1st Energy Tech Forum

Ανοικτή Συνάντηση για τις Ενεργειακές Τεχνολογίες και την Καινοτομία

Pilot hybrid park for thermal and electrical energy generation in the municipality of Topeiros

Pantelis N. Botsaris, Assoc. Prof. DUTh

1 April 2016, Technopoli, Gazi, Athens

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“Προώθηση της χρήσης γεωθερμικών πηγών μέσω της ανάπτυξης οδηγιών για την προώθηση της πράσινης επιχειρηματικότητας”

“Fostering the use of low temperature geothermal sources through the development of operational exploitation guidelines and green energy solutions of enterprising”

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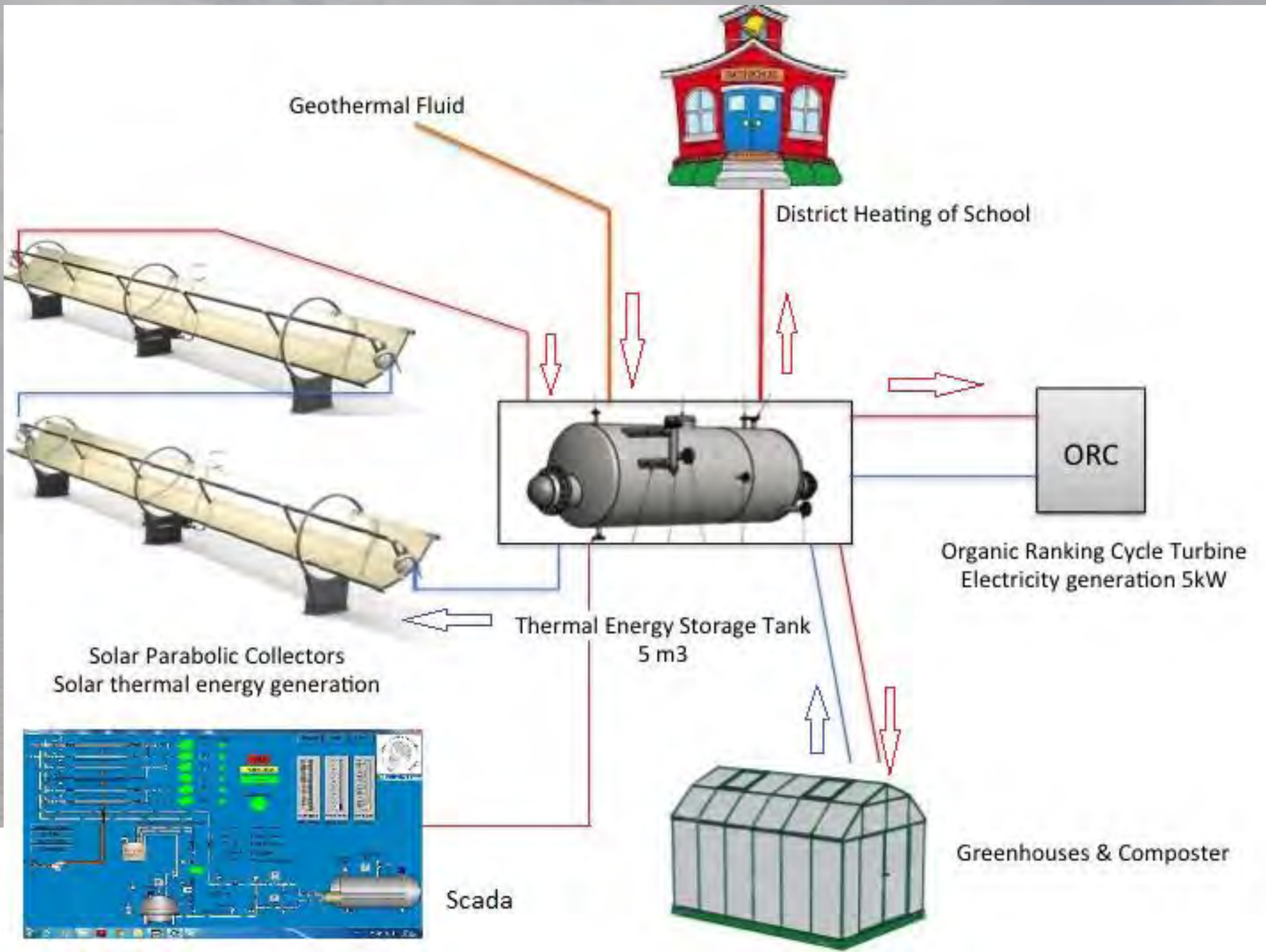
Δομή παρουσίασης

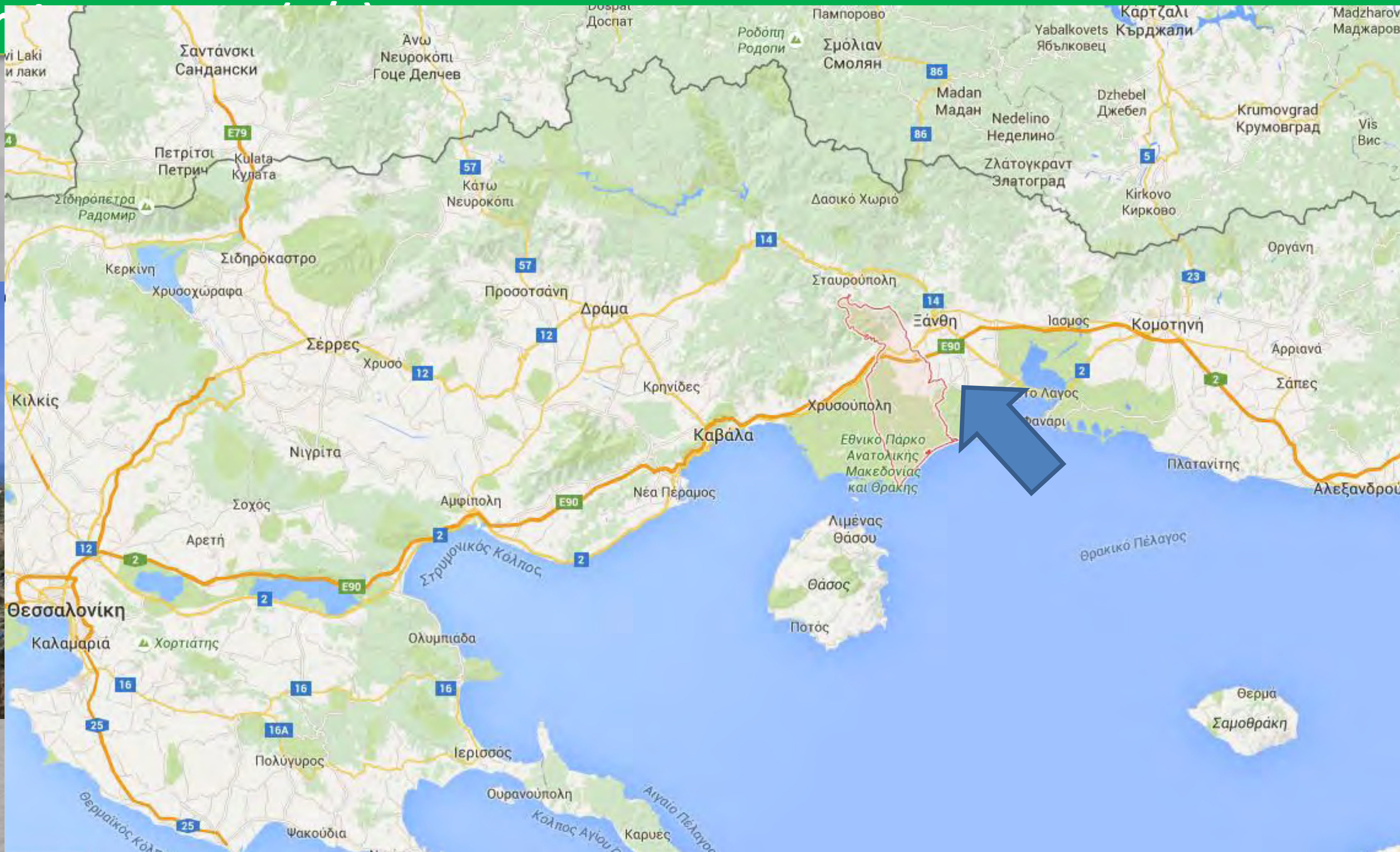
- ✓ *Ποιοι είμαστε και τι κάναμε*
- ✓ *Περιγραφή-στόχοι*
- ✓ *Υβριδοποίηση ενεργειακών πηγών*
- ✓ *Στάδια κατασκευής*
- ✓ *Σύστημα παρακολούθησης και καταγραφής*
- ✓ *Το πάρκο σε αριθμούς*


Geothermal Fluid
District Heating of School
ORC
Organic Ranking Cycle Turbine
Electricity generation 5kW
Thermal Energy Storage Tank
5 m3
Solar Parabolic Collectors
Solar thermal energy generation
Scada
Greenhouses & Composter

Description- Main Objectives

- The pilot hybrid project aims to study:
- a) the production of electric energy using Organic Rankine Cycle (ORC) engine, which will be powered by the combined operation of solar thermal and low enthalpy geothermal field (hybridization) and
- b) the simultaneous exploitation of the thermal energy produced by the combined operation of solar and geothermal system for the heating/cooling of a building (school)/process (composter) and a greenhouse unit.

Pr



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Project stages.. (2/5)

- **2: Permitting**

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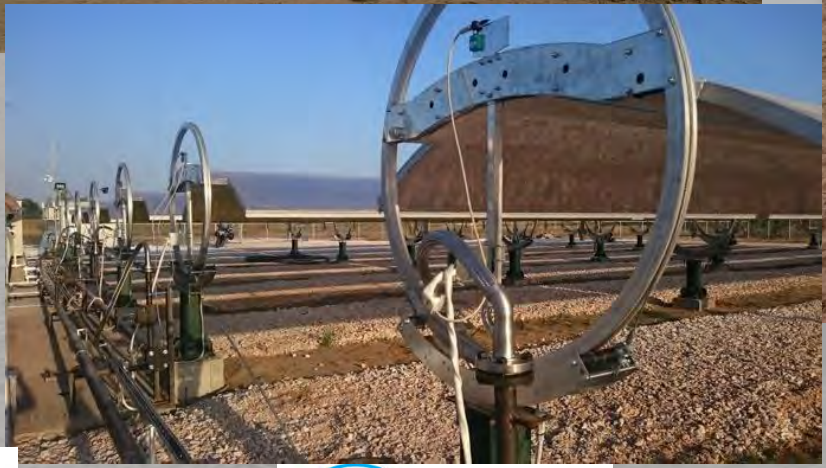
Project stages.. (3/5)

- **3: Construction**



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Project stages.. (4/5)

- **4: Commissioning**

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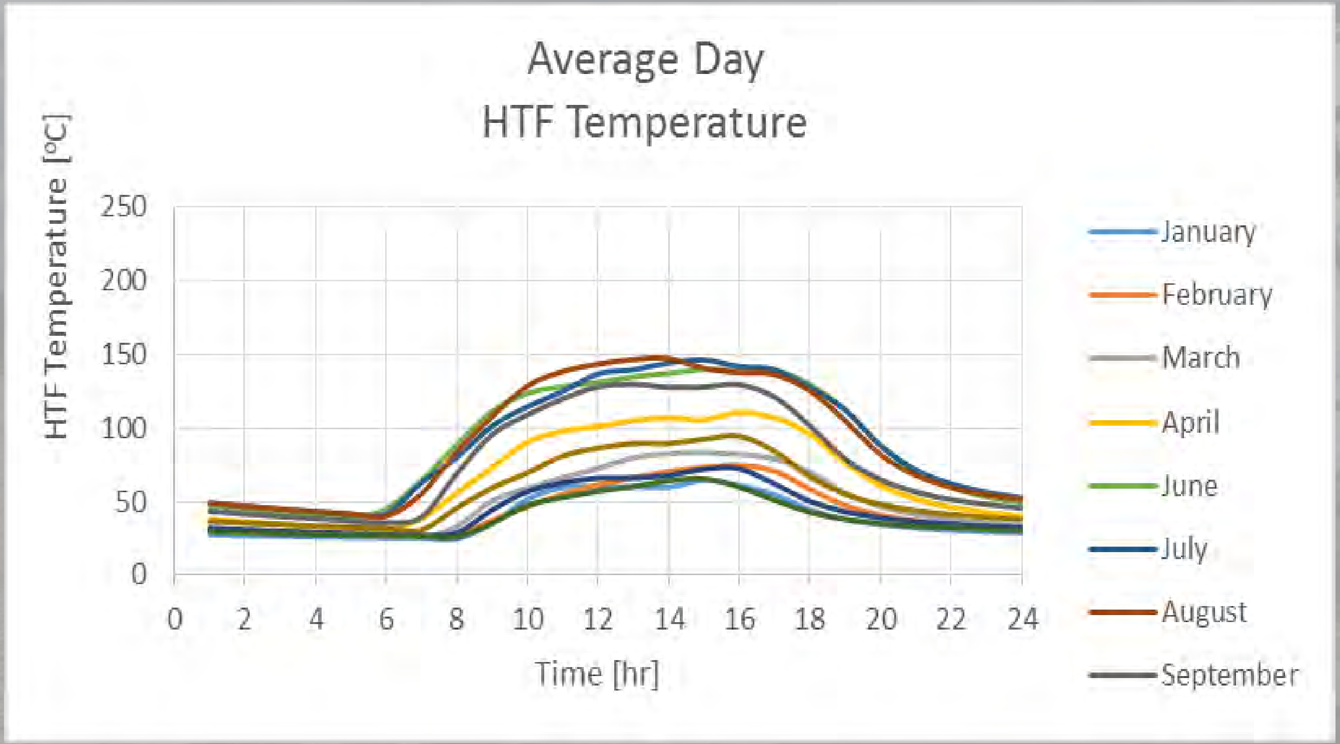
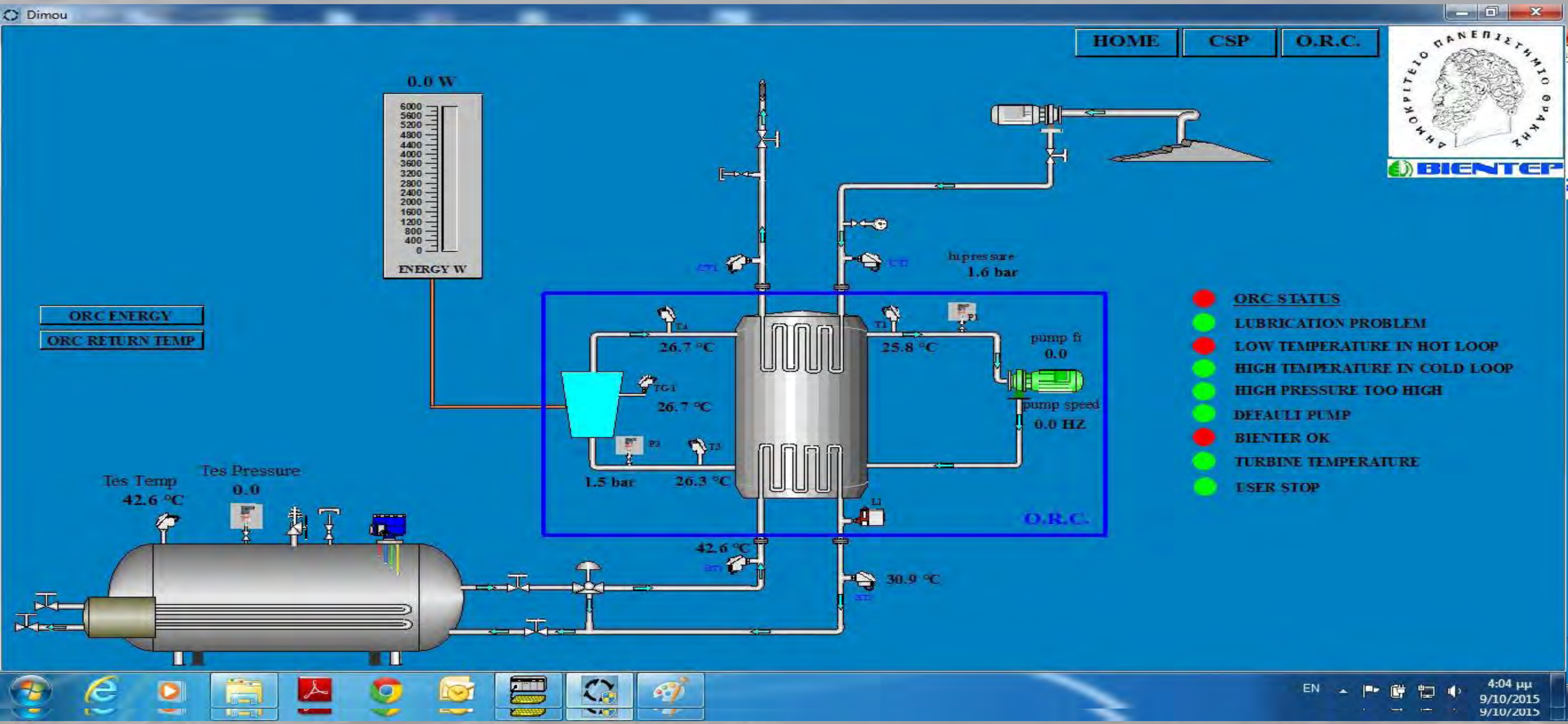
Project stages.. (5/5)

- **5: Operational Performance**



Scada



Dimou
HOME
CSP
O.R.C.
0.0 W
ENERGY W
ORC ENERGY
ORC RETURN TEMP
hi pressure
1.6 bar
26.7 °C
25.8 °C
pump fr
0.0
26.7 °C
pump speed
0.0 HZ
1.5 bar
26.3 °C
O.R.C.
Tes Temp
42.6 °C
Tes Pressure
0.0
42.6 °C
30.9 °C
ORC STATUS
LUBRICATION PROBLEM
LOW TEMPERATURE IN HOT LOOP
HIGH TEMPERATURE IN COLD LOOP
HIGH PRESSURE TOO HIGH
DEFAULT PUMP
BIENTER OK
TURBINE TEMPERATURE
USER STOP
4:04 μμ
9/10/2015

Hybridization– Υβριδοποίηση ενεργειακών πόρων

- Solar thermal (CSP) and geothermal energy generation methods utilize Rankine thermodynamic cycle. Therefore, the two energy generation technologies differ in energy input (heat collection) but share the same power output asset. It is therefore technically feasible to combine the two.
- Additionally, there is an inverse relation between the two technologies' operational efficiencies with ambient temperature. Rankine cycle geothermal power plants lose a lot of their efficiency when operating in high temperatures, such as during summer and daytime ambient temperature peaks. The base geothermal plant can produce only 60% of its peak generation during summer. Solar thermal technologies operate at peak efficiency at exactly these times when ambient temperature is highest and efficiency of geothermal plants is at their lowest.

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Why?

1. **Availability of resources**

2. **Maximizing operational efficiency**

   - CSP's operational peaks at high ambient temperatures compensate for the loss of efficiency in the geothermal system

3. **Equipment sharing**

4. **Maximizing energy generation**

5. **Financial mitigation**

   - A hybrid system can mitigate the high cost of solar projects with the low cost of geothermal projects

6. **Ability to capture incentives**

   - By combining geothermal and solar technology, hybrid systems can qualify for more forms of economic support

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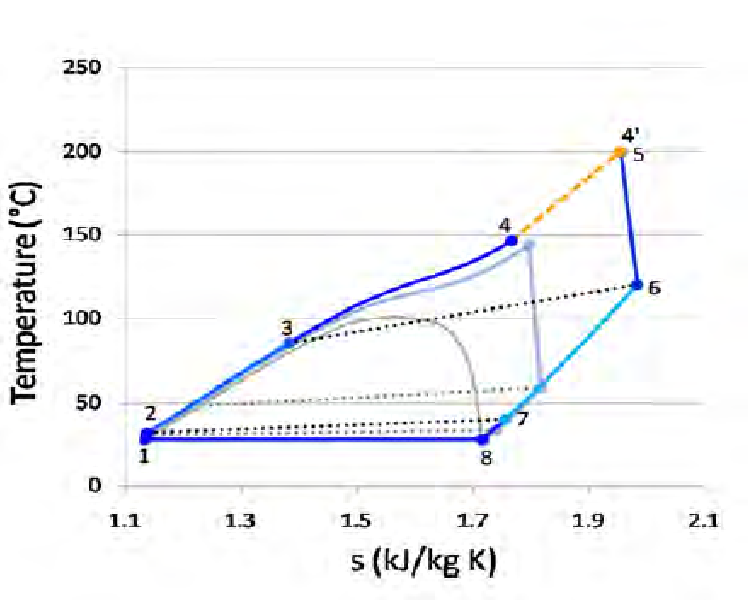
Hybridization ways

1. **Working fluid superheat concept**
2. **Brine preheat concept**
3. **Brine recirculation concept**
4. **Brine preheat / recirculation concept**
5. **Brine cascade reheat concept**

- Solar heat raises the temperature of the working fluid in a geothermal power generation cycle before it enters the turbines, resulting in higher working fluid exergy and power generation



- Solar heat raises the temperature of the recirculating brine coming out of the heat exchanger to or above its original temperature and feed this to a second heat exchanger / power generation unit

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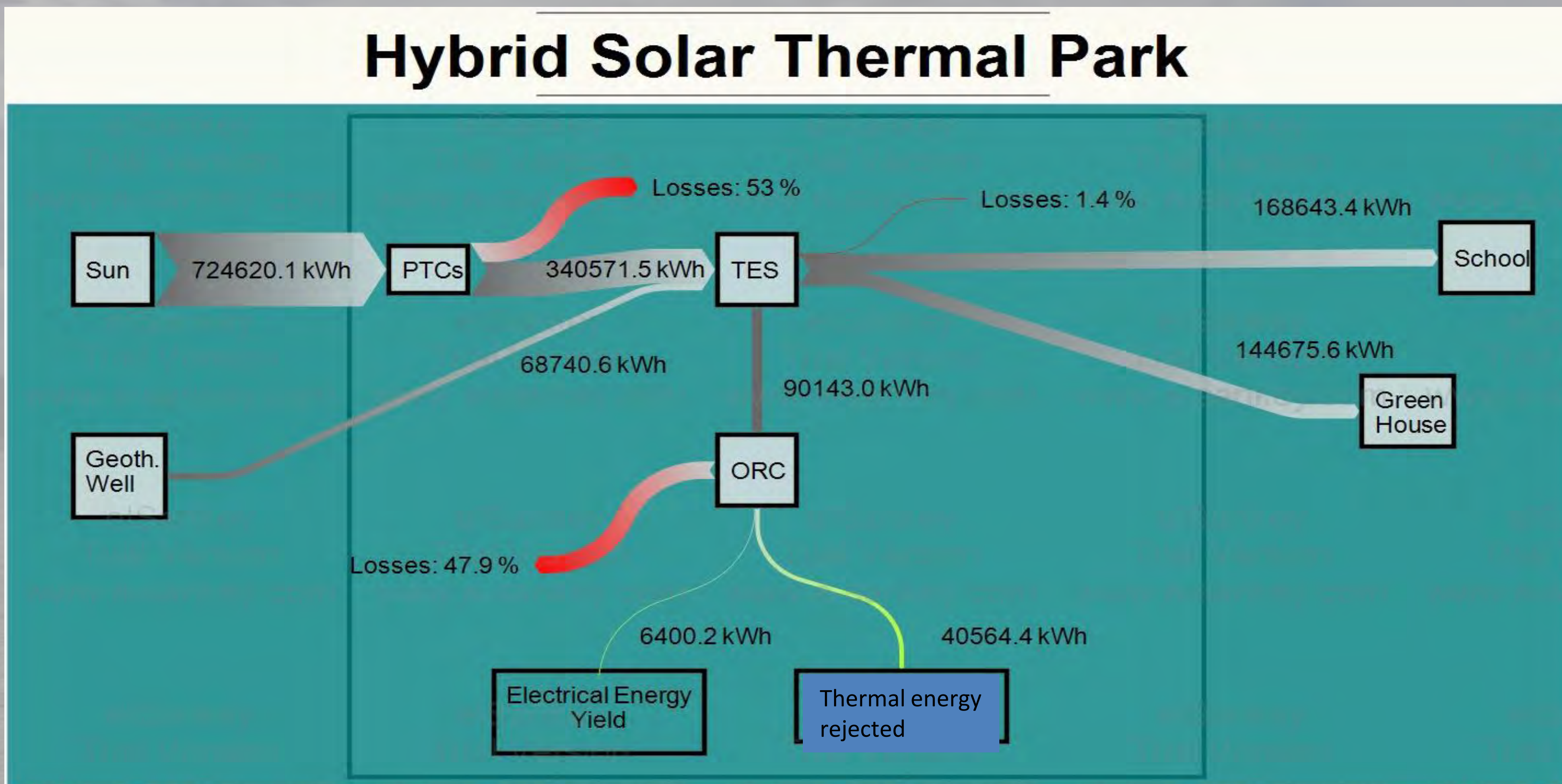
Energy flow shot (yearly)

- **Estimation assumptions:** solar radiation 1603 kWh/m^2/y, PTCs area 450 m^2, PTCs efficiency 47%, geothermal well (w.h. 1500, q=8 m^3/h, ΔT=5 ^{o}C), school (w.h. 2121, q=2 m^3/h, ΔT=45 ^{o}C), greenhouse 814 MJ/ m^2/y, ORC (w.h. 992, q=2 m^3/h, ΔT=40 ^{o}C)



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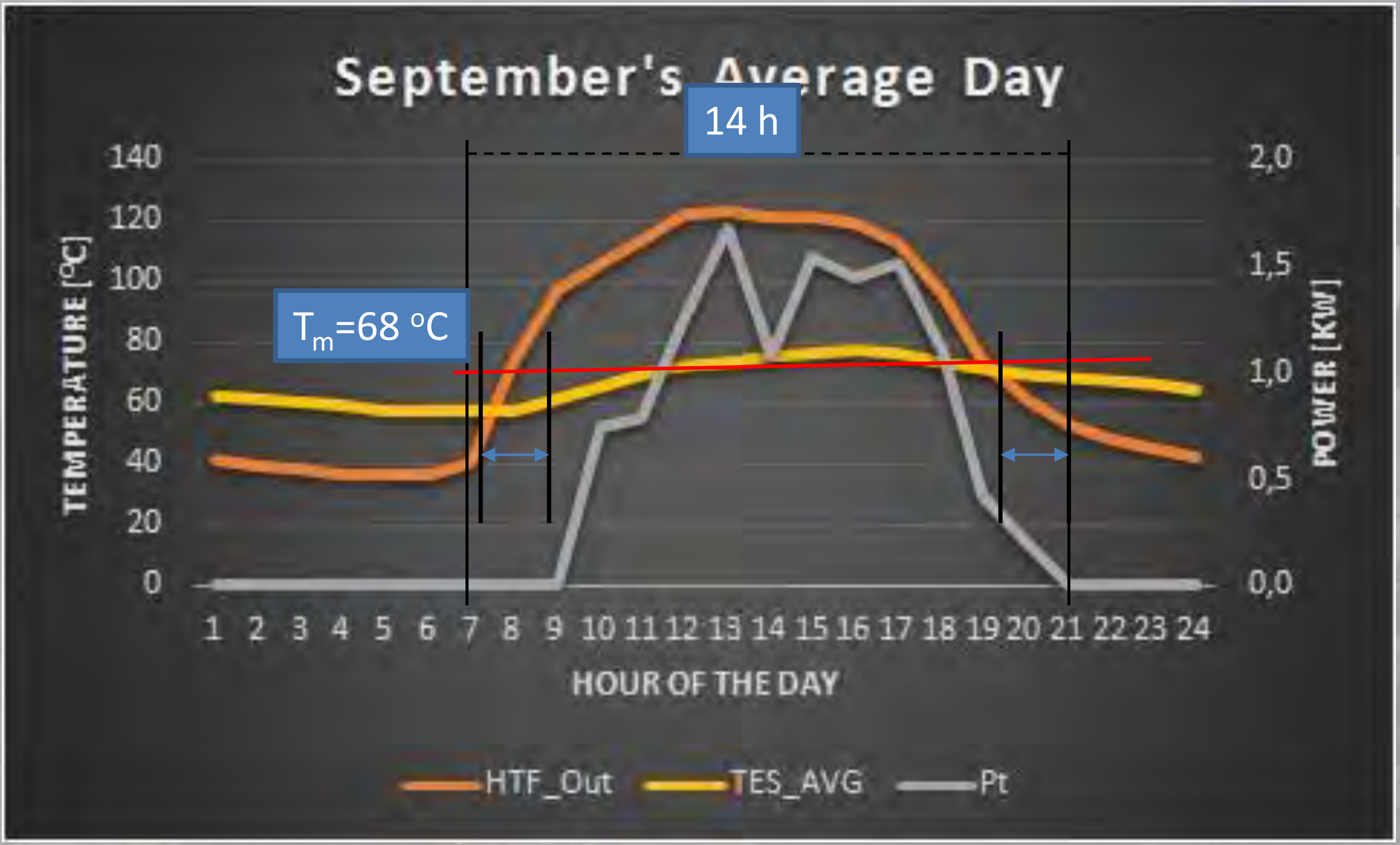
Operational Performance (a day shot)



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The park with numbers

Project Name	ENERGEIA
Site Location	GREECE
Solar Collectors	Rackam s20
ORC turbine	ENOGIA 10kWe

Project Size and Performance	Units	Input Value
Nominal thermal power of solar collector	kWth	39
Number of solar collectors installed	-	6
Total nominal thermal power of solar collectors	kWth	234
Solar collectors net area	m2	75,36
Total solar collectors net area	m2	452,16
Energy received (solar irradiation)	KWh/m2/year	1603
Overall system efficiency	%	47%
Solar thermal energy generated	kWth	340.571,50
Thermal energy used for electricity generation	kWth	90.143,00
Geothermal energy consumed	kWth	68.741,00
Production of total thermal energy (ex. Elec.)	kWhth	319.169,50
ORC net power	kWel	5,00
ORC efficiency	%	6,8%
Electrical energy generated by ORC	kWhel	6.400,00
Project Useful Life	years	20

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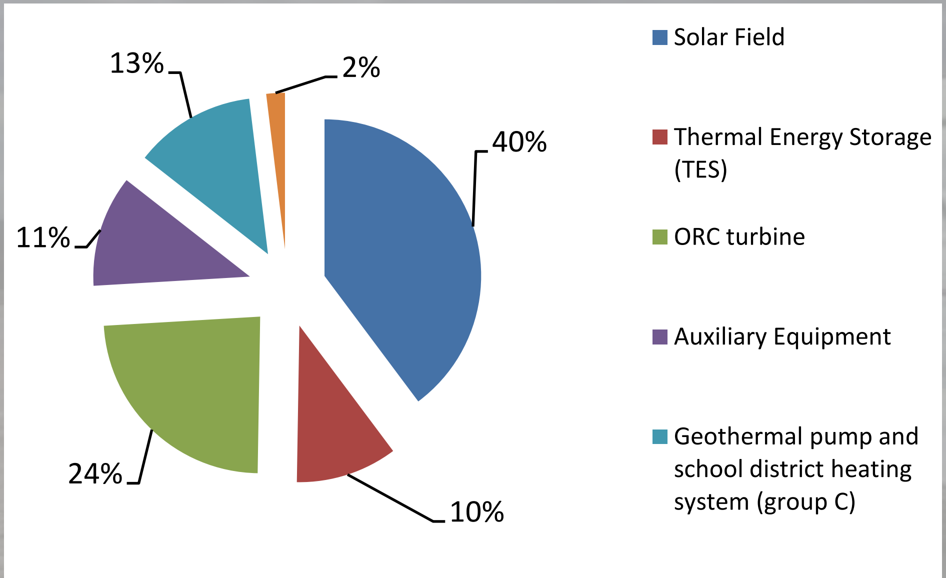
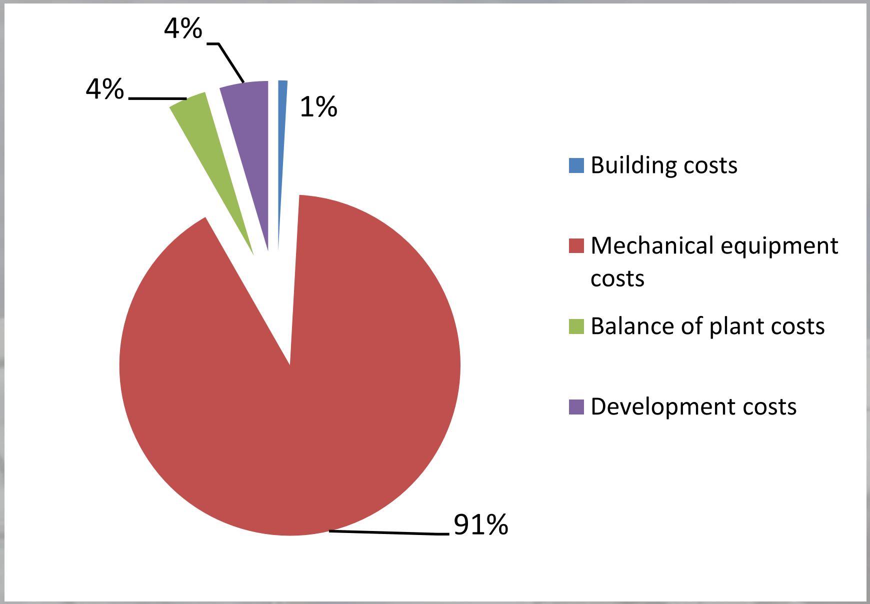
Capital Cost Breakdown





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Capital Cost Breakdown

Hybrid Solar Geothermal Capital Cost Breakdown

Cost Assumptions	Without Storage	With Storage
Solar field (€/m^2)	561,9	563,16
Heat transfer fluid (HTF) system (€/kWe)	7.300	14.000
Power block (€/kWe)	15.230	21.930
Storage (€/kWhth)	0	0,55
Contingency (%)	15	15
Solar field and site (€)	254.500	321.500
HTF and Power block (€)	225.580	292.850
Storage (€)	0	67.000
Buildings cost (€)	5.600	5.600
Mechanical Equipment (incl. electr) (€)	514.310	581.310
BOP (Balance of Plant) (€)	23.300	23.300
Development Cost (€)	29.500	29.500
Total Cost (€/kW)	2.228,44	2.489,14

Specific implementation cost of main equipment of hybrid park

Main equipment	Specific cost (€/kW_{th})
Solar field	716,90
ORC turbine	429,01
Thermal Energy Storage (TES)	188,73
Auxiliary equipment	207,18

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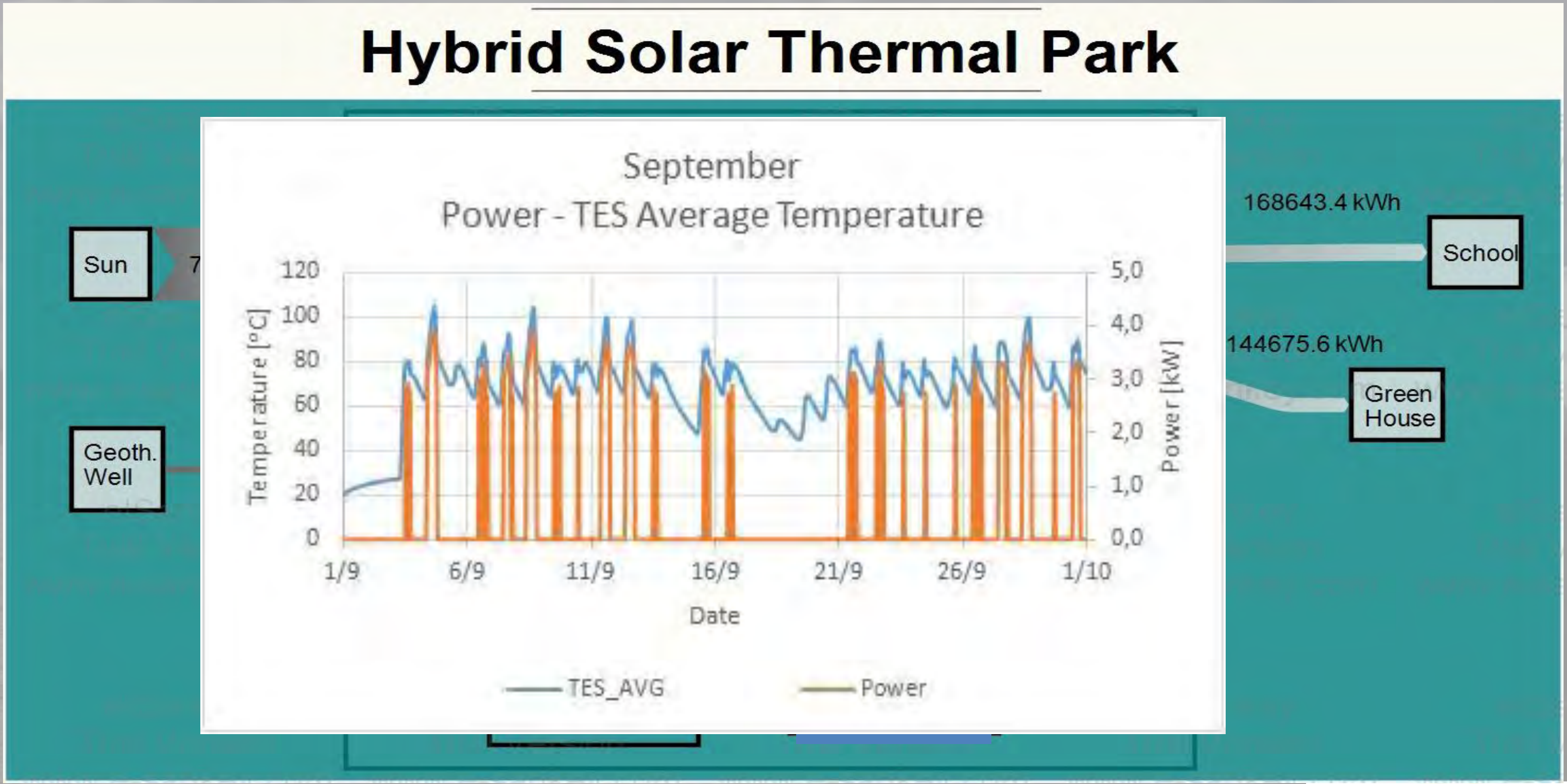
Further work



- P.N. Botsaris, K. Limperopoulos, A. Pechtelidis, "Installation and operation of a pilot hybrid park utilizing solar parabolic collectors and geothermal energy", 5th International Conference on Renewable Energy Sources and Efficiency-New challenges, 5-6 May, 2016, Nicosia, Cyprus.

Thank you for your attention.

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