rethymno: 27868 (Rethymnon prefecture)
4. Ierapetra: 23707 (Lassithi prefecture)
5. AgiosNikolaos: 19462 (Lassithi prefecture)
6. Sitia: 14338 (Lassithi prefecture)

All these cities except of Ierapetra (southeast) are spread along the north coastline of the island with Chania being the western one, followed by Rethymno, Heraklio, AgiosNikolaos and Sitia at the eastern edge (seeFigure 1.1). The cities are linked with an extensive road network along the coastline. Several junctions lead to the central and southern part of the island.


**Figure 1.1. The island of Crete – The main cities and prefectures**

## 1.3 Economy

The economy of Crete which was mainly based on farming in the past started changing visibly during the 70's. While there is still an emphasis on farming and stock breeding, due to the climate and the terrain type of the island, there is a drop in manufacturing and a big increase on the services industry (mainly tourism related).

All three sectors of the Cretan economy: agriculture (primary), processing-packaging (secondary), services (tertiary)), are directly connected and interdepended. Crete has an average per capita income which is close to 100% of the Greek average.

The work force in Crete during the past decade was mainly occupied in the tertiary sector (tourist services) followed by the primary sector (agriculture) and the secondary sector (close related to the primary sector activities). A gradual shift from the primary to the tertiary sector is observed since the tourist sector experienced a rapid development.

Although the unemployment the past years has been always rather lower than the national average (apx. 5-7% with national values 8-10%) the last two years Crete's economy is affected by the international and national crisis and the unemployment has reached rather high values (~12% in 2010) close to the national average. This is also depicted by the decrease of the GDP the last two years.

In the following tables detailed information for Crete's economy and employment are provided.

| **Year** | **2002** | **2003** | **2004** | **2005** | **2006** | **2007** | **2008** | **2009** | **2010** |
|---|---|---|---|---|---|---|---|---|---|
| GDP p.c. [M€] | 14.309 | 15.295 | 16.200 | 17.494 | 18.964 | 20.247 | 21.157 | 20.896 | 20.425 |
| Crete/Nat. [%] | 100.39 | 97.78 | 96.72 | 99.71 | 100.06 | 99.80 | 100.35 | 100.32 | 100.32 |
| $GDP_{Crete}$ share [%] | 5.46 | 5.32 | 5.25 | 5.41 | 5.42 | 5.40 | 5.43 | 5.43 | 5.43 |
| Crete/EU [%] | 69.80 | 73.53 | 74.65 | 77.75 | 80.02 | 80.99 | 84.29 | 88.92 | 83.37 |

**Table 1.3. GDP evolution (source: El.STAT, eurostat)**

| **Contribution of each activity sector to gross value added [%]** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Year** / Activity Sector | | **2002** | **2003** | **2004** | **2005** | **2006** | **2007** | **2008** | **2009** |
| Primary | Agriculture, Forestry, fishing | **10.66** | **8.94** | **9.97** | **8.26** | **7.05** | **6.32** | **5.51** | **5.53** |
| Secondary | Industry including energy | 7.13 | 6.64 | 6.65 | 6.97 | 7.01 | 7.04 | 7.48 | 7.09 |
| | Constructions | 6.09 | 6.34 | 7.03 | 6.56 | 7.04 | 6.83 | 6.36 | 6.18 |
| | **Subtotal** | **13.22** | **12.98** | **13.69** | **13.53** | **14.05** | **13.87** | **13.84** | **13.27** |
| Tertiary | Wholesale and retail trade … | 38.30 | 39.59 | 37.34 | 40.29 | 40.10 | 40.42 | 40.34 | 40.45 |
| | Financial intermediation, real estate, renting and business activities | 15.06 | 15.98 | 16.23 | 15.19 | 15.51 | 15.87 | 15.81 | 15.90 |
| | Other service activities | 22.76 | 22.51 | 22.77 | 22.73 | 23.29 | 23.53 | 24.51 | 24.85 |
| | **Subtotal** | **76.12** | **78.08** | **76.34** | **78.21** | **78.90** | **79.81** | **80.66** | **81.20** |

**Table 1.4. Gross Added Value evolution per activity sector (source: EL.STAT)**

| Share of Employees in each activity sector [%] | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Year** / Activity Sector | | **2000** | **2001** | **2002** | **2003** | **2004** | **2005** | **2006** | **2007** | **2008** |
| Primary | Agriculture, Forestry, fishing | **28.68** | **29.24** | **28.76** | **26.47** | **22.26** | **21.29** | **21.17** | **17.78** | **17.73** |
| Secondary | Industry including energy | 6.33 | 6.52 | 6.57 | 7.14 | 7.25 | 7.09 | 7.09 | 7.37 | 7.35 |
| | Constructions | 6.67 | 7.43 | 7.79 | 7.57 | 7.33 | 8.29 | 8.62 | 8.98 | 8.87 |
| | **Subtotal** | **13.00** | **13.95** | **14.36** | **14.71** | **14.58** | **15.37** | **15.71** | **16.35** | **16.22** |
| Tertiary | Wholesale and retail trade … | 35.12 | 33.53 | 33.11 | 33.43 | 33.96 | 34.76 | 34.81 | 35.88 | 36.05 |
| | Financial intermediation, real estate, renting and business activities | 4.68 | 4.95 | 4.50 | 5.07 | 6.29 | 5.60 | 5.86 | 7.62 | 7.74 |
| | Other service activities | 18.53 | 18.32 | 19.28 | 20.31 | 22.90 | 22.97 | 22.45 | 22.38 | 22.27 |
| | **Subtotal** | **58.32** | **56.80** | **56.89** | **58.82** | **63.16** | **63.33** | **63.12** | **65.87** | **66.05** |

**Table 1.5. Employment evolution per activity sector (source: EL.STAT)**

| **Year** | **2004** | **2005** | **2006** | **2007** | **2008** | **2009** | **2010** |
|---|---|---|---|---|---|---|---|
| Unemployment [%] | 7.70 | 7.06 | 7.03 | 5.25 | 6.30 | 8.79 | 11.60 |

**Table 1.6. Unemployment evolution (source: EL.STAT)**

## 1.4 Political and administrative structures

Crete is one of the 13 regions of Greece. The Regional Authority (**Region of Crete**) and the Decentralized Administration of Crete are based in Heraklion. The island is divided into four (4) prefectures (Chania, Rethymnon, Heraklion and Lassithi). A late administrative reformation resulted to a decrease of the number of municipalities from 71 to 24. Several small municipalities and communities were unified with neighboring greater ones (Kallicratis reform).

With the current administrative structure the municipalities for each prefecture are as follows:

1. Prefecture of Chania
    a. Municipality of Chania
    b. Municipality of Apokoronas
    c. Municipality of Platania
    d. Municipality of Kissamos
    e. Municipality of Kantanos – Selino
    f. Municipality of Gaudos
    g. Municipality of Sfakia

2. Prefecture of Rethymnon
    a. Municipality of Rethymno
    b. Municipality of Mylopotamos
    Municipality of Amari
    c. Municipality of AgiosVasileios
    d. Municipality of Anogeia

3. Prefecture of Heraklion
    a. Municipality of Heraklio
    b. Municipality of Malevizi
    c. Municipality of Archanes – Asterousia
    d. Municipality of Viannos
    e. Municipality of Gortyna
    f. Municipality of Minoa Pediada
    g. Municipality of Faistos
    h. Municipality of Hersonissos

4. Prefecture of Lassithi
    a. Municipality of Agios Nikolaos
    b. Municipality of Ierapetra
    c. Municipality of Oropedio Lassithiou
    d. Municipality of Sitia

The **Regional Energy Agency of Crete (REAC)** serves as the Region's main energy consulting body. The organizational structure of REAC and the network of public bodies related to the regional energy field are presented in the following diagram.

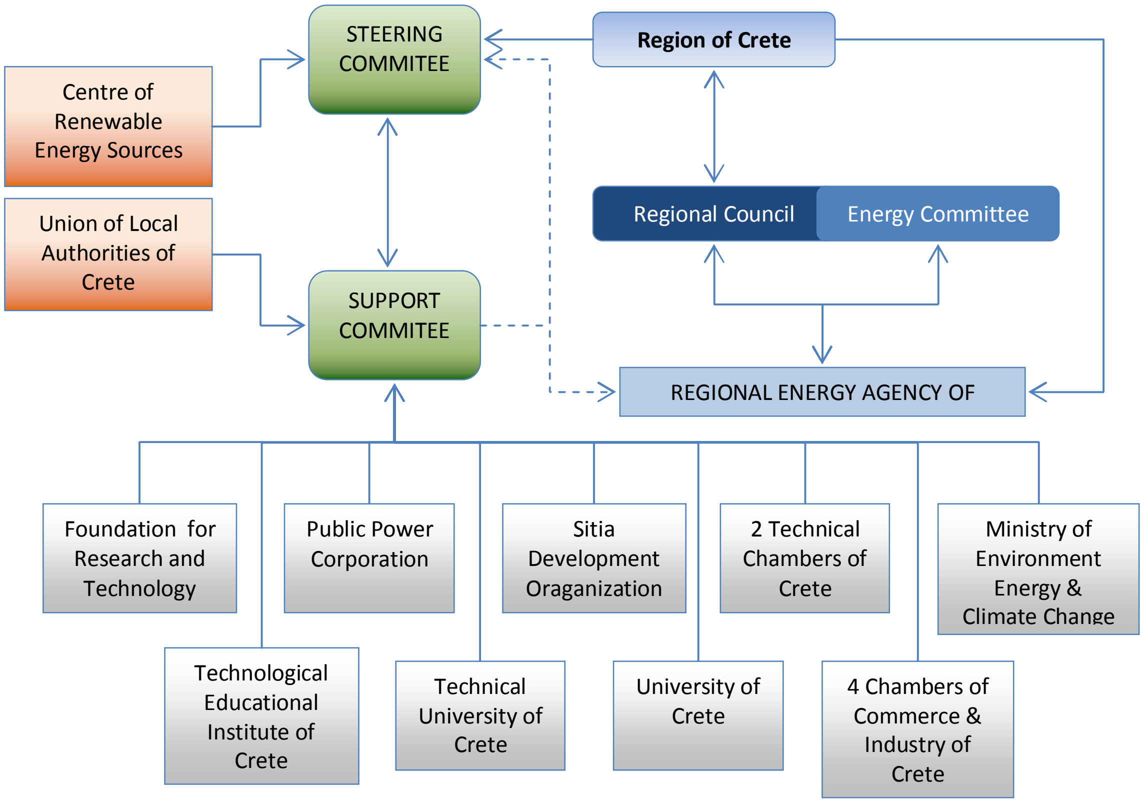



**Figure 1.2. Organisational structure of REAC (source: REAC)**

# 2 OVERALL STRATEGY

## 2.1 Current framework and vision for the future

Crete's rapid development the last decades boosted mainly by the primary (agriculture) and tertiary (tourism) sectors is followed by an increasing energy demand. This is clearly depicted in the following graph where the annual electricity production and respective peak demand for the last 45 years is presented. Although the electricity production has decreased the period 2008 - 2009, mainly affected by the recent financial crisis, the production in 2010 returned to an increasing trend which is expected to be retained the following years raising the question of meeting the energy demand of the island.

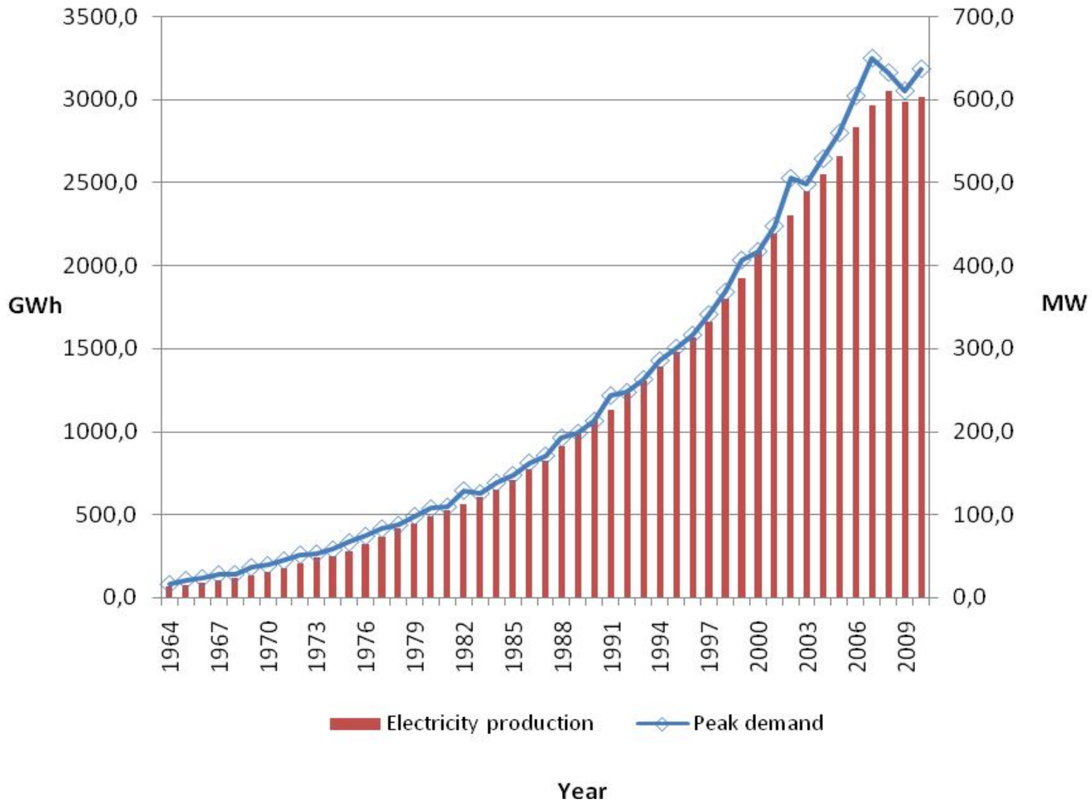



**Figure 2.1. Historical electricity production and peak demand (source: PPC)**

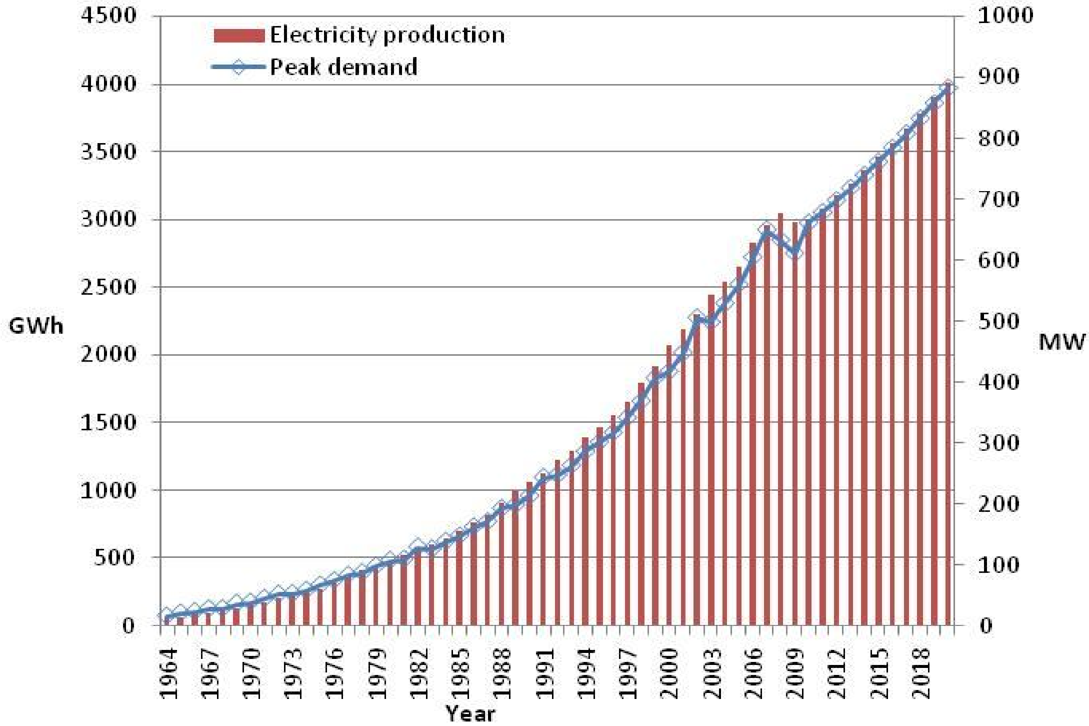



**Figure 2.2΄΄. Historical and Prevision of electricity production**

The energy needs of the island are covered by a centralized autonomous electrical system on the island and of course by the energy carriers consumed directly by the end users. The electrical system is powered mainly by fossil fuels (fuel oil, diesel). Also back in 60's small hydroelectric plants were installed delivering a minor amount of electricity to the system. In 1993 the first wind park was installed on the island. The last years there is also a strong PV installation trend which is expected to get even more intensive the following years making solar energy an important energy carrier for the electricity system.

In the following graph the historical electricity production per energy carrier is presented. The minor production by hydro turbines is excluded. It is clear that fossil fuels are the dominant energy carriers, with fuel oil being the predominant one the last five (5) years resulting also to a high electricity production cost mainly because of the cost of importing diesel on the island.

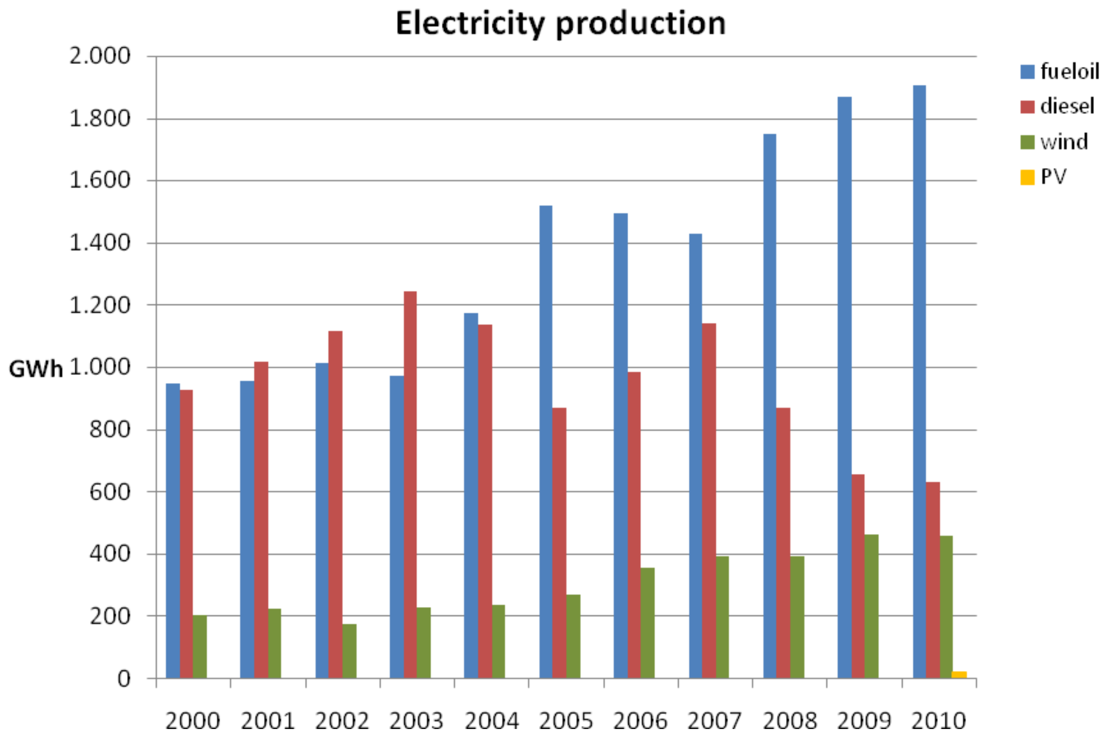



**Figure 2.3. Electricity production per energy carrier 2000 - 2009 (source: PPC)**

The current installed capacity of the power generating systems and the respective type of fuels for the conventional units is presented in the following table 2010:

| Technology | Steam generators | Diesel generators | Gas turbines | Combined Cycle | Wind turbines | Hydro turbines | PV |
|---|---|---|---|---|---|---|---|
| **Fuel type** | Fuel oil | Fuel oil | Diesel | Diesel | - | - | - |
| **Power[MW]** | 211.2 | 167.2 | 478.8 | 133.4 | 166.7 | 0.6 | 30.7 |

**Table 2.1. Power generating systems (source: PPC)**

The latest modifications in the conventional unit installations were the introduction of two (2) new steam generators of 50MW each in 2007 and 2008 respectively in Atherinolakos power station, the introduction of one (1) rented (RENT) diesel generator of 16MW power capacity also in Atherinolakos power station. Also in 2010 the first PV stations were connected to the electrical network of Crete reaching by the end of the year the power capacity of 30.7MW.

In the unit dispatch schedule priority is given to the steam generators which need to operate at their technical minimums in order to be efficient and react to the production fluctuations. The RES production from wind, hydro and PV is absorbed right after followed by the diesel generators and gas turbines which are fast responding engines to load fluctuations and can respond fast near the peak load demand. In the following figures the share of electricity production per energy carrier and technology is presented for year 2010.

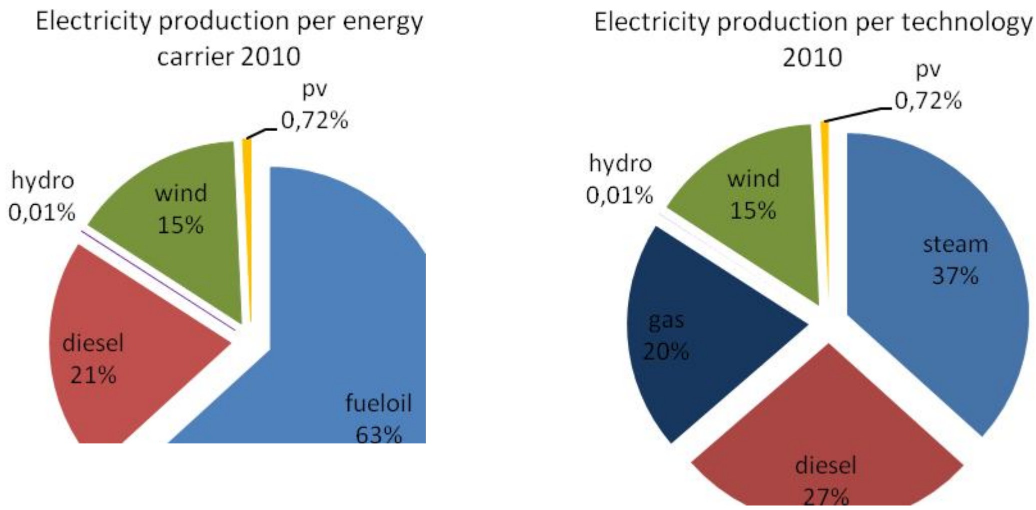



**Figure 2.4. Electricity production per energy carrier and technology for year 2010**

Crete is an island with **great potentialities for a sustainable development** based on renewable energy sources (RES). However, in order to secure the stability of the electrical production the potential installed capacity of stochastic RES (wind, solar) is limited. This limit is estimated roughly to 30% of the previous year peak demand. According to 2010 values, where the peak demand reached 637.5MW, this limit should not raise over 200MW.

It is apparent that with a current RES installed capacity ~200MW this limit has already been reached. This problem is expected to be solved with the combination of RES applications with energy storage units with the most popular system being the hybrid wind-hydro unit. With this system the surplus of electricity produced from wind will be supplied to pump-storage in order to store energy at a higher elevation reservoir in the form of hydraulic energy. This energy can be exploited the days with low wind increasing the capacity credit of the hybrid stations.

Also RES units based on biomass to electricity and solar thermal electricity production units can serve as base load units allowing a further introduction of RES in the system. Furthermore, by 2020 natural gas combined cycle units are expected to be introduced in the electrical system of Crete, which because of their quick responding in load fluctuations - could also provide further potential development of RES units. Finally, the possible future **interconnection** of Crete with the mainland will give a boost to the RES development on the island surpassing the technical limitations of an autonomous system. This is an ambitious project of national and european importance which however is not expected to be delivered before 2017.

The **short-term** vision for Crete is to optimize the autonomous power system aiming to maximization of the clean energy production followed by extensive measures for rational energy use, energy saving and energy efficiency in the end use.

The **long-term** vision however is even more ambitious by considering the increased possibilities of RES production through the planned electrical interconnection of Crete to the main land. The island can be transformed to a 100% green island providing clean energy even to the mainland of Greece. However, it should be noted that the development of RES units **shall comply with the sustainable development of Crete's ecosystem as a whole.**

The short-term actions are expected to focus both on the **energy production and the demand side**. For the production **side,** the maximum capacity of RES which will be introduced to the system will be followed by the use of natural gas as an alternative to high emitting fuels like fuel oil and diesel. On the other hand for the demand side extensive energy saving and energy efficiency measures will be implemented in the public sector promoting similar actions to the rest of the activity sectors. Taking into consideration the high number of visitors on the island (1.7millions in 2009) it is clear that energy saving initiatives shall be focused on the sectors related to tourism like accommodation and food service activities.

The great challenge for the Region of Crete is to succeed into managing and coordinating the implementation and monitoring of the ISEAP for an island of more than 600000 permanent inhabitants of many tourists and of numerous municipalities. The collaboration between citizens, stakeholders, Municipalities and the Region should be strong and committed in order face this challenge and will be coordinated by the Regional Energy Agency of Crete.

## 2.2 Objectives and targets

In December 2008 the EU adopted an integrated energy and climate change policy, including ambitious targets for 2020. It hopes to set Europe on the right track - towards a sustainable future with a low-carbon, energy-efficient economy - by:

- cutting greenhouse gases by 20% (30% if international agreement is reached)
- reducing energy consumption by 20% through increased energy efficiency
- meeting 20% of our energy needs from renewable sources.

Especially for Greece these targets were initially translated into 4% reduction of greenhouse gases according to 2005 levels and 18% penetration of renewable energy sources into the gross energy consumption.

In 2010 Greece set even more ambitious goals to increase the penetration of RES into the final energy consumption to 20%, translated into 40% participation of RES into electricity production, 20% into heat and cold production and 10% into transports.

In the framework of "Pact of Islands the Region" of Crete committed into going even further than national targets and become a "good to best example" for the rest of the country. Crete is lucky to have a wide range of RES potential making the island an ideal area to promote sustainable development based on RES combined also with substantial actions in increasing energy efficiency and energy saving.

The Region of Crete by submitting the following "Island Sustainable Energy Action Plan" (ISEAP) sets clear targets towards sustainability.

Specifically, the main two targets set are:

3. **25% reduction of $CO_2$ emissions in comparison to 2005**
4. **36% participation of RES into electricity production**

Besides that, through the planned actions of this ISEAP a wide range of horizontal actions will be carried out (Demand Side Management, DSM actions) focusing on the increase of energy efficiency and the maximization of energy savings in all activity sectors.

In this way Crete is becoming a national frontrunner into the fight against climate change and energy sustainable development urging more regions, cities and islands to materialize the motto "think globally, act locally".

# 3 ENERGY BALANCE AND EMISSION INVENTORY

For the island of Crete the **year 2005 is chosen as the baseline year**. An extensive energy data collection and modeling of the baseline year is carried out in order to develop an accurate emission inventory. According to the resulted baseline emission inventory a **Business As Usual (BAU)** scenario is developed to show the trend of the emissions evolution until the target year 2020.

The energy planning programming carried out to develop the BAU scenario, as the first phase of the ISEAP elaboration, is based on an approach **combining the bottom-up and top-down analysis**. This approach is supported by existing data and findings from other, relevant to the ISEAP, studies.

The energy planning process can be divided in **three major parts**.

1. **Data collection**: Statistical and energy data are gathered from different sources (statistical database, energy providers, past energy planning studies).

2. **Baseline year energy planning**: The collected data supported by different assumptions are provided to a bottom-up analysis computational tool in order to simulate Crete's energy profile in the baseline year (2005). The simulation follows the modeling demands of the project providing the results of the final energy demand, the secondary energy production, the primary energy demand and the respective CO2 emissions. The results from the bottom-up analysis are cross-verified with the existing data from the energy providers following a top-down approach.

3. **BAU scenario**: The BAU scenario is developed for the period 2005 –2020. For the period 2006 – 2010 the planning process follows the existing historical data combining again the bottom-up analysis with the top-down approach. For the period 2011 – 2020 the planning process considers the expected changes in population, in financial and social activities and the corresponding development of the island's activity sectors.

## 3.1 Data collection

The data collected for year 2005, essential to carry out the baseline year energy balance, are grouped in **six categories**. These are the general, the climatologic, the touristic, the transportation, the electricity and the fuel data categories. The specific data for each category are presented in the following list.

1. **General data** (source: EL.STAT.)

| | |
|---|---|
| Permanent population | 601131 |
| Number of households | 200299 |
| Number of civil servants | 102897 |
| Number of hospital beds | 3129 |
| Number of pupils | 73037 |
| Number of stores in the wholesale and retail sale sector (NACE G45,46,47) | 16956 |
| Number of stores in other services (NACE H,J,K,L,M,N,R,S,T,U52,53,58…82,90…99) | 11407 |
| Number of restaurants (NACE I56) | 6223 |

2. **Touristic data** (source: EL.STAT.)

| | | |
|---|---|---|
| Number of national visitors | | 316501 |
| Number of international visitors | | 1412968 |
| Number of tourist beds | 1* | 10018 |
| | 2** | 44048 |
| | 3*** | 28896 |
| | 4**** | 42309 |
| | 5***** | 18209 |
| | Total | 143480 |
| Number of hotels | 1* | 233 |
| | 2** | 741 |
| | 3*** | 295 |
| | 4**** | 200 |
| | 5***** | 37 |
| | Total | 1506 |

| Month | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Occupation rate [%] | 20 | 22 | 25 | 48 | 65 | 85 | 90 | 95 | 77 | 53 | 28 | 25 |
| Availability rate [%] | 77 | 61 | 68 | 74 | 77 | 87 | 100 | 100 | 97 | 71 | 60 | 62 |

3. **Climatological data** (source: National Observatory of Athens)

| Month | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Average air temperature [°C] | 13.4 | 12.5 | 13.7 | 16.7 | 20.1 | 24.5 | 27.0 | 26.4 | 23.5 | 20.8 | 17.3 | 15.8 |
| Average ground-water temperature [°C] | 15 | 13 | 15 | 16 | 19 | 21 | 24 | 24 | 24 | 22 | 18 | 18 |
| Average sun-hours | 4 | 5 | 6 | 8 | 10 | 12 | 12 | 11 | 9 | 7 | 5 | 4 |

4. **Transportation data** (source: EL.STAT. – assumptions)

| | Number of vehicles | | | |
|---|---|---|---|---|
| Vehicle type | Cars | Motorcycles | Trucks | Buses |
| Public | 1409 | 337 | 1838 | 1220 |
| Private | 254499 | 120900 | 121432 | - |
| Visitors (owned) | 79125 | 39563 | - | - |
| Visitors (rented) | 235495 | 353492 | - | - |

The data for the public and private sectors are based on pure statistical data. However, for the estimation of the visitors' vehicles some assumptions were essential. The calculation is mainly based on the number of national and international visitors. The national visitors are assumed to arrive to the island with their own vehicles ("Visitors owned") and on the other hand the international are assumed to rent vehicles ("Visitors rented") on the island.

The assumptions for the two categories of vehicles are presented in the following tables:

| Visitors (owned vehicle) | |
|---|---|
| Share of visitors with cars | 75% |
| Share of visitors with motorcycles | 25% |
| Average number of visitors per car | 3 |
| Average number of visitors per motorcycle | 2 |

| Visitors (rented vehicle) | |
|---|---|
| Share of visitors with cars | 50% |
| Share of visitors with motorcycles | 50% |
| Average number of visitors per car | 3 |
| Average number of visitors per motorcycle | 2 |

5. **Electricity data** (provided by the Public Power Company, PPC and REAC)
   The following data are directly depicted in the baseline year energy planning process.
    a. Electricity production
    b. Electricity production per technology and fuel type
    c. Fuel consumption per fuel type
    d. Self-consumption and distribution losses
    e. Electricity consumption per activity sector (EL.STAT.)
6. **Fuel data** (provided by fuel providers and existing studies, REAC)
   The following data are directly depicted in the baseline year energy planning process.
    a. Fuel consumption per fuel type
    b. Fuel consumption per activity sector

These are global data referring explicitly to the baseline year 2005. Further data needed for the calculations are assumed according to standard values and by taking into consideration the special characteristics of Crete.

## 3.2 Energy balance in base year

The year 2005 was selected as base year for the energy planning process of Crete's ISEAP, following the EU targets set for fighting climate change. In the following figures and table Crete's energy profile for the year 2005 is shown in short. The strong dependence on fossil fuels is apparent.

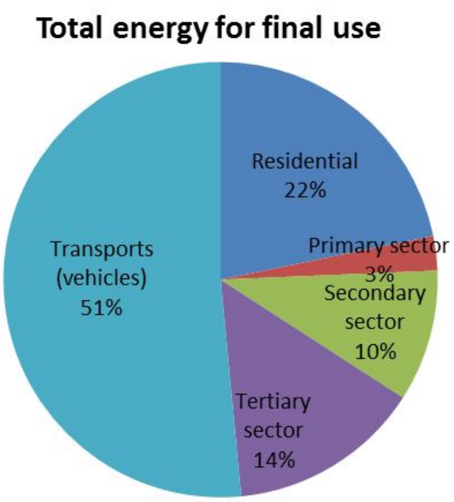



**Figure 3.2.1 Total Energy for Final Use**

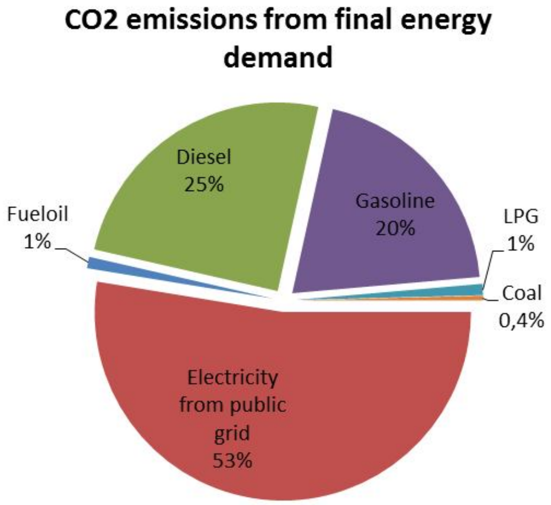



**Figure 3.2.2 CO2 Emissions from Final energy demand**

| $CO_2$ emissions from primary energy demand [t] | | | | | | |
|---|---|---|---|---|---|---|
| Fueloil | Diesel | Gasoline | LPG | Coal | Urbanwaste | **TOTAL** |
| 1337199 | 1787300 | 811073 | 398301 | 16461 | 333 | **3992198** |

## 3.3 Final energy demand

The final energy demand depicts the **consumers' energy needs**. These energy fluxes can be provided either by centralized energy services (electrical network) or by direct use of fossil fuels and renewable energy sources from the consumers. It should be noted that in order to reassure the accuracy of the calculations the electricity network efficiency is assumed to be 90% taking into account the self-consumption losses and the distribution losses from the power units till the low-voltage power network. The assumption is based on the data provided by PPC.

According to the project template the final **energy demand is categorized in 5 main activity sectors** (residential, primary, secondary, tertiary, and transports) and several sub-sectors. The calculation process for each one of them is based on the bottom-up approach making use of the collected data and further assumptions.

In the following chapters the distribution of the final energy demand among the energy uses and carriers for the 5 main sectors and subsectors in 2005 are presented.

### 3.3.1 Residential sector

For the residential sector the biggest part of the energy carriers is equally shared among the electricity from the public grid and diesel followed by biomass, solar and LPG (see Figure 3.3.1).The most energy demanding sectors are the heating and cooling followed by the hot water, cooking and lighting. The most energy demanding electrical appliance is the refrigerator/freezer (see Figure 3.3.2).

The energy need for hot water use is covered almost equally by electricity, diesel and solar (see Figure 3.3.3), for heating and cooling diesel is the predominant energy carrier followed by electricity and biomass and for cooking half of the energy demand is covered by electricity and the rest is equally shared between LPG and biomass (see Figure 3.3.5).

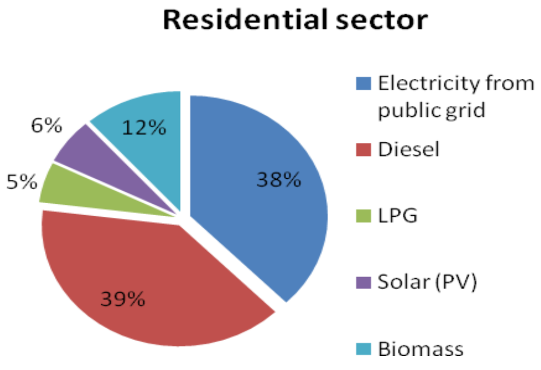



**Figure 3.3.1. Residential sector energy demand per energy carrier (2005)**

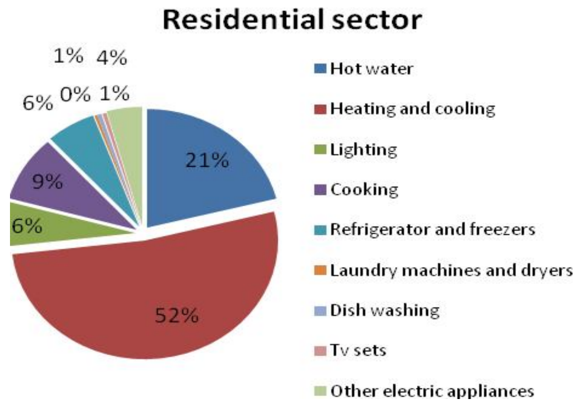



**Figure 3.3.2. Residential sector energy demand per energy use sector (2005)**

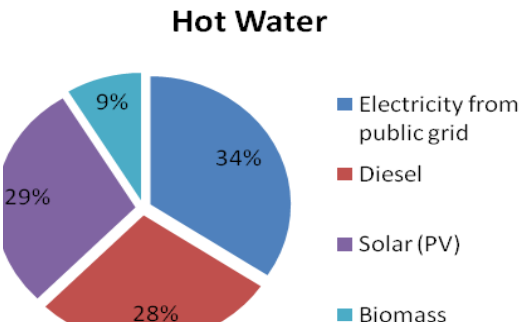



**Figure 3.3.3.Hot water energy demand per energy carrier**

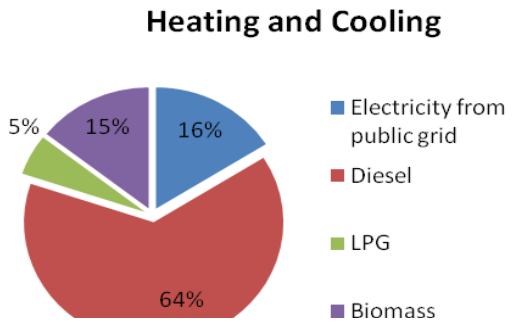



**Figure 3.3.4.Heating and Cooling energy demand per energy carrier**

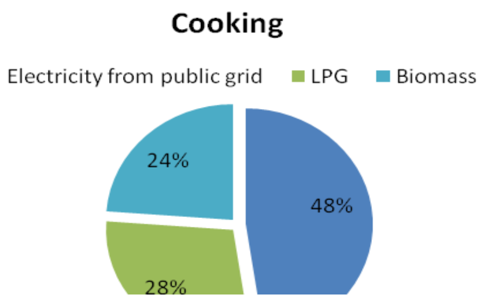



**Figure 3.3.5**. **Cooking energy demand per energy carrier**

In the following graphs the sharing of the energy carriers (electricity from public grid, diesel, LPG, biomass) to the different energy uses is shown (see Figure 3.3.6, Figure 3.3.7, Figure 3.3.8, Figure 3.3.9). The solar energy carrier is exclusively (100%) covering hot water needs through the solar boiler technology.

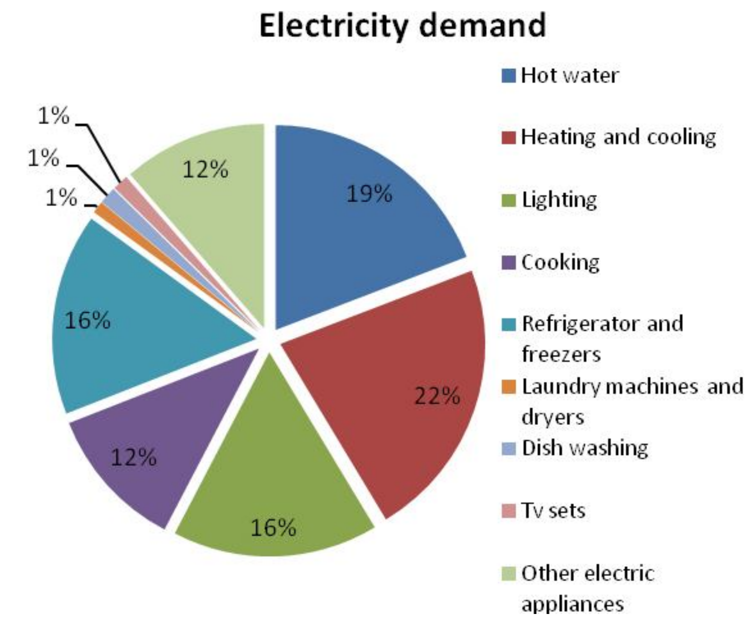



**Figure 3.3.6. Residential sector - Electricity demand per energy use**

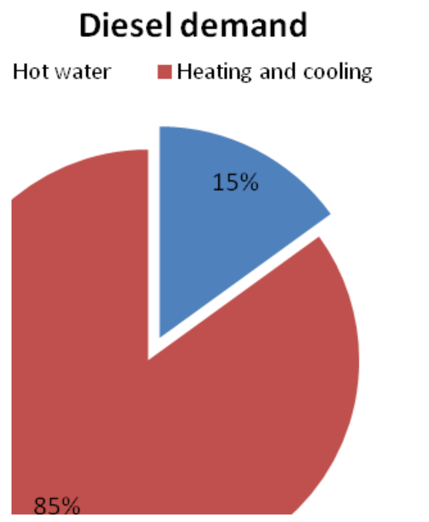



**Figure 3.3.7. Residential sector - Diesel demand per use**

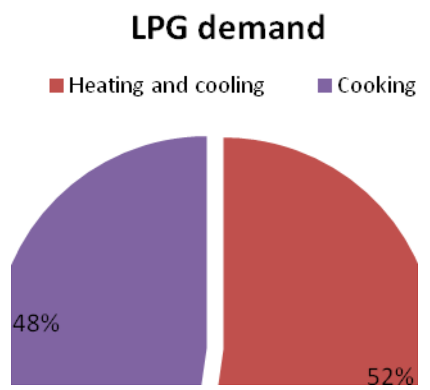



**Figure 3.3.8. Residential sector - LPG demand per energy use**

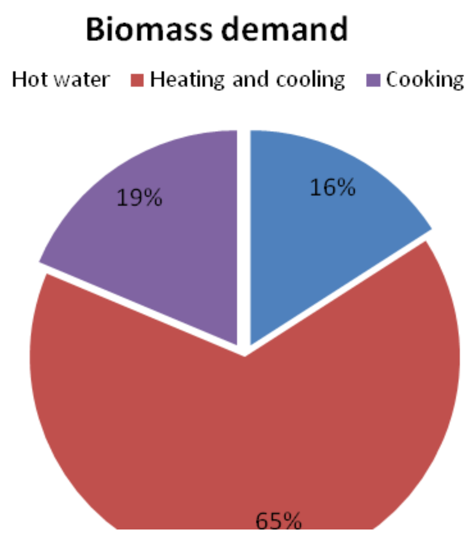



**Figure 3.3.9. Residential sector - Biomass demand per energy use**

### 3.3.2 Primary sector

For the primary sector, represented mainly by the agriculture activities in Crete, the most of the energy demand is covered by electricity whereas smaller fractions are taken over by diesel and biomass (see Figure 3.3.10). The greenhouse installations represent the biggest part of the energy demand.

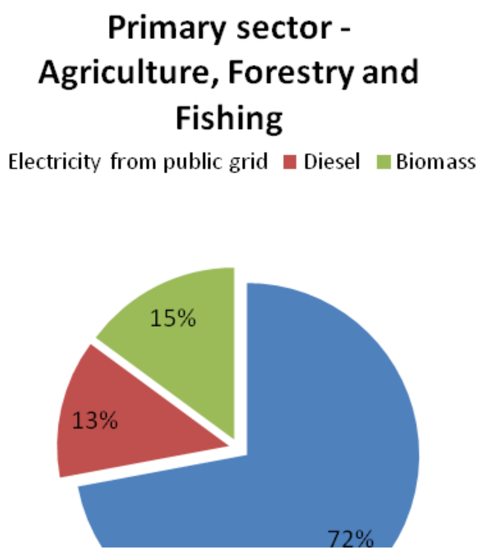



**Figure 3.3.10. Primary sector (Agriculture, Forestry and Fishing) energy demand per energy carrier**

### 3.3.3 Secondary sector

In the following graphs the energy demand of the secondary sector per energy carrier and energy sector are presented (see Figure 3.3.11, Figure 3.3.12).

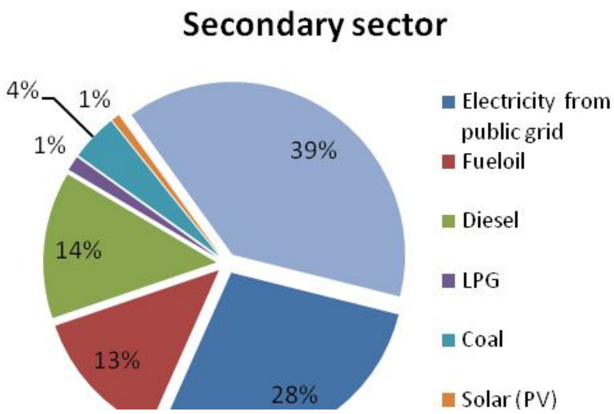



**Figure 3.3.11. Secondary sector energy demand per energy carrier**

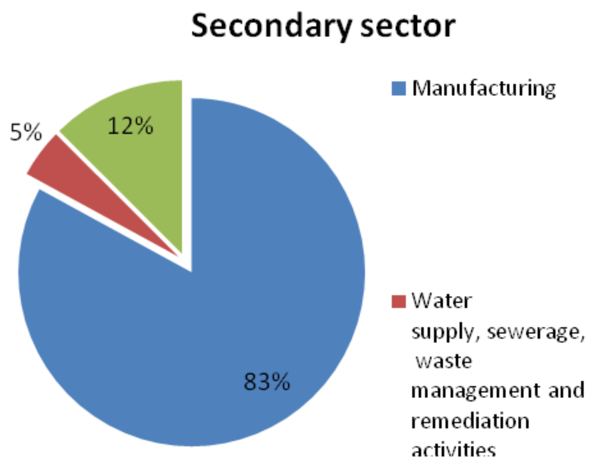



**Figure 3.3.12. Secondary sector energy demand per energy use sector**

In the following graphs the energy demand per energy carrier for the secondary sub-sectors are presented. The energy demand of the water supply, sewerage, waste management and remediation activities sub-sector is assumed to be fully covered by electricity (see Figure 3.3.13, Figure 3.3.14).

Also the sharing of the energy carriers (electricity, fuel oil and diesel) to the different energy uses is shown (see Figure 3.3.15, Figure 3.3.16, Figure 3.3.17). The coal, LPG, solar and biomass energy carriers are exclusively (100%) covering manufacturing needs.

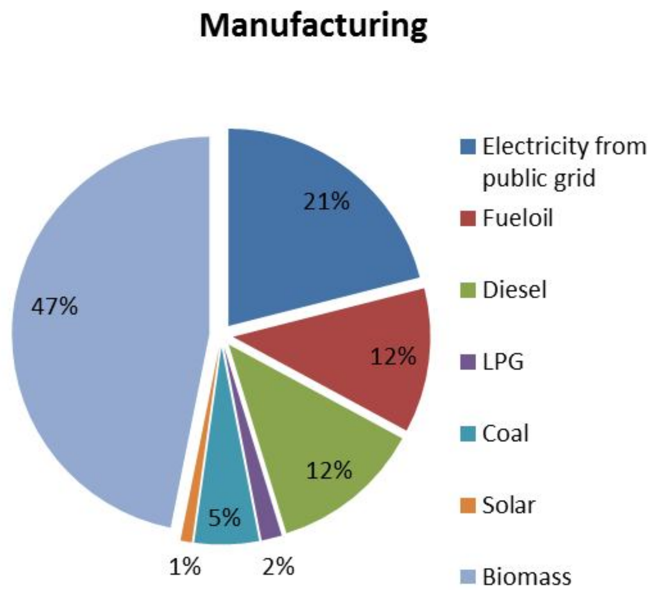



**Figure 3.3.13. Manufacturing energy demand per energy carrier**

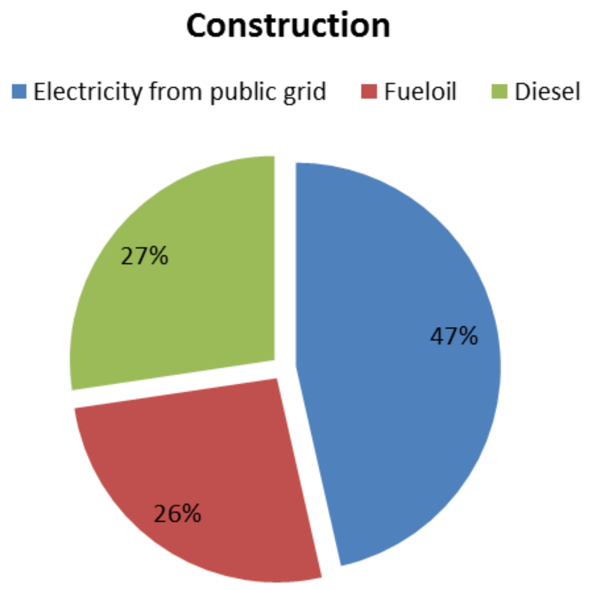



**Figure 3.3.14. Construction energy demand per energy carrier**

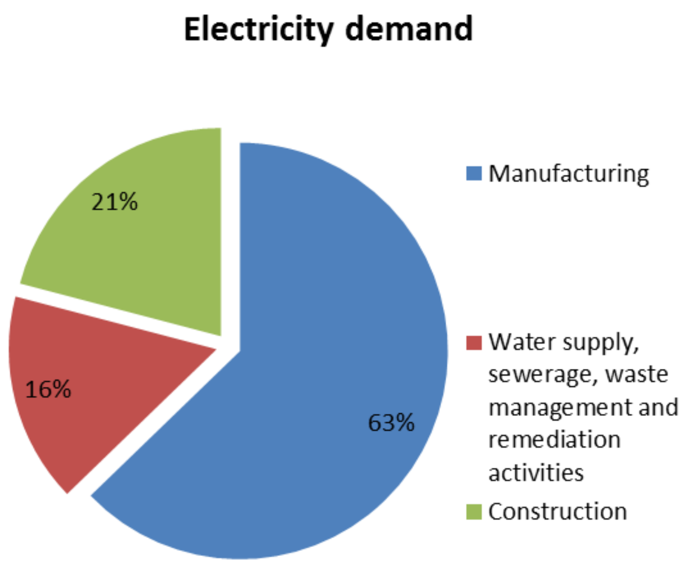



**Figure 3.3.15. Secondary sector - Electricity demand per energy use**

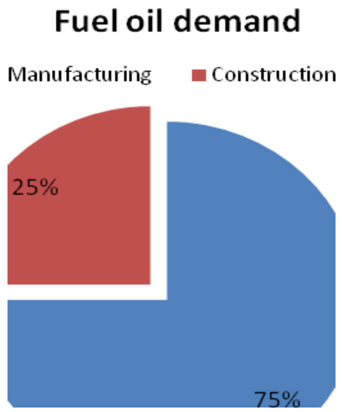



**Figure 3.3.16. Secondary sector - Fuel oil demand per energy use**

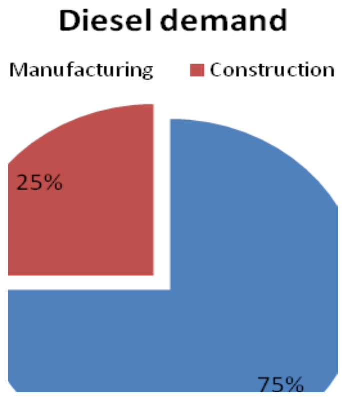



**Figure 3.3.17. Secondary sector - Diesel demand per energy use**

## 3.3.4 Tertiary sector

The energy demand per energy carrier and energy use of the tertiary sector are presented in the following figures. Electricity from public grid is the predominant energy carrier for the tertiary sector (see Figure 3.3.18). The wholesale and retail trade sub-sector followed by the accommodation and food service activities sub-sector have the biggest share of energy demand for the sector. The other services and public administration sub-sectors follow with the education, human activities and public lighting ones having an equally minor share in the energy demand share of the tertiary sector (see Figure 3.3.19).

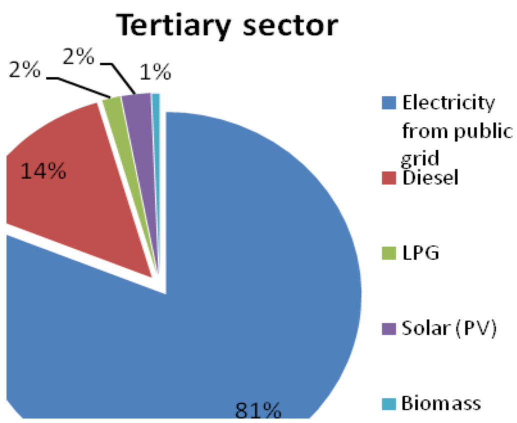



**Figure 3.3.18. Tertiary sector energy demand per energy carrier**

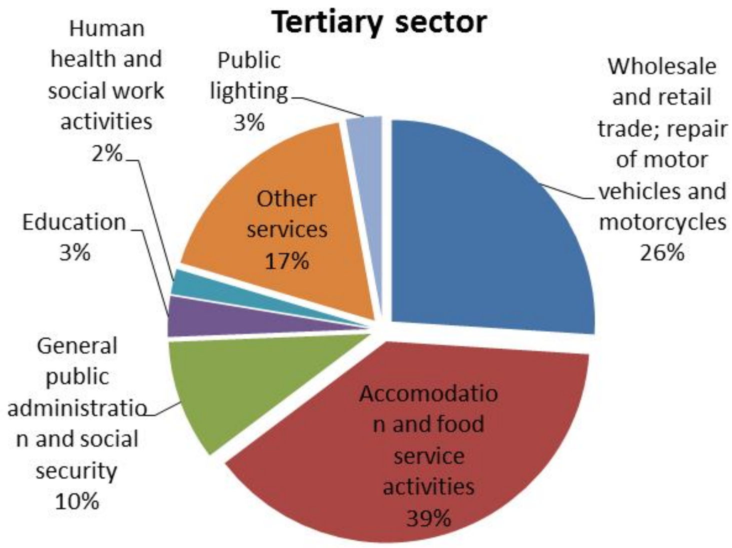



**Figure 3.3.19. Tertiary sector energy demand per energy use sector**

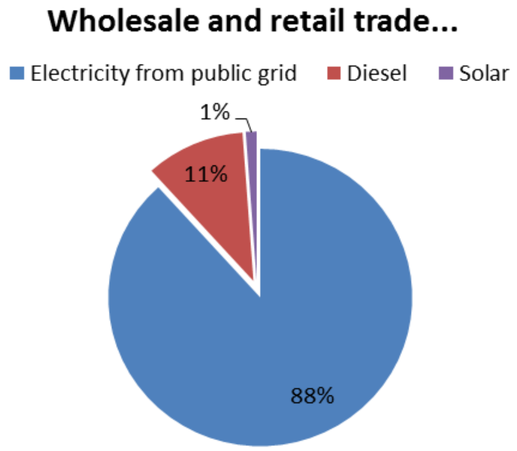



**Figure 3.3.20. Wholesale and retail trade energy demand per energy carrier**

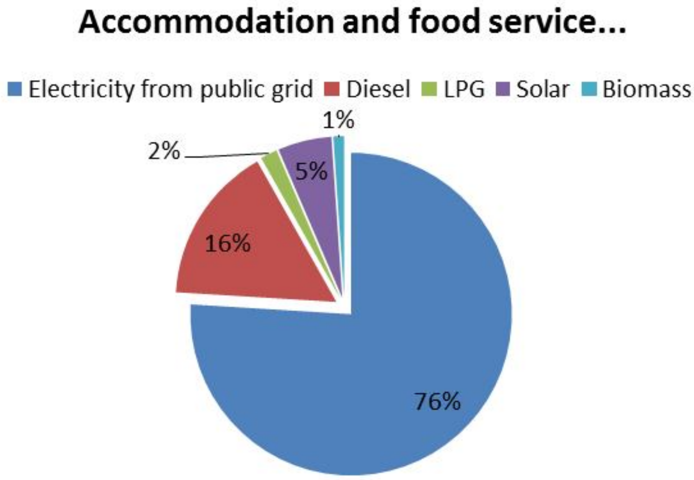



**Figure 3.3.21. Accommodation and food service activities energy demand per energy carrier**

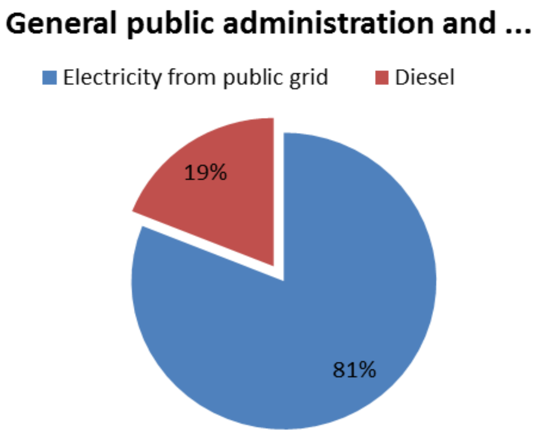



**Figure 3.3.22. General public administration energy demand per energy carrier**

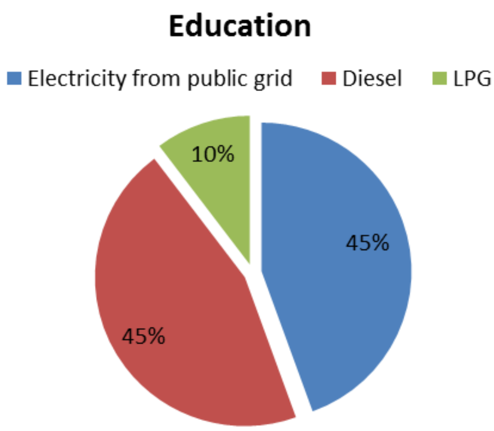



**Figure 3.3.23. Education energy demand per energy carrier**

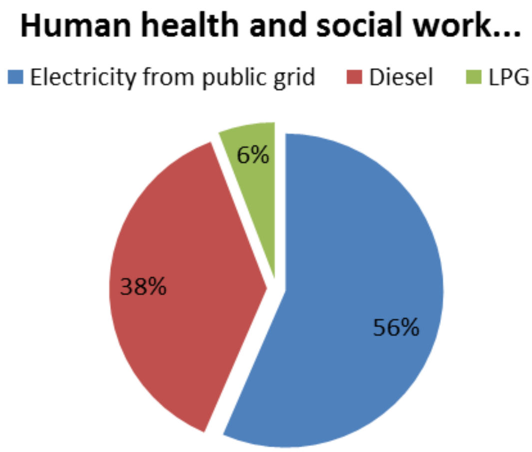



**Figure 3.3.24. Human health and social work activities energy demand per energy carrier**

The shares of each energy carrier for the respective energy uses of the tertiary sector are presented in the previous figures. For the wholesale and retail trade, the accommodation and food service activities and the general public administration sub-sectors electricity is the predominant energy carrier covering the energy demand followed mainly by diesel (see Figure 3.3.20, Figure 3.3.21, Figure 3.3.22). For the education and human health and social work activities sub-sectors the energy demand is covered almost equally from electricity and diesel (see Figure 3.3.23, Figure 3.3.24).

In the following figures the sharing of the energy carriers (electricity from public grid, diesel, LPG and solar) to the different energy uses is shown (seeFigure 3.3.25, Figure 3.3.26). The biomass energy carrier is exclusively (100%) covering needsof the accommodation and food service activities energy uses.

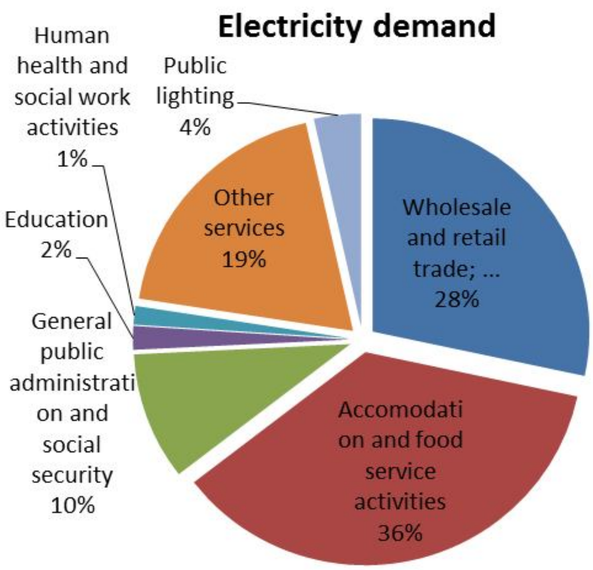



**Figure 3.3.25. Tertiary sector - Electricity energy demand per energy use**

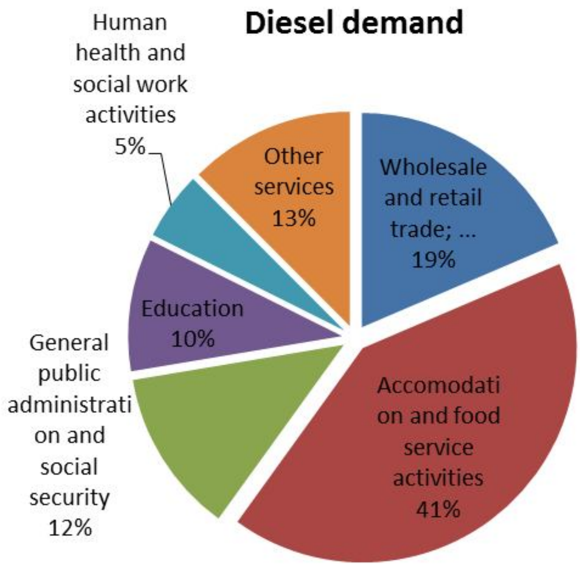



**Figure 3.3.26. Tertiary sector - Diesel demand per energy use**

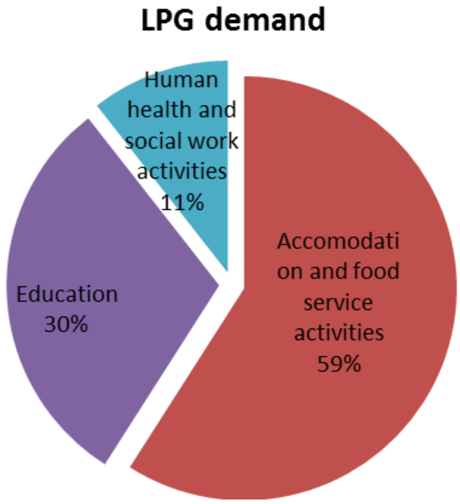



**Figure 3.3.27. Tertiary sector - LPG demand per energy use**

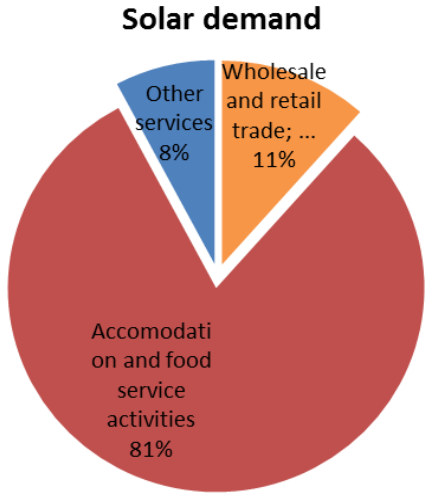



**Figure 3.3.28. Tertiary sector - Solar demand per energy use**

## 3.3.5 Transports sector

The energy demand per energy carrier and energy use of the transports sector are presented in the following figures. Gasoline and diesel are the energy carriers in use with gasoline covering a slight bigger part of the energy demand than diesel (seeFigure 3.3.29). The sub-sectors of private transports followed by the freight transport by road and removal services have the biggest share of energy demand for the sector. The passenger transport by road and the other fleet for public and private services have an equally minor share in the energy demand share (seeFigure 3.3.30).

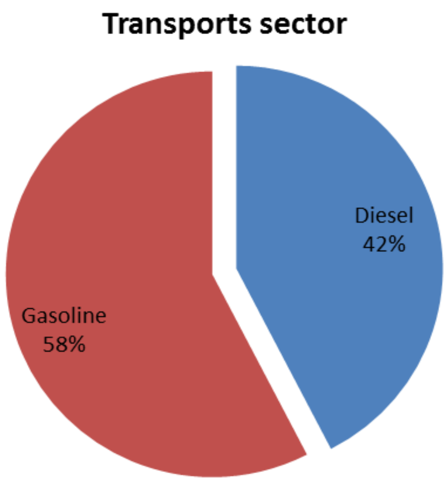



**Figure 3.3.29. Transports sector energy demand per energy carrier**

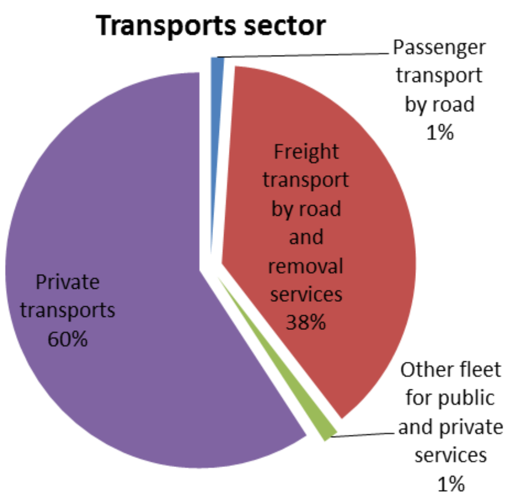



**Figure 3.3.30. Transports sector energy demand per energy use sector**

Similarly to the previous sectors the shares of each energy carrier for the respective energy uses of the transports sector and vice versa are presented in the following figures (see Figure 3.3.31, Figure 3.3.32, Figure 3.3.33, Figure 3.3.34, Figure 3.3.35 andFigure 3.3.36).

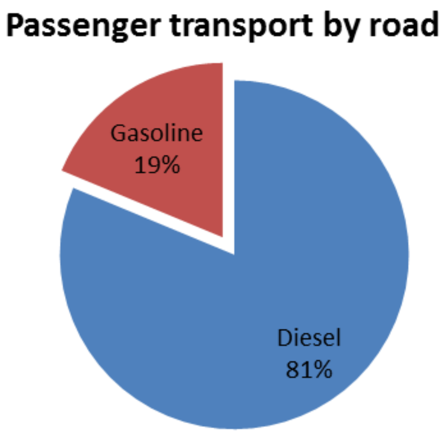



**Figure 3.3.31. Passenger transport by road energy demand per energy carrier**

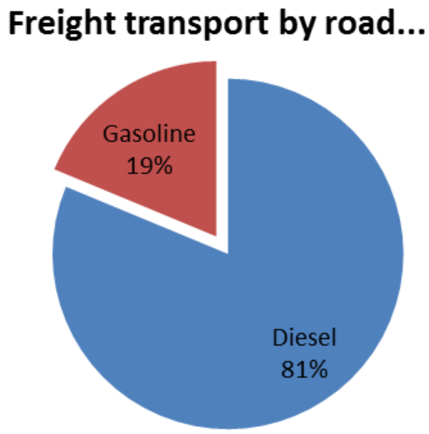



**Figure 3.3.32. Freight transport by road services energy demand per energy carrier**

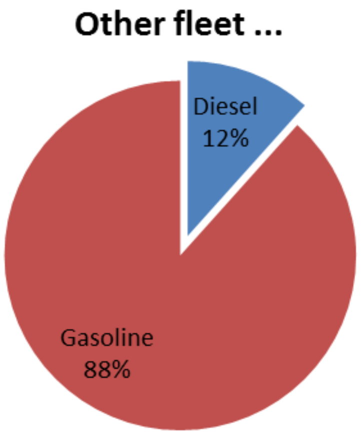



**Figure 3.3.33. Other fleet energy demand per energy carrier**

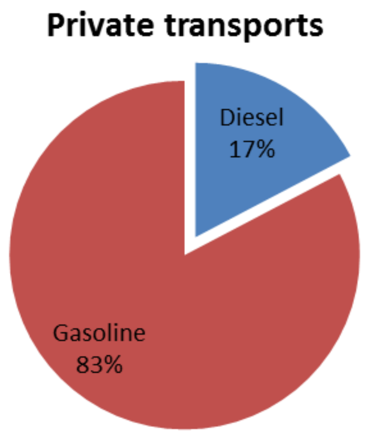



**Figure 3.3.34. Private transports energy demand per energy carrier**

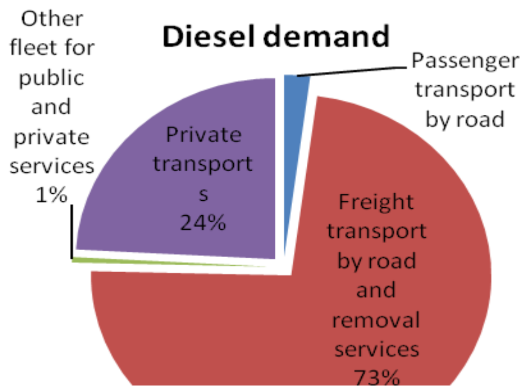



**Figure 3.3.35. Transposrts sector - Diesel demand per energy use**

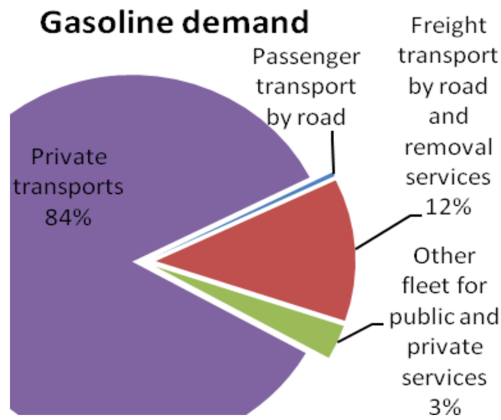
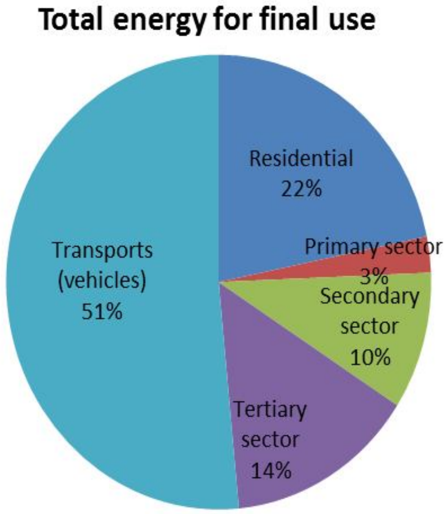



**Figure 3.3.36.. Transports sector - Gasoline demand per energy use**

### 3.3.6 Overall results

Finally the distribution of the energy carriers and the total energy for **final use to the main sectors** is presented to the following figures (seeFigure 3.3.37, Figure 3.3.40, Figure 3.3.42). The transports sector appears as the most energy demanding sector mainly because of the large and extensive road network of the island and the intensive transportation of the primary sector goods from production to the ports to supply the mainland. The residential, tertiary, secondary and primary sectors follow in terms of total energy demand.



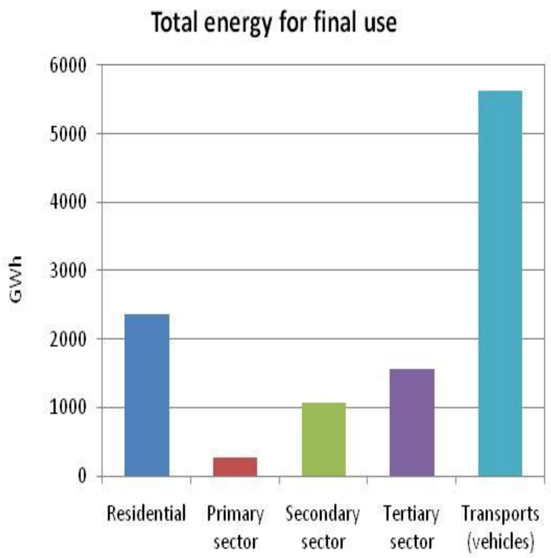
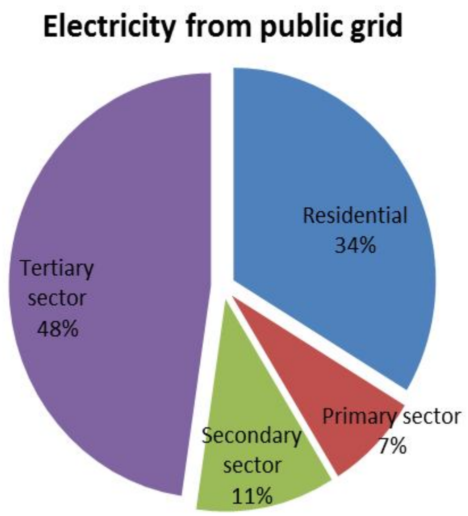




**Figure 3.3.37. Distribution of the total energy for final use to the main demand sectors**



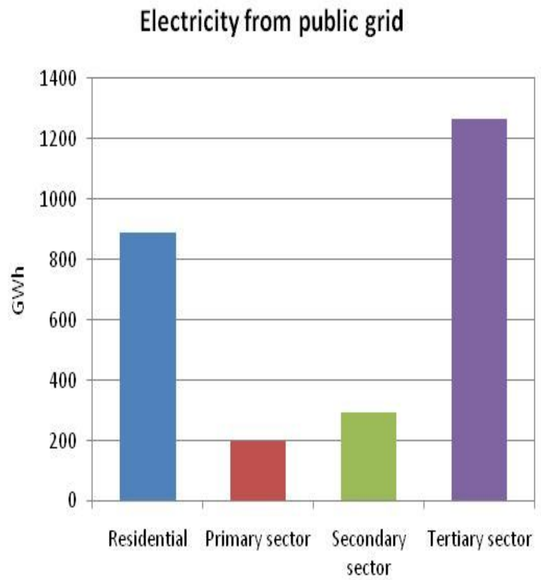




**Figure 3.3.38 Distribution of electricity demand to the main demand sectors**

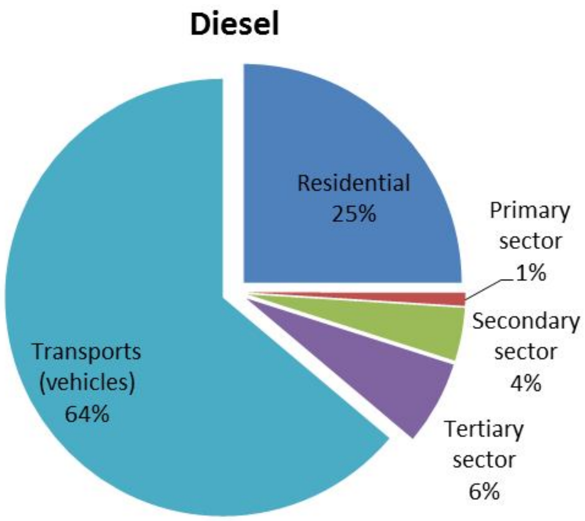



**Figure 3.3.39. Distribution of diesel to the main demand sectors**

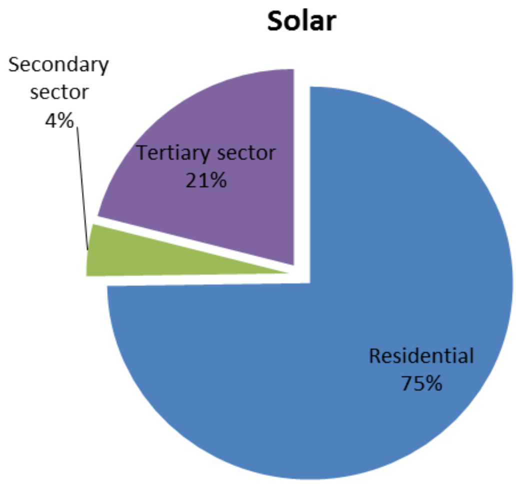



**Figure 3.3.41. Distribution of LPG to the main demand sectors**

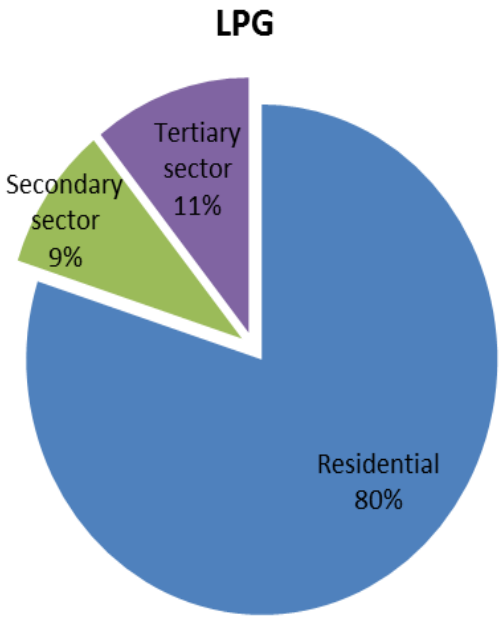



**Figure 3.3.40. Distribution of solar energy to the main demand sectors**

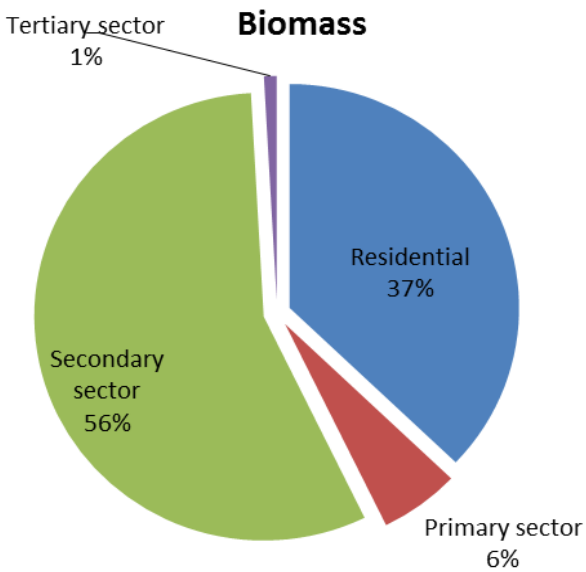



**Figure 3.3.42. Distribution of biomass to the main demand sectors**

The final energy demand analytical distribution per demand sector (main sectors and sub-sectors) and energy carrier for the baseline year 2005is presented in the table of the following two pages.

| DEMAND SECTOR | ENERGY FOR FINAL USE - 2005 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Centralized energy services | | Fossil fuels | | | | | | Renewable energy sources | | | TOTAL |
| Sector description | Electricity from public grid | Sub-total | Fueloil | Diesel | Gasoline | LPG | Coal | Sub-total | Solar | Biomass | Sub-total | |
| **Residential** | **892.658** | **892.658** | | **929.971** | | **127.761** | | **1.057.732** | **144.388** | **272.240** | **416.628** | **2.367.018** |
| Hot water | 171.126 | **171.126** | | 139.575 | | | | **139.575** | 144.388 | 43.316 | **187.704** | **498.406** |
| Heating and cooling | 198.188 | **198.188** | | 790.396 | | 66.794 | | **857.190** | | 178.117 | **178.117** | **1.233.495** |
| Lighting | 145.401 | **145.401** | | | | | | | | | | **145.401** |
| Cooking | 101.612 | **101.612** | | | | 60.967 | | **60.967** | | 50.806 | **50.806** | **213.385** |
| Refrigerator and freezers | 142.613 | **142.613** | | | | | | | | | | **142.613** |
| Laundry machines and dryers | 8.680 | **8.680** | | | | | | | | | | **8.680** |
| Dish washing | 12.151 | **12.151** | | | | | | | | | | **12.151** |
| Tv sets | 11.290 | **11.290** | | | | | | | | | | **11.290** |
| Other electric appliances | 101.597 | **101.597** | | | | | | | | | | **101.597** |
| **Primary sector** | **200.008** | **200.008** | | **36.209** | | | | **36.209** | | **41.337** | **41.337** | **277.555** |
| Agriculture, forestry and fishing | 200.008 | **200.008** | | 36.209 | | | | **36.209** | | 41.337 | **41.337** | **277.555** |
| **Secondary sector** | **295.712** | **295.712** | **139.430** | **145.733** | | **14.709** | **46.500** | **346.372** | **8.279** | **413.395** | **421.674** | **1.063.758** |
| Manufacturing | 185.642 | **185.642** | 104.573 | 109.300 | | 14.709 | 46.500 | **275.081** | 8.279 | 413.395 | **421.674** | **882.397** |
| Water supply, sewerage, waste management and remediation activities | 48.190 | **48.190** | | | | | | | | | | **48.190** |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Construction | 61.881 | **61.881** | 34.858 | 36.433 | | | | **71.291** | | | | **133.171** |
| **Tertiary sector** | **1.265.137** | **1.265.137** | | **224.314** | | **23.492** | | **247.806** | **40.458** | **10.000** | **46.975** | **1.560.315** |
| Wholesale and retail trade; repair of motor vehicles and motorcycles | 358.498 | **358.498** | | 42.897 | | | | **42.897** | 4.671 | | **4.671** | **406.065** |
| Accommodation and food service activities | 458.065 | **458.065** | | 88.978 | | 16.399 | | **105.377** | 29.559 | 10.000 | **39.560** | **603.002** |
| General public administration and social security | 122.551 | **122.551** | | 28.644 | | | | **28.644** | | | | **151.195** |
| Education | 22.680 | **22.680** | | 23.060 | | 5.265 | | **28.325** | | | | **51.005** |
| Human health and social work activities | 17.808 | **17.808** | | 11.876 | | 1.828 | | **13.704** | | | | **31.513** |
| Other services | 241.177 | **241.177** | | 28.858 | | | | **28.858** | 3.142 | | **3.142** | **273.177** |
| Public lighting | 44.358 | **44.358** | | | | | | | | | | **44.358** |
| **Transports (vehicles)** | | | | **2.378.158** | **3.257.322** | | | **5.635.480** | | | | **5.635.480** |
| Passenger transport by road (public transport, taxi, tourism, transfers, etc.) | | | | 49.535 | 11.422 | | | **60.957** | | | | **60.957** |
| Freight transport by road and removal services | | | | 1.742.988 | 401.903 | | | **2.144.891** | | | | **2.144.891** |
| Other fleet for public and private services | | | | 11.561 | 97.225 | | | **108.786** | | | | **108.786** |
| Private transports | | | | 574.073 | 2.746.772 | | | **3.320.845** | | | | **3.320.845** |
| **TOTAL** | **2.653.515** | **2.653.515** | **139.430** | **3.714.384** | **3.257.322** | **165.962** | **46.500** | **7.323.599** | **190.039** | **736.972** | **927.011** | **10.904.125** |

**Table 3.1. Energy for final use in the baseline year 2005**

## 3.4 Secondary energy conversion

**In Crete the secondary energy production takes place only in the 3 power stations** supplying electricity to the whole of the island. There are neither district heating or cooling systems nor conversion of electricity or heat to cold. Also, there are no energy storage units or any external connection since the electrical system of Crete is autonomous. The distribution of the electricity production to the different energy carriers (fossil fuels, renewables) is presented in the following figures (see Figure 3.3.43, Figure 3.3.44) and table. The distribution losses and self-consumption of the power stations is estimated to 3.6% of the electricity produced.

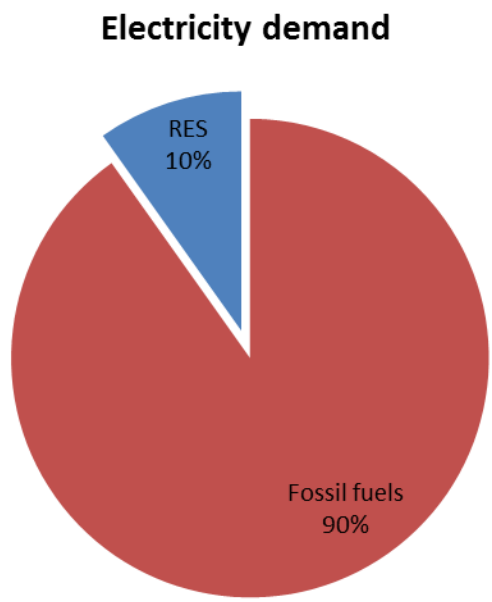



**Figure 3.3.43. Fossil fuels and RES share to electricity production**

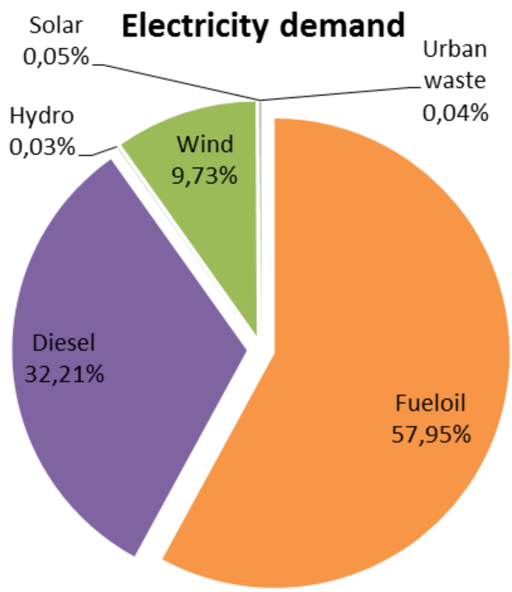



**Figure 3.3.44. Energy carriers share to electricity production**

| PRODUCTION SECTOR | ENERGY SOURCE | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Fossilfuels | | | Renewable energy sources (from systems connected to public networks) | | | | | Sub-total |
| Energy product | Fueloil | Diesel | Sub-total | Hydro | Wind | Solar | Urban waste | Sub-total | |
| Electricity | 1.594.264 | 886.191 | **2.480.455** | 832 | 267.580 | 1.400 | 1.000 | **270.812** | **2.751.267** |

**Table 3.2 Secondary energy for electricity production (2005)**

## 3.5 Primary energy demand

Having calculated the final energy demand, depicting the end use demand, and the primary energy demand for electricity production as a centralized service through the secondary energy conversion, a full modeling of Crete's energy profile, analyzed per energy carrier, is accomplished.

In this way the total primary energy demand for the baseline year 2005 is calculated by adding for every energy carrier the respective contribution from the final energy demand and the primary energy demand for secondary energy production. There are neither electricity imports and exports nor energy re-exportation.

In the following figures and table the primary energy demand per energy carrier is presented where fossil fuels constitute the vast majority of primary energy.

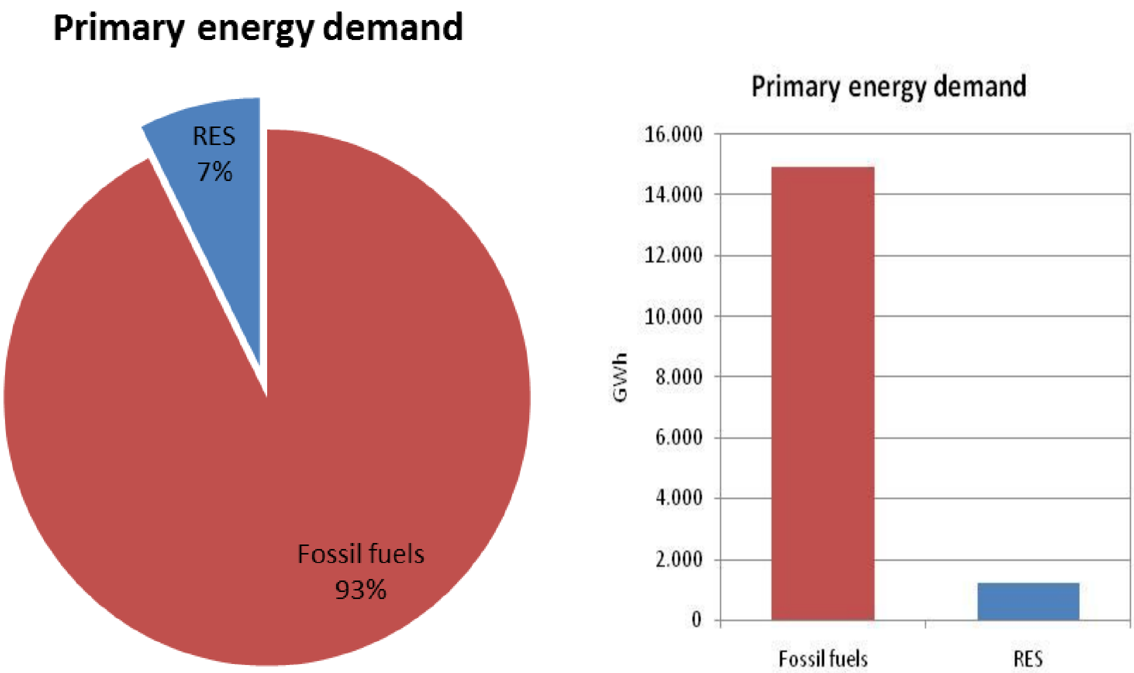



**Figure 3.3.45. Fossil fuels and RES share to primary energy demand (2005)**

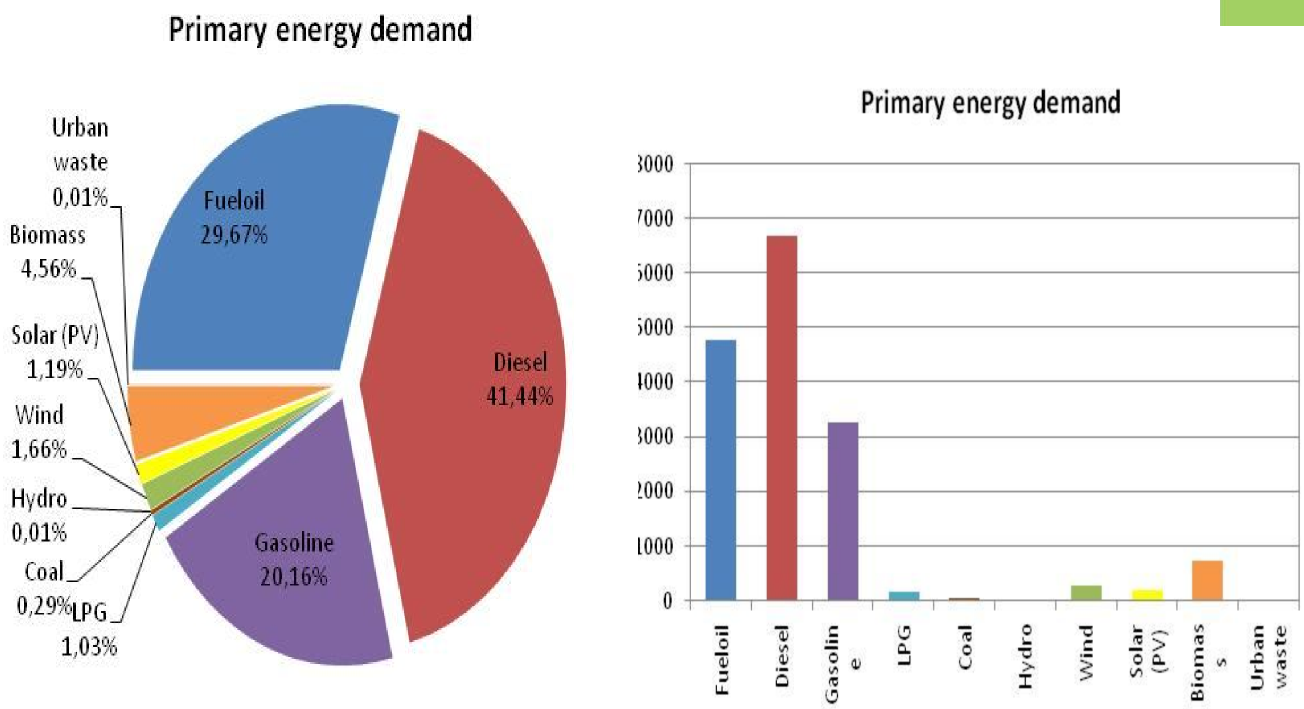



**Figure 3.3.46. Energy carriers share to primary energy demand (2005)**

| Year | PRIMARY ENERGY SOURCE | | | | | | |
|---|---|---|---|---|---|---|---|
| | Fossilfuels | | | | | | TOTAL |
| | Fueloil | Diesel | Gasoline | LPG | Coal | Sub-total | |
| 2005 | 4.792.829 | 6.697.431 | 3.257.322 | 165.962 | 46.500 | **14.956.623** | **16.118.138** |
| | Renewableenergysources | | | | | | |
| | Hydro | Wind | Solar | Biomass | Urban waste | Sub-total | |
| | 832 | 267.580 | 194.525 | 736.972 | 1.000 | **1.197.823** | |

**Table 3.3. Primary energy demand**

## 3.6 Emissions of carbon dioxide

The $CO_2$ emissions are calculated by multiplying the energy amounts with the $CO_2$ emission factors as defined by the **IPCC standards**. The share of $CO_2$ emissions per energy carrier from the final energy demand are presented inFigure 3.3.47 whereas in the total $CO_2$ emissions per energy carrier from the primary energy demand ($CO_2$ emissions from final use excluding those from electricity demand plus the emission for secondary energy production converted to primary energy demand).

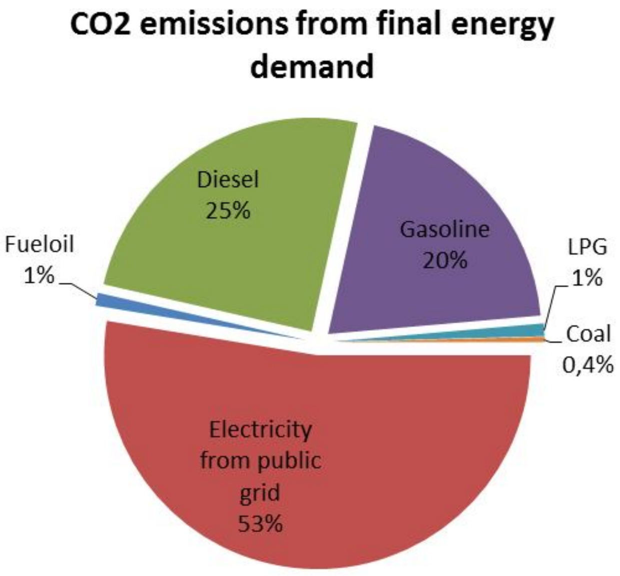
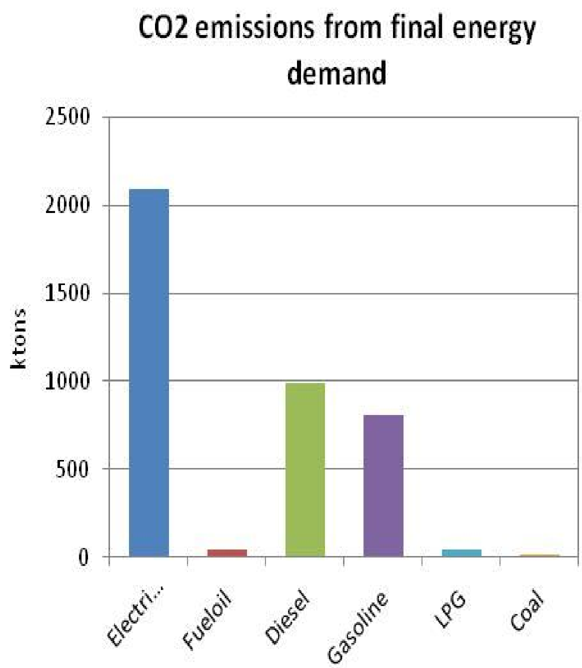



**Figure 3.3.47. $CO_2$ emissions from final energy demand**



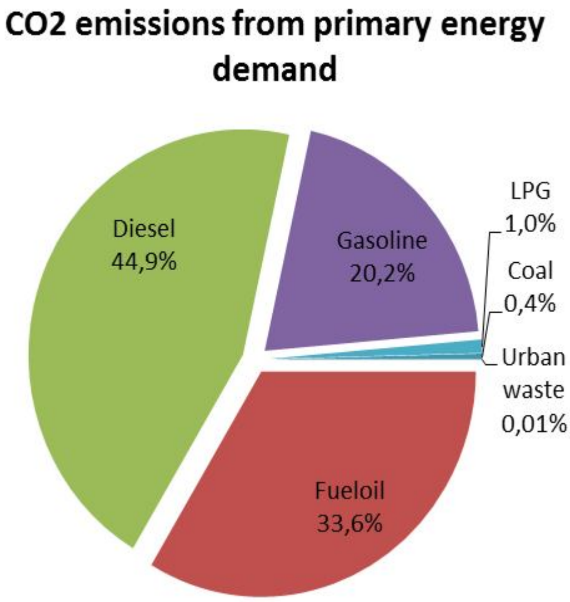
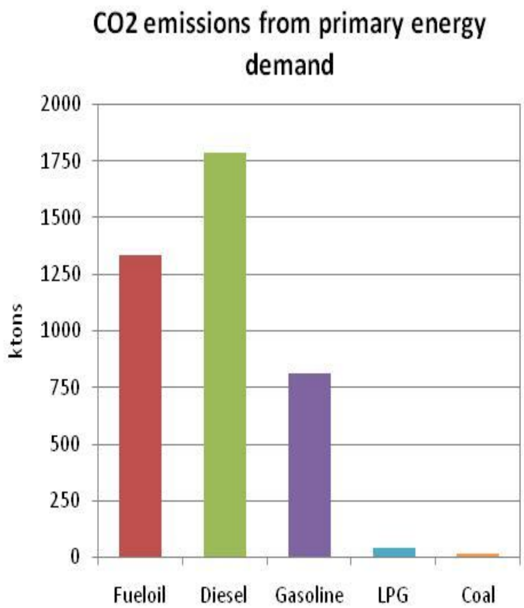




**Figure 3.3.48. CO2 emissions from primary energy demand**



In the following table the absolute values of the $CO_2$ emissions from final and primary energy demand are presented. The first represent the emissions emitted from direct consumption of energy sources while the latter of energy sources that where converted to electricity before being consumed.

| $CO_2$ emissions from final energy demand [t] | | | | | | |
|---|---|---|---|---|---|---|
| Electricity | Fueloil | Diesel | Gasoline | LPG | Coal | TOTAL |
| 2094191 | 38901 | 991741 | 811073 | 398301 | 16461 | 3992198 |
| $CO_2$ emissions from primary energy demand [t] | | | | | | |
| Fueloil | Diesel | Gasoline | LPG | Coal | Urbanwaste | TOTAL |
| 1337199 | 1787300 | 811073 | 398301 | 16461 | 333 | 3992198 |

**Table 3.4. $CO_2$ emissions from final and primary energy demand**

## 3.7 Business as Usual scenario (BAU)

The BAU scenario depicts the development of Crete's energy system taking as a starting (baseline) year 2005, assuming that this development will follow a linear process until the target year 2020. This means that no special measures will be taken to reduce $CO_2$ emissions either by introducing more RES in the energy mix or increasing energy efficiency and reducing energy consumption. In a few words the energy system will retain the status quo making sure that the expected increasing energy demand will be secured by the energy production.

### 3.7.1 Energy modeling (2006 – 2010) – Historical data

Adopting 2005 as the baseline year, a planning period of five years, until 2010, is already known. The electricity production data available from the PPC's annual reports combined with the final electricity consumption available from the statistical authority made possible the accurate calculation of the electricity production and demand for the years 2006 – 2010. To avoid extra calculations, the rest of the final energy demand (except of centralized electrical services), consumed directly from the end users, is assumed to follow the same growth rates as the ones of the electricity demand.

The growth rates for each useful energy need are estimated according to the growth rates of the greater sectors and the alterations in the financial and social activities.

In the following data the historical data of electricity demand are presented:

| Year | Electricity demand [GWh] | Annual growth rate [%] |
|---|---|---|
| 2005 | 2654 | - |
| 2006 | 2830 | 6.6 |
| 2007 | 2958 | 4.5 |
| 2008 | 3044 | 2.9 |
| 2009 | 2977 | -2.2 |
| 2010 | 3010 | 1.1 |

**Table 3.5. Electricity demand – Electricity growth rate 2005 – 2010**

In the next table is shown the electricity production per energy carrier as it got formulated the past years.

| Year | Fuel-oil [GWh] | Diesel [GWh] | Wind [GWh] | Hydro [GWh] | PV [GWh] |
|---|---|---|---|---|---|
| 2006 | 1.568 | 1.023 | 355 | 0,43 | 1,5 |
| 2007 | 1.465 | 1.208 | 393 | 0,33 | 1,7 |
| 2008 | 1.816 | 908 | 430 | 0,82 | 1,9 |
| 2009 | 1.898 | 719 | 462 | 0,72 | 7,2 |
| 2010 | 1.939 | 703 | 456 | 0,45 | 21,7 |

**Table 3.6. Electricity production per energy carrier 2005 – 2010**

## 3.7.2 Energy modeling (2011 – 2020) – Forecasted data

The energy modeling for the forecasted period (2011 – 2020) of the BAU scenario is based on the reliable analysis for the development of the electrical network of Crete and the possible interconnection with the mainland. This study was carried out by the **Regulatory Authority for Energy (RAE), the Hellenic Transmission System Operator (HTSO) and Public Power Corporation (PPC) and got published on April 2011 setting the foundations for Crete's future energy system**.

Adopting the findings of this study results to a top-down analysis since the growth rates for the electrical system development are known. The same growth rates are assumed also for the rest of the energy carriers in the final energy demand. However, it should be noted that the growth rates are estimated according to past trends and they are subject to change in future re-estimations. According to the published study, different scenarios are considered for the future development of Crete's electrical network where the interconnections with mainland define the main alternative and more innovative scenarios providing possibilities for extensive penetration of RES in the electrical system.

**The BAU scenario does not consider the interconnection possibility of Crete with the mainland electrical network**. It preserves the current autonomous electrical system based mainly on fossil fuels (fuel oil, diesel). The BAU scenario is defined by the following characteristics:

- Autonomous electrical system
- Fuel oil and diesel supplied generators
- Introduction of 100MW diesel generators (fuel oil supplied) in 2014 in the Atherinolakos power station substituting 61,2MW of steam generators in Linoperamata (LIN1, LIN2, LIN3, LIN4)
- Introduction of 50MW diesel generators (fuel oil supplied) in 2018 substituting 50MW of steam generators in Linoperamata (LIN5, LIN6)
- Linearly decrease the share of gas turbines (diesel supplied) to 15% of total electricity production by 2020
- Penetration of RES up to 30% of the annual peak demand
- Minor increase in energy efficiency (2011 – 2015: 0.2%, 2016 – 2020: 0.1%)
- Transports growth rate decaying until 2020 since it is assumed to have reached the peak demand in the present situation (2011 – 2015: 1.2%, 2016 – 2020: 0.6%)
- The growth rate of most sectors is assumed to follow more or less the developing trend of the electricity demand
- New RES installations already planned to operate in the following period are taken into account (PV's, wind-hydro hybrid systems, solar thermal units)
- The energy conversion factors and the distribution losses are considered stable for the modeling period

The forecasted electricity demand and the forecasted RES installations for centralized electricity production are presented in the following tables[1]:

| Year | Electricity demand [GWh] | Annual growth rate [%] | Peak demand [MW] |
|---|---|---|---|
| 2010 | 3010 | - | 638 |
| 2015 | 3476 | 2.9 | 740 |
| 2020 | 4032 | 3.0 | 840 |

**Table 3.7. Forecasted electricity demand – peak demand 2010 – 2020 (BAU scenario)**

[1] The hydro plant is negligible and is not presented in the following table. Although its production shows a decreasing trend, for the BAU scenario it is assumed that the energy production will remain constant for the ISEAP implementation period.

| Year | Wind | | Wind-hydro | | PV | | Solar thermal | |
|---|---|---|---|---|---|---|---|---|
| | [MW] | [GWh] | [MW] | [GWh] | [MW] | [GWh] | [MW] | [GWh] |
| 2010 | 166,7 | 456 | 0 | 0 | 30,7 | 21,7[2] | 0 | 0 |
| 2015 | 185 | 508 | 7,4 | 13 | 40 | 56 | 5 | 13 |
| 2020 | 201,6 | 554 | 10,1 | 18 | 50 | 70 | 10 | 26 |

**Table 3.8 Forecasted RES development 2010 – 2020 (BAU scenario)**

### 3.7.3 BAU scenario results

From the following figures it can be observed the increasing growth trend of the final energy demand in total (see Figure 3.3.49) and analyzed per sector (see Figure 3.3.50). The effect of financial national crisis is depicted in the energy values in year 2009. The energy demand for the tertiary and residential sectors appear to have the highest growth rates resulting to a more rapid increase until 2020. The primary and secondary sectors appear to have the smaller energy demand growth rate increase. This is explained by the expectation that tourism will continue to represent the highest part of the local GDP, intensifying its role through time.

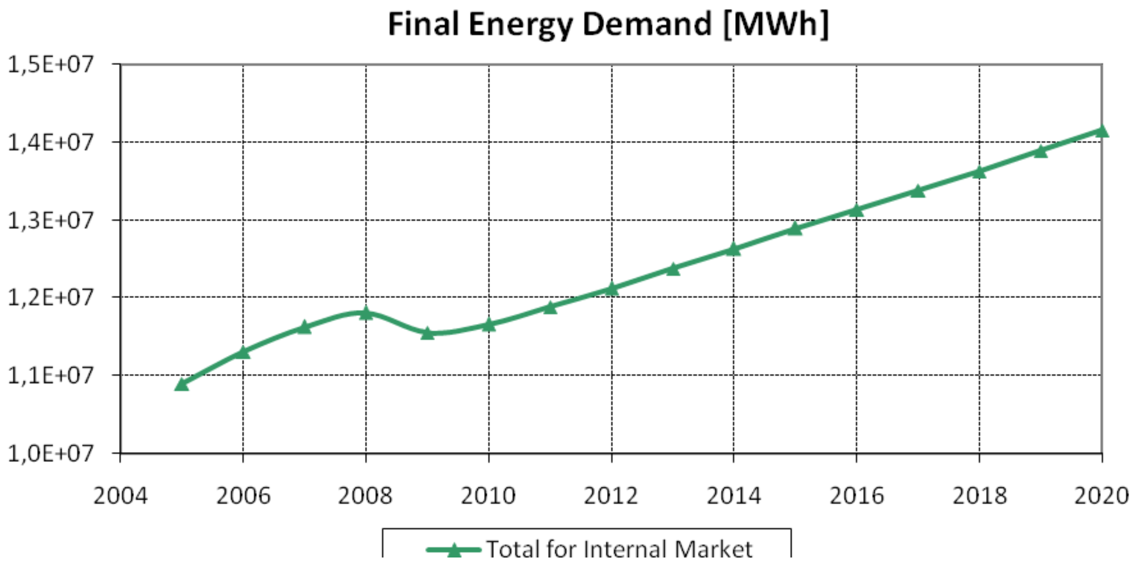



**Figure 3.3.49. BAU scenario growth trend of total final energy demand**

[2] It should be noted that the energy production from the installed PV units in 2010 does not correspond to the installed capacity (a minimum energy intensity of 1400MWh/MW is estimated) since the majority of the PV units were installed close to the end of the year.

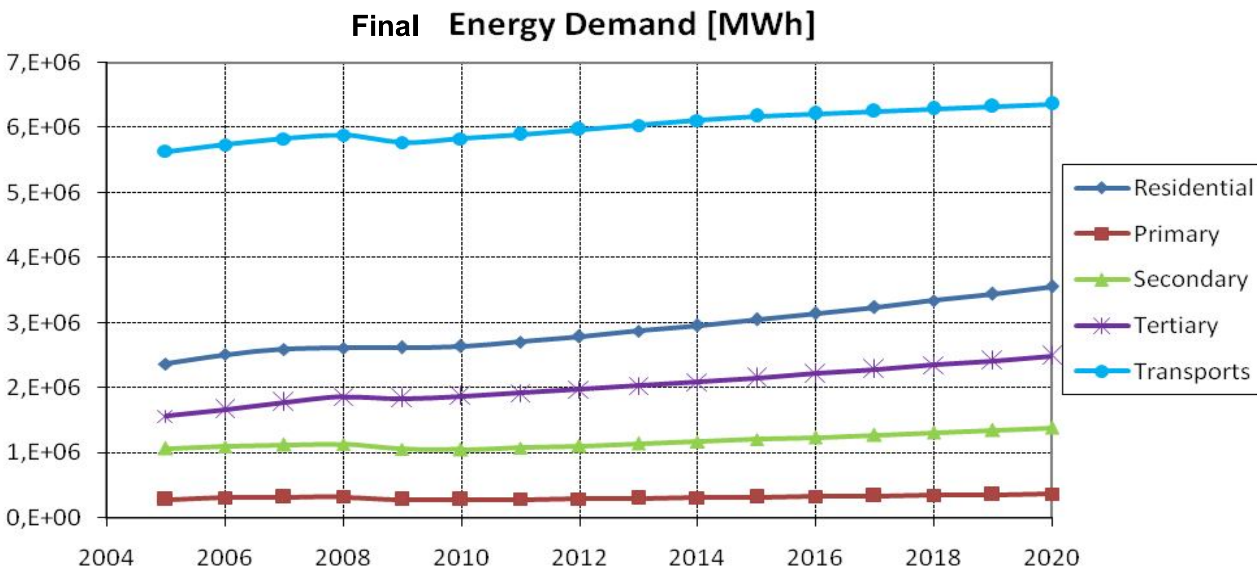



**Figure 3.3.50. BAU scenario growth trend of final energy demand per sector**

The $CO_2$ emissions from final use follow a similar trend as the final energy demand per sector. The emission factor (tons/MWh) for the transportation sector it appears to be lower than the resperctive for the residenatial and tertiary sectors resulting to a convergence of CO2 emissions from the 3 sectors by 2020.

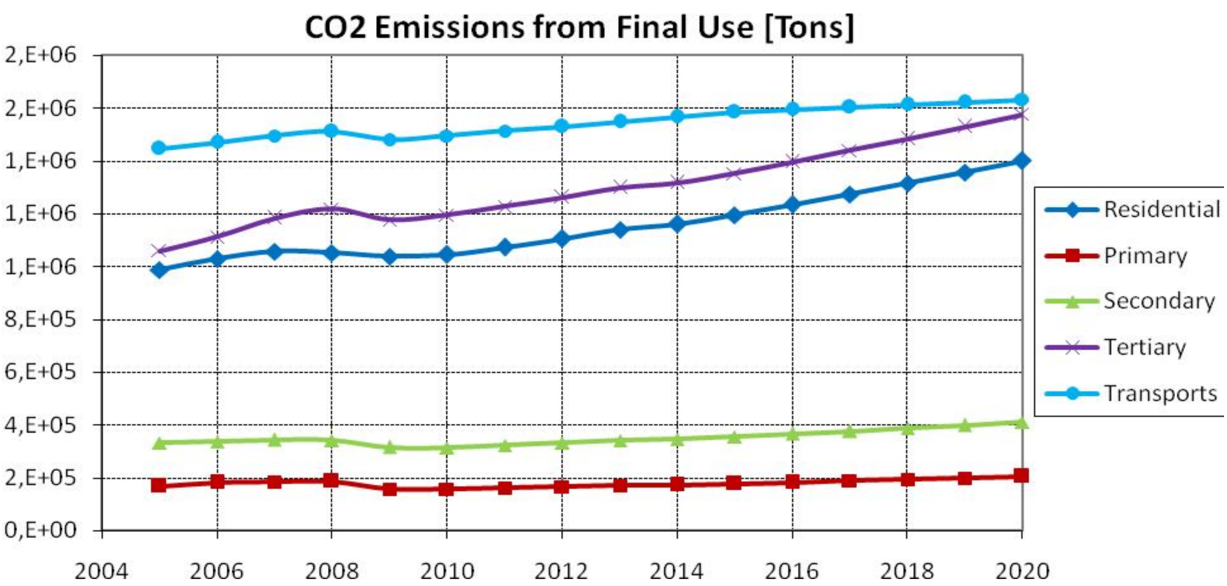



**Figure 3.3.51. BAU scenario growth trend of CO2 emissions from final use per sector**

According to the secondary energy production growth trend (see Figure 3.3.52), the participation of RES in the energy mix is intensified by 2020 representing the 16% from 10% in 2005 of total energy production.

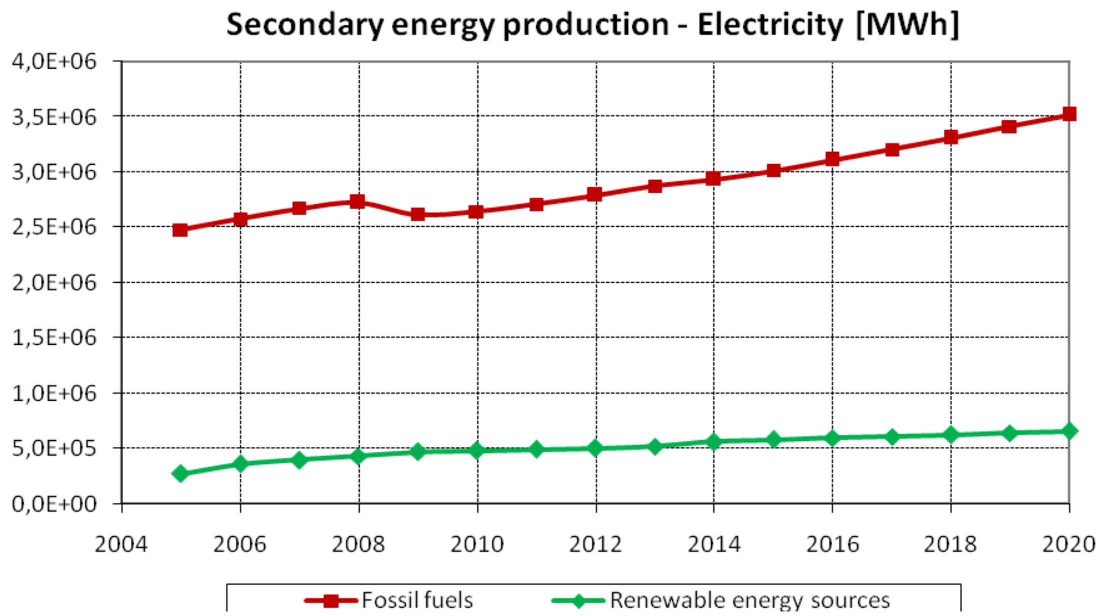



**Figure 3.3.52. BAU scenario growth trend of secondary energy production based on fossil fuels and renewable energy sources**

Also the primary energy demand (see Figure 3.3.53) follows the growth rate of the final energy demand where after the short period of decreasing trend (2008 – 2009) the energy demand retains an almost linear increasing trend.

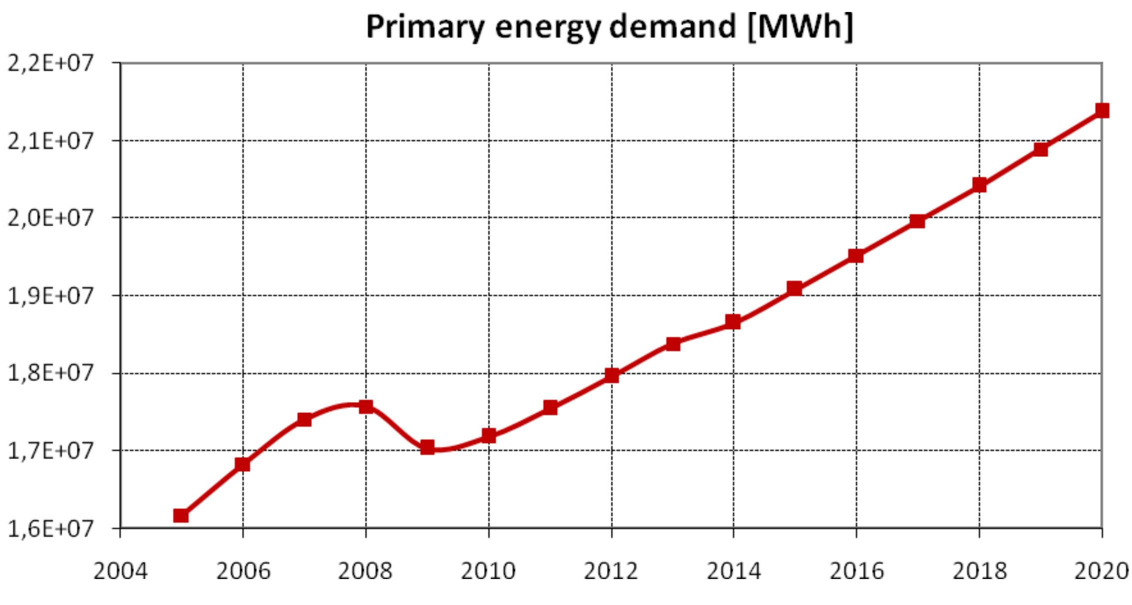



**Figure 3.3.53. BAU scenario growth trend of primary energy demand**

The total CO2 emissions (see Figure 3.3.54), based on the primary energy demand, follow the same growth trend as the primary energy itself and from almost 3991kt of CO2 in 2005 they get as high as 5228kt in 2020, designating an increase of **~31%** of CO2 emissions in 2020 in comparison to 2005 levels.

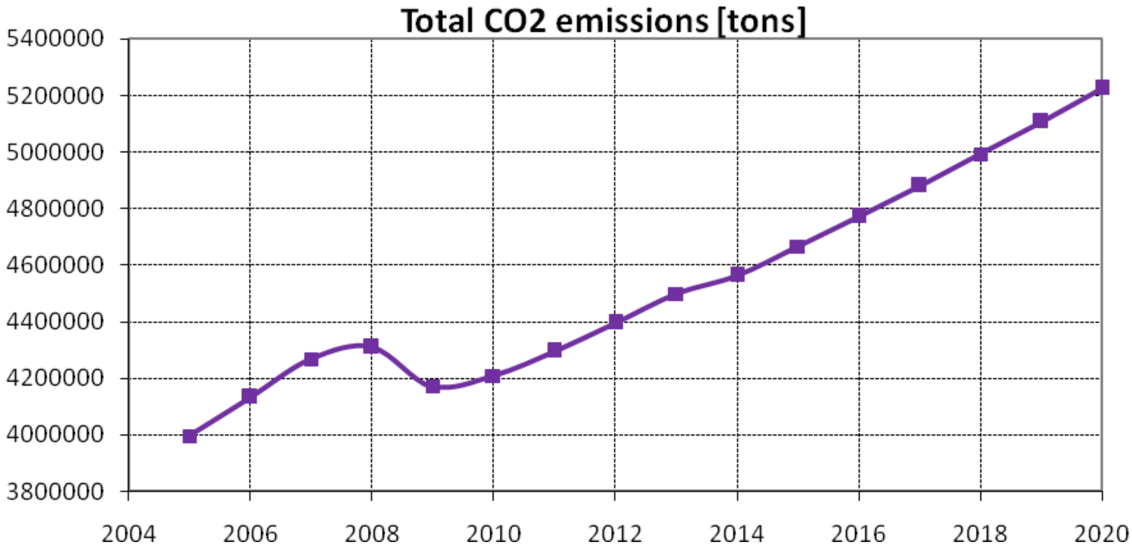



**Figure 3.3.54. BAU scenario growth trend of the total CO2 emissions**

# 4 ACTIONS

**Three** scenarios were considered for the ISEAP development of Crete.Those are based on **the two possible future electricity production profiles of the island**.

- The **first** is based on the assumption that the island will remain electrically autonomous until 2020 and that natural gas will be introduced in the electricity production fuel mix in 2020.
- The **second and third scenario** are based on the assumption that the island will be interconnected to the mainland in 2017 permitting further introduction of RES units.

Further analysis of the electrical production profile and the respective actions of each scenario will be analyzed in the secondary energy conversion chapter following.

For all scenarios a variety of Demand Side Management (DSM) actions are planned which are presented in the following chapter 4.1.

## 4.1 Final energy demand

For all **three scenarios** it is crucial to promote and implement actions related to the demand side. These actions are considered unchanged for all the scenarios.

For each demand sector (residential, secondary, tertiary and transports), and the respective subsectors, three (3) main categories of actions are introduced:

1. Reduction of annual energy growth rate by promoting energy saving measures
2. Increase of energy efficiency by promoting the use of energy efficient systems
3. Reduction of conventional energy systems by promoting substitution or introduction of energy systems based on RES or energy saving technologies.

It should be pointed out that the overall energy demand and $CO_2$ reduction is not derived as the absolute sum of the effect from the actions implemented in each individual sector but as the effect of introducing the full action plan.

However, in the following paragraphs the individual effect of each category of actions for every sector (grouping the sub-sector effects) will be presented to show the relative profit from the actions planned.

### 4.1.1 Actions planned for the residential sector

For the residential sector the Region of Crete and its Regional Energy Agency in collaboration with the local authorities will function as promoter of sustainable energy development with a multilevel approach. The description of the actions planned for each category follows:

***Actions R1:*** Reduction of the annual residential energy demand growth rate by 10%, incomparison to the growth rates forecasted in the BAU scenario by promoting the implementation of everyday energy saving measures from the consumers:

**Description:** An action mainly directed to the **energy demand behavior** of the consumers. Leaflets will be distributed in public to the citizens to inform them about the possible energy saving measures in their houses by adopting sustainable energy consumption behaviors while consuming **hot water, heating and cooling the house, while cooking and using the lighting and the electrical appliances**.

- Reduce the hot water consumption (use it consciously when you really need it)
- Reduce the heating and cooling operating hours (adjust the thermostat temperature to a reasonable constant temperature, reduce the temperature during nighttime, avoid covering the heaters, etc.)
- Reduce the lighting energy load (remember to close the light when you exit a room, avoid using the lamps when there is sufficient natural light, avoid over-lighting rooms)
- Reduce the cooking energy demand (cover the pots with their lids while cooking)
- Reduce the electricity demand **ofelectrical** appliances (avoid stand-by load, remember to turn off appliances when they are not anymore in use, etc.)

Additionally a **questionnaire** will be distributed among a representative group of different types of residencies in the different geographical areas of the island before and after the measure to realize its effectiveness.

**Result:**The increase percentage of total $CO_2$ emissions by 2020 in comparison to 2005 levels is reduced by **1.11%**, from 30.97% (BAU scenario) to 29.86% accounting for **44263 tons**of $CO_2$ savings.

***Actions R2:*** Increase the energy efficiency of residential energy consuming systems by promoting the **replacement or upgrade of old systems** from the consumers

**Description:** For each sub-sector specific actions are planned focusing on the energy systems that can be easily upgraded and become more efficient.

*Heating:*

- Energy saving systems in the heat production units (boiler compensation, network insulation, circulators with inverter, thermostatic valves, solar thermal for space heating, etc.)
- Retrofitting measures (wall and roof insulation, windows frame replacement, etc.)

*Cooling:*

- Increase by 30% the energy efficiency of air-conditioning systems by 2020 through the promotion of air-conditioning with inverter (energy class A, A+)

*Lighting:*

- Increase by 20% the energy efficiency of lighting systems by 2020 through the promotion of energy efficient lamps (CF and LED lighting)

*Cooking/Electrical appliances:*

- Increase by 20% the energy efficiency of cooking/electrical appliances by 2020 through the promotion of old devices substitution with more efficient ones (labeled with at least energy class B according to the EU standards)

Leaflets and informative material will be distributed in public to the citizens to inform them about the possible measures to increase the efficiency of the energy consuming systems in their houses.

Additionally **questionnaires** will be distributed among a representative group of different types of residencies in the different geographical areas of the island before and after the measure to realize its effectiveness.

**Result:** The increase percentage of total $CO_2$ emissions by 2020 in comparison to 2005 levels is reduced by **4.03%**, from 30.97% (BAU scenario) to 26.94% accounting for **161017 tons** of $CO_2$ savings.

***Actions R3:*** Increase the penetration of **residential heating and hot water systems** supplied by **renewable energy sources** by promoting the adoption of new technologies.

**Description:** For each sub-sector actions are planned focusing on specific technologies which are mature, affordable and adequate for the special characteristics and the RES potential of Crete.

*Hot water:*

- Increase to 50% the total hot water energy demand supplied from solar thermal by 2020.The action is supported by the new regulation (KENAK) for the buildings energy efficiency according to which all new buildings and the old ones extensively renovated in order to receive the essential energy certificate should be supplied by solar water heating systems covering at least the 60% of the respective energy needs.
- Increase to 20% the total hot water energy demand supplied from biomass by 2020

*Heating:*

- Increase to 30% the total space heating energy demand supplied from biomass by 2020. The use of biomass (mainly olive kernel residues and other biomass potential e.g. pellets provided by the agricultural and forestry sector) is promoted to cover the combined needs of hot water and heating.

- Increase by 20% the total space heating energy demand supplied from heat pumps by 2020. Although the air to air or air to water heat pumps increase the electricity demand, direct consumption of fossil fuels (diesel) is avoided and the extra electricity need will be able to be compensated by RES production in the secondary sector. Solar geothermy is also included in this category.

Leaflets and informative material will be distributed in public to the citizens to inform them about the advantages of using heating and hot water systems supplied by RES for their houses.

Additionally a questionnaire will be distributed among a representative group of different types of residencies in the different geographical areas of the island before and after the measure to realize its effectiveness.

**Result:** The increase percentage of total $CO_2$ emissions by 2020 in comparison to 2005 levels is reduced by **3.56%**, from 30.97% (BAU scenario) to 27.41% accounting for **142189 tons** of $CO_2$ savings.

**Overall Results:** Combining the three action categories the increase percentage of total $CO_2$ emissions by 2020 in comparison to 2005 levels is reduced by **8.55%**, from 30.97% (BAU scenario) to 22.42% accounting for **341444 tons** of $CO_2$ savings (see Figure 4.1.1).

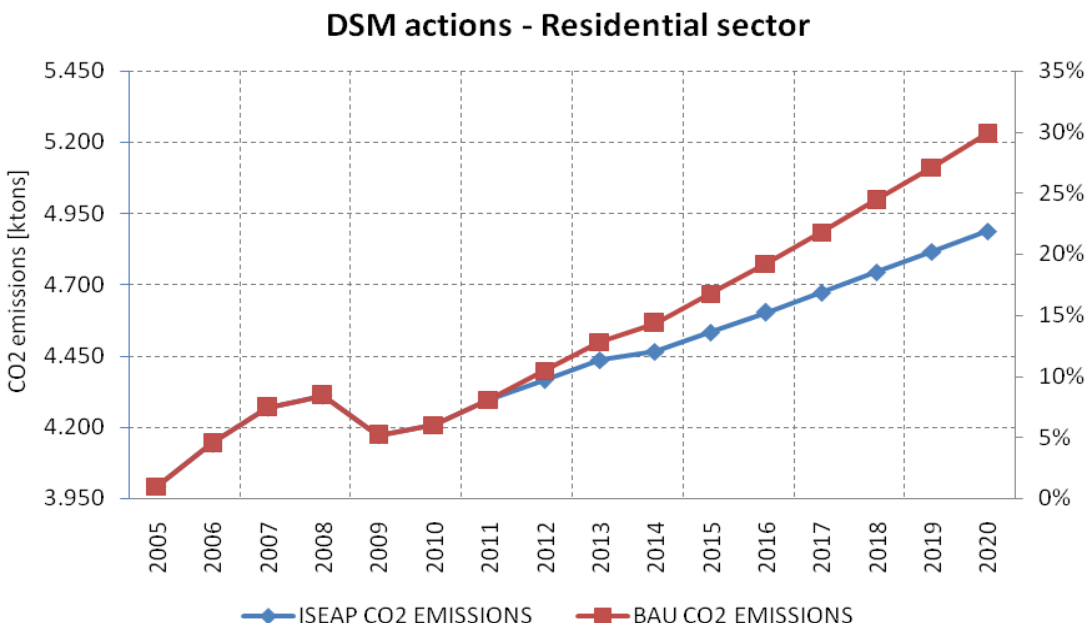



**Figure 4.1.1. CO2 emissions development before and after DSM actions in the residential sector**

Also in the following table (see Table 4.1) is shown the primary energy demand change after implementing the DSM actions for the residential sector in comparison to the BAU scenario as an accumulated effect in year 2020. In the first line of the table the absolute change per energy carrier is shown whereas on the second line the percentage change.

A significant increase of RES and decrease of fossil fuels but also of the total primary energy demand is observed.

| | Fossil fuels | | | | Renewable energy sources | | | |
|---|---|---|---|---|---|---|---|---|
| | **Fueloil** | **Diesel** | **LPG** | **Sub-total** | **Solar** | **Biomass** | **Sub-total** | **TOTAL** |
| MWh | -820078 | -401979 | -22140 | -1244198 | 156550 | 61519 | 218069 | -1026128 |
| % | -9.39 | -5.97 | -9.00 | -6.40 | 45.42 | 6.07 | 11.23 | -4.80 |

**Table 4.1. Primary energy demand change after DSM actions for the residential sector**

## 4.1.2 Actions planned for the primary sector

For the primary sector the Region of Crete and its Regional Energy Agency in collaboration with the local authorities and the agricultural and fishing associations will function as promoter of sustainable use of energy consumption by the professionals of the sector. The actions are mainly focused on the reduction of the energy demand growth rate and the increase of energy efficiency of the systems used in the sector. The description of the actions planned for each category follows:

***Actions P1:*** Reduction of the agricultural and fishing[3]annual energy demand growth rate by 10%, in comparison to the growth rates forecasted in the BAU scenario by promoting the implementation of everyday energy saving measures by the professionals.

**Description:** An action mainly directed to the **energy demand behavior** of the professionals working in the agriculture and fishing sectors. Leaflets will be circulated and other raise awareness actions addressed to the professionals related to the specific sector to inform them about the possible energy saving measures.

Additionally a questionnaire will be distributed among a representative group of professionals(with the assistance of the associations) in the different geographical areas of the island before and after the measure to realize its effectiveness.

**Result:**The increase percentage of total $CO_2$ emissions by 2020 in comparison to 2005 levels is reduced by **0.15%**, from 30.97% (BAU scenario) to 30.82% accounting for **5938tons** of $CO_2$ savings.

[3]Main activities of the primary sector in Crete

***ActionP2:*** Increase by 20% (in comparison to BAU scenario)the energy efficiency of electrical-mechanical systems (energy consuming) used in the wider agricultural sector and especially in greenhouses by 2020 through the promotion of old systems' upgrading or substitution with new more efficient ones

**Description:** This action is explicitly focused on the agricultural sector, and mainly in **greenhouse installations** which have a significant contribution to Grete's local GDP, in order to promote energy saving through the adoption of **advanced electrical-mechanical systems** with increased energy efficiency and minimization of resources consumption.

Leaflets and informative material will be distributed to the professionals related to the specific sector to inform them about the energy and raising awareness addressed actions saving and financial advantages of buying new or substituting old electrical-mechanical systems with energy efficient ones. The possible financial support from national or European funding schemes will also be promoted.

Additionally a questionnaire will be distributed among a representative group of different types of professionals of the primary sector in the different geographical areas of the island before and after the measure to realize its effectiveness.

**Result:** The increase percentage of total $CO_2$ emissions by 2020 in comparison to 2005 levels is reduced by **1.21%**, from 30.97% (BAU scenario) to 29.76% accounting for **48406 tons** of $CO_2$ savings.

**Overall Results: Combining the three action categories** the increase percentage of total $CO_2$ emissions by 2020 in comparison to 2005 levels is reduced by **1.33%**, from 30.97% (BAU scenario) to 29.64% accounting for **53158 tons** of $CO_2$ savings (see **Figure 4.1.2**).

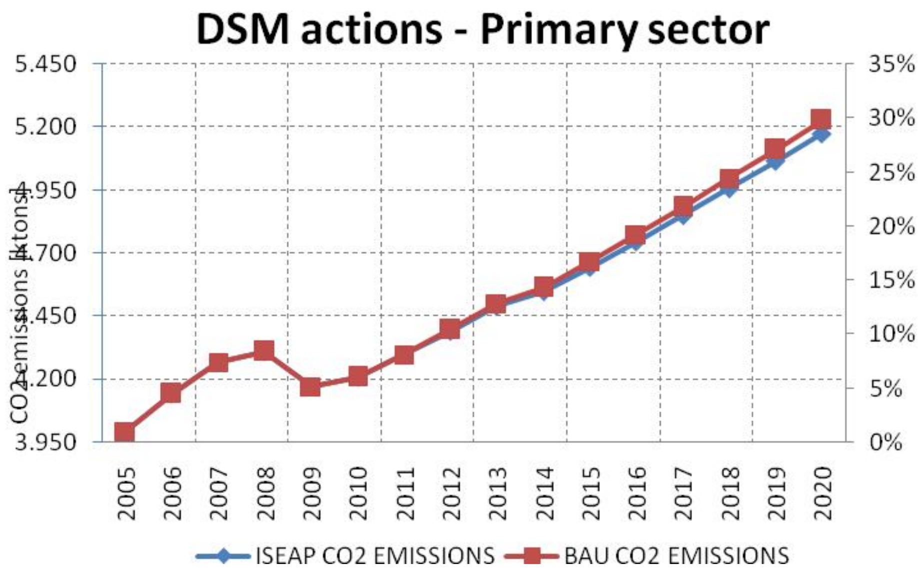



**Figure 4.1.2. CO2 emissions development before and after DSM actions in the primary sector**

Also in the following table (see Table 4.2) is shown the primary energy demand change after implementing the DSM actions for the primary sector in comparison to the BAU scenario as an accumulated effect in year 2020. In the first line of the table the absolute change per energy carrier is shown whereas on the second line the percentage decrease.

A minor decrease of fossil fuels but also of the total primary energy demand is observed. The planning of further action to be included in the ISEAP can be made possible in the implementation and monitoring period, in this case the list of actions for the primary sector will be updated accordingly.

| | Fossil fuels | | | Renewable energy sources | | |
|---|---|---|---|---|---|---|
| | Fueloil | Diesel | Sub-total | Biomass | Sub-total | TOTAL |
| MWh | 140553 | 52224 | 192777 | 12014 | 12014 | 204791 |
| % | 1.61% | 0.78% | 0.99% | 1.19% | 0.62% | 0.96% |

**Table 4.2. Primary energy demand change after DSM actions for the primary sector**

## 4.1.3 Actions planned for the secondary sector

For the secondary sector the Region of Crete and its Regional Energy Agency in collaboration with the local authorities the professionals and the respective associations of the manufacturing and construction sectors but also the local authorities themselves as operators of the water supply, sewerage, waste management and remediation activities will function as promoters and actors of sustainable use of energy consumption by the professionals of the sector. The actions are mainly focused on the reduction of the energy demand growth rate and the increase of energy efficiency of the systems used in the sector. The description of the actions planned for each category follows:

***Actions S1:*** Reduction of the secondary sector annual **energy demand growth** rate by 10%, incomparison to the growth rates forecasted in the BAU scenario, by promoting the implementation of everyday energy saving measures by the professionals/owners/employees/consumers.

**Description:** An action mainly directed to the **energy demand behavior** of the professionals/owners and employees related to the manufacturing and construction sectors but also the consumers making use of the facilities related to the water supply, sewerage, waste management and remediation activities. Leaflets will be circulated and raising awareness activities addressed to the professionals/owners/employees and consumers related to the respective sub-sectors of the secondary sector to inform them about the possible energy saving measures that they can implement in the everyday use of energy consuming equipment or facilities.

Additionally questionnaires will be distributed among representative groups of users from the different sub-sectors (with the assistance of the associations and the local authorities) in the different geographical areas of the island before and after the measures to realize their effectiveness.

**Result:** The increase percentage of total $CO_2$ emissions by 2020 in comparison to 2005 levels is reduced by **0.29%**, from 30.97% (BAU scenario) to 30.69% accounting for **11395 tons** of $CO_2$ savings.

***Actions S2:*** Increase by 20% (in comparison to BAU scenario) the energy efficiency of the energy consuming systems used in the secondary section by 2020 by promoting the introduction of new or substitution of old with new more efficient ones.

**Description:** This action is focused on the different energy systems used in the sub-sectors of the secondary sector, in order to promote energy saving through the **adoption of technological advanced systems with increased energy efficiency**. Specifically:

- For the manufacturing and construction sub-sectors the substitution of old energy inefficient systems with new more efficient ones will be promoted.
- For the water supply, sewerage, waste management and remediation activities subsector the local authorities in collaboration with the respective public/municipal companies will either install inverters to existing pumping stations or substitute old stations with new efficient ones.

Leaflets and informative material will be distributed to the owners of manufacturing and construction units to inform them about the energy saving and financial advantages of buying new or substituting old systems with energy efficient ones.

Similarly communication and collaboration between the local authorities and the water supply, sewerage, waste management and remediation activities public/municipal companies will aim to prioritize the upgrade of existing pumping stations to energy efficient units.

Additionally a questionnaire will be distributed among a representative group of different types of professionals of the secondary sector in the different geographical areas of the island before and after the measure to realize its effectiveness.

**Result:** The increase percentage of total $CO_2$ emissions by 2020 in comparison to 2005 levels is reduced by **2.56%**, from 30.97% (BAU scenario) to 28.42% accounting for **102015tons**of $CO_2$ savings.

**Overall Results: Combining the three action categories** the increase percentage of total $CO_2$ emissions by 2020 in comparison to 2005 levels is reduced by **2.33%**, from 30.97% (BAU scenario) to 29.64% accounting for **92898 tons** of $CO_2$ savings (see Figure 4.1.3).

Also in the following table (see Table 4.3) is shown the primary energy demand change after implementing the DSM actions for the secondary sector in comparison to the BAU scenario as an accumulated effect in year 2020. In the first line of the table the absolute change per energy carrier is shown whereas on the second line the percentage decrease.

A decrease of fossil fuels but also of the total primary energy demand is observed. The planning of further action to be included in the ISEAP can be made possible in the implementation and monitoring period; in this case the list of actions for the secondary sector will be updated accordingly.

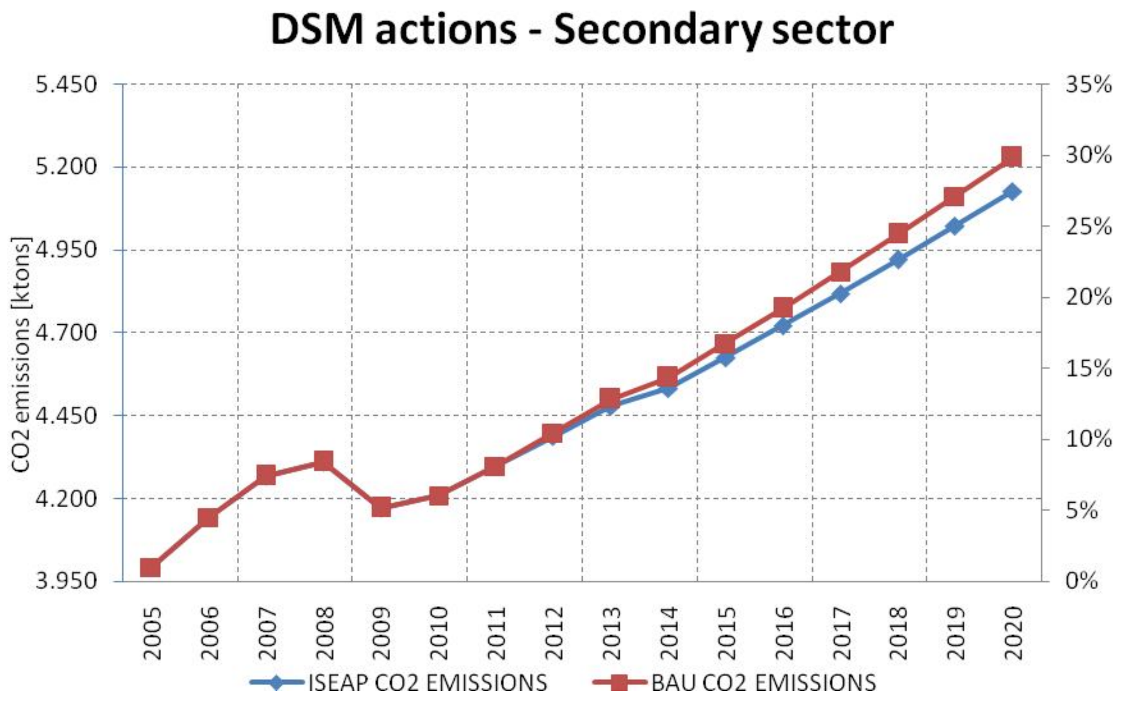



**Figure 4.1.3. CO2 emissions development before and after DSM actions in the secondary sector**

| | Fossil fuels | | | | | Renewable energy sources | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Fueloil | Diesel | LPG | Coal | Sub-total | Solar | Biomass | Sub-total | TOTAL |
| MWh | 246845 | 102858 | 4181 | 13218 | 367102 | 2353 | 117508 | 119862 | 486964 |
| % | 2.83% | 1.53% | 1.70% | 21.96% | 1.89% | 0.68% | 11.60% | 6.17% | 2.28% |

**Table 4.3. Primary energy demand change after DSM actions for the secondary sector**

### 4.1.4 Actions planned for the tertiary sector

For the tertiary sector the actions included in the ISEAP are grouped in **three main groups**. The **first** related to the **commercial** sector including the wholesale and retail trade and the other services sub-sectors, the **second** related to the **tourism** sector including the accommodation and food service activities sub-sectors and the **third** related to the **public sector** including the general public administrations and social security, education, human health and social work activities and public lighting sub-sectors.

For each group of actions the Region of Crete and its Regional Energy Agency in collaboration with the local authorities will function either as a promoter or an actor for the sustainable energy development of the respective sectors. The separate description of the actions planned and the respective overall results ofeach group follow:

***Commercial sector*** *(Wholesale and retail trade – Other services)*

***Actions TC1:*** Reduction of the annual commercial energy demand growth rate by 10%, incomparison to the growth rates forecasted in the BAU scenario by promoting the implementation of everyday energy saving measures from the owners and employees

**Description:** An action mainly directed to the **energy demand behavior** of the people running or employed in businesses of the commercial sector. Leaflets will be distributed and raising awareness activities addressed to the businesses of the commercial sector to inform them about the possible energy saving measures by adopting sustainable energy consumption behavior while using energy consuming systems (heating, cooling, hot water) and appliances (electrical appliances).

Additionally a questionnaire will be distributed among a representative group of different types of businesses (mainly of different sizes, i.e. different energy needs) related to the commercial sector in the different geographical areas of the island before and after the measure to realize its effectiveness.

**Result:** The increase percentage of total $CO_2$ emissions by 2020 in comparison to 2005 levels is reduced by **0.56%**, from 30.97% (BAU scenario) to 30.41% accounting for **22266tons** of $CO_2$ savings.

***ActionsTC2:*** Increase the energy efficiency of commercial energy consuming systems by promoting the replacement or upgrade of old systems

**Description:** The promotionof specific actions is planned focusing on the **energy systems that can be easily upgraded and become more efficient** but also appearing to have the most significant energy demand among the energy consuming systems of the sector.

*Cooling:*

- Increase by 30% the energy efficiency of **air-conditioning** systems by 2020 through the promotion of air-conditioning with inverter (energy class A, A+)

*Electrical appliances:*

- Increase by 20% the energy efficiency of **cooking/electrical appliances** by 2020 through the promotion of old devices substitution with more efficient ones (labeled with at least energy class B according to the EU standards)

Leaflets and informative material will be distributed and raising awareness activities addressed to the businesses related to the commercial sector to inform them about the possible measures to increase the efficiency of air-conditioning and electrical appliances.

Additionally a questionnaire will be distributed among a representative group of different types of businesses (mainly of different sizes, i.e. different energy needs) related to the commercial sector in the different geographical areas of the island before and after the measure to realize its effectiveness.

**Result:** The increase percentage of total $CO_2$ emissions by 2020 in comparison to 2005 levels is reduced by **4.97%**, from 30.97% (BAU scenario) to 26.00% accounting for **198372 tons** of $CO_2$ savings.

***Actions TC3:*** Increase the penetration of commercial heating systems supplied by renewable energy sources by promoting the adoption of new technologies.

**Description:** Actions are planned focusing on **specific technologies** which are mature, affordable and adequate for the special characteristics and the RES potential of Crete.

*Heating:*

- Increase to 10% the total **space heating energy demand** supplied from **biomass** by 2020. The use of biomass (mainly olive kernel residues, pellets and other biomass potential provided by the agricultural and forestry sector) is promoted to cover mainly the needs for heating and partially for hot water[4] whenever there is relative demand.
- Increase by 20% the total space heating energy demand supplied from heat pumps by 2020. Although the air to air or air to water heat pumps increase the electricity demand, direct consumption of fossil fuels (diesel) is avoided and the extra electricity need will be able to be compensated by RES production in the secondary sector

Leaflets and informative material will be distributed and targeted actions will be addressed to the businesses related to the commercial sector to inform them about the advantages of using heating and hot water systems supplied by RES for their houses.

Additionally a questionnaire will be distributed among a representative group of different types of businesses (mainly of different sizes, i.e. different energy needs) related to the commercial sector in the different geographical areas of the island before and after the measure to realize its effectiveness.

**Result:** The increase percentage of total $CO_2$ emissions by 2020 in comparison to 2005 levels is increased by **0.16%**, from 30.97% (BAU scenario) to 31.13% accounting for **6229 tons** of $CO_2$. The small increase in $CO_2$emissions is because of the electricity demand increase by the introduction of heat pumps. However, as already mentioned the energy profit by replacing fossil fuels with electricity is that the latter can be produced by RES as will be shown in the secondary energy production sector.

**Overall Results:** Combining the three action categories the increase percentage of total $CO_2$ emissions by 2020 in comparison to 2005 levels is reduced by **5.29%**, from 30.97% (BAU scenario) to 25.68% accounting for **211280 tons** of $CO_2$ savings (see Figure 4.1.4).

[4]the majority of businesses in the commercial sector do not consume hot water

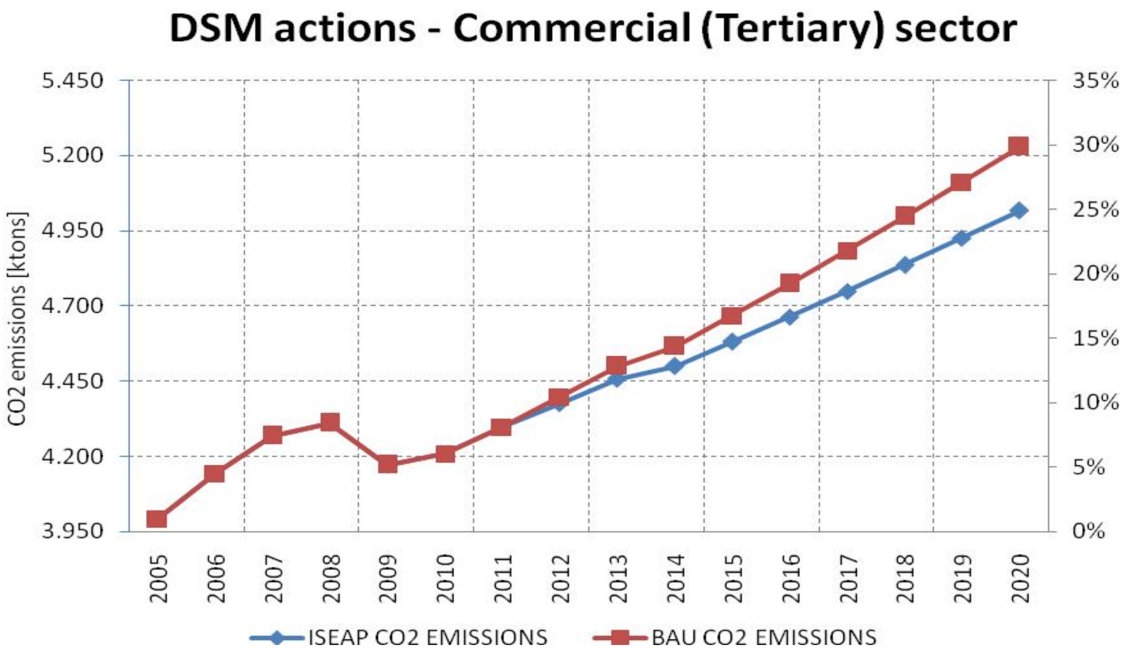



**Figure 4.1.4. CO2 emissions development before and after DSM actions in the commercial sector**

Also in the following table (see Table 4.4) is shown the primary energy demand change after implementing the DSM actions for the commercial sector in comparison to the BAU scenario as an accumulated effect in year 2020. In the first line of the table the absolute change per energy carrier is shown whereas on the second line the percentage decrease.

A minor increase of RES and decrease of fossil fuels but also of the total primary energy demand is observed. The solar energy demand also decreases because of the general decrease of the energy demand (hot water) growth rate and not because of replacement from other technologies[5].

| | Fossil fuels | | | Renewable energy sources | | | |
|---|---|---|---|---|---|---|---|
| | Fueloil | Diesel | Sub-total | Solar | Biomass | Sub-total | TOTAL |
| MWh | 514007 | 254204 | 768210 | 3145 | -19739 | -16593 | 751617 |
| % | 5.89 | 3.78 | 3.95 | 0.91 | -1.95 | -0.85 | 3.51 |

**Table 4.4. Primary energy demand change after DSM actions for the commercial sector**

[5] The hot water produced by solar thermal is absorbed in priority (whenever there is sunshine) in relation to other systems producing hot water (biomass boilers, diesel boilers)

***Tourism sector*** *(Accommodation activities – Food service activities)*

***Actions TT1:*** Reduction of the annual tourism energy demand growth rate by 10%, incomparison to the growth rates forecasted in the BAU scenario by promoting the implementation of everyday energy saving measures from the owners, personnel and visitors

**Description:** An action mainly directed to the **energy demand behavior** of the people running, employed or being guests in hotels (rooms to let, camping) and restaurants.

Leaflets will be distributed to the businesses of the tourism sector to inform them about the possible energy saving measures by adopting sustainable energy consumption behaviors while using energy consuming systems (heating, cooling, hot water) and appliances (electrical appliances). There will be a different types of leaflets addressed to the guests in order to be informed about the efforts of the business towards sustainability and the ways they can contribute while being hosted in the hotel/restaurant and generally in the island of Crete.

Additionally a questionnaire will be distributed among a representative group of different types of businesses (mainly of different sizes, i.e. different energy needs) related to the tourism sector in the different geographical areas of the island before and after the measure to realize its effectiveness. There will be different questionnaires addressed to the owners and personnel of the businesses and different for the visitors. The latter is expected to depict the overall impression of the visitors and their willingness to participate in the efforts of the business, and in extent the island, towards the reduction target of $CO_2$ emissions and sustainable energy development.

**Result:** The increase percentage of total $CO_2$ emissions by 2020 in comparison to 2005 levels is reduced by **0.47%**, from 30.97% (BAU scenario) to 30.50% accounting for **18908tons** of $CO_2$ savings.

***Actions TT2:*** Increase the energy efficiency of energy consuming systems used in the tourism sector by promoting the replacement or upgrade of old systems

**Description:** The promotionof specific actions is planned focusing on the **energy systems that can be easily upgraded and become more efficient** but also appearing to have the most significant energy demand among the energy consuming systems of the sector.

*Cooling:*

- Increase by 30% the energy efficiency of air-conditioning systems by 2020 through the promotion of **air-conditioning with inverter** (energy class A, A+)

*Electrical appliances:*

- Increase by 30% the energy efficiency of electrical appliances by 2020 through the promotion of old devices substitution with more efficient ones (labeled with at least energy class B according to the EU standards), by introducing the **key card electricity deactivating system** (accommodation activities sector) and by introducing **motion sensors** for the toilet lighting (accommodation and food service activities sectors)
- Increase by 30% the **energy efficiency of infrastructure** systems, like elevators and water pumps, waste treatment units, etc.

*Cooking*

- Increase by 30% the energy efficiency of **cooking** appliances by 2020 through the promotion of old devices substitution with more efficient ones

Leaflets and informative material will be distributed to the businesses related to the tourism sector to inform them about the possible measures to increase the efficiency of the different energy consuming systems.

Leaflets will be distributed to the businesses of the tourism sector to inform them about the possible measures to increase the efficiency of the different energy consuming systems. There will be a different types of leaflets addressed to the guests in order to be informed about the efforts of the business towards sustainability and the ways they can contribute while being hosted in the hotel/restaurant and generally in the island of Crete.

Additionally a questionnaire will be distributed similarly to actions TT1 to monitor the implementation and the success of the actions.

**Result:** The increase percentage of total $CO_2$ emissions by 2020 in comparison to 2005 levels is reduced by **3.67%**, from 30.97% (BAU scenario) to 27.30% accounting for **1463737 tons** of $CO_2$ savings.

***Actions TT3:*** Increase the penetration of tourism heating and hot water systems supplied by renewable energy sources by promoting the adoption of new technologies.

**Description:** Actions are planned focusing on specific technologies which are mature, affordable and adequate for the special characteristics and the RES potential of Crete.

*Heating:*

- Increase to 10% the total **space heating energy demand supplied from biomass** by 2020. The biomass resources are mainly olive kernel residues and other biomass potential (e.g. pellets) provided by the agricultural and forestry sector.
- Increase by 20% the total space heating energy demand supplied from **heat pumps** by 2020. Although the air to air or air to water heat pumps increase

the electricity demand, direct consumption of fossil fuels (diesel) is avoided and the extra electricity need will be able to be compensated by RES production in the secondary sector

*Hot water:*

- Increase to 10% the total **hot water** energy demand supplied from biomass by 2020
- Increase by 20% the total **hot water** energy demand supplied from **solar thermal** by 2020

Leaflets and informative material will be distributed in public to the citizens to inform them about the advantages of using heating and hot water systems supplied by RES for their houses.

Additionally a questionnaire will be distributed among a representative group of different types of residencies in the different geographical areas of the island before and after the measure to realize its effectiveness.

**Result:** The increase percentage of total $CO_2$ emissions by 2020 in comparison to 2005 levels is reduced by **0.16%**, from 30.97% (BAU scenario) to 30.81% accounting for **6229 tons** of $CO_2$ savings. The small decrease in $CO_2$ emissions is because of the electricity demand increase by the introduction of heat pumps (including solar geothermy systems). However, as already mentioned the energy profit by replacing fossil fuels with electricity is that the latter can be produced by RES as will be shown in the secondary energy production sector.

**Overall Results:** Combining the three action categories the increase percentage of total $CO_2$ emissions by 2020 in comparison to 2005 levels is reduced by **4.63%**, from 30.97% (BAU scenario) to 26.34% accounting for **184849 tons** of $CO_2$ savings (see Figure 4.1.5).

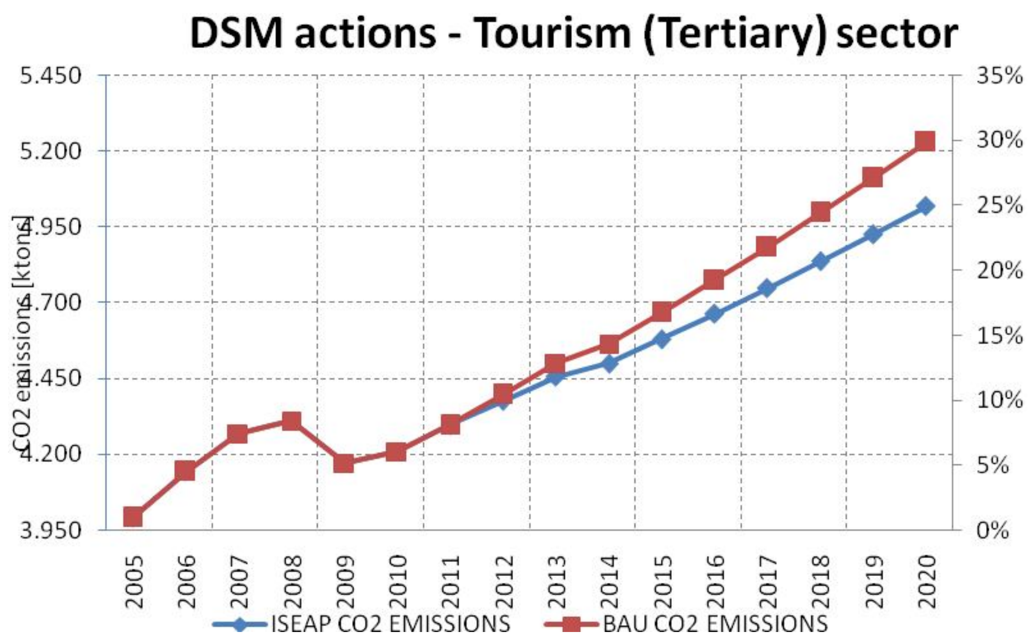



**Figure 4.1.5. CO2 emissions development before and after DSM actions in the tourism sector**

Also in the following table (see Table 4.5)is shown the primary energy demand change after implementing the DSM actions for the **tourism sector** in comparison to the BAU scenario **as an accumulated effect** in year 2020. In the first line of the table the absolute change per energy carrier is shown whereas on the second line the percentage decrease.

A significant increase of RES and decrease of fossil fuels but also of the total primary energy demand is observed.

| | Fossil fuels | | | | Renewable energy sources | | | |
|---|---|---|---|---|---|---|---|---|
| | Fueloil | Diesel | LPG | Sub-total | Solar | Biomass | Sub-total | TOTAL |
| MWh | 442275 | 224562 | 6233 | 673071 | -17589 | -18066 | -38637 | 634433 |
| % | 5.07% | 3.34% | 2.53% | 3.46% | -5.10% | -1.78% | -1.99% | 2.97% |

**Table 4.5. Primary energy demand change after DSM actions for the tourism sector**

***Public sector*** *(General administration and social security – Education – Human health and social work activities – Public lighting)*

***Actions TP1:*** Reduction of the annual public energy demand growth rate by 10%, in comparison to the growth rates forecasted in the BAU scenario by promoting the implementation of everyday energy saving measures from the civil servants, the professors and students in the education sub-sector, the employees/guests/visitorsin the human health sub-sector and the local authorities for the operation of the lighting units under their authority.

**Description:** An action mainly directed to the **energy demand behavior** of the users of the different public buildings (administration buildings, schools, health centers, hospitals, etc.) and the local authority as operator of public lighting units. Specifically for the **public lighting sector** the local authorities in collaboration with REAC and the PPC will promote the smart use of public lighting systems by reducing the operating hours of the lighting network where its use is not considered substantial.

Generally leaflets will be distributed to

- the employees of the different departments in the general public administration and social security;
- the professors of the educational sector to inform them about the possible energy saving measures in the schools. Professors teaching physics or environmental courses will promote the energy saving measures to the students through a series of presentations and possible interactive learning methods;
- the employees/guests/visitors of the health centers and hospitals;
- the citizens to inform them about the benefits (reduced municipal taxes – environmental benefits) of reducing the public lighting energy demand;

to inform them about the possible energy saving measures by adopting **sustainable energy consumption behaviors** while using energy consuming systems (heating, cooling, hot water) and appliances (electrical appliances). There will be a different types of leaflets addressed to the guests/visitors of the human health sector in order to be informed about the efforts of the local authorities, in collaboration with the respective health centers/hospitals, towards sustainability and the ways they can contribute while using the facilities.

Additionally a questionnaire will be distributed to the users of the respective sub-sectors of the public sector before and after the measure to realize its effectiveness. There will be different questionnaires addressed to the employees of the sector and different for the guests/visitors. Also, in relation to the public lighting action a questionnaire will be distributed among a representative group of households in different local authorities of the island before and after the measure to realize its effectiveness and its impact to everyday life.

**Result:** The increase percentage of total $CO_2$ emissions by 2020 in comparison to 2005 levels is reduced by **0.17%**, from 30.97% (BAU scenario) to 30.80% accounting for **6919tons** of $CO_2$ savings.

***Actions TP2:*** Increase the energy efficiency of energy consuming systems used in the public sector by replacing or promoting the replacement or upgrade of old systems

**Description:** The promotion of specific actions is planned focusing on the **energy systems that can be easily upgraded and become more efficient** but also appearing to have the most significant energy demand among the energy consuming systems of the sector.

*Cooling:*

- Increase by 30% the energy efficiency of **air-conditioning** systems by 2020 through the promotion of air-conditioning with **inverter** (energy class A, A+) in the public buildings (mainly public administration and hospital/health center buildings[6])

*Heating:*

- Increase by 30% the energy efficiency of heating systems by 2020 through the **replacement of old windows** and door frames of public buildings with more efficient ones and the introduction of more efficient **boilers**, **circulators** and **control units** (boiler compensation, thermostatic valves, etc.)

*Electrical appliances:*

- Increase by 30% the energy efficiency of **electrical appliances** used in public buildings (general administration, schools, hospitals/health centers) by 2020 through the substitution of old devices with more efficient ones (**green procurement)** and by introducing motion sensors for the toilet lighting

The REAC and local authorities of each prefecture will proceed gradually to the energy inspection of the public buildings related to the respective subsectors recording their current state and their energy consumption. The following measures will be promoted where there is a relevant potential.

- Substitution of old air-conditioning systems with energy efficient ones supplied with inverters.
- Substitution of old electrical appliances with energy efficient ones (green procurement).
- Installation of motion sensors to reduce the electricity consumption of toilet lighting.
- Replacement of old window and door frames will be carried out combined with the introduction of control systems to increase the heating efficiency of the buildings.

[6] Air-conditioning is usually not used in schools

**Result:** The increase percentage of total $CO_2$ emissions by 2020 in comparison to 2005 levels is reduced by **1.67%**, from 30.97% (BAU scenario) to 29.30% accounting for **66487 tons** of $CO_2$ savings.

***Actions TP3:*** Increase the penetration of heating and hot water systems supplied by renewable energy sources in the public buildings by adopting new technologies.

**Description:** Actions are planned focusing on specific technologies which are mature, affordable and adequate for the special characteristics and the RES potential of Crete.

*Heating:*

- Increase to30% the total space heating energy demand supplied from **heat pumps** by 2020 (including solar geothermy systems). Although the air to air or air to water heat pumps increase the electricity demand, direct consumption of fossil fuels (diesel) is avoided and the extra electricity need will be able to be compensated by RES production in the secondary sector

*Hot water:*

- Increase to30% the total hot water energy demand supplied from **solar thermal** for the hospitals/health centers by 2020

Similarly to actions TP2 REAC and the local authorities of each prefecture having finalized the energy inspection of the public buildings they will gradually proceed to the introduction or promotion of heat pumps technology supplied with inverters and smart control systems in order to reduce the heating demand either from old energy inefficient heating systems or from future installations of conventional heating systems in new buildings.

Following the prior measures and the recording of the energy needs and current used technologies for water heating of the hospitals and local clinics the installation of solar thermal units will be promoted from the local authorities.

**Result:** The increase percentage of total $CO_2$ emissions by 2020 in comparison to 2005 levels is increased by **0.29%**, from 30.97% (BAU scenario) to 31.26% accounting for **11572 tons** of $CO_2$ savings. The small increase in $CO_2$ emissions is because of the electricity demand increase by the introduction of heat pumps. However, as already mentioned the energy profit by replacing fossil fuels with electricity is that the latter can be produced by RES as will be shown in the secondary energy production sector.

**Overall Results:** Combining the three action categories the increase percentage of total $CO_2$ emissions by 2020 in comparison to 2005 levels is reduced by **1.69%**, from 30.97% (BAU scenario) to 29.29% accounting for **67333 tons** of $CO_2$ savings (seeFigure 4.1.6).

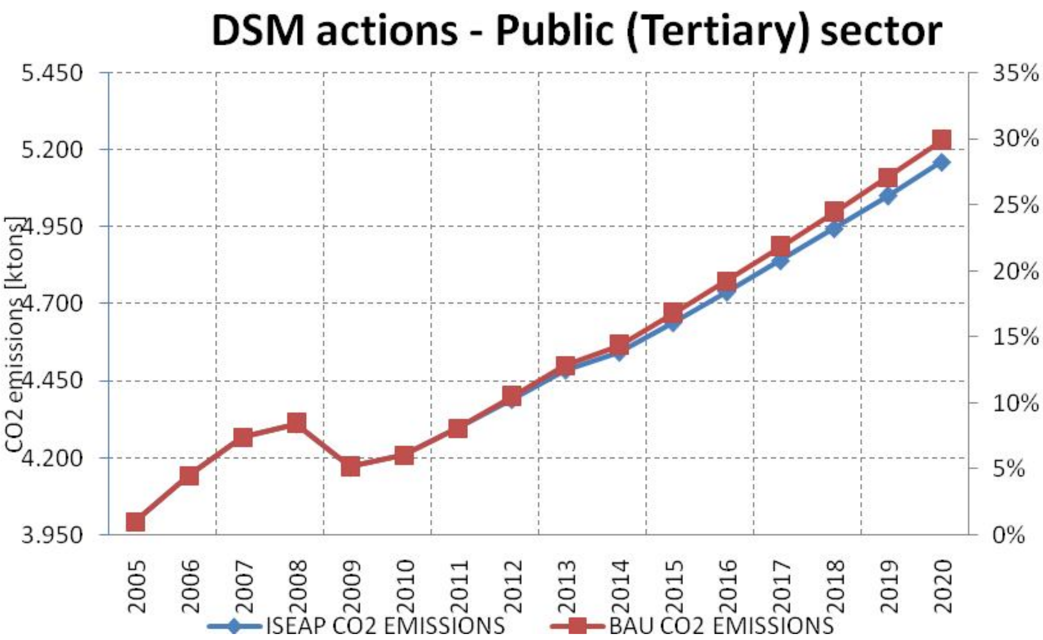



**Figure 4.1.6. CO2 emissions development before and after DSM actions in the tourism sector**

Also in the following table (see Table 4.6)is shown the primary energy demand change after implementing the **DSM actions for the public sector** in comparison to the BAU scenario as an **accumulated effect** in year 2020. In the first line of the table the absolute change per energy carrier is shown whereas on the second line the percentage decrease.

A significant increase of RES and decrease of fossil fuels but also of the total primary energy demand is observed.

| | Fossil fuels | | | | Renewable energy sources | | |
|---|---|---|---|---|---|---|---|
| | Fueloil | Diesel | LPG | Sub-total | Solar | Sub-total | TOTAL |
| MWh | 140658 | 102552 | 2949 | 246159 | -11233 | -11233 | 234926 |
| % | 1.61 | 1.52 | 1.20 | 1.27 | -3.26 | -0.58 | 1.10 |

**Table 4.6. Primary energy demand change after DSM actions for the public sector**

## 4.1.5 Actions planned for the transports sector

For the transports sector the Region of Crete and its Regional Energy Agency in collaboration with the local authorities and the companies related to the respective transports sub-sectors will promote the sustainable mobility on the island of Crete. The actions are mainly focused on the reduction of the energy demand growth rate by promoting the use of means of public transport, the increase of energy efficiency of the vehicles by promoting eco-driving techniques and by promoting the use of hybrid and electric vehicles and the introduction of biofuels in transports. The description of the actions planned for each category follows:

***ActionTR1:*** Double the annual passenger transport by road energy demand growth rate in favor of public transport by 2020 by enhancing and the quality offered by the public transports and promoting its use. The action is combined with reduction in half of the respective growth rate of the private transports sector.

**Description:** The REAC and local authorities of each prefecture in collaboration with the companies related to passenger transport by road sector will promote the use of public **transport** at means (mainly buses) in the main urban areas of the island but also for suburban transportation in order to reduce the use of private transports by improving the services provided (buses quality, schedules frequency, schedules accuracy). Also the use of bicycle will be promoted while in parallel new bike roads will be designed and constructed to reassure a better biking quality. Additionally new pedestrian roads will be constructed into the city centers linked with new parking areas and new transport information systems for the citizens and drivers. Leaflets will be distributed to the citizens to inform the about the profits (financial – environmental – increased quality of life) of using buses. Also TV spots will be broadcasted from the local TV stations to inform the citizens for the same matters. Questionnaires will be distributed among a representative group of households before and after its implementation to realize its effectiveness.

Questionnaires will be distributed among a representative group of households and business before and after its implementation to realize its effectiveness.

**Result:** The increase percentage of total $CO_2$ emissions by 2020 in comparison to 2005 levels is reduced by **0.79%**, from 30.97% (BAU scenario) to 30.18% accounting for **31628 tons** of $CO_2$ savings.

***Actions TR2:*** Increase by 20% (in comparison to BAU scenario)the energy efficiency of all transports sub-sectors by 2020 through the promotion of eco-driving practices.

**Description:** REAC and the local authorities of each prefecture in collaboration with the companies related to the different sub-sectors will promote the adoption of **eco-driving practices** by their professional drivers but also citizens (private transports) in order to increase the energy efficiency of their vehicles.

Leaflets will be distributed to the personnel and seminars will be carried out in order to introduce eco-driving. Also TV spots will be broadcasted in order to achieve the widespread promotion of eco-driving. Questionnaires will be distributed to a representative group of drivers before and after the measure to realize its effectiveness.

**Result:**The increase percentage of total $CO_2$ emissions by 2020 in comparison to 2005 levels is reduced by **10.63%**, from 30.97% (BAU scenario) to 20.34% accounting for **424230 tons** of $CO_2$ savings.

***Actions TR3:*** Increase to 10% the transports energy demand supplied from electricity by 2020 through the promotion of hybrid – electrical vehicles for all transports sub-sectors and to 10% the freight transport by road and removal services and passenger transport by road energy demand supplied from biomass by 2020 through the promotion of bio-fuels use. Into the same direction is also the future use of hydrogen cars.

**Description:** The local authorities of each prefecture in collaboration with the companies related to each transports sub-sector will promote the introduction of hybrid – electric buses, trucks and vehicles. Furthermore, REAC and the local authorities in collaboration with the companies related to fuel distribution on the island will promote the introduction of bio-fuels in the transportation fuel mix.

**Result:** The increase percentage of total $CO_2$ emissions by 2020 in comparison to 2005 levels is increased by **8.23%**, from 30.97% (BAU scenario) to 39.21% accounting for **328740 tons** of $CO_2$ savings. This increase is the effect of introducing electric-hybrid vehicles in the transports sector. However, as already mentioned the energy profit by replacing fossil fuels with electricity is that the latter can be produced by RES as will be shown in the secondary energy production sector.

**Overall Results: Combining** the three action categories the increase percentage of total $CO_2$ emissions by 2020 in comparison to 2005 levels is reduced by **4.05%**, from 30.97% (BAU scenario) to 26.92% accounting for **161564 tons** of $CO_2$ savings (seeFigure 4.1.7).

Also in the following table (seeTable 4.7) is shown the primary energy demand change after implementing the DSM actions for the transports sector in comparison to the BAU scenario as an **accumulated effect** in year 2020. In the first line of the table the absolute change per energy carrier is shown whereas on the second line the percentage decrease.

A significant decrease of gasoline and diesel is observed as a result of the overall actions which are followed also by increase of fuel oil, as a primary energy source of producing electricity, in order to cover the increase of electricity demand by the electric-hybrid vehicles. The final effect of the transports actions will be totally quantified after implementing the actions related to RES penetration in the secondary energy production sector.

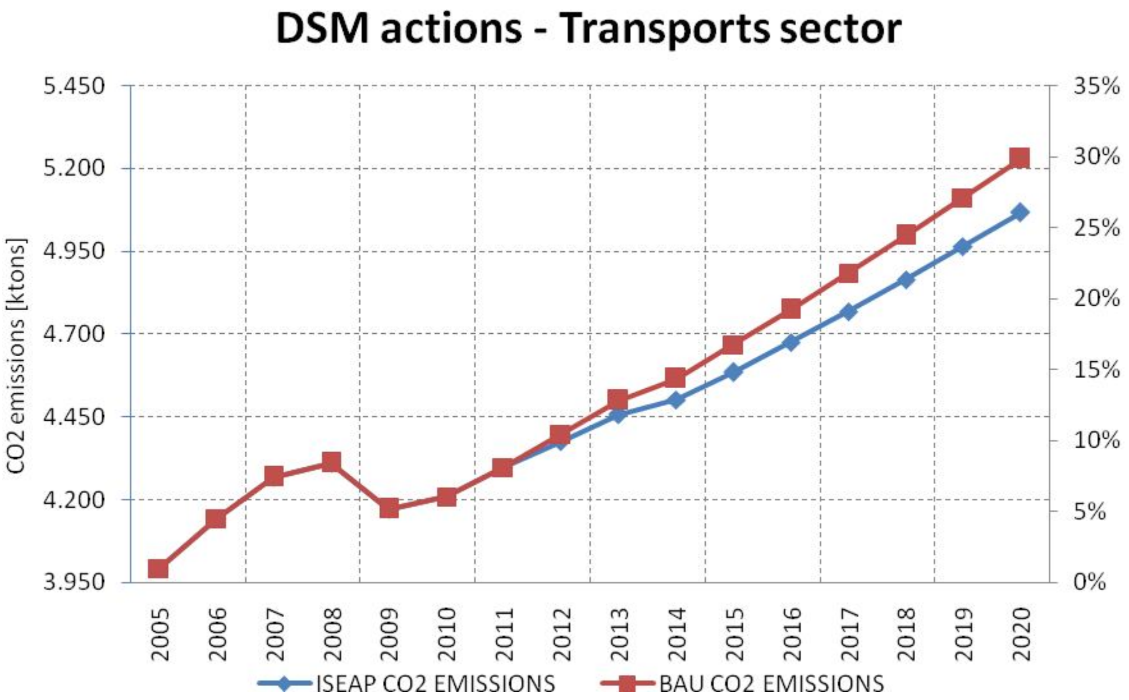



**Figure 4.1.7. CO2 emissions development before and after DSM actions in the transports sector**

| | Fossil fuels | | | | Renewable energy sources | | |
|---|---|---|---|---|---|---|---|
| | Fuel oil | Diesel | Gasoline | Sub-total | Biomass | Sub-total | TOTAL |
| MWh | -1356323 | 622158 | 1501454 | 767290 | -232969 | -232969 | 534321 |
| % | -15.54 | 9.25 | 40.82 | 3.95 | -23.00 | -11.99 | 2.50 |

**Table 4.7. Primary energy demand change after DSM actions for the transports sector**

## 4.1.6 Overall results from demand side management actions

The Region of Crete, and its Regional Energy Agency (REAC) as shown in the previous paragraphs, will manly be involved as promoter and consultant but also as actor in the demand side management actions. The elaboration, monitoring and the overall success of the DSM actions are of high importance for the ISEAP since they depict the level of participation of the citizens, of the local companies and bussiness and generally of the different stakeholders related to the island.

**DSM Overall Results:** Accounting the **accumulated effect** of all the actions planned for the final energy demand increase the percentage of total $CO_2$ emissions by 2020 in comparison to 2005 levels is reduced by **27.74%**, from 30.97% (BAU scenario) to 3.33% accounting for **1107547 tons** of $CO_2$ savings (seeFigure 4.1.8).

Also in the following table (seeTable 4.8) is shown the primary energy demand change after implementing all the DSM actions in comparison to the BAU scenario as an accumulated effect in year 2020. In the first line of the table the absolute change per energy carrier is shown whereas on the second line the percentage decrease.

A significant decrease of gasoline and diesel is observed as a result of the actions planned for the transports sector and the decrease in heating energy demand or alteration for diesel boilers to heat pumps and biomass boilers. The decrease in fuel oil (fuel oil is the main fuel of the conventional power units) is related with the general decrease of electricity demand, whereas the LPG and coal demand decrease are related explicitly with the actions planned for the sub-sector involving cooking (residential, tourism) and the secondary sector respectively. On the other hand the RES production increases significantly for both biomass and solar sources, mainly through the actions planned to cover the space heating and water heating energy needs.

Finally the overall energy demand is decreased depicting the impact of the planned actions related to growth rate decrease and energy efficiency increase, since the alteration of fossil fuels with RES do not account for overall energy decrease but definitely for $CO_2$ emissions decrease.

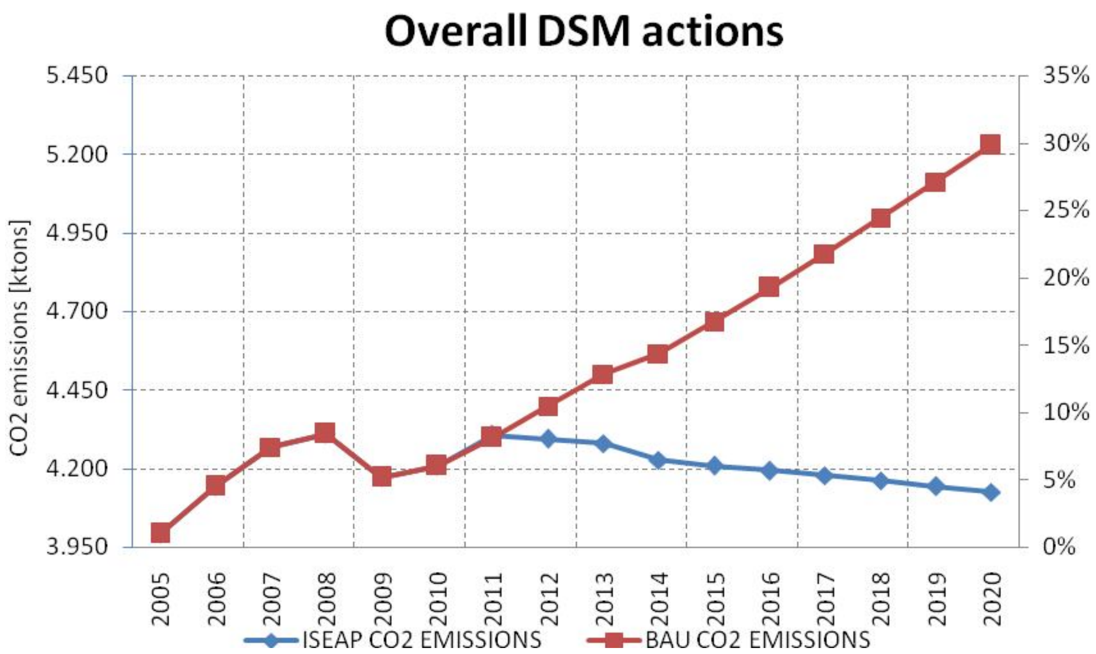



**Figure 4.1.8. CO2 emissions development before and after overall DSM actions**

| | Fossil fuels | | | | | | Renewable energy sources | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Fuel oil | Diesel | Gasoline | LPG | Coal | Sub-total | Solar | Biomass | Sub-total | TOTAL |
| MWh | 382350 | 2285162 | 1500986 | 34861 | 13064 | 4216423 | -180684 | -476735 | -660401 | 3556022 |
| % | 4.38 | 33.96 | 40.80 | 14.16 | 21.71 | 21.69 | -52.42 | -47.06 | -34.00 | 16.63 |

**Table 4.8. Primary energy demand change after overall DSM actions**

In the following table (see Table 4.9) and figures (see Figure 4.1.9and Figure 4.1.10) the overall contribution by each activity sector to the total energy demand and $CO_2$ emissions reduction is presented. The **residential**, **tertiary** and **transports** sectors appear to have the greater contribution both in the primary energy demand and $CO_2$ emissions reduction. On the other hand, the primary and public sector have the smallest contribution.

| Activity sector | | Primary energy demand reduction | | $CO_2$ emissions reduction | |
|---|---|---|---|---|---|
| | | Percentage decrease[%] | Absolute decrease[MWh] | Percentage decrease[%] | Absolute decrease[ktons] |
| **Residential** | | 4.80 | 1026128 | 3.56 | 142189 |
| **Primary** | | 0.96 | 204791 | 1.33 | 53158 |
| **Secondary** | | 2.28 | 486964 | 2.33 | 92898 |
| **Tertiary** | **Commercial** | 3.51 | 751617 | 5.29 | 211280 |
| | **Tourism** | 2.97 | 634433 | 4.63 | 184849 |
| | **Public** | 1.01 | 215353 | 1.55 | 61976 |
| **Transports** | | 2.50 | 534321 | 4.05 | 161564 |
| **Total** | | **16.63** | **3556022** | **27.74** | **1107547** |

**Table 4.9. Contribution of each activity sector in the primary energy demand and $CO_2$ emissions reduction through the implementation of DSM actions by 2020**

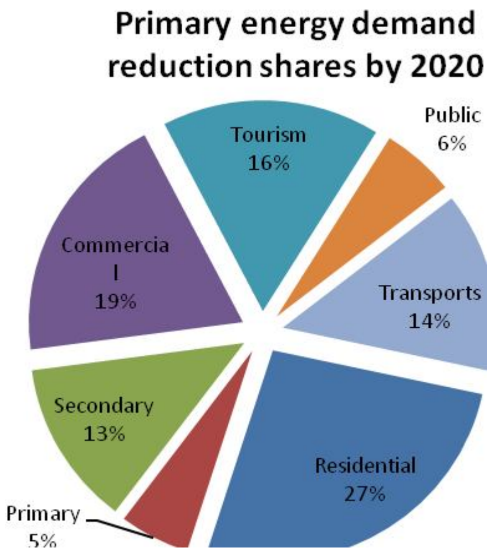



**Figure 4.1.9. Share of the primary energy demand reduction per activity sector resulting from the DSM actions**

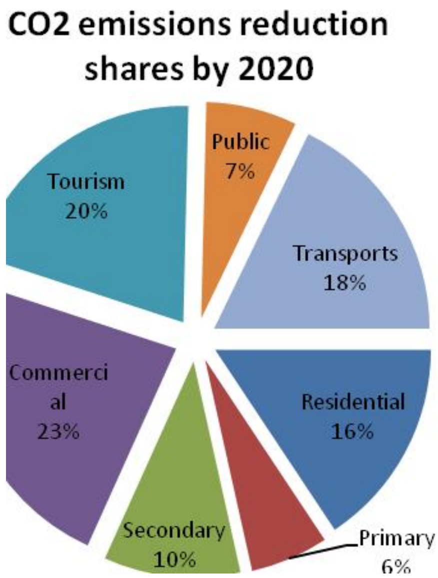



**Figure 4.1.10. Share of the $CO_2$emissions reduction per activity sector resulting from the DSM actions**

## 4.2 Secondary energy conversion

The actions considered for the secondary energy conversion sector formulate also, as already mentioned, the three studied alternative scenarios for the ISEAP development. The main characteristic defining the **three scenarios** is the possible electrical interconnection of Crete with mainland Greece. This is a rather important parameter since the interconnection of Crete would make possible the further introduction of electricity production from RES.

A short description of all the scenarios, the corresponding actions planned and the respective results will be given in the following paragraphs. However, it should be noted that the selection of the final scenario to be implemented in the ISEAP of Crete is based on a very principal idea.

**Although the electrical interconnection of Crete is more or less an announced project and the current studies expect its development to be finalized by 2017, it is still a very difficult project and the timetable can easily go beyond the announced deadlines.**

**For this reason, taking into account the current situation and the foreseen development of Crete's electrical system the scenario to be adopted in the ISEAP (scenario A) will retain the current electrical network overall design of an autonomous system.** The maximization of RES exploitation and the introduction of natural gas in the energy mix will be the main characteristics of the actions planned for the secondary energy conversion sector.

### 4.2.1 Scenario A: Autonomous electrical network

For this scenario it is assumed that the electrical network of Crete will remain **autonomous** as it is today, however an **extensive and intensive effort** will be made to promote the maximization of the RES penetration in the electricity production system and the introduction of **natural gas** as an alternative fossil fuel with lower $CO_2$ emissions.

The actions planned in relation to this scenario are presented next.

#### *Conventional power units – Natural gas combined cycle generators*

The development of the conventional power units remains as in the BAU scenario, meaning that diesel generator supplied with fuel oil of 100MW and 50MW capacity will be installed in the Atherinolakos power station in 2014 and 2018 respectively in order to meet the forecasted increasing electricity demand of the island and substitute the steam generators in Linoperamata.

The **main difference with the BAU** scenario is the introduction of **natural gas** combined cycle generators of 250MW estimated installed capacity in a new power plant in the Korakia area supplied by boat transferred LNG[7] . This power station is

[7] Based on information provided by PPC

expected to substitute the diesel generators (49.2MW) and gas turbines (123.8MW) of the old power station in Linoperamata. The natural gas generators are expected to satisfy both base and peak loads. The share of gas turbines will remain 15% of the total electricity production till 2019 in order to operate as peak load units. The share of gas turbines (and diesel energy carrier in the energy balance) will obviously decrease after the introduction of natural gas.

Because of the lower CO2 emissions factor of natural gas the increase percentage of CO2 emissions, in the framework of the ISEAP only from a single year use of the new power plant, is expected to be reduced by **11.99%**, from 30.97% (BAU scenario) to 18.98% accounting for **463355 tons** of $CO_2$ savings (seeFigure 4.1.11).

The Region of Crete and its Regional Energy Agency in collaboration with PPC will promote the introduction of natural gas in the electrical system of Crete getting involved in the different development phases, informing the local authorities and the citizens about the profits of the new power unit. Further aim of the Region, for the post ISEAP period (2020 – 2030) is to promote the domestic use of natural gas for heating and cooking purposes.

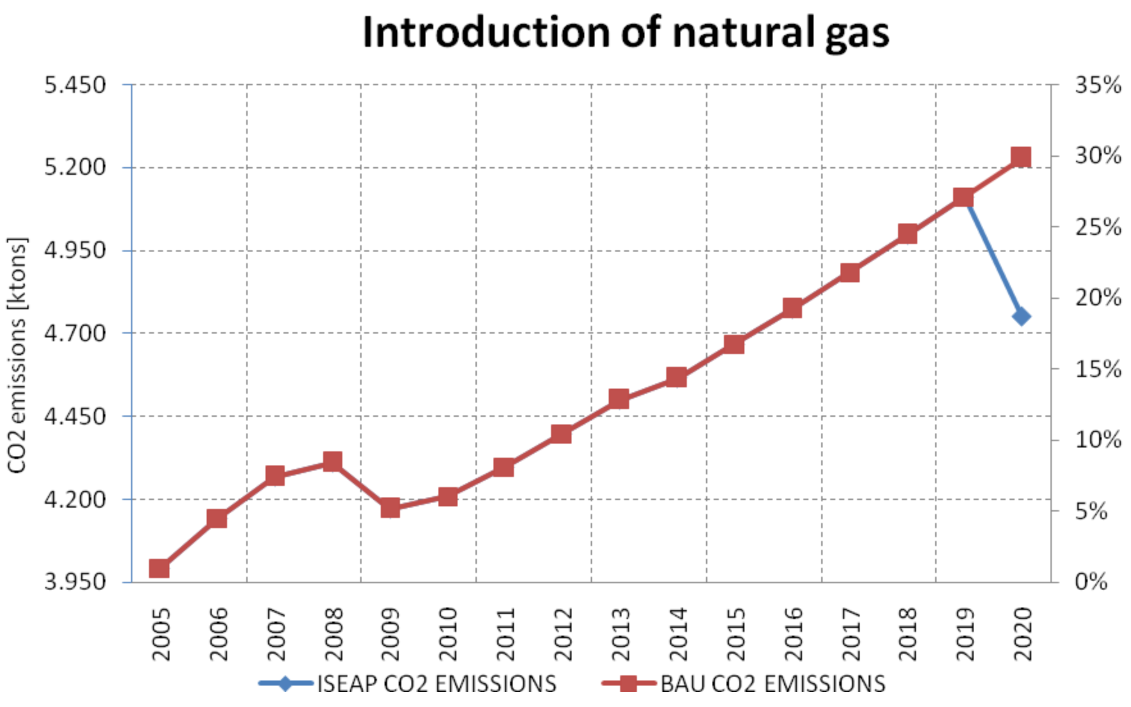



**Figure 4.1.11. CO2 emissions before and after the installation of the natural gas combined cycle generators**

Also in the following table (see Table 4.10) is shown the primary energy demand change after the installation of the natural gas combined cycle generators in comparison to the BAU scenario as an accumulated effect in year 2020. In the first line of the table the absolute change per energy carrier is shown whereas on the second line the percentage decrease.

A significant decrease of fuel oil and diesel is observed as a result of the replacement of the diesel generators and the gas turbines. Additionally because of the higher conversion efficiency of the new power unit in comparison with the ones being replaced the total primary energy demand is decreased.

| | Fossil fuels | | | | |
|---|---|---|---|---|---|
| | Fuel oil | Diesel | Natural gas | Sub-total | TOTAL |
| MWh | 3576796 | 821298 | -3656250 | 741844 | 3556022 |
| % | 40,97% | 12,21% | - | 3,82% | 3,47% |

**Table 4.10. Primary energy demand change after the installation of the natural gas combined cycle generators**

### *RES power units*

The Region of Crete and its Regional Energy Agency (REAC) in collaboration with the local authorities will promote the extensive exploitation of renewable energy sources aiming to the greenest possible energy mix covering the electricity demand of Crete.

Main principle of the action is the maximization of the local authorities and the citizens involvement in the installation process of electricity production units based on RES (wind, wind-hydro, photovoltaic, solar thermal, biomass). This involvement can be either in the financial - investment part (joint ventures, capital shares open to the citizens, cooperative projects, municipal projects, etc.) or in the planning part (land-use planning, environmental and cultural impacts, etc.).

For this scenario the types of RES technologies to be exploited for electricity production are the same with the BAU scenario with the addition of minor biomass (oil kernels) units. The **main characteristics of the planned RES units are**:

- Extensive introduction of wind which can operate with a high capacity credit and reliability of the assured electricity production combined with reverse wind hydro systems)
- Installed capacity of wind turbines up to 30% of the forecasted peak demand
- Extensive introduction of solar thermal power units (high temperature – solar tower and parabolic trough plants)
- Extensive installation of PV units on the ground (75%) and on building roofs (25%).
- Minor biomass installations

The electrical system profile up to 2020 under **scenario A** is presented in the following table per technology type[8].

| [MW] | Wind | | Wind-Hydro | | PV | | Solar Thermal | | Biomass | |
|---|---|---|---|---|---|---|---|---|---|---|
| Year | BAU | Sc. A | BAU | Sc. A | BAU | Sc. A | BAU | Sc. A | BAU | Sc. A |
| 2010 | 170 | 170 | 0 | 0 | 30.7 | 20 | 0 | 0 | 0 | 0 |
| 2015 | 185 | 222 | 7.4 | 20 | 40 | 81.4 | 5 | 5 | 0 | 0 |
| 2020 | 201.6 | 260 | 10.1 | 183 | 50 | 118 | 10 | 88 | 0 | 7 |

**Table 4.11. Scenario A - Planned installed capacity of electricity production RES units**

The increase percentage of total $CO_2$ emissions by 2020 in comparison to 2005 levels is decreased by **16.33%**, from 30.97% (BAU scenario) to 14.64% accounting for **652111 tons** of $CO_2$ savings (see Figure 4.1.12).

Also in the following table (see Table 4.12) is shown the primary energy demand change after the installation of the RES electricity production units in comparison to the BAU scenario as an accumulated effect in year 2020. In the first line of the table the absolute change per energy carrier is shown whereas on the second line the percentage decrease.

A significant decrease of fuel oil and diesel is observed as a result of the substitution of conventional electricity production from the diesel generators and the gas turbines with electricity based on RES. Additionally because of the higher conversion efficiency of the RES power units in comparison with the conventional ones the total primary energy demand is decreased.

[8] Based on information provided by PPC and REAC

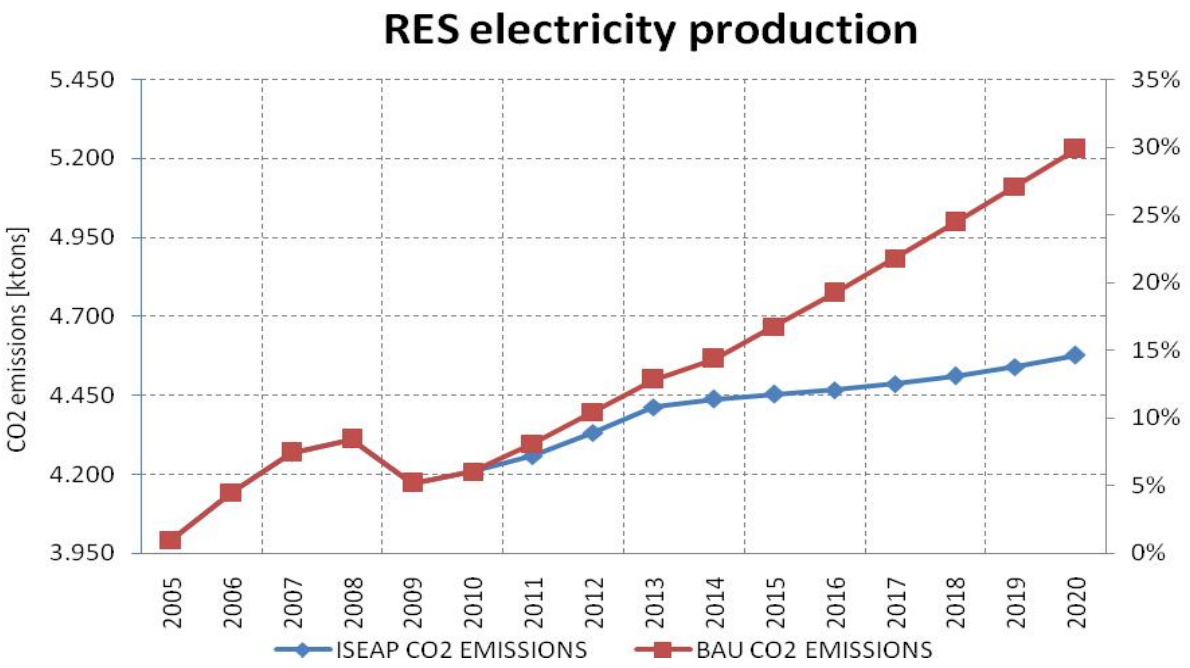



**Figure 4.1.12. Scenario A : CO2 emissions before and after the installation of the RES electricity production units**

| | Fossil fuels | | | Renewable energy sources | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fueloil | Diesel | Sub-total | Wind | PV | Wind - Hydrohybrid | Solar thermal - high temp. | Biomass | Urbanwaste | Sub-total | TOTAL |
| MWh | 1860100 | 499306 | 2359405 | -175214 | -58382 | -305134 | -200831 | -42150 | -515 | -782226 | 1577180 |
| % | 21,31% | 7,42% | 12,14% | -32,48% | -16,94% | -1704,02% | -775,82% | -4,16% | -46,74% | -40,27% | 7,38% |

**Table 4.12. Primary energy demand change after the installation of the RES electricity production units (Scenario A)**

Among the technologies based on RES, the wind – hydro hybrid stations and the high temperature solar thermal units appear to increase sharply their production followed by wind, PV and biomass (see Figure 4.1.13).

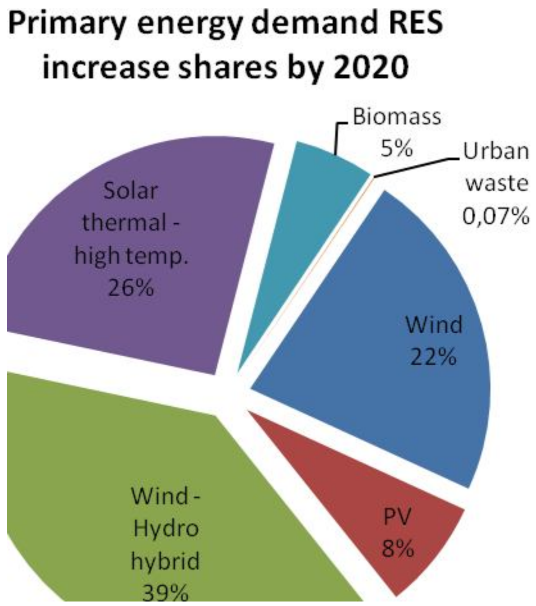



**Figure 4.1.13. Share of the primary energy demand increase per RES technology resulting from the RES electricity production units (Scenario A)**

### *Scenario A: Overall results*

Combining the actions in the secondary energy conversion **(SEC)** sector related to the installation of natural gas and RES power units for electricity production the increase percentage of total $CO_2$ emissions by 2020 in comparison to 2005 levels is decreased by **28.32%**, from 30.97% (BAU scenario) to 2.65% accounting for **1130761 tons** of $CO_2$ savings (see Figure 4.1.14) reaching emission level rather close to ones of the baseline year.

The change of energy carriers in the primary energy demand is mainly dominated by the natural gas plant followed by the new wind-hydro hybrid, solar thermal (high temperature), wind parks and PV units (see Figure 4.1.15).

However, when this change is translated into $CO_2$ emissions the share of natural gas is decreased to half since the $CO_2$ savings from the introduction of natural gas in the energy mix occurs because of the lower $CO_2$ emission factor (0.202) in comparison to the current fossil fuels (fuel oil: 0.279, diesel: 0.267). On the other hand, the change of primary energy demand by introducing new RES electricity production units provides 100% $CO_2$ emission savings since they have null $CO_2$ emissions factors (see Figure 4.1.16).

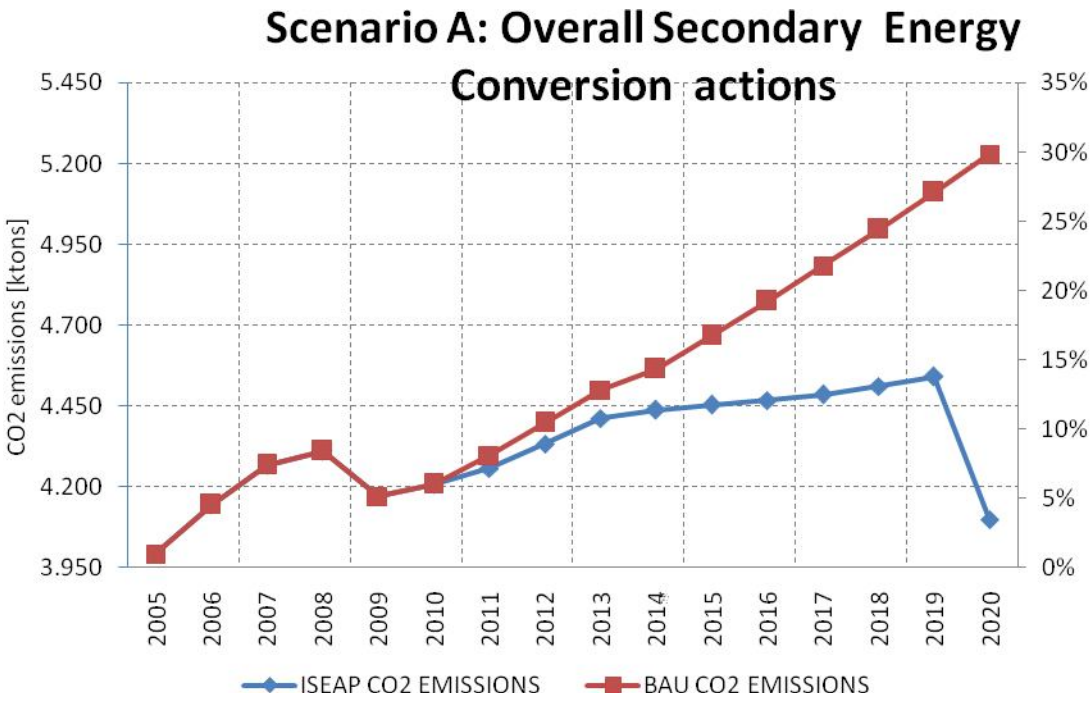



**Figure 4.1.14. Scenario A: CO2 emissions development before and after overall SEC actions**

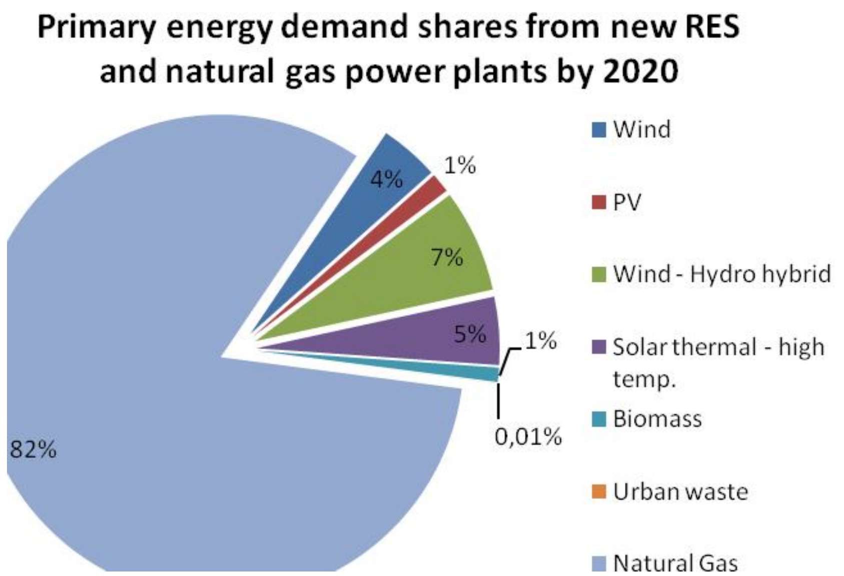



**Figure 4.1.15. Scenario A: Primary energy demand shares of the energy sources used in the SEC actions**

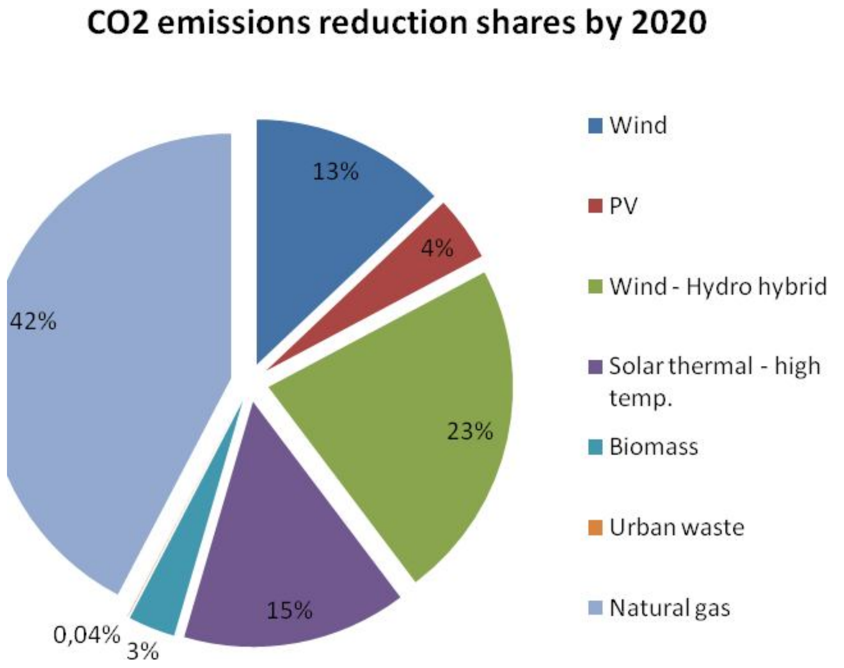



**Figure 4.1.16. Scenario A: Share of the $CO_2$emissions reduction per activity sector resulting from the REC actions**

## 4.2.2 Scenario B: Interconnected electrical network basic

For this scenario it is assumed that Crete will be interconnected with the mainland electrical network in 2017 providing the potential for extensive development of the RES technologies. The electrical system profile is based on the **study** carried out by the Regulatory Authority for Energy (RAE), the Hellenic Transmission System Operator (HTSO) and the Public Power Corporation (PPC) (published on April 2011).

For the interconnection characteristics it is assumed a hybrid DC connection between Crete (Korakia) and Peloponnese (Megalopoli) of **700MW total capacity** (2cablesX350MW) and total cable length 370km (250 submarine cable from Korakia till Monemvasia and 120km high voltage transfer lines on land).

According to this scenario an extra **1000MW potential of RES installations** on Crete is expected until 2025 (of which 800MW wind parks). The production of these units will mainly serve as electricity exports to the mainland.

### *Conventional power units – Natural gas combined cycle generators*

Until 2017 the conventional electricity production will develop as in BAU scenario and scenario A. In this case 100MW of diesel generators will be installed in 2014 to meet the rising electricity demand and to substitute the 61,2MW steam generators in Linoperamata.

The installation of 50MW in 2018 is excluded in this scenario since the interconnection will have already been accomplished by 2017. However, the remaining 50MW of steam generators in Linoperamata will be paused leaving as reserve to the interconnected system power units of total capacity ~90% of the peak demand. The remaining steam and diesel generators will operate at least to their technical minimums serving the system as spinning reserve in case of interconnection failure. The gas turbines will also operate occasionally in order to manage fast changes in demand or RES electricity production

The period 2017 – 2019 the electricity production from fuel oil and diesel will decrease in favor of wind-hydro and biomass plants which can serve as spinning reserve units.

Additionally, the capacity of the natural gas station planned to be installed in Korakia area in 2020 is reduced from 250MW to 200MW, taking into consideration the fact that after the island is interconnected, electricity imports through the cable can serve as electricity back-up. Further development of the natural gas combined cycle units will be decided after the operation of the interconnected system.

### *RES power units*

The main characteristics of this scenario for the RES electricity production are:

- Introduction of RES units until 2020 as foreseen in Scenario A
- Further introduction of RES units in 2017 (560MW total) when the interconnection is expected and linear increase till 2020 reaching 725MW in total (all RES technologies) of extra RES units.
- Wind parks represent the 80% of the total extra RES units; the remaining 20% is shared among the rest RES technologies relatively to their current share.

The RES units installed capacity up to 2020 under **scenario B** is presented in the following table (see Table 4.13) per technology type[9].

| [MW] | Wind | | Wind-Hydro | | PV | | Solar Thermal | | Biomass | |
|---|---|---|---|---|---|---|---|---|---|---|
| Year | BAU | Sc. B | BAU | Sc. B | BAU | Sc. B | BAU | Sc. B | BAU | Sc. B |
| 2010 | 170 | 170 | 0 | 0 | 30.7 | 20 | 0 | 0 | 0 | 0 |
| 2015 | 185 | 222 | 7.4 | 20 | 40 | 81.4 | 5 | 5 | 0 | 0 |
| 2017 | 197 | 687.9 | 8.5 | 146.3 | 44 | 143.8 | 7 | 67.8 | 0 | 3.13 |
| 2020 | 201.6 | 840 | 10.1 | 241 | 50 | 176 | 10 | 115.6 | 0 | 8.45 |

**Table 4.13. Scenario B - Planned installed capacity of electricity production RES units**

[9] Based on information available from the study carried out by RAE, HTSO and PPC

The extra RES units installed capacity after the interconnection with the mainland network is solely presented in the following table (seeTable 4.14):

| Year | Wind | Wind-Hydro | PV | Solar Thermal | Biomass | Total |
|---|---|---|---|---|---|---|
| 2017 | 448 | 44.8 | 44.8 | 21.3 | 1.12 | 560 |
| 2018 | 492 | 49.2 | 49.2 | 23.4 | 1.23 | 615 |
| 2019 | 536 | 53.6 | 53.6 | 25.5 | 1.34 | 670 |
| 2020 | 580 | 58 | 58 | 27.6 | 1.45 | 725 |

**Table 4.14. Scenario B – Extra annualy accumulated RES installed capacity after interconnection**

By 2020 more than 50% of Crete's electricity demand will be supplied by RES units. However, the total RES electricity production corresponds to 85% of the total electricity needs of Crete. Finally, 30% of the total primary energy demand is covered by RES.

### *Electricity imports - exports*

The electricity transfers through the cable interconnection are assumed to be defined by the following approach:

- The electricity exports on an annual basis to the mainland correspond to the 75% of the extra RES electricity production
- The electricity imports on annual basis to cover part of Crete's electricity demand correspond to the 20% of the extra RES electricity production

### *Scenario B: Overall results*

Combining the actions in the secondary energy conversion (SEC) sector related to the installation of natural gas and RES power units for electricity production the increase percentage of total $CO_2$ emissions by 2020 in comparison to 2005 levels is decreased by **57.39%**, from 30.97% (BAU scenario) to -26.41% accounting for **2291021 tons** of $CO_2$ savings (see Figure 4.1.17) reaching emission levels much lower than the ones of the baseline year.

The change of energy carriers in the primary energy demand is similarly to scenario A mainly dominated by the natural gas plant followed in this case by the wind parks, wind-hydro hybrid, solar thermal (high temperature), and PV units (see

Figure 4.1.18). Finally, the imported electricity appears as a new energy carrier because of the available interconnection.

Similarly to scenario A when this change is translated into $CO_2$ emissions the wind parks contribute more than half of the emissions reduction followed by natural gas and the rest of RES (seeFigure 4.1.19). The profit for the $CO_2$ emissions reduction in this scenario is obvious since the electrical interconnection of Crete permitting the extensive development of RES and mainly wind parks. However, it should be noted that the $CO_2$ emission reduction is not derived by covering solely local energy demand but also through exporting electricity to the mainland. Specifically the 72% of the total $CO_2$ emissions is linked to local primary energy demand and the rest with electricity exportation.

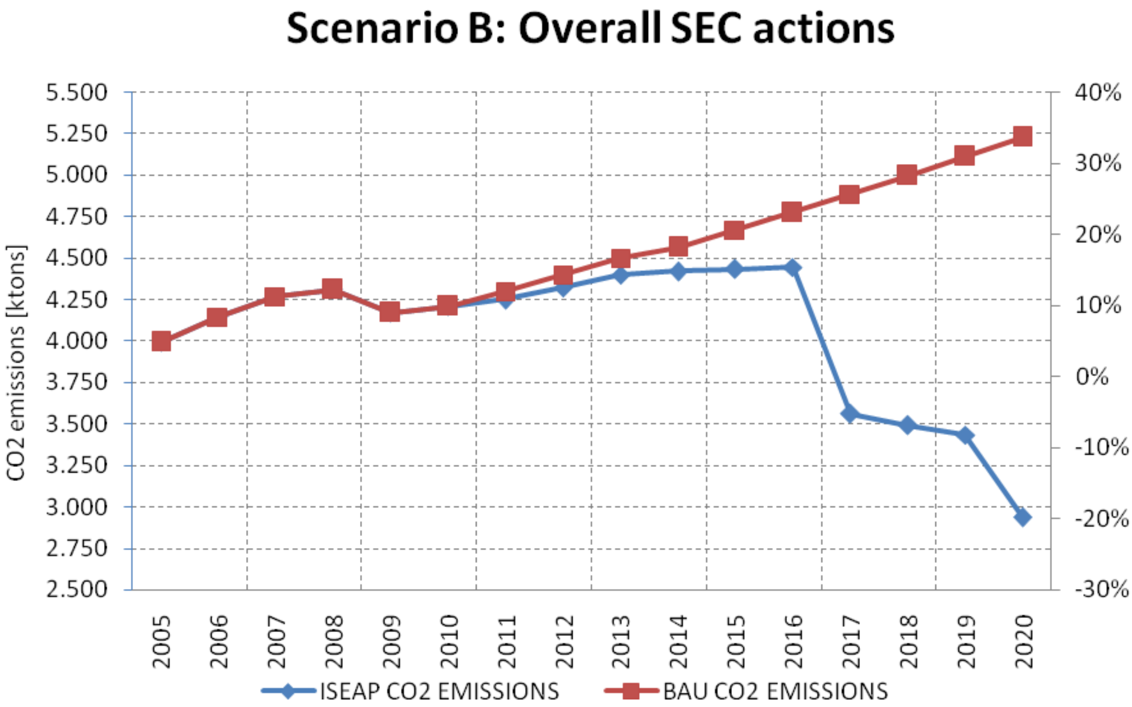



**Figure 4.1.17. Scenario B: CO2 emissions development before and after overall SEC actions**

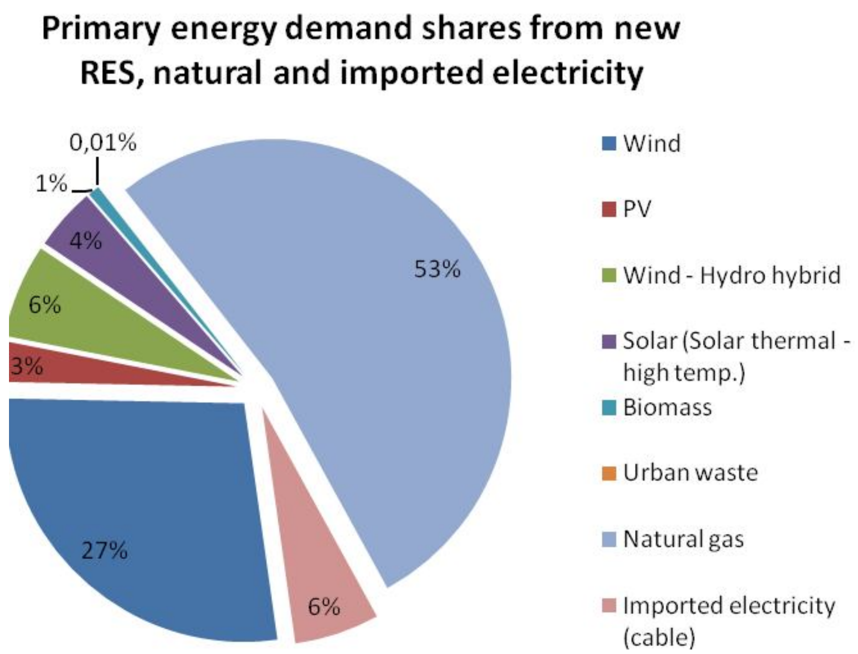


**Figure 4.1.18. Scenario B: Primary energy demand shares of the energy sources used in the SEC actions**

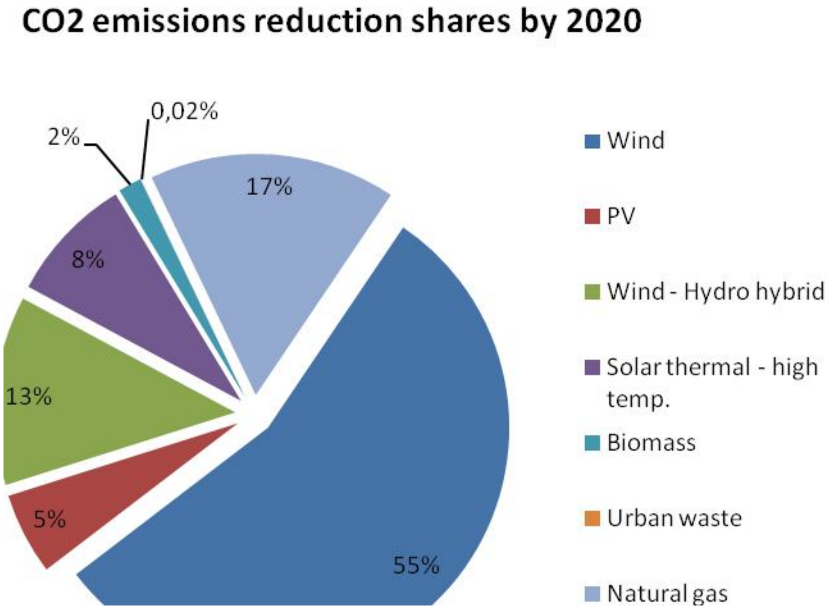



**Figure 4.1.19. Scenario B: Share of the $CO_2$emissions reduction per activity sector resulting from the REC actions**

## 4.2.3 Scenario C: Interconnected electrical network extended

This scenario is an **extended version of scenario B**, where further penetration of RES units will be made possible through a different interconnection option.

It is assumed a DC connection between Crete (Korakia) and Attica of **1000MW capacity in 2017** and a second connection between Crete (Korakia) and Peloponnese (Megalopoli) again of **1000MW capacity**.

According to this scenario an **extra 2000MW potential** of RES installations on Crete is expected until 2025 (of which 1600MW wind parks). The production of these units will mainly serve as electricity exports to the mainland.

### *Conventional power units – Natural gas combined cycle generators*

For the conventional power units the situation remains as in scenario B. However, in this case a smaller natural gas combined cycle unit of 150MW, instead of 200MW, is assumed to be installed in 2020 since the higher capacity of wind-hydro and biomass units will serve as spinning reserve units.

### *RES power units*

The main characteristics of this scenario C for the RES electricity production are similar with those of scenario B:

- Introduction of RES units until 2020 as foreseen in Scenario A and B
- Further introduction of RES units in 2017 (450MW total) when the interconnection is expected and linear increase till 2020 reaching 1031MW in total (all RES technologies) of extra RES units.
- Wind parks represent the 75% of the total extra RES units; the remaining 25% is shared among the rest RES technologies relatively to their current share.

The RES units installed capacity up to 2020 under scenario C is presented in the following table per technology type[10] (see Table 4.15).

| [MW] | Wind | | Wind-Hydro | | PV | | Solar Thermal | | Biomass | |
|---|---|---|---|---|---|---|---|---|---|---|
| Year | BAU | Sc. C | BAU | Sc. C | BAU | Sc. C | BAU | Sc. C | BAU | Sc. C |
| 2010 | 170 | 170 | 0 | 0 | 30.7 | 20 | 0 | 0 | 0 | 0 |
| 2015 | 185 | 222 | 7.4 | 20 | 40 | 81.4 | 5 | 5 | 0 | 0 |
| 2017 | 197 | 576.9 | 8.5 | 146.5 | 44 | 144 | 7 | 68 | 0 | 3.15 |
| 2020 | 201.6 | 1033 | 10.1 | 286.1 | 50 | 176 | 10 | 115.6 | 0 | 9.58 |

**Table 4.15. Scenario C - Planned installed capacity of electricity production RES units**

The extra RES units installed capacity after the interconnection with the mainland network is solely presented in the following table (seeTable 4.16):

| | Extra RES installed capacity after interconnection [MW] | | | | | |
|---|---|---|---|---|---|---|
| Year | Wind | Wind-Hydro | PV | Solar Thermal | Biomass | Total |
| 2017 | 338 | 45 | 45 | 21.4 | 1.13 | 450 |
| 2018 | 483 | 64.4 | 64.4 | 30.6 | 1.61 | 644 |
| 2019 | 628 | 83.8 | 83.8 | 39.8 | 2.09 | 838 |
| 2020 | 773 | 103.1 | 103.1 | 49 | 2.58 | 1031 |

**Table 4.16. Scenario C – Extra annualy accumulated RES installed capacity after interconnection**

By 2020 more than 64% of Crete's electricity demand will be supplied by RES units. However, the total RES electricity production corresponds to more than 100% of the

[10] Based on information available from the study carried out by RAE, HTSO and PPC

total electricity needs of Crete. Finally, 34% of the total primary energy demand is covered by RES.

### *Electricity imports - exports*

The electricity transfers through the cable interconnection are assumed to be defined by the same approach as in scenario B:

- The electricity exports on an annual basis to the mainland correspond to the 75% of the extra RES electricity production
- The electricity imports on annual basis to cover part of Crete's electricity demand correspond to the 20% of the extra RES electricity production

### *Scenario C: Overall results*

Combining the actions in the secondary energy conversion (SEC) sector related to the installation of natural gas and RES power units for electricity production the increase percentage of total $CO_2$ emissions by 2020 in comparison to 2005 levels is decreased by **66.24%**, from 30.97% (BAU scenario) to -35.27% accounting for **2644501 tons** of $CO_2$ savings (seeFigure 4.1.20) reaching emission levels evenlower than the ones of scenario B.

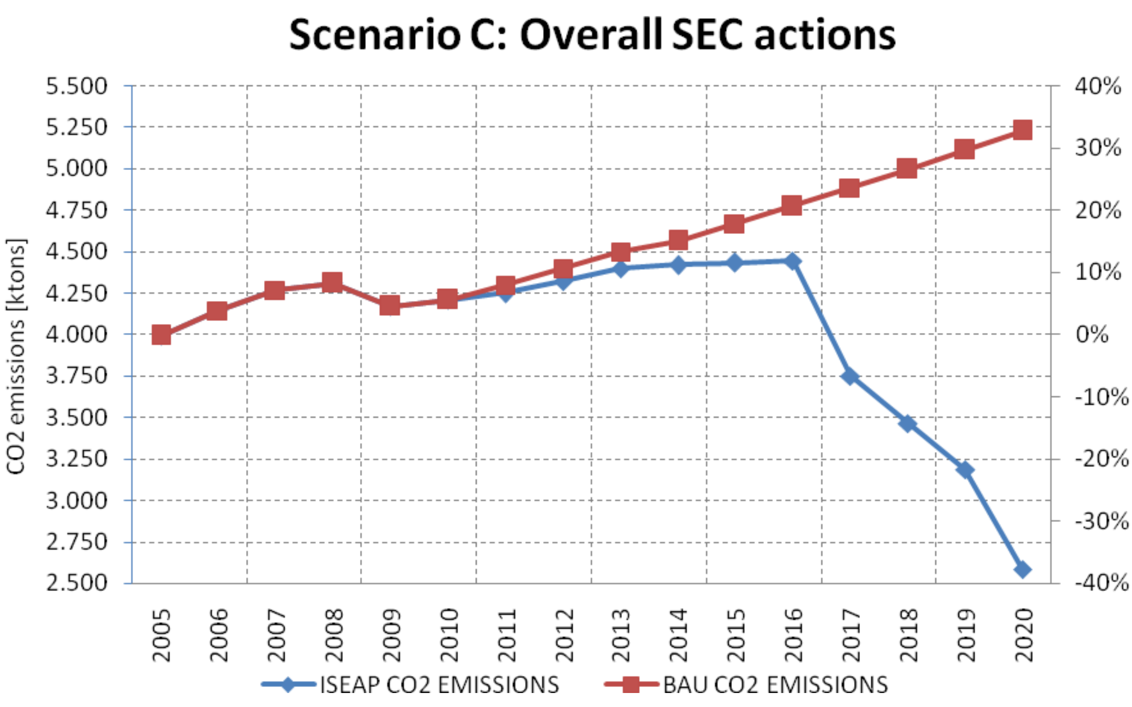



**Figure 4.1.20. Scenario C: CO2 emissions development before and after overall SEC actions**

The share of each energy carrier in the primary energy demand change and their respective contribution in the $CO_2$ emissions reduction are presented in the following figures (see Figure 4.1.21 and Figure 4.1.22) similarly to scenario B.

The contribution of RES is generally intensified since greater penetration is made possible through the current interconnection option. The further reduction of $CO_2$ emissions is attributed to the exportation of electricity. Specifically the 66% of the total $CO_2$ emissions is linked to local primary energy demand and the rest with electricity exportation.

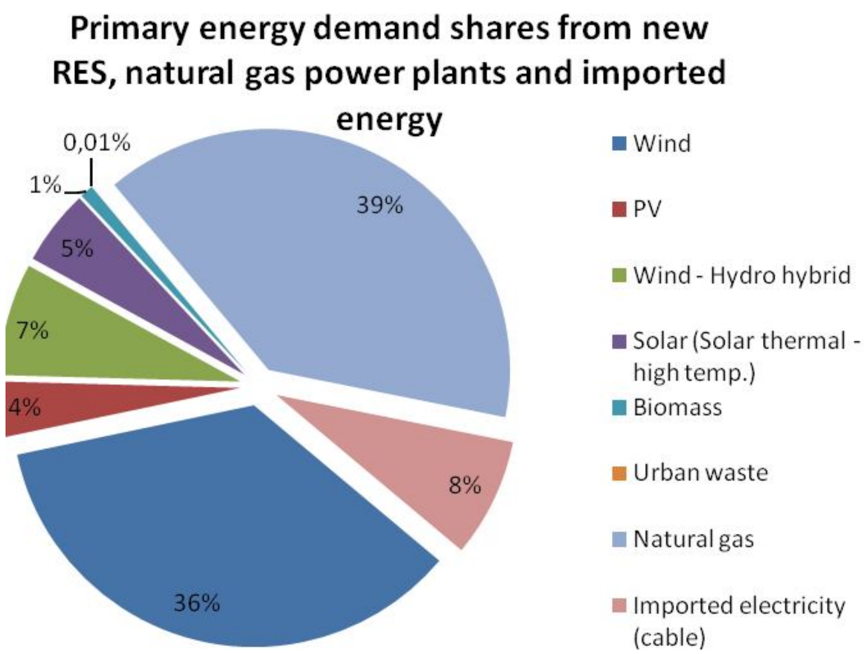



**Figure 4.1.21.Scenario C: Primary energy demand shares of the energy sources used in the SEC actions**

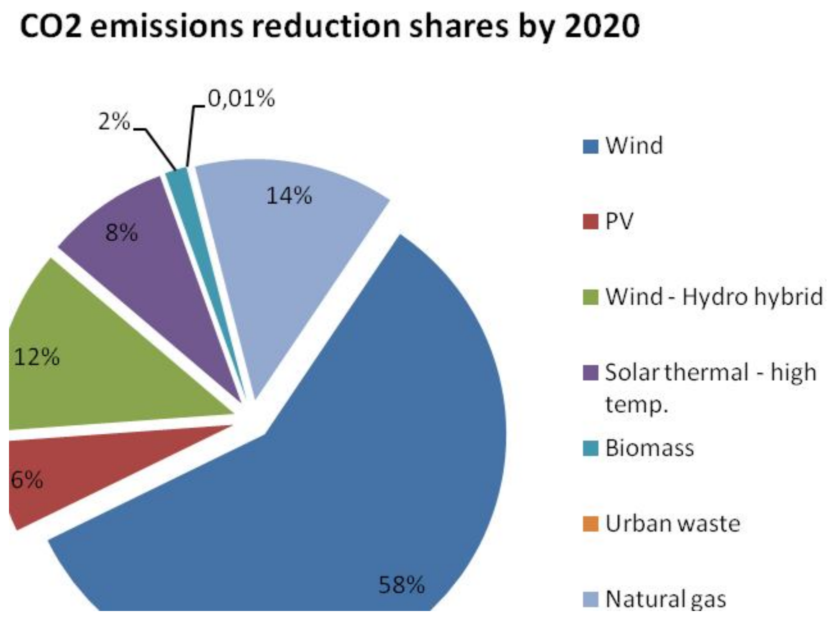



**Figure 4.1.22. Scenario C: Share of the $CO_2$emissions reduction per activity sector resulting from the REC actions**

## 4.2.4 Scenarios comparison

In the following figures and tables the results from the BAU and the three (3) possible ISEAP scenarios presented before, representing the foreseen possible development of Crete's electrical system after implementing the respective ISEAP, are compared. The reduction trend of the $CO_2$ emissions for each scenario is shown in Figure 4.1.23, whereas Table 4.17contains the respective values for the target year 2020.

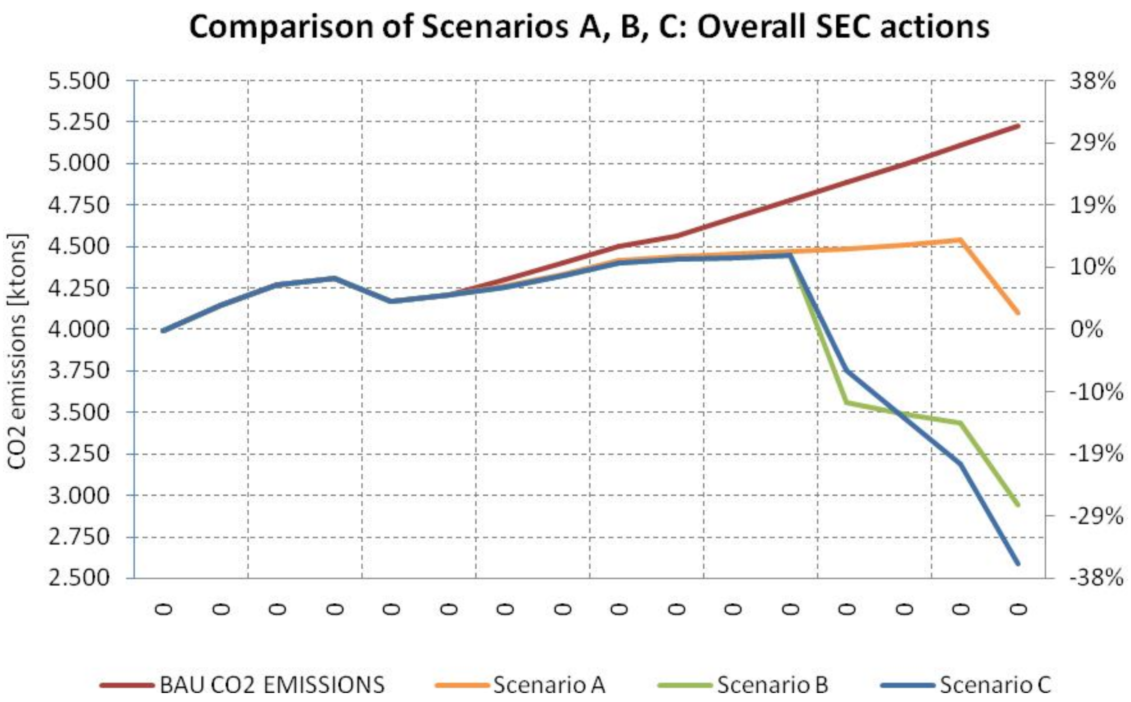



**Figure 4.1.23. Scenarios comparison:CO2 emissions development before and after overall SEC actions**

| Scenario | CO2 emissions change by 2020 in comparison to 2005 values [t] | CO2 emissions change by 2020 in comparison to 2005 values | CO2 emissions change by 2020 in comparison to BAU scenario [%] |
|---|---|---|---|
| BAU Scenario | 5228 | 31% | - |
| Scenario A | 4097 | 3% | -28% |
| Scenario B | 2937 | -26% | -57% |
| Scenario C | 2584 | -35% | -66% |

**Table 4.17. Scenarios comparison: CO2 emissions reduction by 2020 in comparison to 2005 values and the BAU scenario**

In Figure 4.1.24 and Table 4.18 the installed capacity of RES power stations in 2020 is presented for the BAU scenario and the three (3) possible ISEAP scenarios.

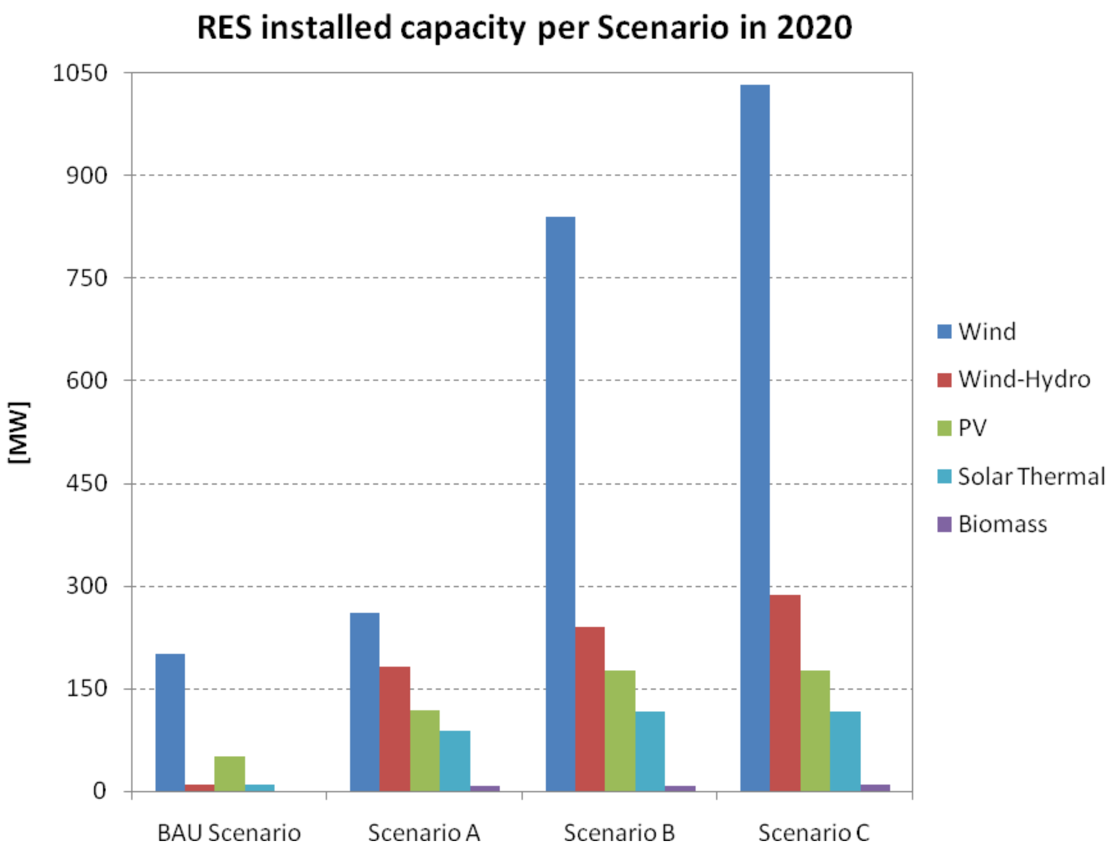



**Figure 4.1.24. PES installed capacity per Scenario in 2020**

| | RES installed capacity per scenario in 2020 [MW] | | | | | |
|---|---|---|---|---|---|---|
| Scenario | Wind | Wind-Hydro | PV | Solar Thermal | Biomass | Total |
| BAU Scenario | 201,6 | 10,1 | 50 | 10 | 0 | **271,7** |
| Scenario A | 260 | 183 | 118 | 88 | 7 | **656** |
| Scenario B | 840 | 241 | 176 | 115,6 | 8,45 | **1381,05** |
| Scenario C | 1033 | 286,1 | 176 | 115,6 | 9,58 | **1620,28** |

**Table 4.18. Scenarios comparison: RES installed capacity per scenarion in 2020**

## 4.3 Primary energy demand

Actions related to the previous sectors of final energy demand and secondary energy conversion can be accounted as actions related also to the primary energy demand. The energy and $CO_2$ emissions profit from these actions is already accounted in the relative sectors and for this reason they will not be re-accounted for their effect in the primary energy demand.

Specifically the actions that improve the primary energy infrastructure can be divided in two sub-categories, those that aim to secure the energy supply and those that aim to make available alternative cleaner energy sources although in some cases actions can apply for both.

***Secure the energy supply:***

- Promotion of locally available renewable energy sources in the secondary energy conversion sector for electricity production (wind parks, PV stations, solar thermal high temperature, biomass, wind-hydro hybrid)
- Introduce natural gas to the electricity production fuel mix to diversify from traditionally used fossil fuels like fuel oil and diesel
- Promotion of locally available renewable energy sources in the final energy demand sector as direct consumption in the end use (biomass, heat pumps, solar thermal low temperature, solar geothermy)
- Reduce the energy consumption in the transportation sector, resulting to less imported fuels
- Introduce biofuels in the transportation sector

***Make available alternative cleaner energy sources:***

- Promotion of biomass use for space heating
- Promotion of solar geothermy for space heating and cooling
- Promotion of solar energy for water heating
- Promotion of biofuels in the transportation sector
- Promotion of hybrid-electric vehicles
- Introduction of natural gas in the electricity production fuel mix as a cleaner fossil fuel to substitute fuel oil and diesel

## 4.4 ISEAP scenario

As already mentioned in the beginning of chapter 4.2 taking into account the risk of delay of the under planning electrical interconnection of Crete with the mainland network, and although the scenarios studied considering the system interconnection could reach very ambitious targets for the $CO_2$ emissions reduction, the **scenario chosen for Crete's ISEAP** the framework of the "Pact of Islands" commitments will combine the **DSM actions with scenario A of the secondary energy conversion sector, retaining the autonomous character of Crete's electrical system until 2020.**

The actions planned under this scenario are described by the following principles:

1. Reduction of annual energy growth rate by promoting rational energy use, energy efficiency and energy saving measures in the different activity sectors
2. Increase of energy efficiency by promoting the use of energy efficient systems in the end use
3. Reduction of conventional energy systems by promoting substitution or introduction of energy systems based on RES or energy saving technologies.
4. Introduction of biofuels and electric-hybrid vehicles in the transportation sector
5. Electricity production based on renewable energy sources
6. Introduction of wind-hydro hybrid and biomass units as base load RES power plants
7. Introduction of natural gas as a substitute of high emitting fossil fuels for conventional electricity production

| Activity sector | | Primary energy demand reduction | | $CO_2$ emissions reduction | |
|---|---|---|---|---|---|
| | | Percentage decrease[%] | Absolute decrease[MWh] | Percentage decrease[%] | Absolute decrease[ktons] |
| **Residential** | | 4.80 | 1026128 | 3.56 | 142189 |
| **Primary** | | 0.96 | 204791 | 1.33 | 53158 |
| **Secondary** | | 2.28 | 486964 | 2.33 | 92898 |
| **Tertiary** | **Commercial** | 3.51 | 751617 | 5.29 | 211280 |
| | **Tourism** | 2.97 | 634433 | 4.63 | 184849 |
| | **Public** | 1.01 | 215353 | 1.55 | 61976 |
| **Transports** | | 2.50 | 534321 | 4.05 | 161564 |
| **Total** | | **16.63** | **3556022** | **27.74** | **1107547** |

**Table 4.19''. Contribution of each activity sector in the primary energy demand and $CO_2$ emissions reduction through the implementation of DSM actions by 2020**

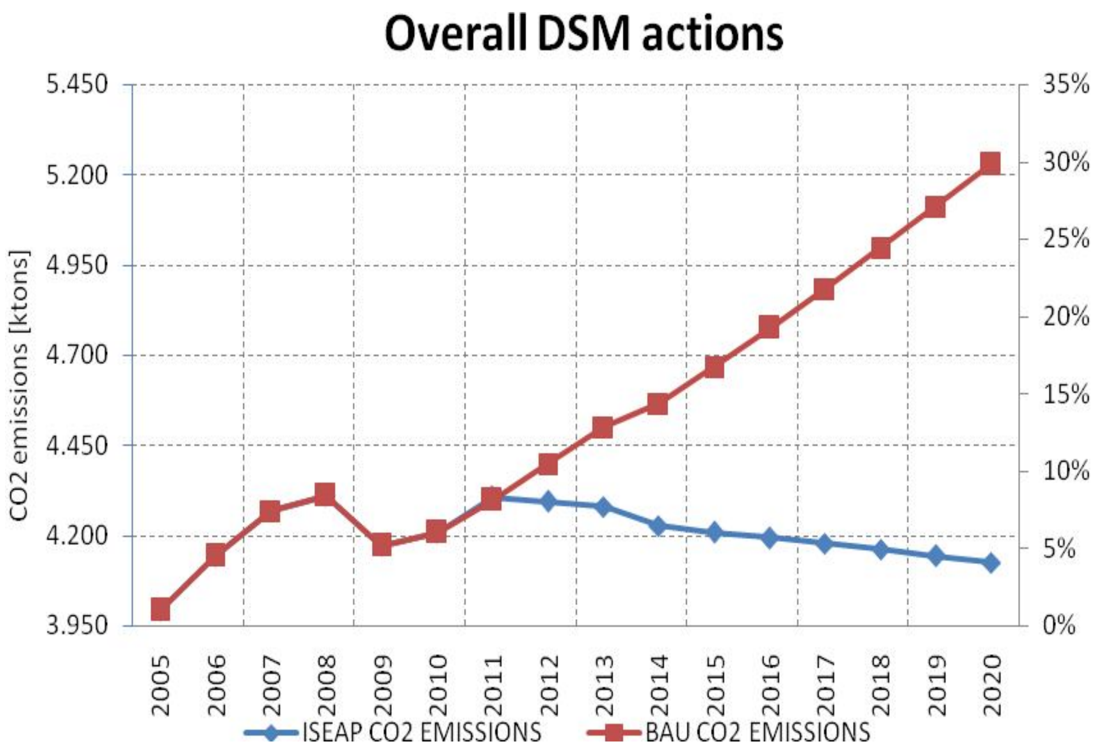



**Figure 4.4.1. CO2 emissions development before and after overall DSM actions**

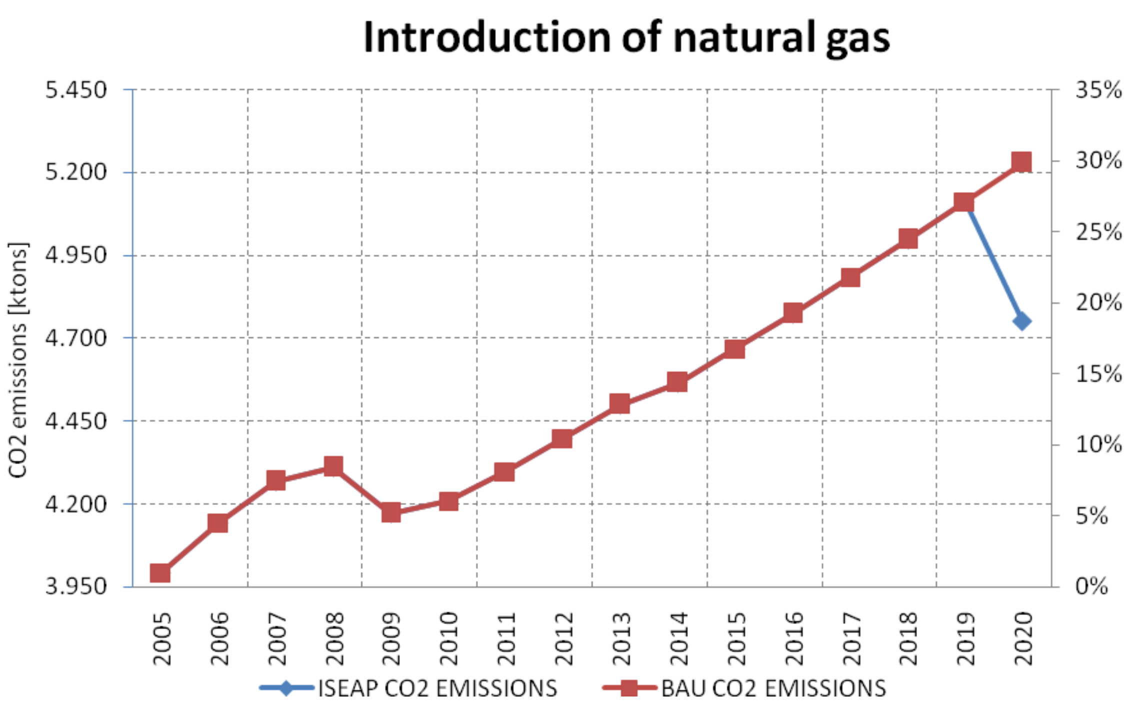



**Figure 4.4.2 CO2 emissions before and after the installation of the natural gas combined cycle generators**

| | Fossil fuels | | | | |
|---|---|---|---|---|---|
| | Fueloil | Diesel | Natural gas | Sub-total | TOTAL |
| MWh | 3576796 | 821298 | -3656250 | 741844 | 3556022 |
| % | 40,97% | 12,21% | - | 3,82% | 3,47% |

**Table 4.20''. Primary energy demand change after the installation of the natural gas combined cycle generators**

| [MW] | Wind | | Wind-Hydro | | PV | | Solar Thermal | | Biomass | |
|---|---|---|---|---|---|---|---|---|---|---|
| Year | BAU | Sc. A | BAU | Sc. A | BAU | Sc. A | BAU | Sc. A | BAU | Sc. A |
| 2010 | 170 | 170 | 0 | 0 | 30.7 | 20 | 0 | 0 | 0 | 0 |
| 2015 | 185 | 222 | 7.4 | 20 | 40 | 81.4 | 5 | 5 | 0 | 0 |
| 2020 | 201.6 | 260 | 10.1 | 183 | 50 | 118 | 10 | 88 | 0 | 7 |

**Table 4.21''. Scenario A - Planned installed capacity of electricity production RES units**

| | Fossilfuels | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Fueloil | Diesel | Sub-total | | | | | |
| MWh | 1860100 | 499306 | 2359405 | | | | | |
| % | 21,31% | 7,42% | 12,14% | | | | | |
| | Renewableenergysources | | | | | | | |
| | Wind | PV | Wind - Hydrohybrid | Solar thermal - high temp. | Biomass | Urbanwaste | Sub-total | TOTAL |
| MWh | -175214 | -58382 | -305134 | -200831 | -42150 | -515 | -782226 | 1577180 |
| % | -32,48% | -16,94% | -1704,02% | -775,82% | -4,16% | -46,74% | -40,27% | 7,38% |

**Table 4.22''. Primary energy demand change after the installation of the RES electricity production units**

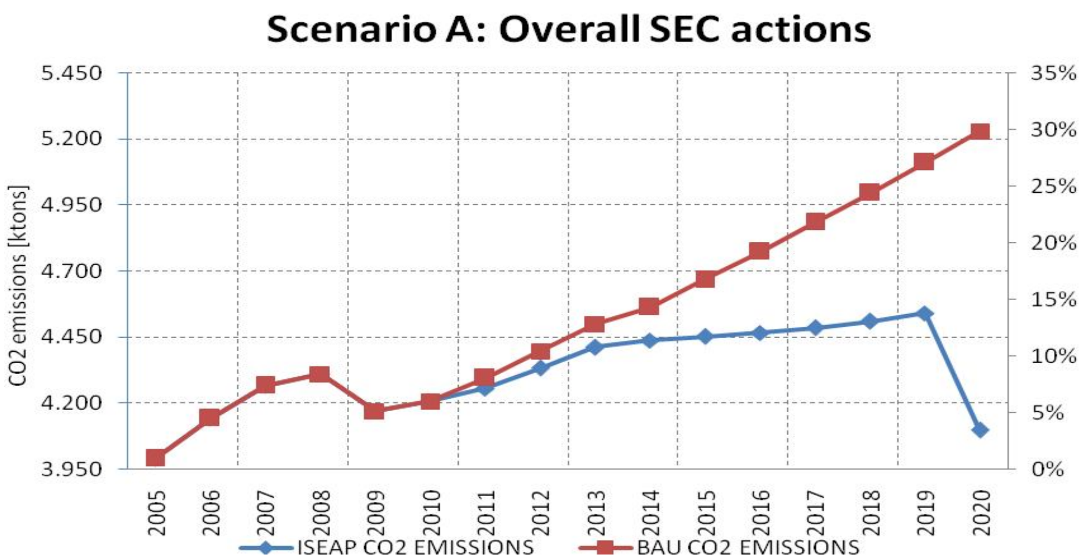



**Figure 4.4.3 Scenario A: CO2 emissions development before and after overall SEC actions**

| | Fossil fuels | | | | |
|---|---|---|---|---|---|
| | Fueloil | Diesel | Naturalgas | Sub-total | TOTAL |
| MWh | 3576796 | 821298 | -3656250 | 741844 | 3556022 |
| % | 40,97% | 12,21% | - | 3,82% | 3,47% |

**Table 4.23''Primary energy demand change after the installation of the natural gas combined cycle generators**

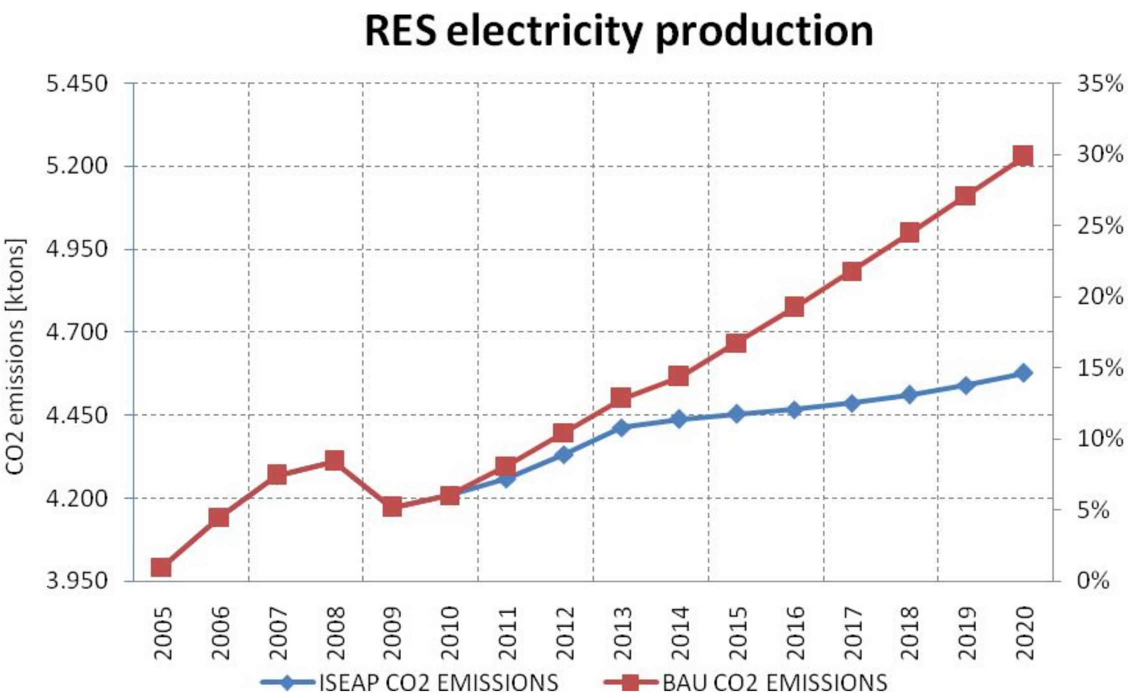



**Figure 4.4.4 SEAP Scenario: CO2 emissions before and after the installation of the RES electricity production units**

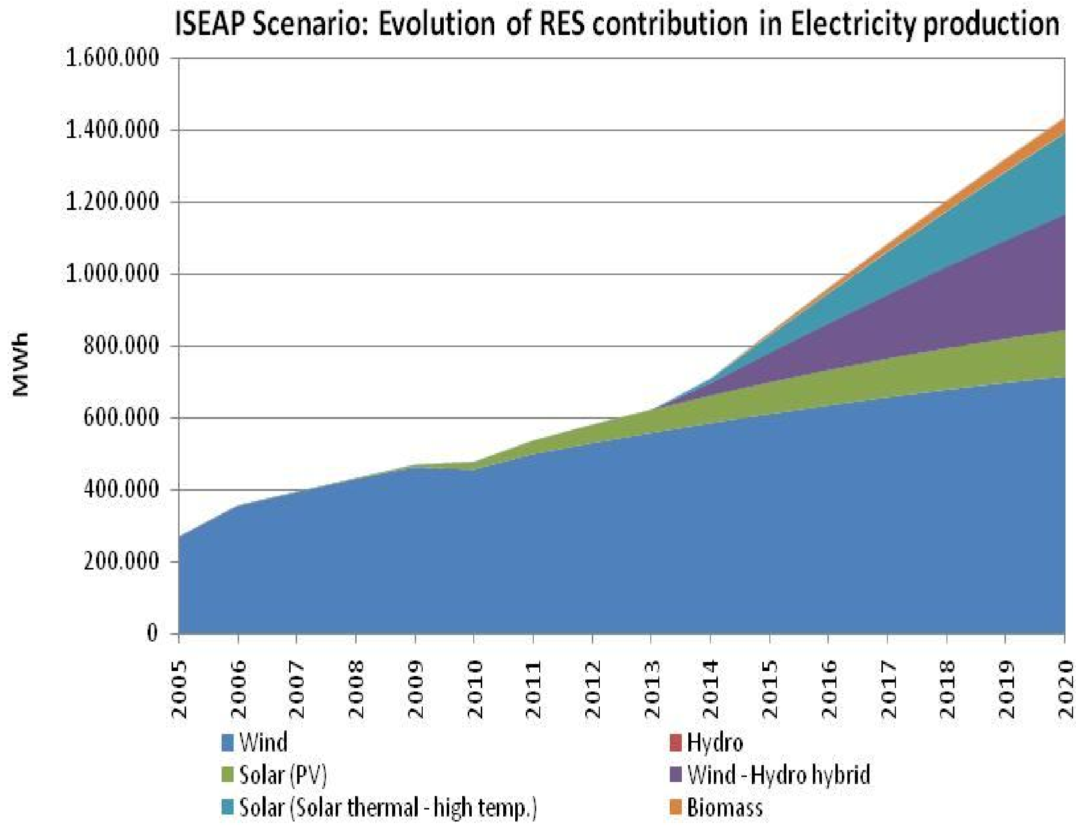



**Figure 4.4.5 . ISEAP Scenario: Evolution of RES contribution in Electricity production**

The combination of the DSM actions and SEC actions of scenario A (which is the chosen as the **ISEAP Scenario**) result to a reduction of **2238237 tons** of $CO_2$ emissions or **56, 07%** by 2020 in comparison to the respective values of the **BAU** scenario.

In comparison to the **baseline year 2005** the adopted ISEAP actions result to a reduction of **997757 tons** of $CO_2$ emissions or **25%** by 2020.

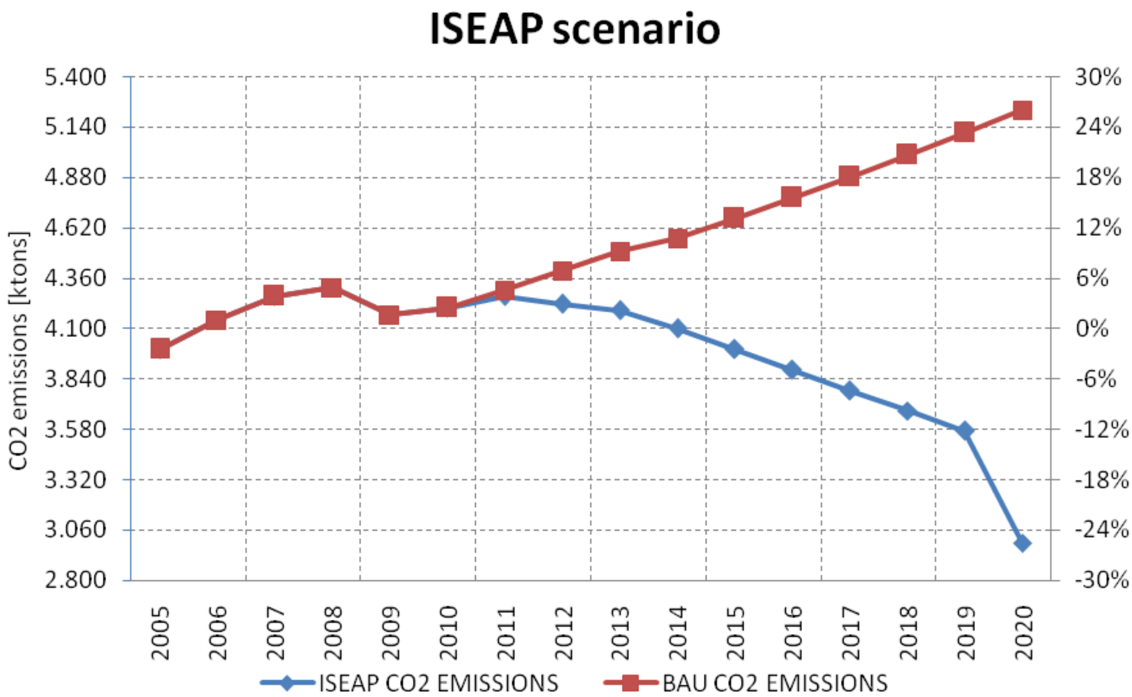



**Figure 4.4.6 " ISEAP - OVERALL Scenario: CO2 emissions development comparison between BAU and ISEAP scenario**

Additionally to that it should be noted that in 2020 through the implementation of the ISEAP the contribution **of RES in the primary energy demand will escalate to 22%** in comparison to the BAU scenario where the percentage would be only 9% (or 7% in comparison to the baseline year 2005.

Finally the contribution of **RES in the electricity production** from 16% in the BAU scenario or 10% in 2005 reaches up to **36%** with the ISEAP.

| | **Base Year (2005)** | **BAU (2020)** | **ISEAP (2020)** |
|---|---|---|---|
| **RES in Primary Energy Demand** | 7% | 9% | 22% |
| **RES contribution in electricity production** | 10% | 16% | 36% |

| **Carbon Dioxide emissions change** | |
|---|---|
| **ISEAP (2020)** | **- 25%** compared to 2005 |
| | **- 56,07%** compared to BAU on 2020 |

**Table 4.24" ISEAP Comparison to BAU and Base Year (2005) for RES electricity and $CO_2$ emissions**

**The final results (2020) are depicted as follows:**

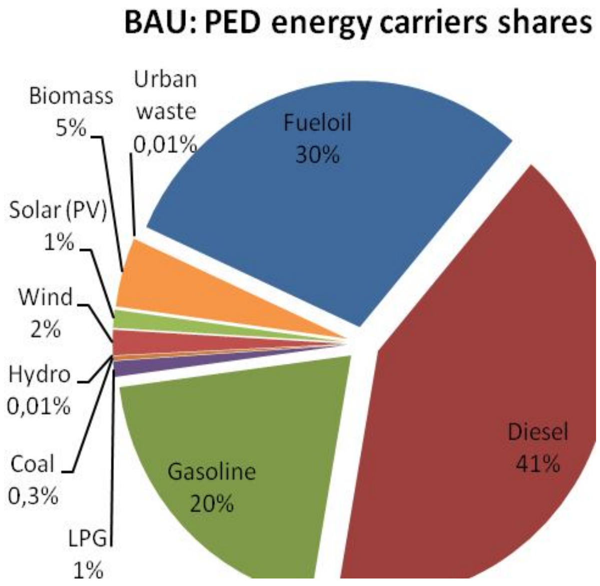



**Figure 4.4.7 BAU scenario: Energy carriers shares to the primary energy demand in 2020**

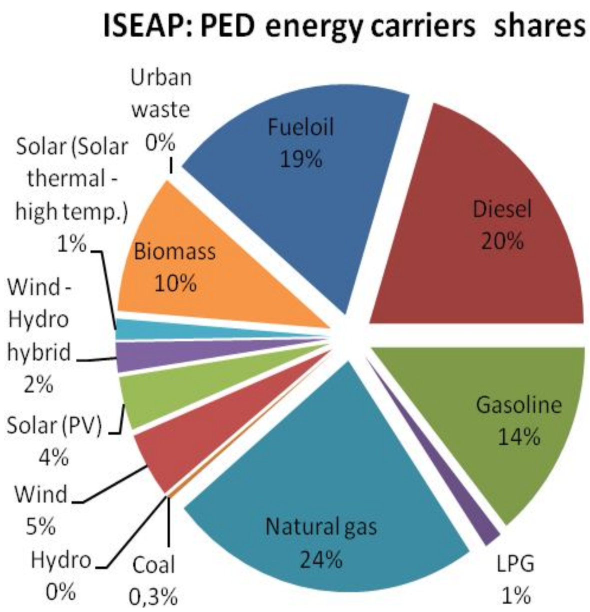



**Figure 4.4.8 ISEAP scenario: Energy carriers shares to the primary energy demand in 2020**

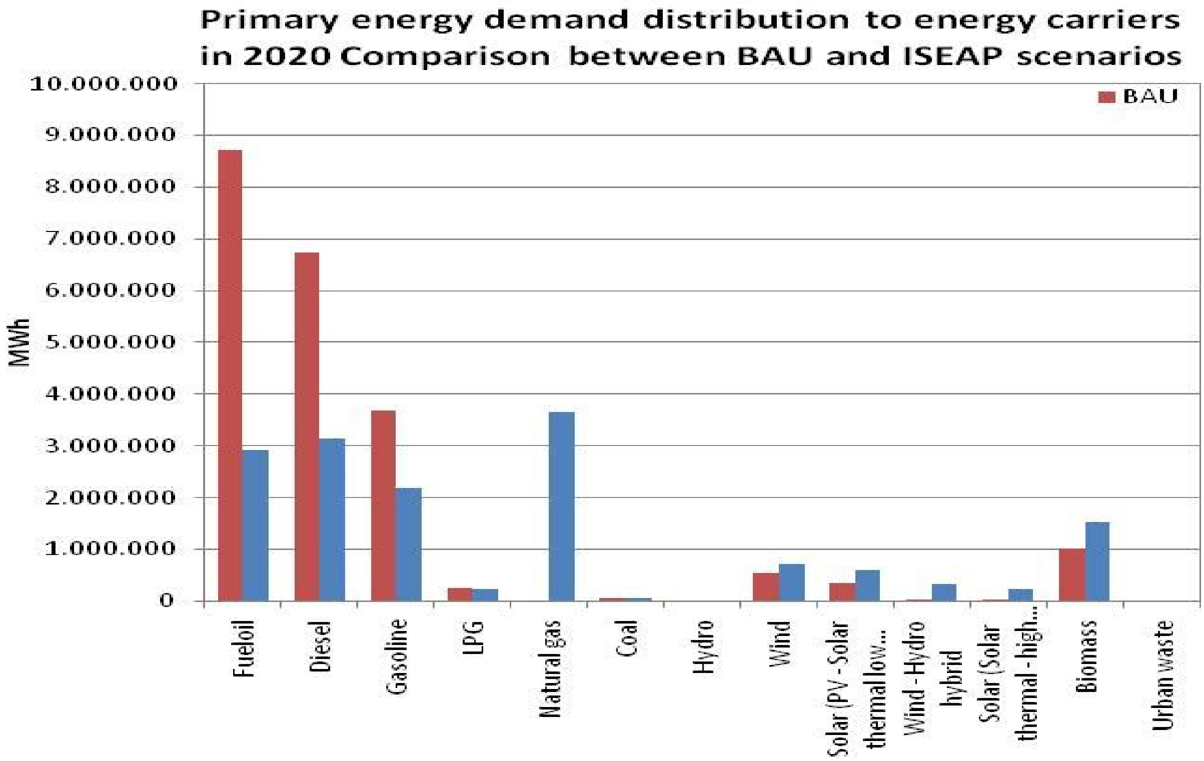



**Figure 4.4.9**. **"Primary energy demand distribution to energy carriers in 2020 Copmarison between BAU and ISEAP scenarios**

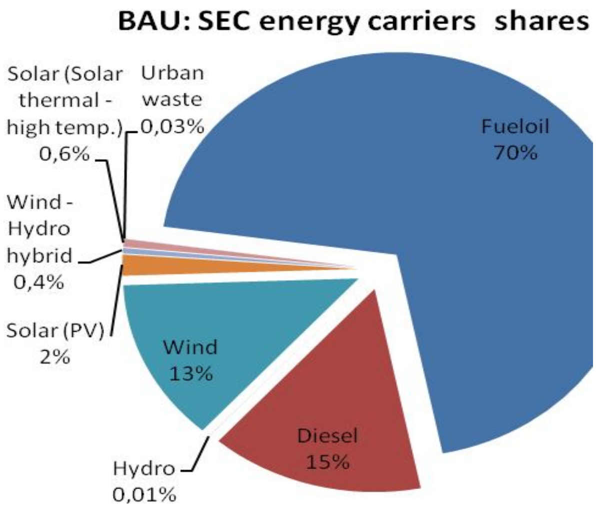



**Figure 4.4.10 BAU scenario: Energy carriers shares to the electricity production in 2020**

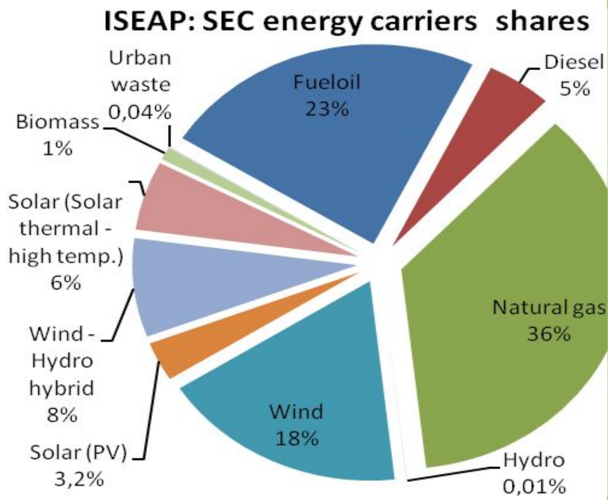



**Figure 4.4.11. ISEAP scenario: Energy carriers shares to the electricity production in 2020**

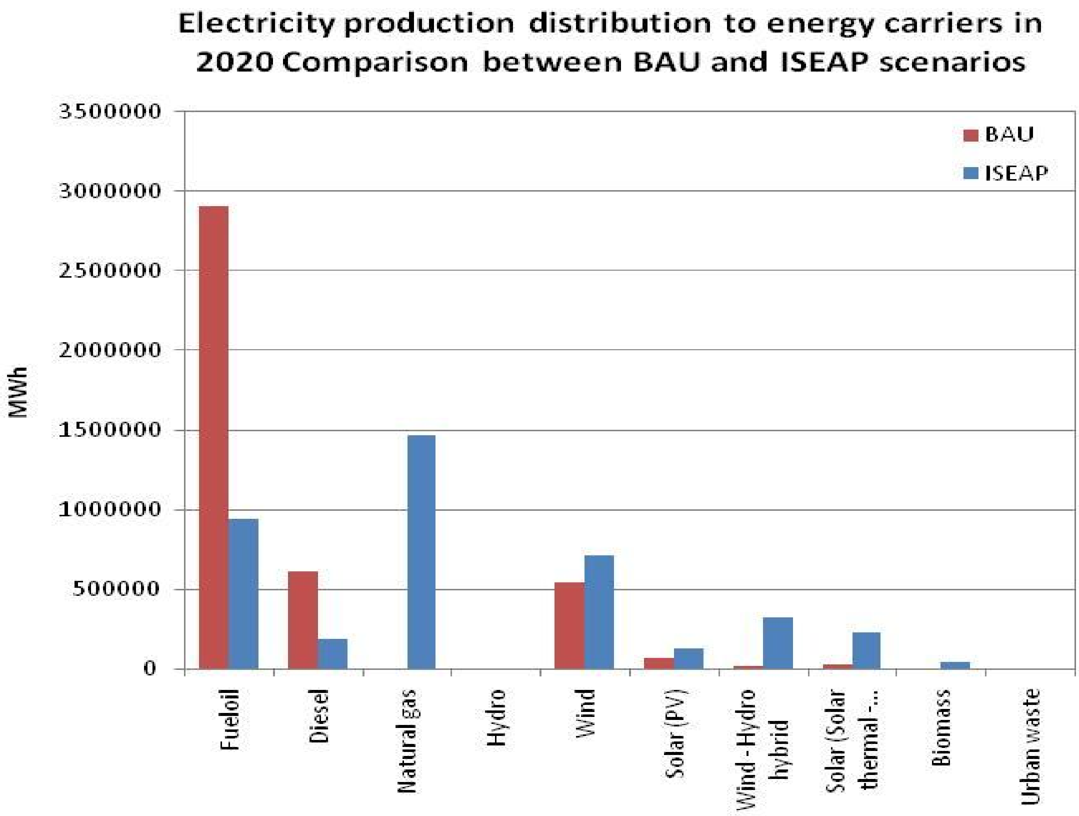



**Figure 4.4.12 .Electricity production distribution to energy carriers in 2020 Comparison between BAU and ISEAP scenarios**

# 5 ORGANIZATIONAL AND FINANCIAL MECHANISMS

The organization and financial framework and the adequate implementation mechanisms are prerequisites for the implementation, monitoring and optimization of ISEAP. They must be flexible, adaptable, efficient and innovative in order to promote the "energy component" as a decisive factor of regional sustainable energy development.

## 5.1 Coordination and organizational structures

The coordination and organizational flowchart is mainly depicted to the paragraph 1.4. The political coordination body is the Regional Council and the coordinating main implementation structure will be the Regional Energy Agency of Crete. All relevant stakeholders will be actively involved. The regional ISEAP will also be linked to the municipal and local ISEAPs which – at the time being – are at initialization phase. The main coordination structure of REAC will be in continuous cooperation with other relevant regional, national and European structures and authorities.

Big RES investments will be assessed in cooperation with the Greek Energy Regulative Authority, the Operator of the Electricity system and the relevant Financial bodies and authorities.

Extensive and intensive information dissemination and promotion will be coordinated and combined with other relevant activities e.g. for climate change. The Mass media, the Web, the social media and other innovative and up-to-date solutions will be adequately used. The support and Steering Committee of REAC could also be used as permanent structure for ISEAP implementation and monitoring.

## 5.2 Staff capacity

The Regional Energy Agency of Crete will be the main coordination and Implementation body of ISEAP. The minimum staff requirements are: The Director, three engineers, one economist, one information-dissemination officer, and secretary support. There will be also strong relations with the President of the Region, the Regional Council the Mayors and all the relevant regional, national and European stakeholders, as well as, with the markets, the citizens and the public.

Continuous cooperation is being developed with the licensing of RES authorities and the financial supports structures.

Information-dissemination activities will be developed in cooperation with educational and school authorities consumers' organizations, Chambers of engineers and professional associations.

The staff capacity will be enhanced by specific training, by participating in European projects, by technical visits and by intensive exchange of experiences and knowhow.

External assistance and experts' support will be used according to specific needs and specific projects and activities. A specific monitoring team of ISEAP, as well as, of other ISEAPs of Local authorities is also needed.

## 5.3 Involvement of stakeholders

The Region of Crete is planning to maximize the involvement of the stakeholders and citizens through the following list of actions:

- Organize ISEAP info days in collaboration to the Municipalities where the citizens and stakeholders will be informed about the progress of the ISEAP and the discussion among the participants will be promoted.

- Invite the citizens into voluntary actions focusing on environmental protection and changing of energy behaviors.

- Distribute questionnaires to the citizens to depict their satisfaction of the ISEAP progress

- Invite stakeholders to working meetings with the steering committee and the working group where the ISEAP goals will be discussed in depth and updated or reformulated if needed.

## 5.4 Budget

The total estimated budget allocations for the implementation and monitoring of the ISEAP are 850.000€ and they are distributed among the different action sectors as follows:

| Action sectors | Budget [€] |
|---|---|
| Residential | 180.000 |
| Primary | 20.000 |
| Secondary | 40.000 |
| Tertiary | 265.000 |
| Transports | 25.000 |
| Secondary Energy Production | 150.000 |
| Citizens and Stakeholders | 70.000 |
| **Total** | **850.00** |

**Table 5.1. ISEAP Budget allocations per action sector**

## 5.5 Financing sources and instruments

The Regions of Crete is foreseeing to exploit in the most favorable way the following financing sources and instruments in order to implement in success the submitted ISEAP:

1) Regional budget
2) National budget
3) Municipal budget
4) Bank Loans
5) NSRF (National Strategic Reference Framework)
6) European Investment Bank
7) Private investments
8) Collaborations between public and private sector
9) European Programs and Initiatives

## 5.6 Monitoring and follow-up

The **Regional Energy Agency of Crete** will actively take over the monitoring task of the ISEAP of Crete.

The monitoring tools provided from the ISLEPACT project in combination with in-house monitoring techniques will be used to ensure the well-functioning of the ISEAP monitoring task.

A specific work team will be created with main responsibility to promote the implementation of the ISEAP and monitor its progress.

*Elaboration:* ***REGIONAL ENERGY AGENCY OF CRETE (REAC)***

**Coordination /Assessment: Dr Nikolaos Zografakis**

## *Financial support:*

EUROPEAN COMMISSION
Directorate-General for Energy

## *Disclaimer*