Crete Power System

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4th International Hybrid Power Systems Workshop

'Out of the Blue Capsis Elite Resort' , Agia Pelagia, Heraklion, Crete, Greece

New Electricity Regulation and Electricity Directive

- Last December (2018) **THE EU REACHED A POLITICAL AGREEMENT.**
- **EU UPDATES ITS ENERGY POLICY IN ORDER TO FACILITATE THE CLEAN ENERGY TRANSITION. THE NEW AGREEMENT WILL EMPOWER EUROPEAN CONSUMERS TO BECOME FULLY ACTIVE PLAYERS IN THE ENERGY TRANSITION AND FIXES NEW TARGETS FOR THE EU FOR 2030:**
- 32% Renewable energy target
- 32,5% Energy efficiency target
- 15% Interconnection target of the electricity market
- 45% Emission reductions relative to 1990

Drivers for implementing renewable energy transition

- increase of the renewable resource potential,
- new technologies
- policy support

As it is written in **European Commission - Press release :**

"The road to a climate neutral economy would require joint action in seven strategic areas:

- energy efficiency
- deployment of renewables
- clean, safe and connected mobility
- competitive industry and circular economy;
- infrastructure and interconnections
- bio-economy and natural carbon sinks
- carbon capture and storage to address remaining emissions.."

NEW INTECONNECTIONS WITH THE MAINLAND ARE UNDER BIDDING AND CONSTRACTION

IT IS THE BIGGEST INSTALLATION IN GREEK ELECTRICITY HISTORY

- Phase I: 150kV AC interconnection, 2×200MVA (~2x140MW) capability, Crete – Peloponnese
- Phase II: DC interconnection, 2×350MW capability, Crete - Attica

1,3 BILLION EUROS FOR BOTH INTERCONNECTIONS:

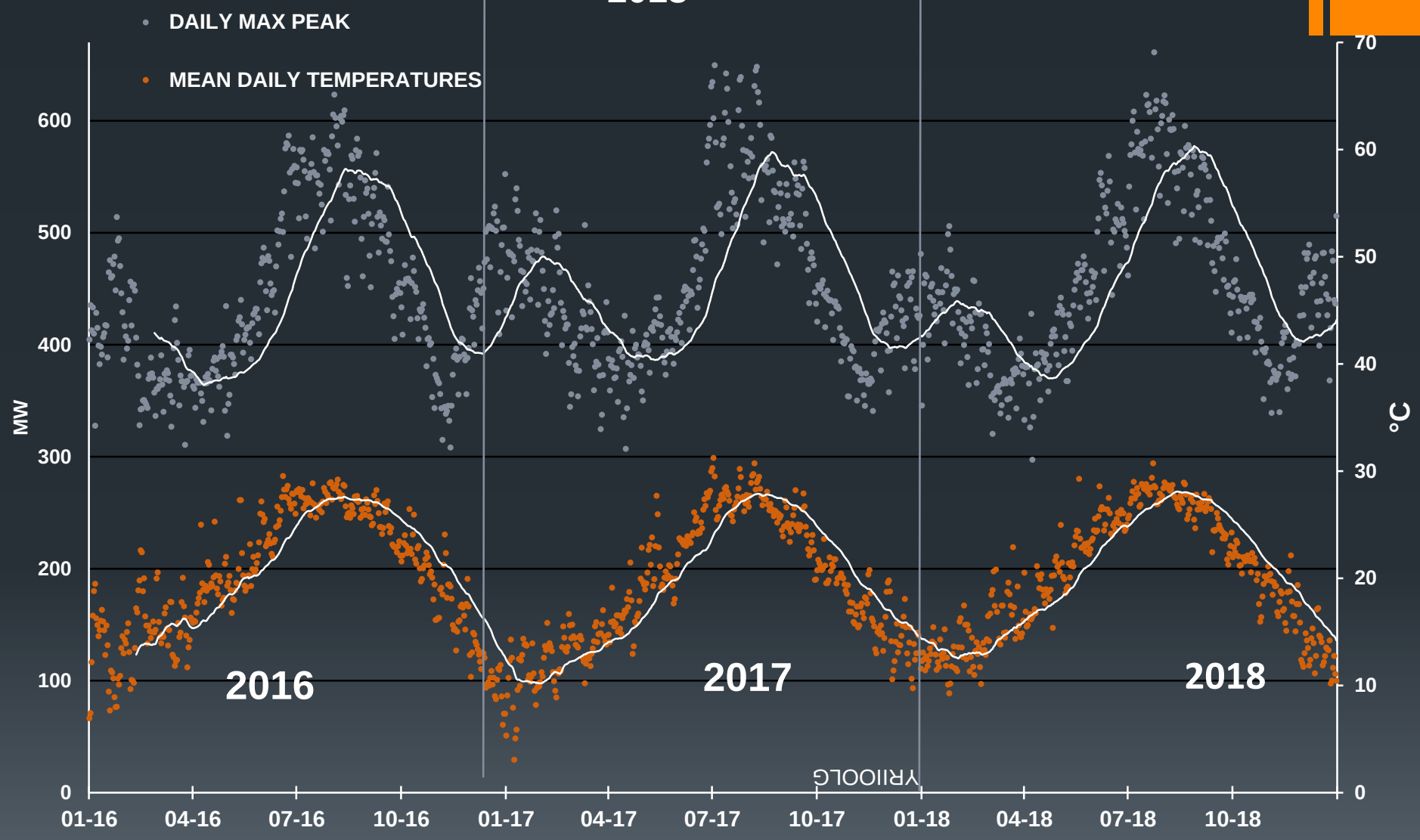
400 MILLION THE ‘SMALL’ AC INTERCONNECTION with Peloponnese, 900 MILLION THE ‘BIG’ DC INTERCONNECTION with Attica

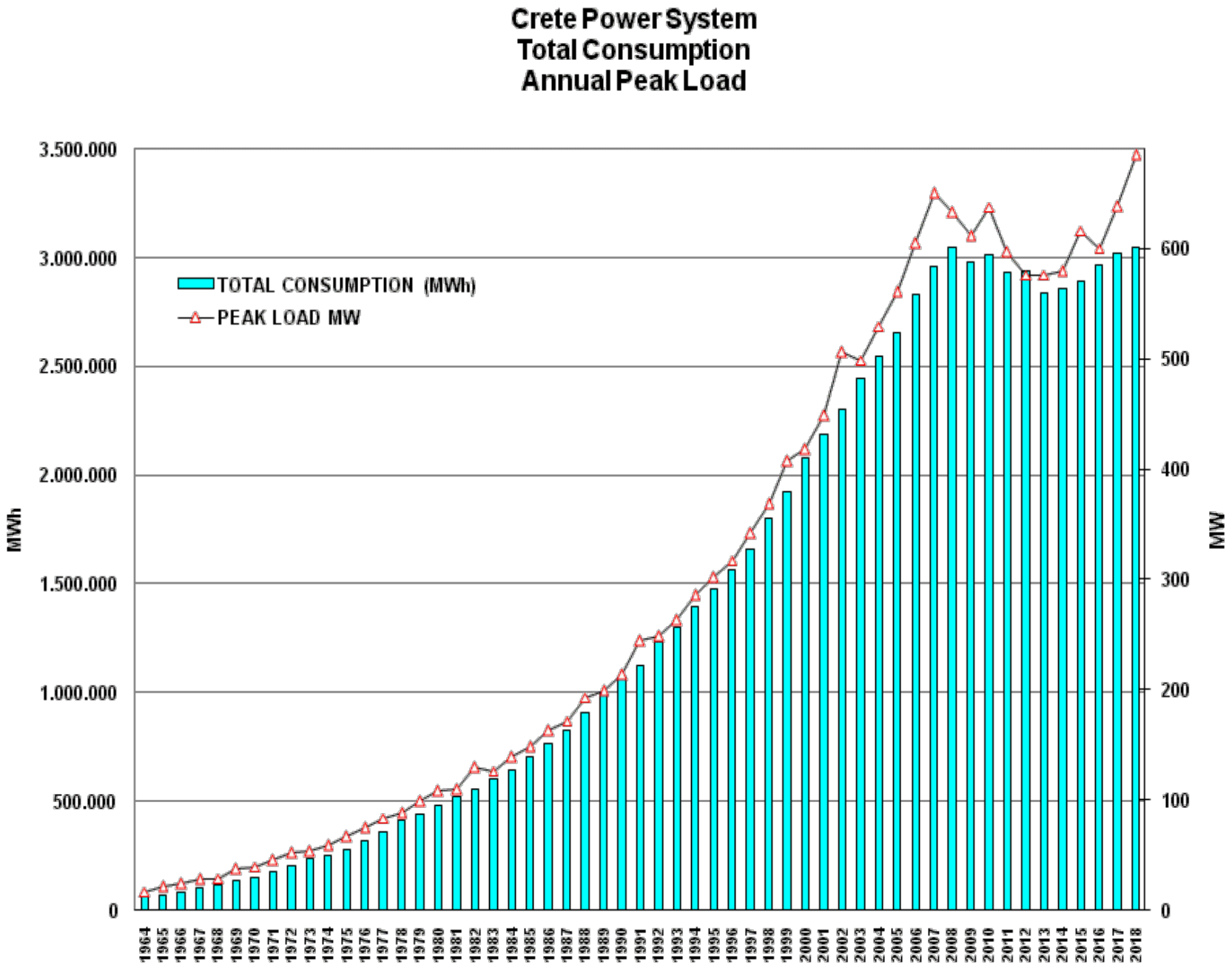
The commissioning of the first project is expected in 2020-21

The installation of a Static Var Compensator (SVC) in Crete will be required for the necessary voltage regulation.

Static Var Compensators (SVCs) are devices that can quickly and reliably control line voltages.

CRETE DAILY MAX PEAK AND MEAN TEMPERATURES 2016-2017-2018




Crete Power System
Total Consumption
Annual Peak Load
TOTAL CONSUMPTION (MWh)
PEAK LOAD MW
MWh
MW
3.500.000
3.000.000
2.500.000
2.000.000
1.500.000
1.000.000
500.000
0
600
500
400
300
200
100
0
1964
1965
1966
1967
1968
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
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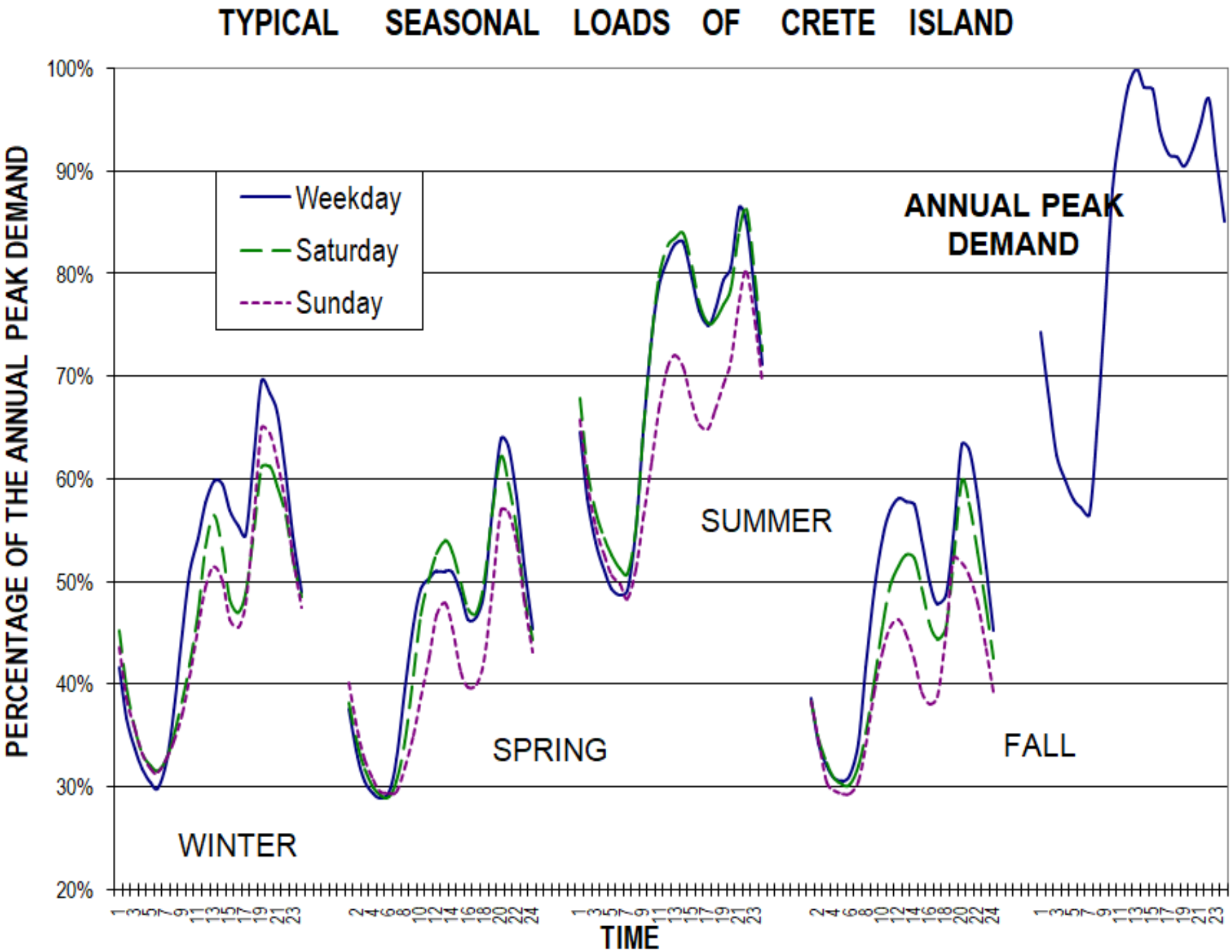
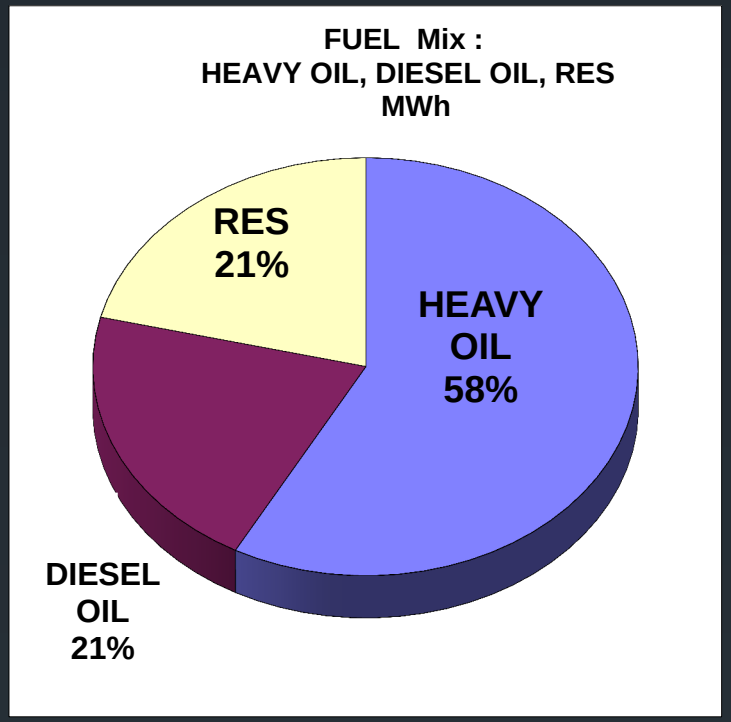
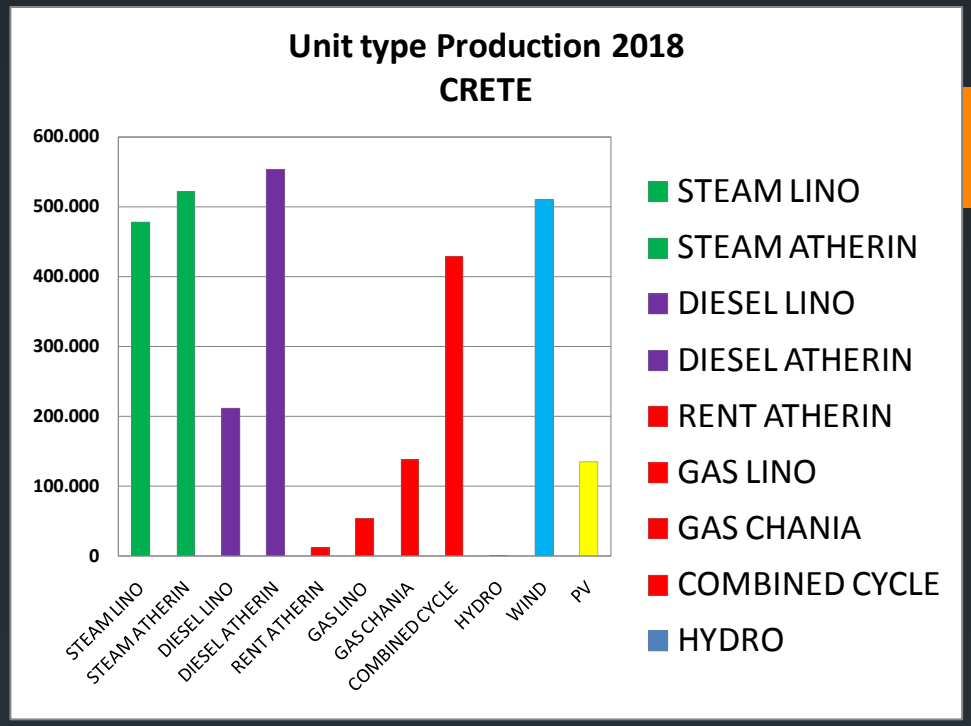
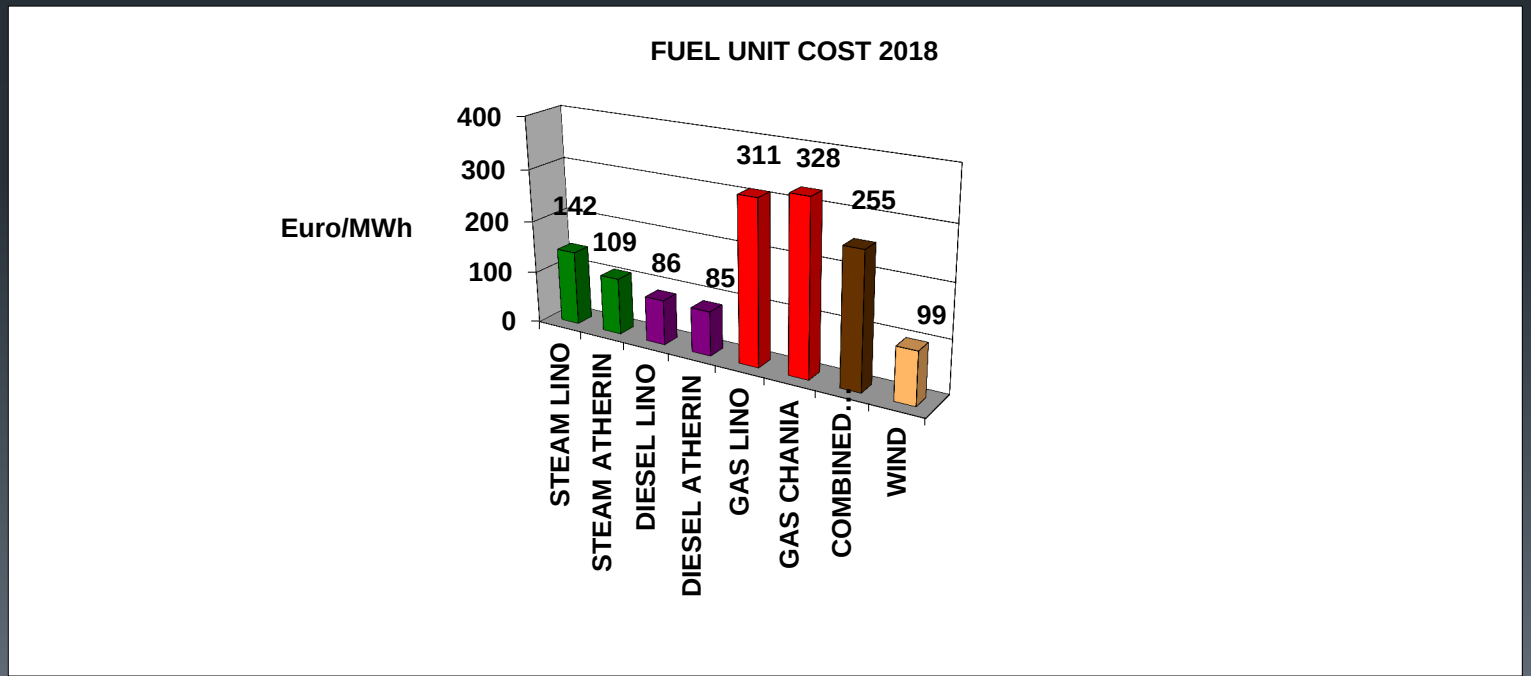
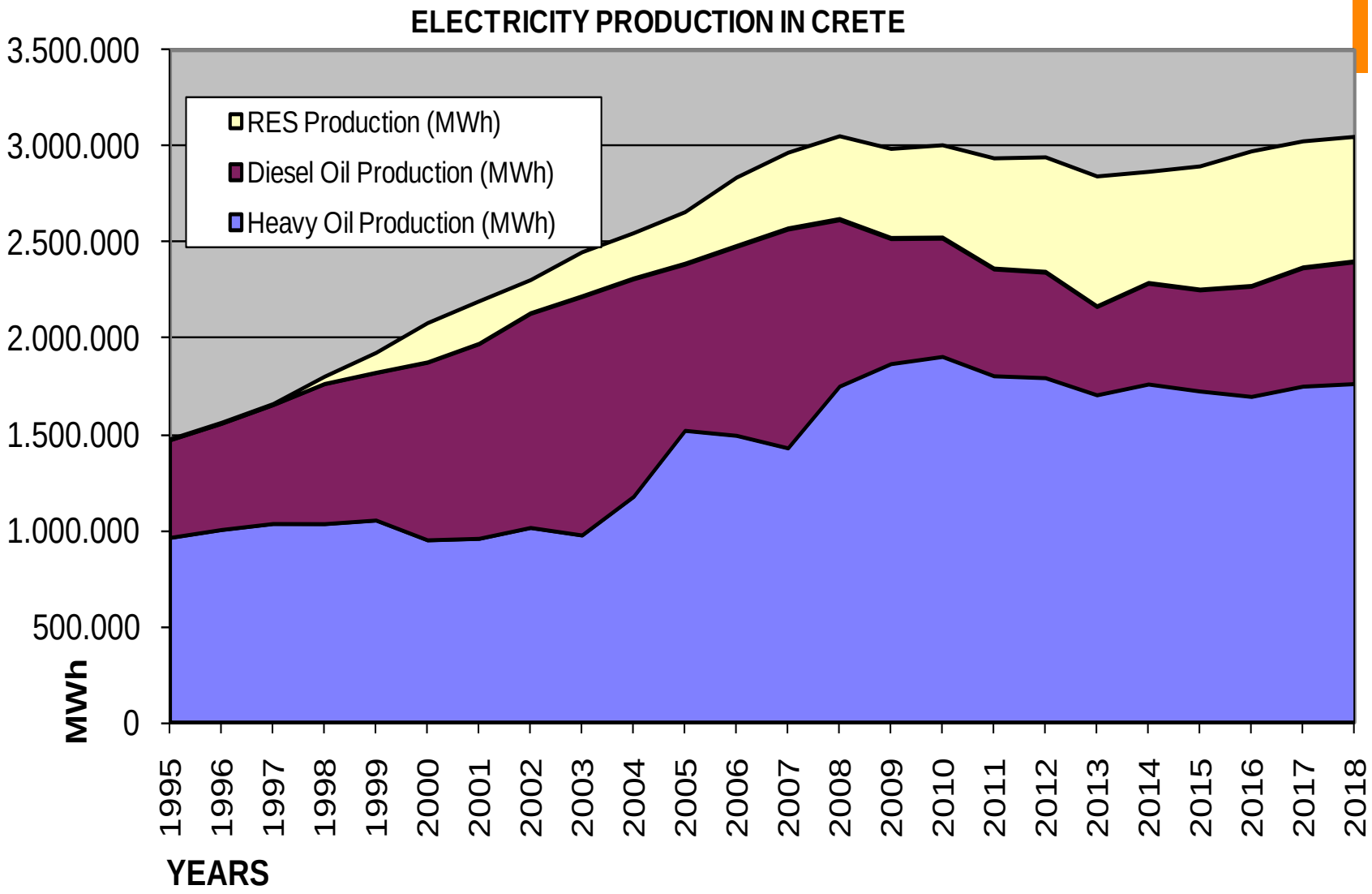
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018


TYPICAL SEASONAL LOADS OF CRETE ISLAND
PERCENTAGE OF THE ANNUAL PEAK DEMAND
100%
90%
80%
70%
60%
50%
40%
30%
20%
Weekday
Saturday
Sunday
ANNUAL PEAK DEMAND
SUMMER
SPRING
FALL
WINTER
TIME


FUEL Mix :
HEAVY OIL, DIESEL OIL, RES
MWh
RES
21%
HEAVY
OIL
58%
DIESEL
OIL
21%


Unit type Production 2018
CRETE
600.000
500.000
400.000
300.000
200.000
100.000
0
STEAM LINO
STEAM ATHERIN
DIESEL LINO
DIESEL ATHERIN
RENT ATHERIN
GAS LINO
GAS CHANIA
COMBINED CYCLE
HYDRO
WIND
PV
STEAM LINO
STEAM ATHERIN
DIESEL LINO
DIESEL ATHERIN
RENT ATHERIN
GAS LINO
GAS CHANIA
COMBINED CYCLE
HYDRO


FUEL UNIT COST 2018
Euro/MWh
400
300
200
100
0
142
109
86
85
311
328
255
99
STEAM LINO
STEAM ATHERIN
DIESEL LINO
DIESEL ATHERIN
GAS LINO
GAS CHANIA
COMBINED...
WIND


ELECTRICITY PRODUCTION IN CRETE
RES Production (MWh)
Diesel Oil Production (MWh)
Heavy Oil Production (MWh)
3.500.000
3.000.000
2.500.000
2.000.000
1.500.000
1.000.000
500.000
0
MWh
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
YEARS


ΝΟΜΟΣ ΧΑΝΙΩΝ
ΝΟΜΟΣ ΡΕΘΥΜΝΟΥ
ΝΟΜΟΣ ΗΡΑΚΛΕΙΟΥ
ΝΟΜΟΣ ΛΑΣΗΘΙΟΥ
ΥΠΟΜΝΗΜΑ

ALTICON © (2007-2009) A7::TX_VIEW - KRHTH6 (94) - Οθόνη Β

A B 49.938 0.06 1-ΑΠΡ-16 07:36:39

150kV

19W

ΣΠΗΛΙ 0W

148V

ΡΕΘΥΜΝΟ

P10 P30 P20 P10

35W

P10 P20 P30 -3W

20W P40 P50 P80 17W -16W ΛΗΚ

6W

-21W P10

151kV ΗΡΙΙΙ

1W

P40

P20 -18W

151V ΗΡΑΚ Ι

P10 0kW

ΣΤΑΛ

150kV -3W

ΧΑΝΙΑ P10

P30 -12W P20

15W

4W -35W

14W -19W

P20 P10

ΒΡΥΣΣΕΣ

11W

17W P10

-28W P20

-2W -6W

P30 P40 P20 2W

150kV

ΗΡΑΚ ΙΙ

-37kW P10

ΑΓ.ΒΑΡΒΑΡΑ

1W

ΑΓΥΙΑ

6W

151kV 38W P30

ΑΘΕΡΙΝΟΛ

51W P20 P40 30W

26W

ΑΓ.Ν

P10

ΜΟΙΡΕΣ

14W

P10

P20

ΚΑΣΤΕΛΙ

8W

P20 -30W

ΣΗΤΕΙΑ

P30 24W

-37W P20

0W ΜΑΡΩΝΙΑ

ΠΡΑΙΤΩΡΙΑ

8W

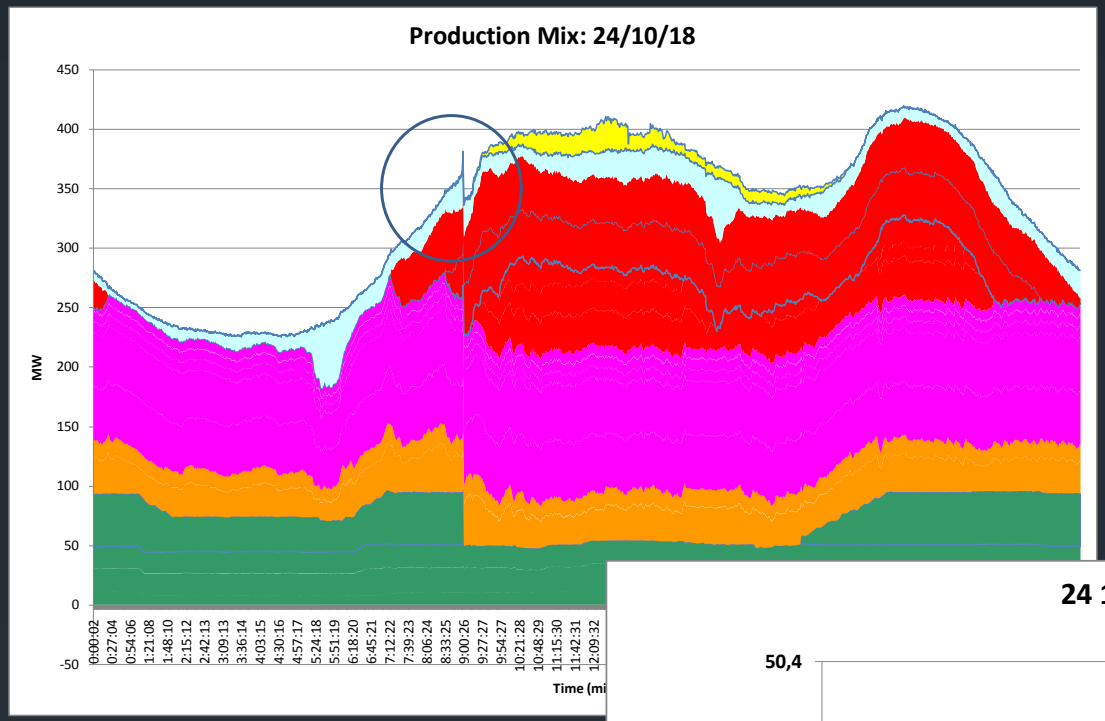
-50W

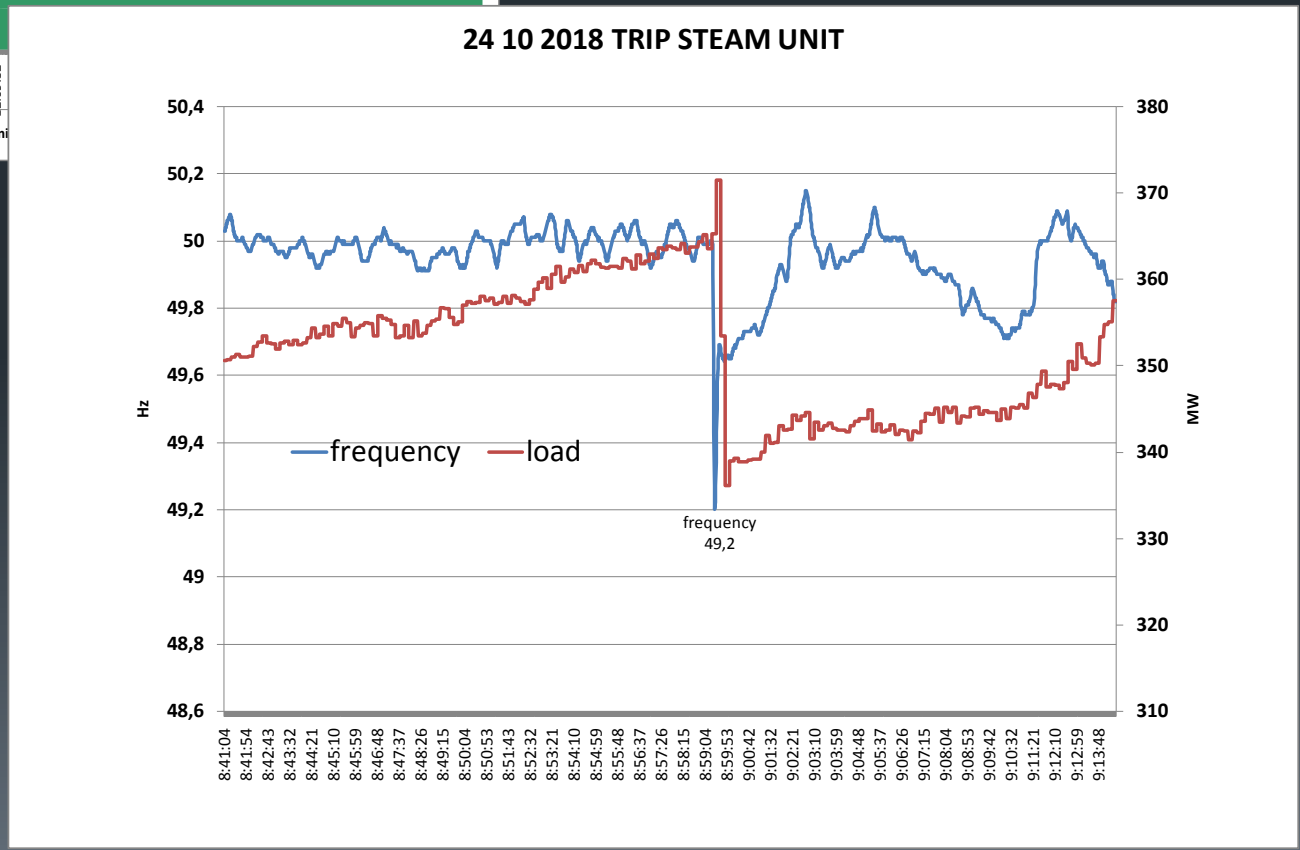
P30 P40 -23W

ΙΕΡΑΠΕΤΡΑ

24W P10 P20 38W

(X,Y) 792:398 Ενημέρωση για Ανενεργό Εικόνα (2)


Production Mix: 24/10/18
MW
450
400
350
300
250
200
150
100
50
0
-50
0:00:02
0:27:04
0:54:06
1:21:08
1:48:10
2:15:12
2:42:13
3:09:13
3:36:14
4:03:15
4:30:16
4:57:17
5:24:18
5:51:19
6:18:20
6:45:21
7:12:22
7:39:23
8:06:24
8:33:25
9:00:26
9:27:27
9:54:27
10:21:28
10:48:29
11:15:30
11:42:31
12:09:32
Time (mi


24 10 2018 TRIP STEAM UNIT
Hz
50,4
50,2
50
49,8
49,6
49,4
49,2
49
48,8
48,6
MW
380
370
360
350
340
330
320
310
frequency
load
frequency
49,2
8:41:04
8:41:54
8:42:43
8:43:32
8:44:21
8:45:10
8:45:59
8:46:48
8:47:37
8:48:26
8:49:15
8:50:04
8:50:53
8:51:43
8:52:32
8:53:21
8:54:10
8:54:59
8:55:48
8:56:37
8:57:26
8:58:15
8:59:04
8:59:53
9:00:42
9:01:32
9:02:21
9:03:10
9:03:59
9:04:48
9:05:37
9:06:26
9:07:15
9:08:04
9:08:53
9:09:42
9:10:32
9:11:21
9:12:10
9:12:59
9:13:48

RES in Crete Power System

- Crete has an electrical isolated power system.
- Although Crete has begun the transition to clean energy, petroleum is still imported to be burnt in conventional power plants. A percentage of 75% of electricity on the island is produced from:
- conventional steam turbines,
- internal combustion units,
- gas turbines
- one combined circle power plant.

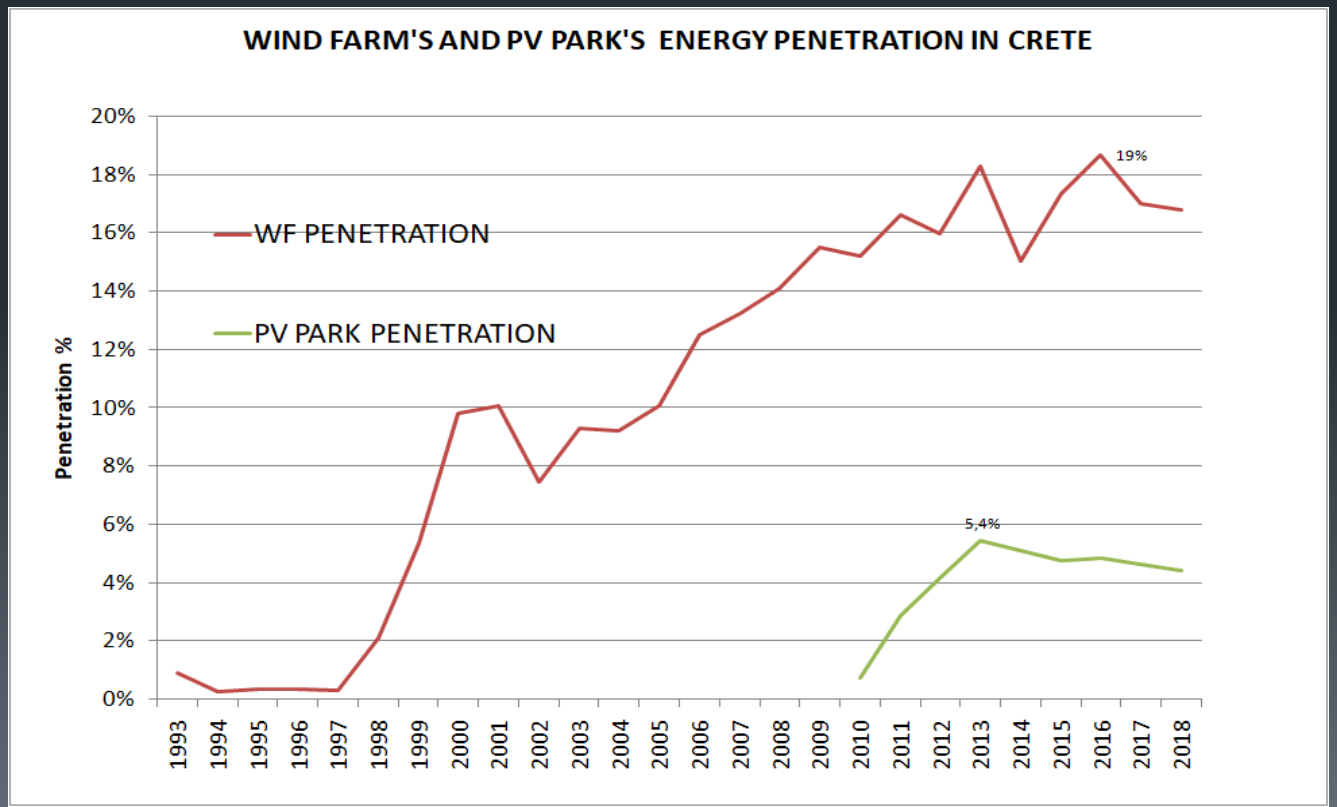
Heavy oil and Diesel oil are the fuels to be burnt

RES in Crete Power System

- The wind and solar potential in Crete is among the largest in Europe.
- After the liberalization of the RES electricity market and the subsidy from the EU and National Funds, many companies proceeded with the installation of Wind Farms.
- During the last 25 years, 202 MW of Wind Farms were installed in Crete.
- Wind Farms contribute up to 17% of the annual energy production until now.
- The annual capacity factor of the Wind Farms reaches an average of 30%. Some WFs in good positions reach an average of 40%.

WIND FARMS

- Since 1993 when the first Wind Farm (WF) was installed by PPC SA (Greek Public Power Utility) in Sitia, 202 MW of WFs are installed in Crete. This is equivalent with the 20% of the total installed power capacity



WIND FARMS

- Control applications for the WFs in Crete Control Center send set-points every 2 minutes and determine the maximum output of each WF. The applications take into consideration the Technical Minimum of the power units in operation, and the maximum allowed penetration of the WFs which is ranged around 30-40% depending on the weather conditions or other distractions of the grid.
- The algorithm works like a decision tree:

<u>The Actual set-point to the WFs is the Minimum of</u>:

- System Load- Sum of the Technical Minimum of the conventional Units
- System Load* C% (allowed penetration) = System Load* 30-40%
- Installed WF capacity

• The instantaneous penetration percentage can be reduced down to 10 % or less, if weather conditions or other system security reasons occur. After many years of tuning of the protection settings, upgrade and maintenance of the interconnection lines of the WFs with the substations, and better specifications of new WFs, an impressive improvement of the System Operation was observed.

• The most serious problem during 20 years of Wind Farms operation in the island of Crete is the loss of communication with the Wind Farms.

• During windy nights if the communication with Big Wind Farms is lost there is the danger of surplus energy to be injected into the network. The conventional units cannot decrease their output more than their technical minimum and the frequency is raised. Opening the circuit breakers of the wind farms and rejecting RES production is the only way for the operators to keep the system safe.

• Up to now there are is no energy storage to absorb the surplus energy and give it back to the system during the day when the production is expensive.

Fault Ride Through Protection

Another problem occurred during network faults when the old wind farms were sensitive to the voltage drops.

During network faults, when the system needed stable production to stabilize the network, the old Wind Farms were tripped worsen the bad situation.

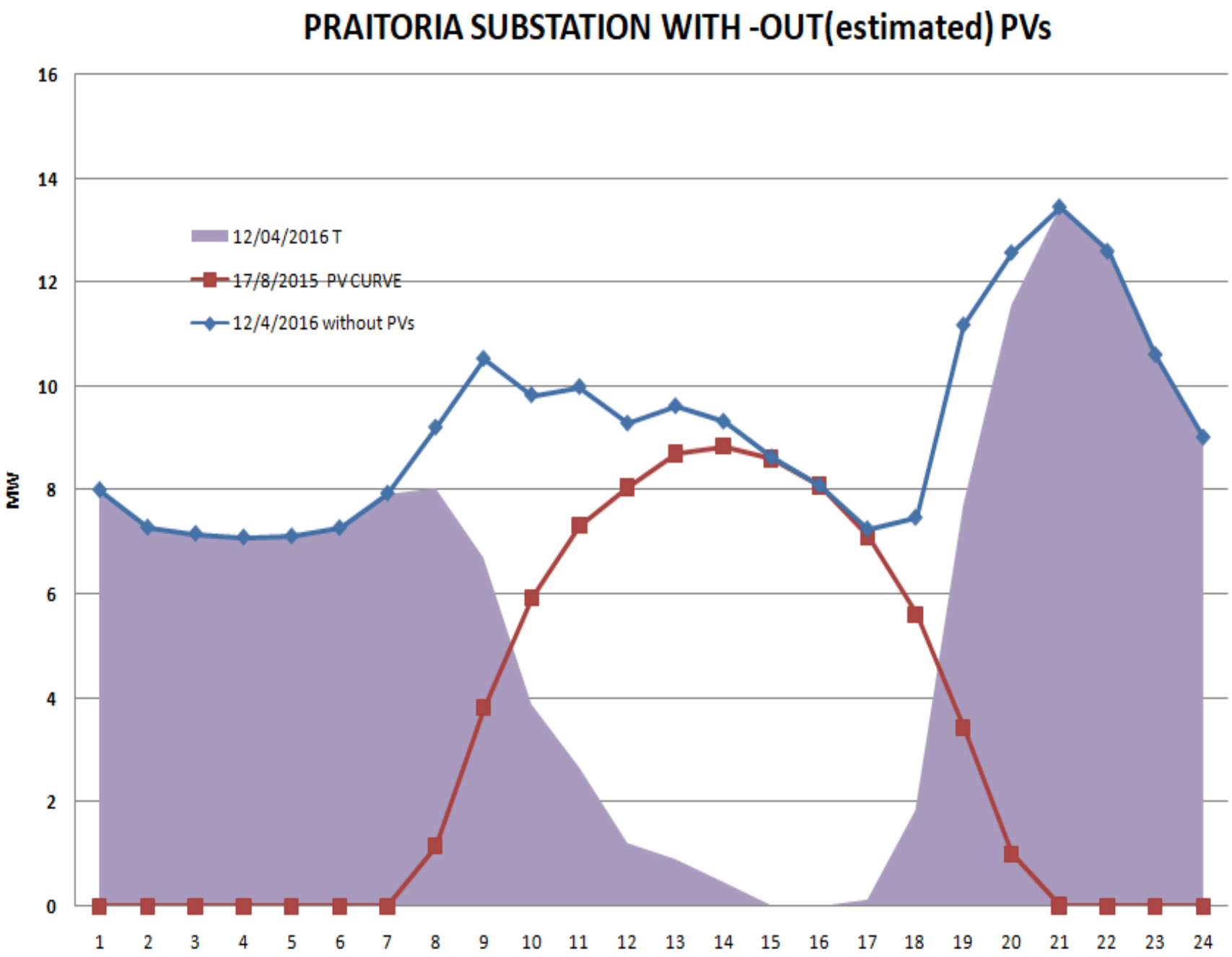
The new WFs are equipped with ‘Fault Ride Through’ protection, and may withstand the sudden voltage deeps during grid faults and prevent the frequency from collapsing.

After Crete experience the new Wind Farms in Greece are obliged to install ‘Fault ride Through’ protection.

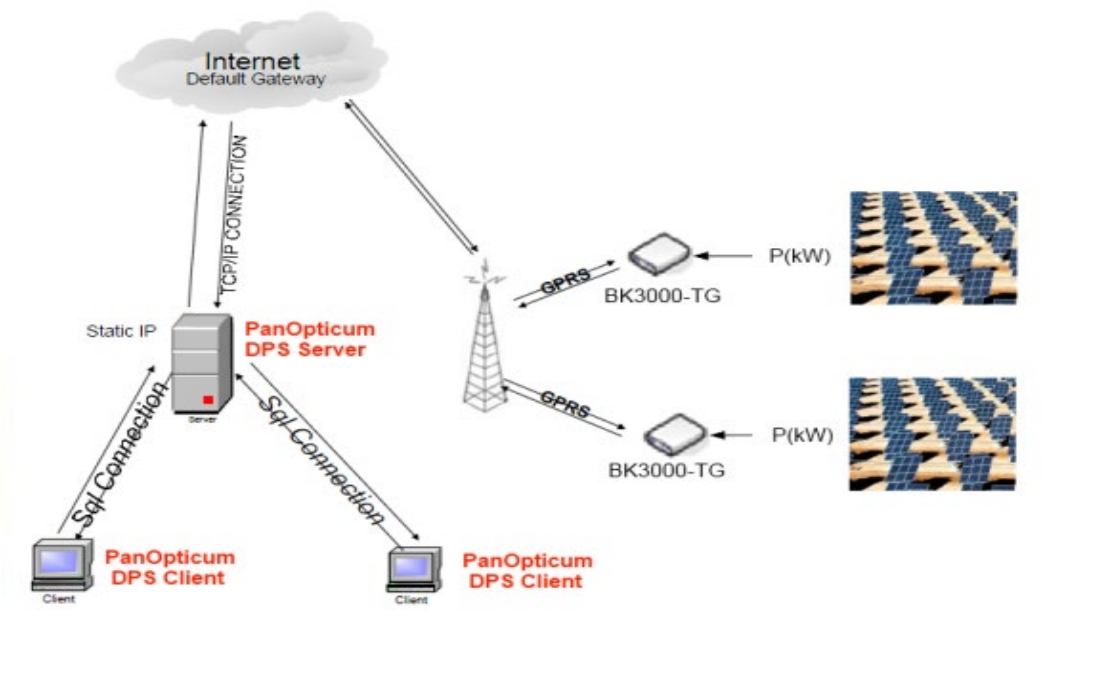
PV PARKS

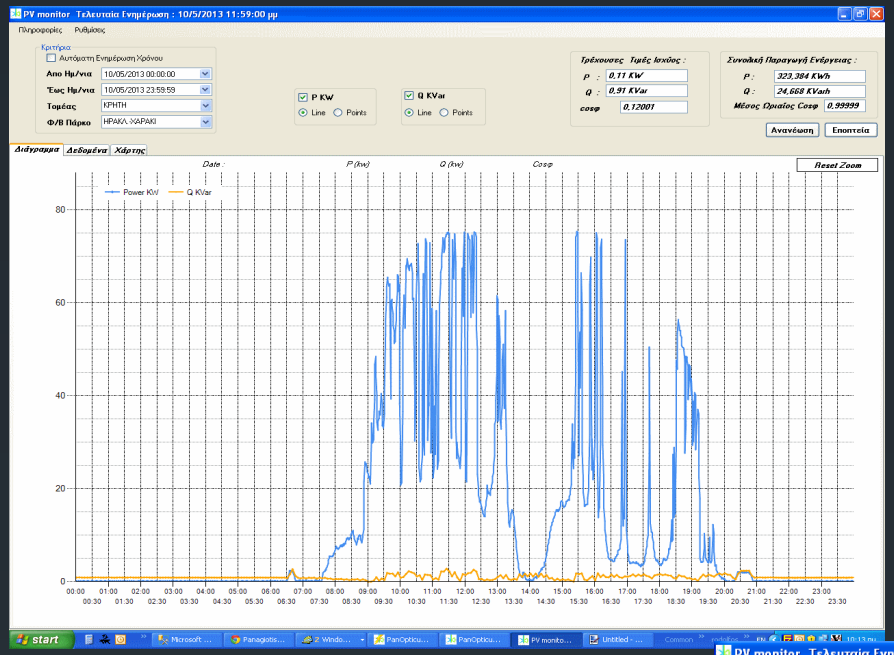
- The first Greek legislation for PV was introduced in 2006 offering generous feed-in-tariffs and setting the details for legalization and authorization of PV systems. The Regulatory Authority for Energy (RAE) in Greece set a limit of 100 MW of PV parks to be installed in the fields of Crete in the countryside. The reason was the weak islanded system, the Technical minimum of the conventional Units and the high Wind installed power. Until now, 97 MW of PV Parks are installed in the fields and on the roofs in Crete Island. The annual capacity factor of the PV Parks reaches 20%.

- The energy of all the PV parks covers much of the morning every day peak throughout the year, and has stabilized the voltage in the villages in the countryside. PV production covers 13% of the Daylight consumption of the island and 4,5-5,5% of the annual consumption.

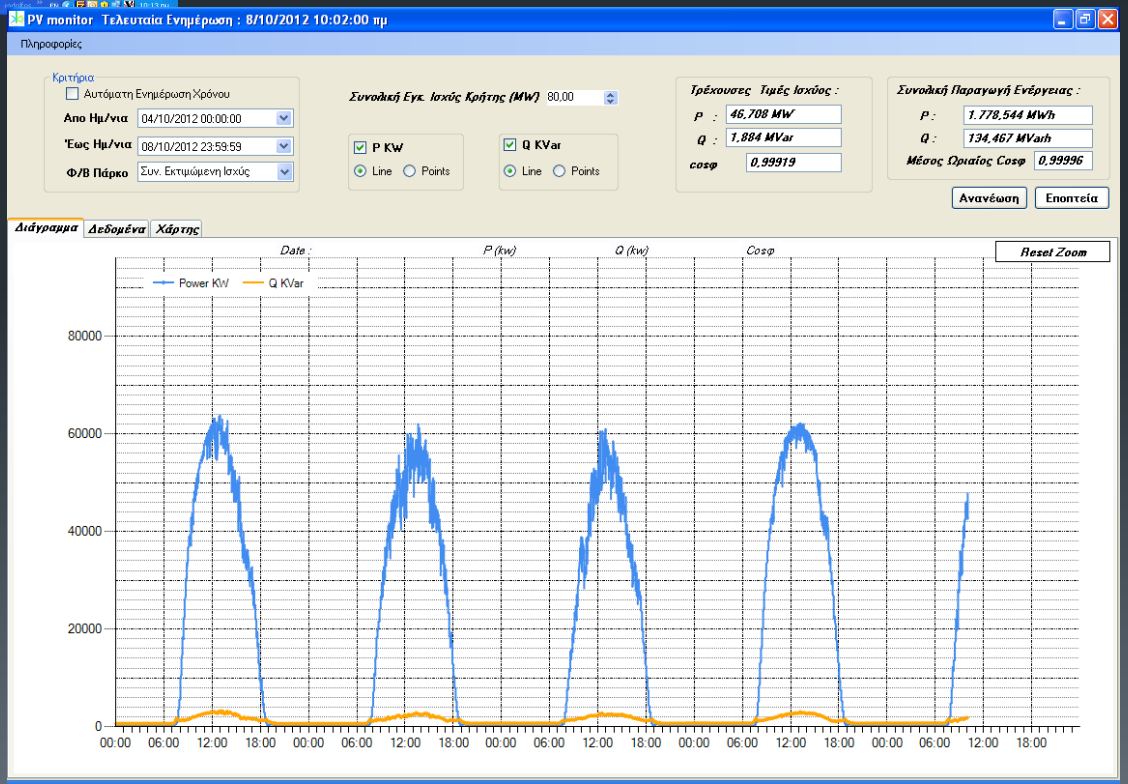

PRAITORIA SUBSTATION WITH -OUT(estimated) PVs
MW
16
14
12
10
8
6
4
2
0
12/04/2016 T
17/8/2015 PV CURVE
12/4/2016 without PVs
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24

It was a big necessity to install a system in order to monitor all this power. Thirty (30) PV Parks were chosen to be monitored. The PV Parks were chosen in order to satisfy the need to have a good representation of the type (fix or rotating trackers) and of the region where PV Parks are installed. A device collects data from one PV Park's active and reactive power output every 20 sec using the pulses of the electricity meter and sends it via mobile phone GPRS with GPS coordinators to a main server. The server collects all data and a moving average is used to smooth out short-term fluctuations and highlight longer-term trends.



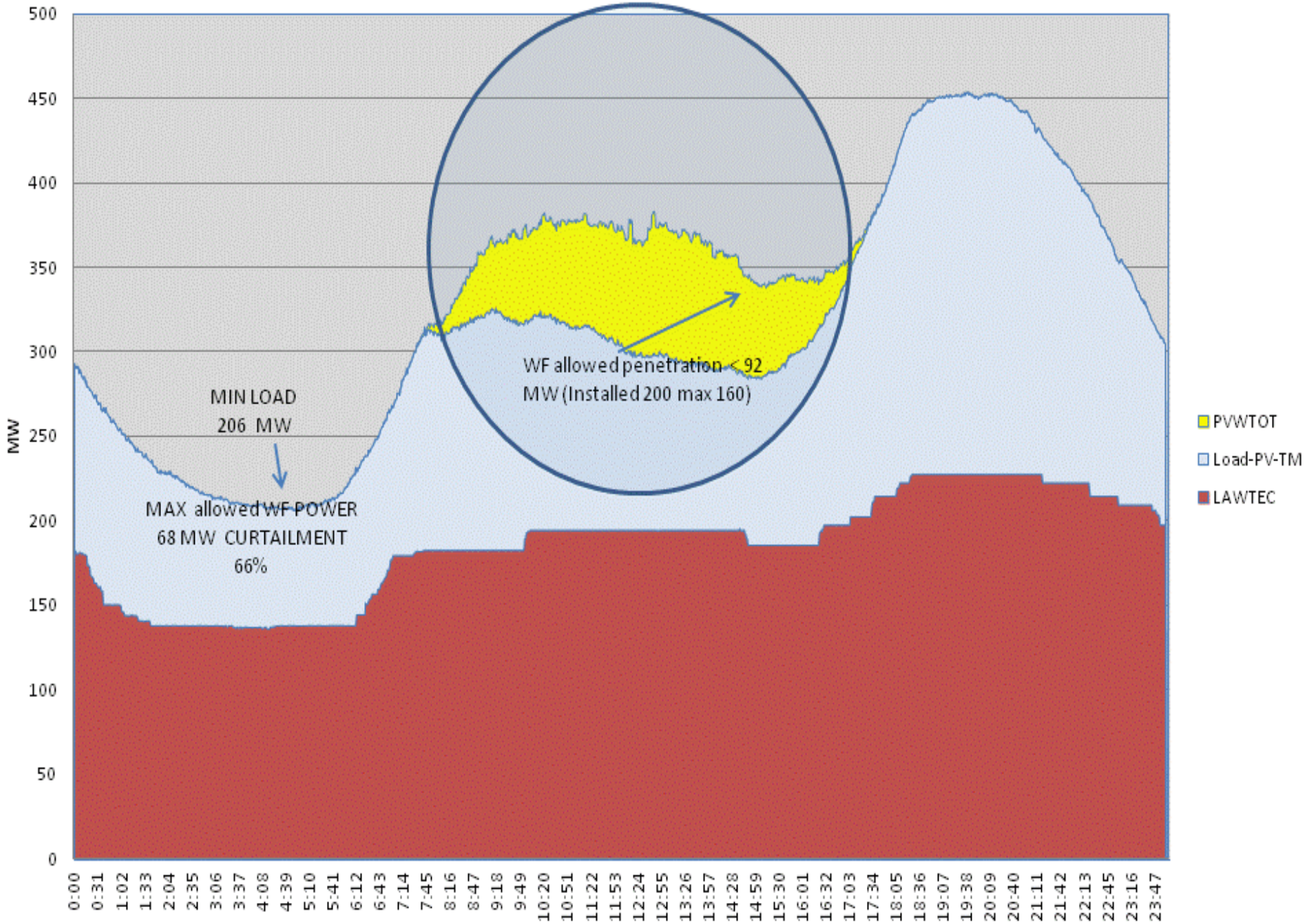


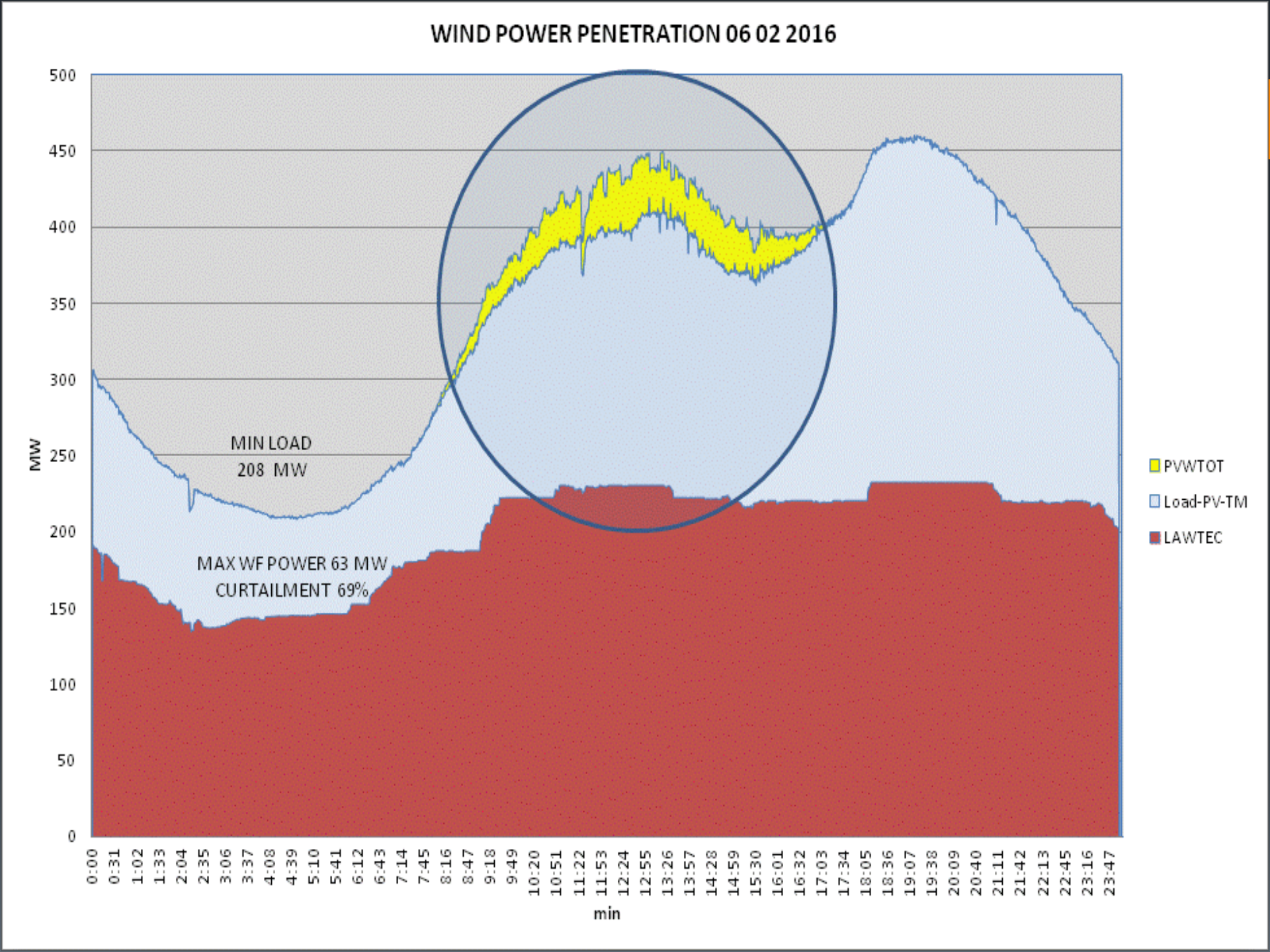
One PV park

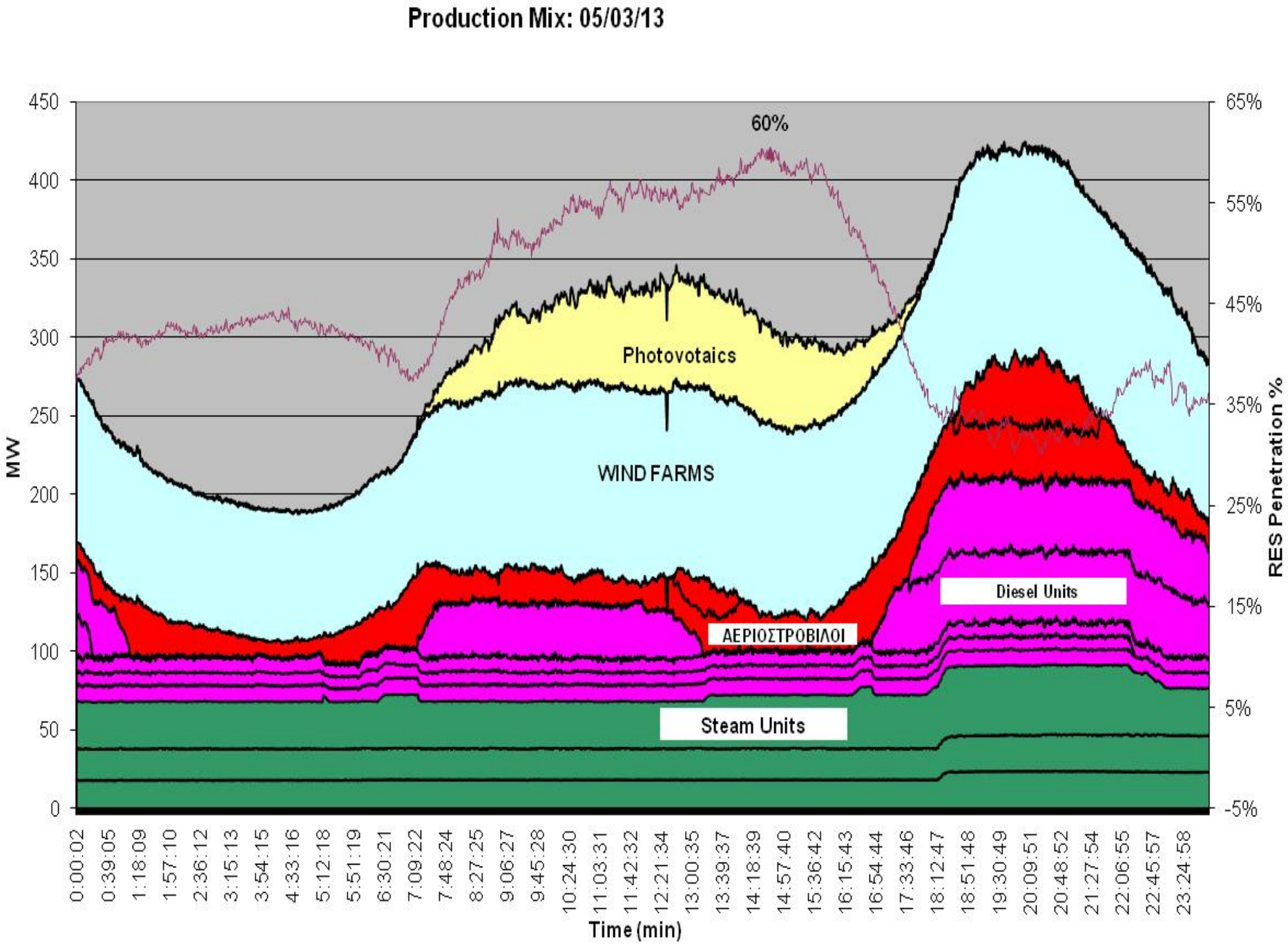


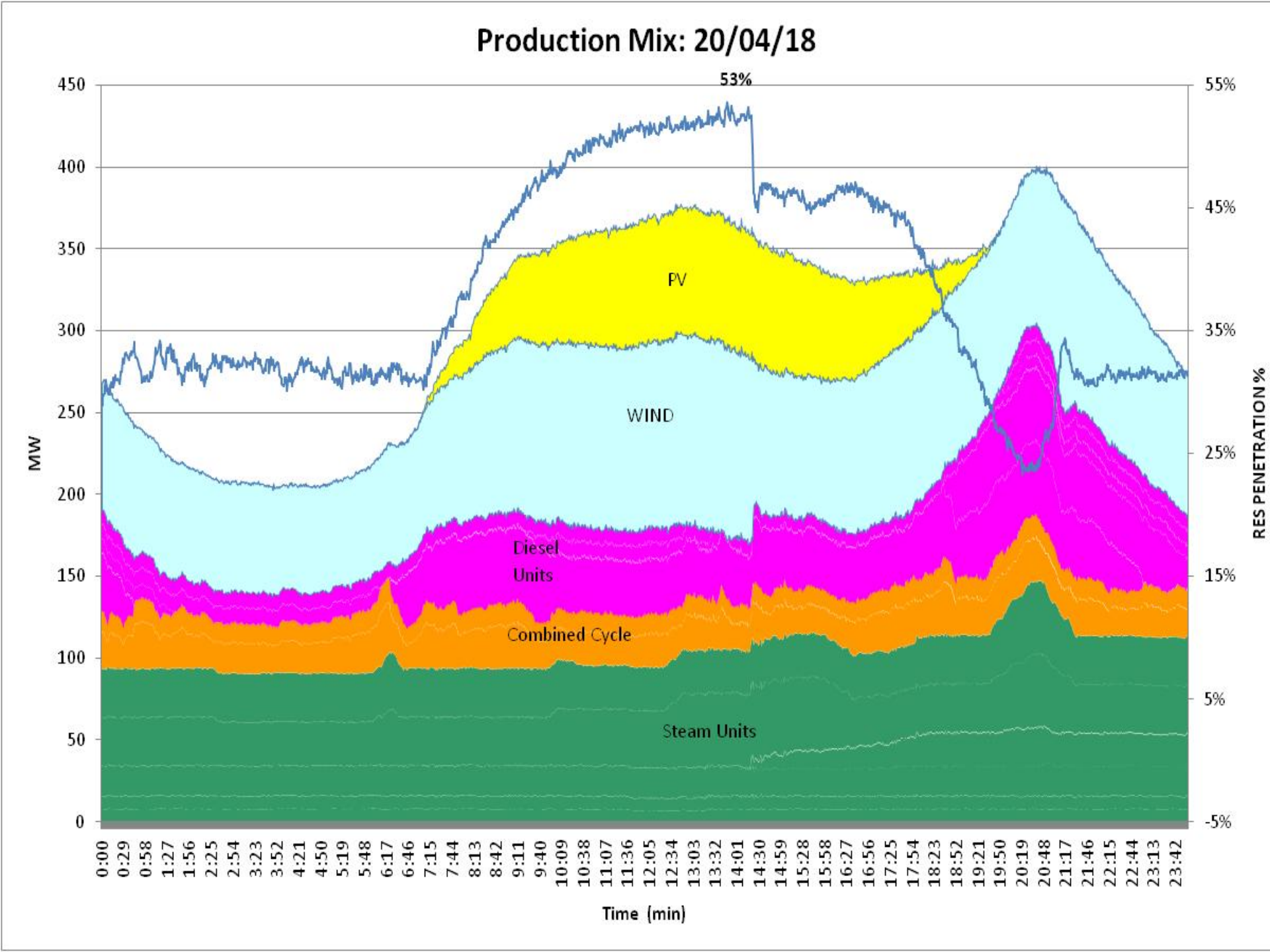
3000 PV parks together

WIND POWER PENETRATION 08 02 2016

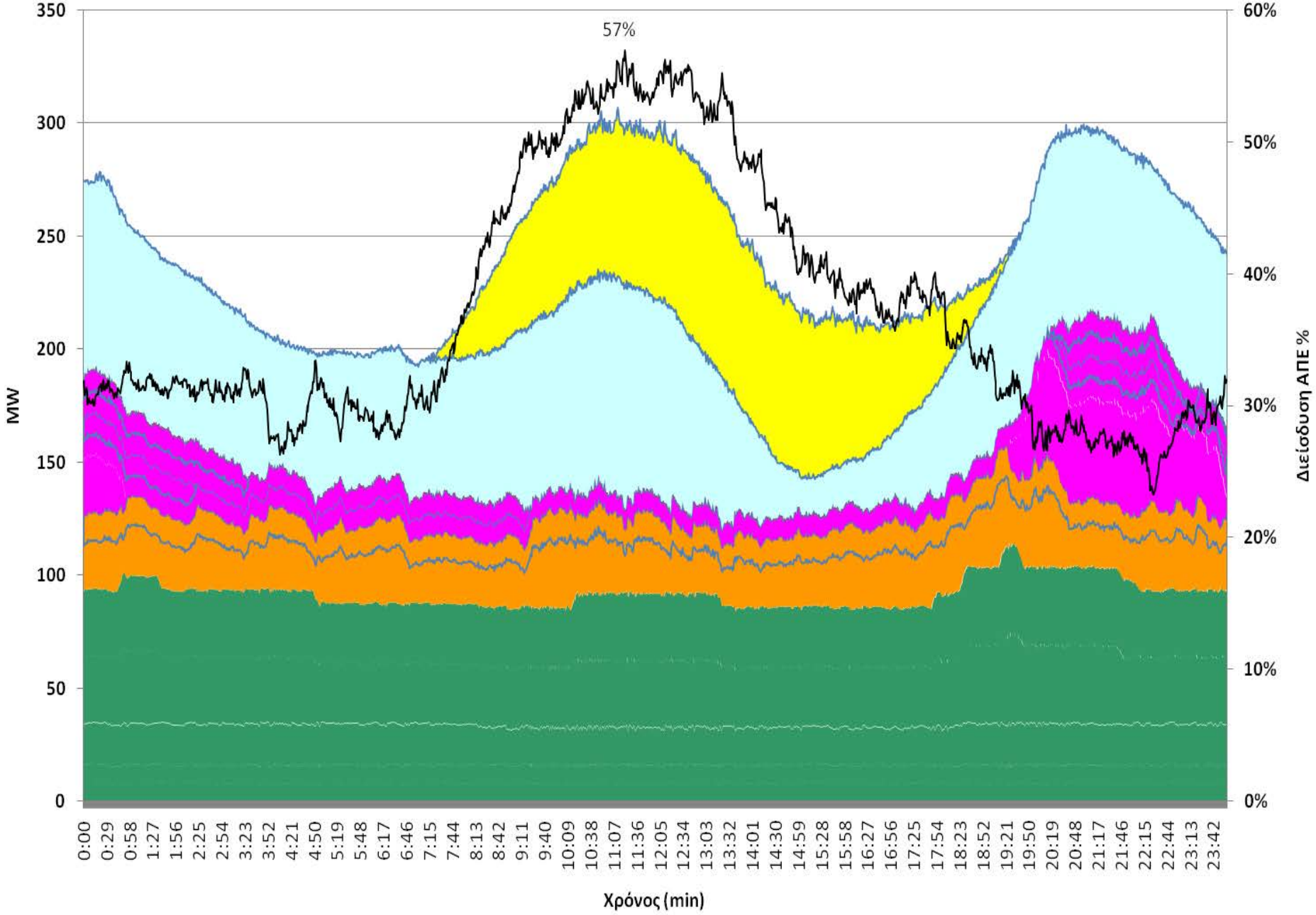



WIND POWER PENETRATION 06 02 2016
MIN LOAD
208 MW
MAX WF POWER 63 MW
CURTAILMENT 69%
MW
min
PVWTOT
Load-PV-TM
LAWTEC

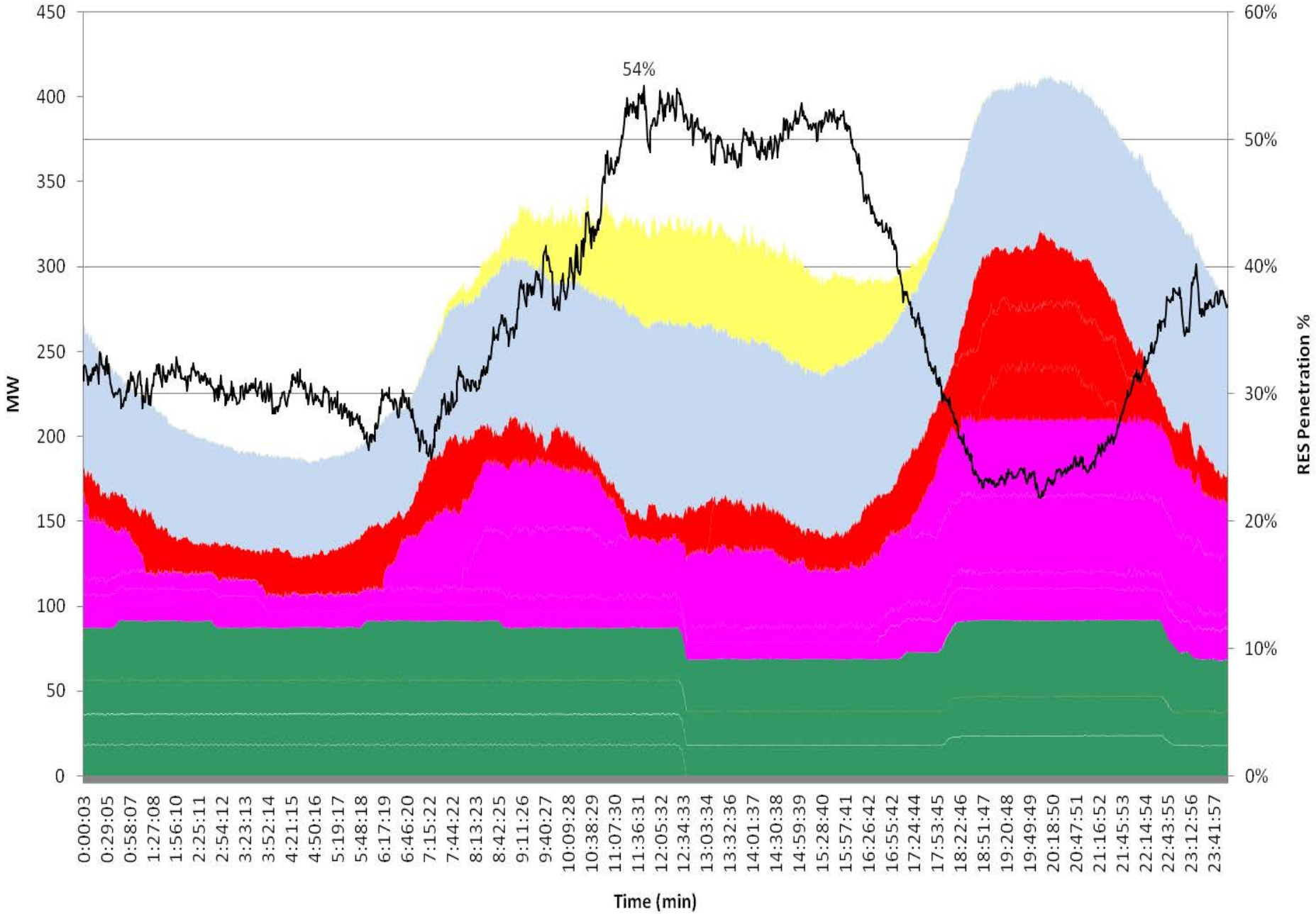

Production Mix: 05/03/13
60%
Photovotaics
WIND FARMS
Diesel Units
ΑΕΡΙΟΣΤΡΟΒΙΛΟΙ
Steam Units
MW
RES Penetration %
Time (min)
450
400
350
300
250
200
150
100
50
0
65%
55%
45%
35%
25%
15%
5%
-5%
0:00:02
0:39:05
1:18:09
1:57:10
2:36:12
3:15:13
3:54:15
4:33:16
5:12:18
5:51:19
6:30:21
7:09:22
7:48:24
8:27:25
9:06:27
9:45:28
10:24:30
11:03:31
11:42:32
12:21:34
13:00:35
13:39:37
14:18:39
14:57:40
15:36:42
16:15:43
16:54:44
17:33:46
18:12:47
18:51:48
19:30:49
20:09:51
20:48:52
21:27:54
22:06:55
22:45:57
23:24:58


Production Mix: 20/04/18
53%
PV
WIND
Diesel
Units
Combined Cycle
Steam Units
MW
RES PENETRATION %
Time (min)
450
400
350
300
250
200
150
100
50
0
55%
45%
35%
25%
15%
5%
-5%
0:00
0:29
0:58
1:27
1:56
2:25
2:54
3:23
3:52
4:21
4:50
5:19
5:48
6:17
6:46
7:15
7:44
8:13
8:42
9:11
9:40
10:09
10:38
11:07
11:36
12:05
12:34
13:03
13:32
14:01
14:30
14:59
15:28
15:58
16:27
16:56
17:25
17:54
18:23
18:52
19:21
19:50
20:19
20:48
21:17
21:46
22:15
22:44
23:13
23:42

Σύνθεση Παραγωγής Κρήτης Ημ/νία : 08/04/18



Production Mix : 04/03/13



Thank you