Potential of the PTC use in the industry of Cyprus: Current status and proposed scenario

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Presentation Outline

I. Introduction
   I. Energy Situation
   II. Solar Energy Potential
   III. Energy for the industrial sector
II. Main Body
   I. Case study
   II. Simulation Dynamic Modelling
   III. Cost analysis
III. Conclusions

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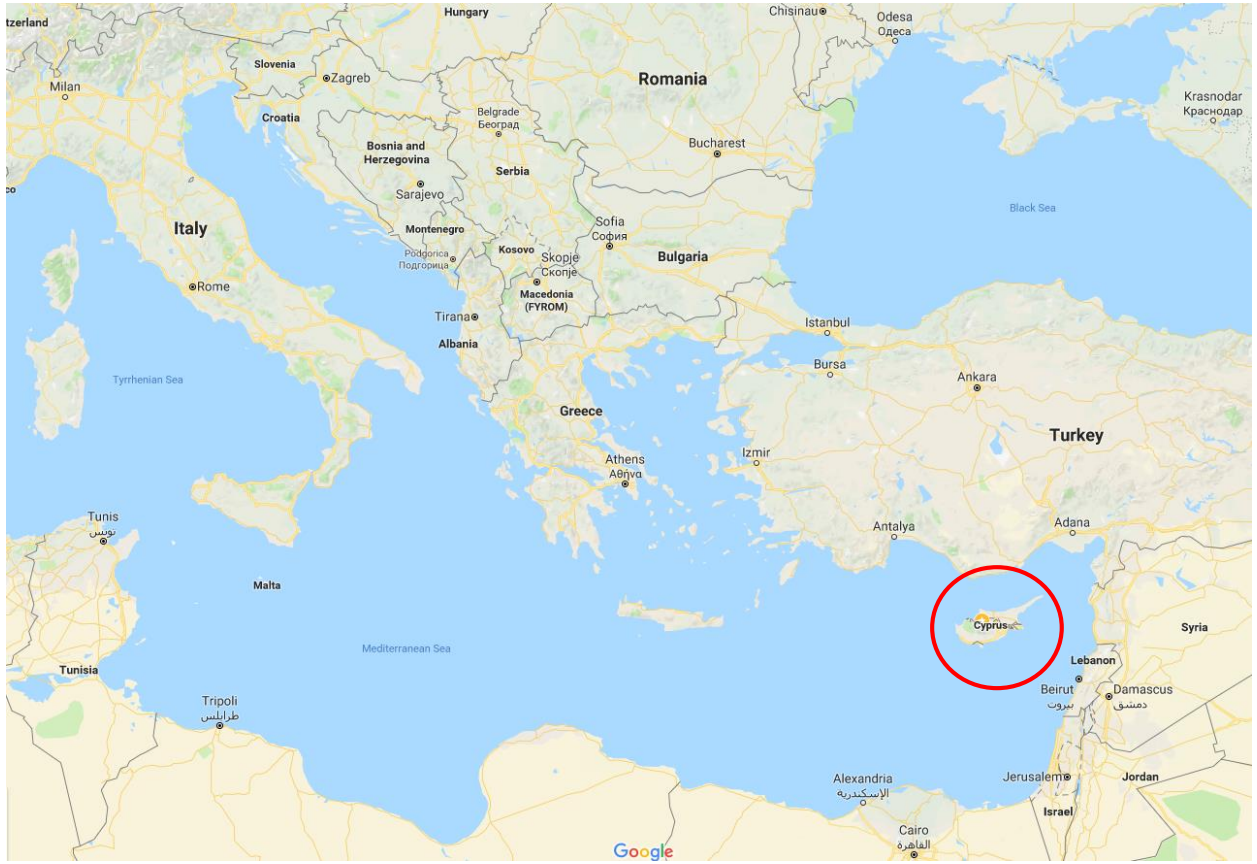
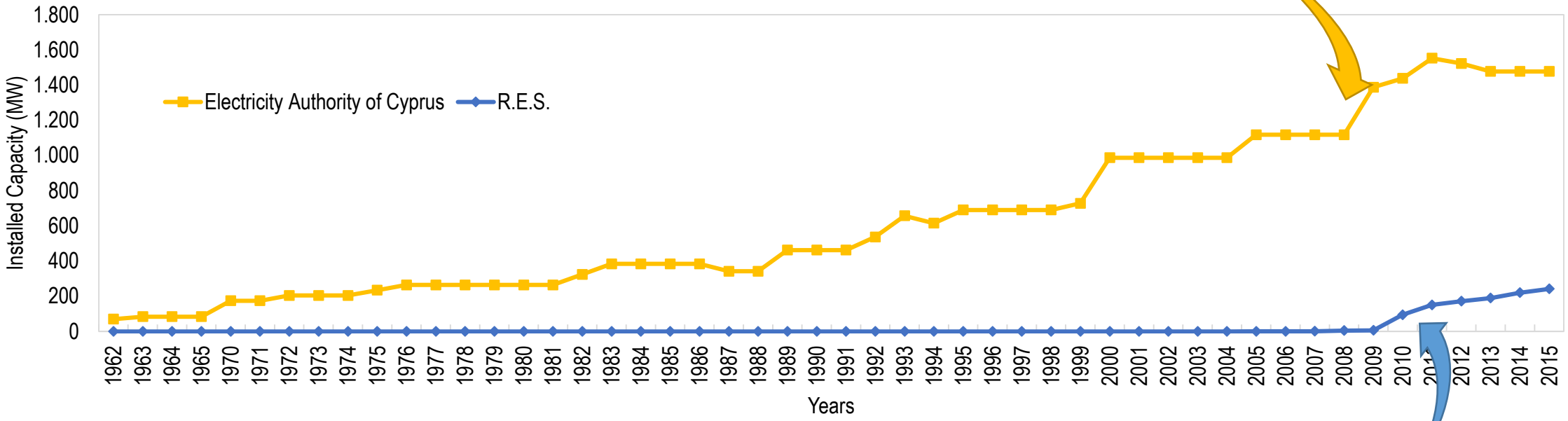
Energy Situation

- Cyprus has a small and isolated energy system which is not connected with other energy networks
- There are no fossil fuel resources
- Very dependent on imported fuels
- Cyprus has 3 Power stations of Dekelia, Moni, and Vasilikos



Energy Situation

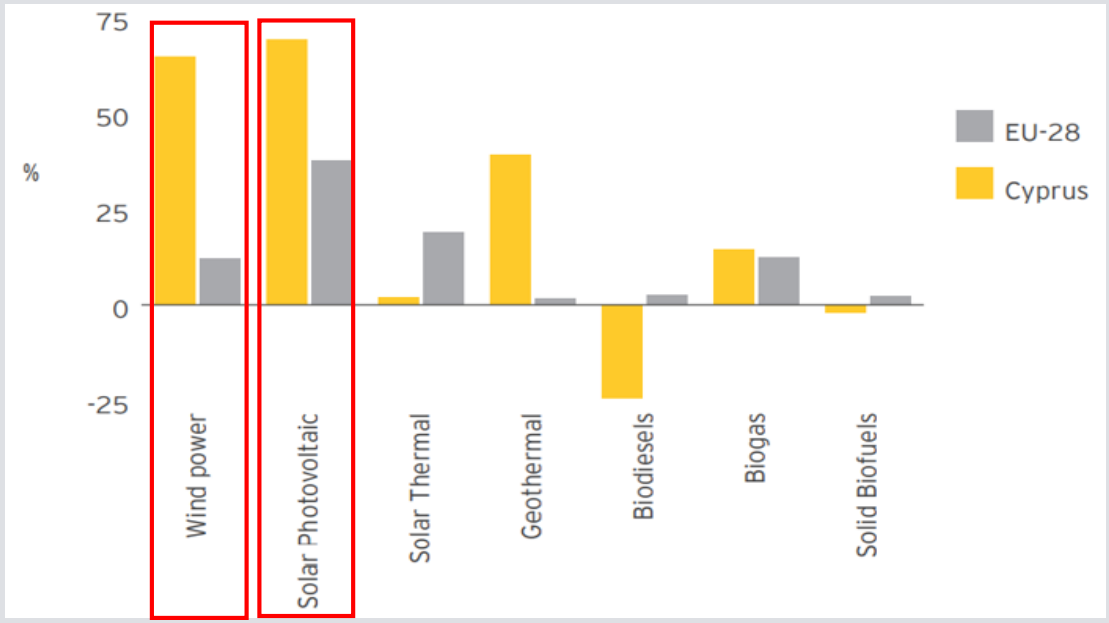
- 94% of the country's energy needs are covered by oil
  → Need for better alternatives: RES



- The last years there is a shift to RES but there is a large space of improvement, education and motivation about energy from RES

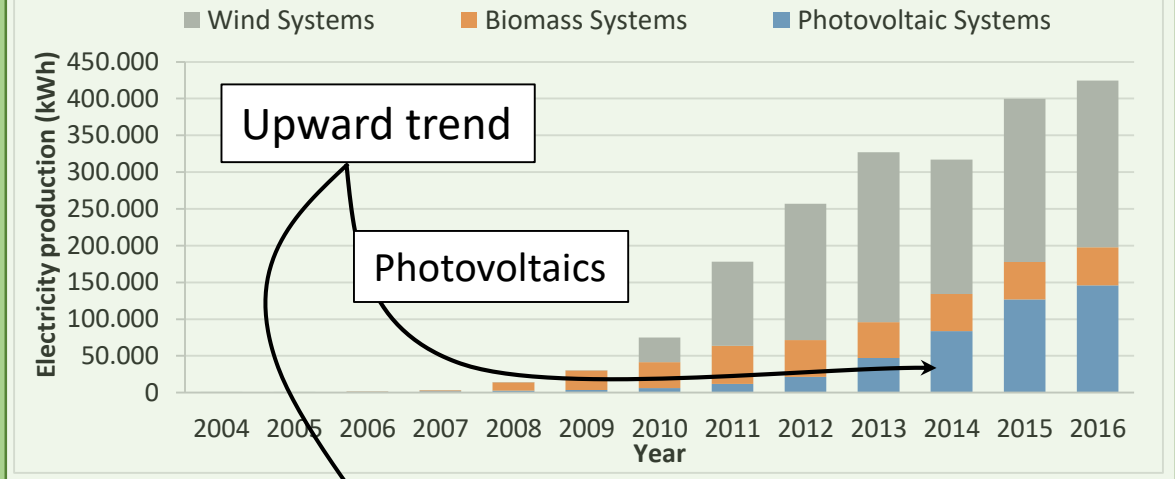
Energy Production by RES

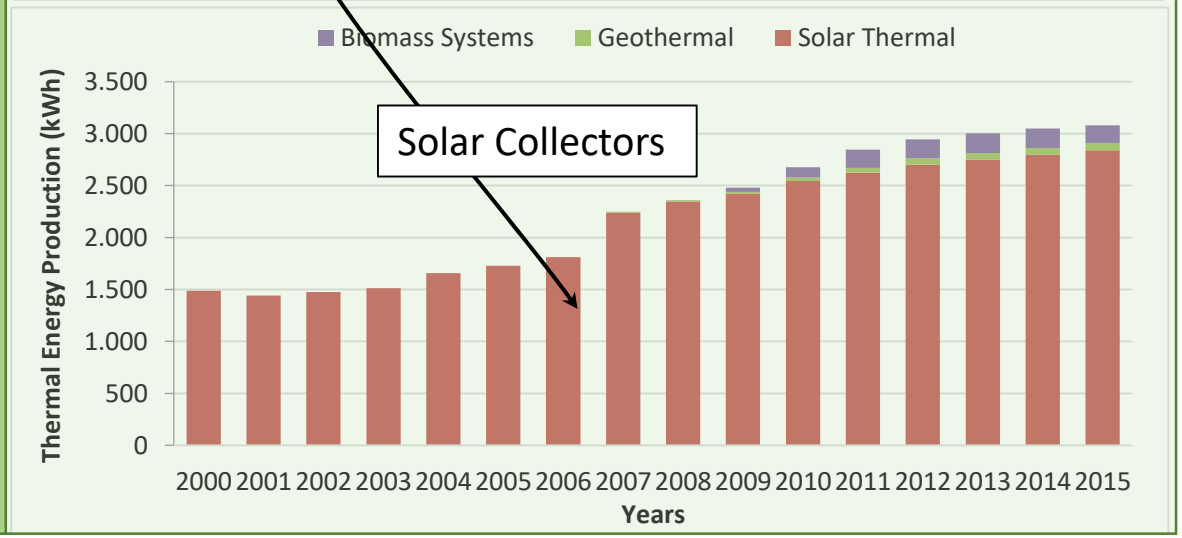
RES production progress from 2010 to 2013



- PV energy: 70% ↑
- Wind energy: 65% ↑

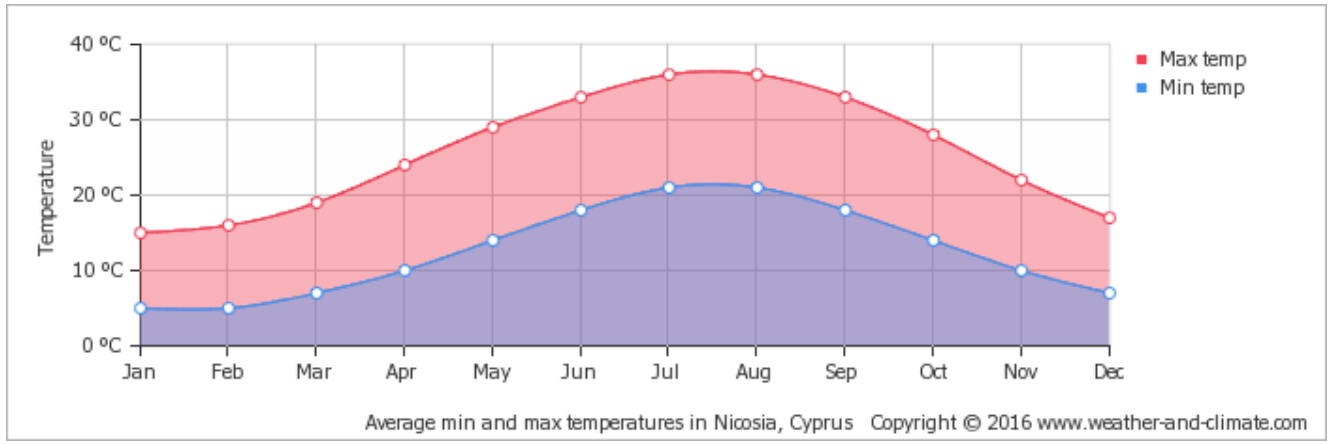
R.E.S production



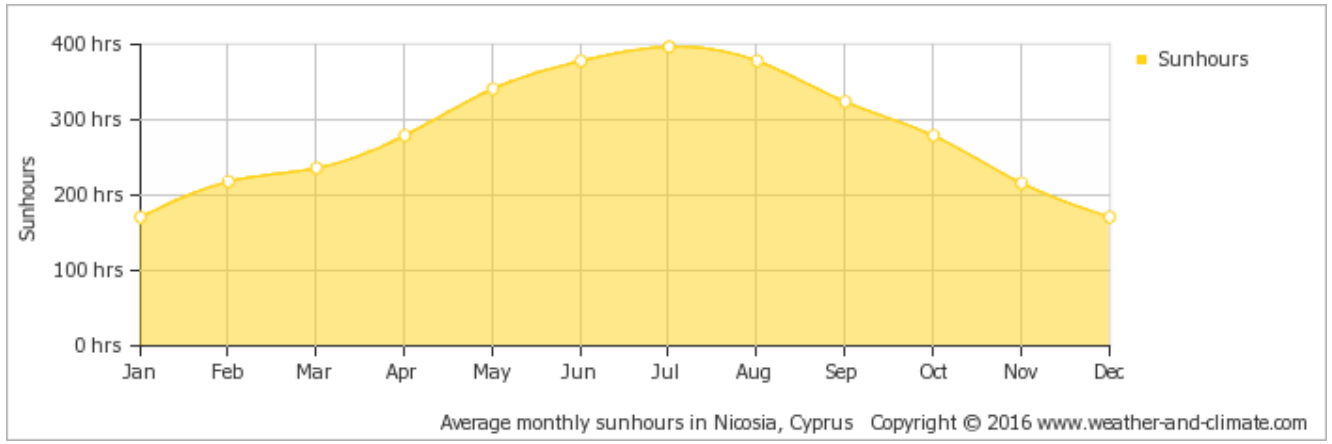


Solar Energy Potential

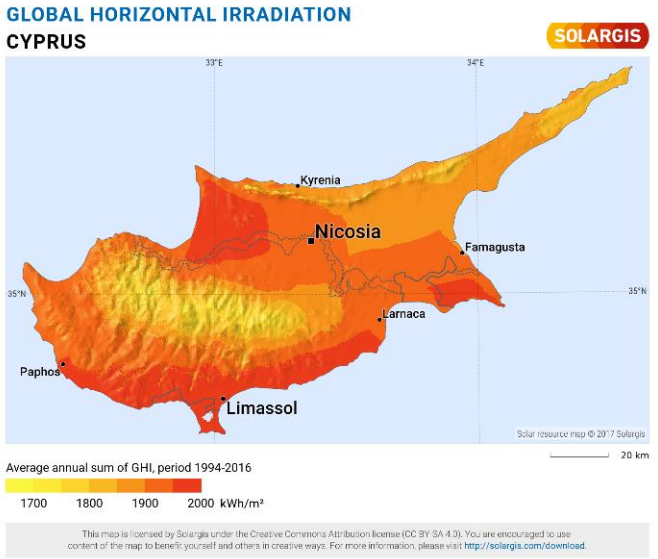
Monthly average temperature in Nicosia, Cyprus



Sunhours in 2016



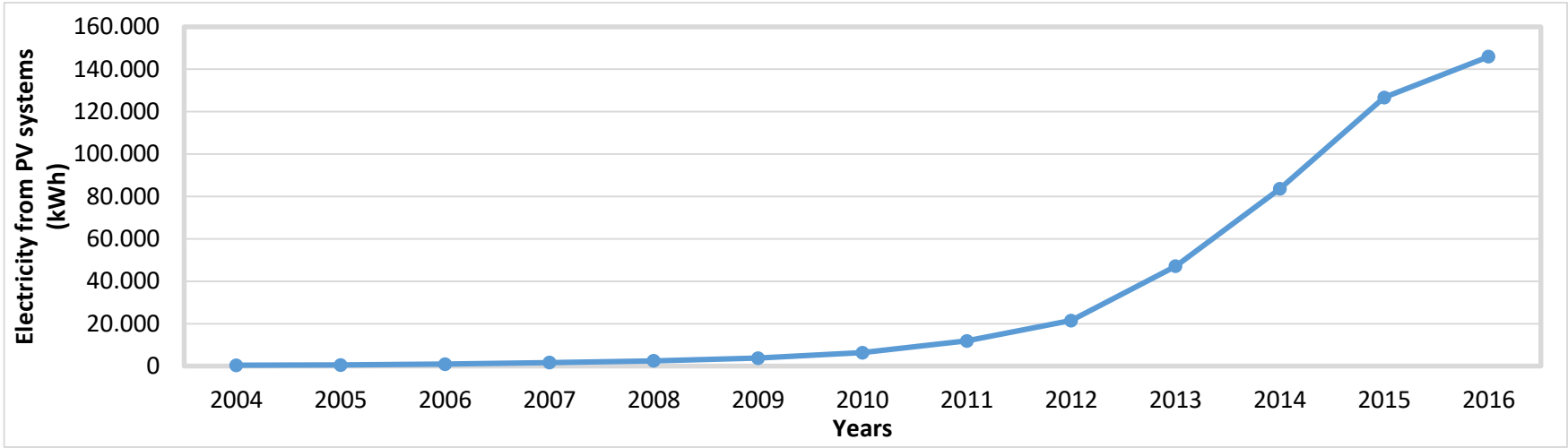
Solar Energy Potential – Solar Radiation



- Daily average solar radiation of about 5.4 kWh/m^2 on a horizontal surface.
- The amount of global radiation falling on a horizontal surface with average weather conditions = 1727 kWh/m^2 per year.

Solar Energy Potential

Shift to Photovoltaics



Solar parks

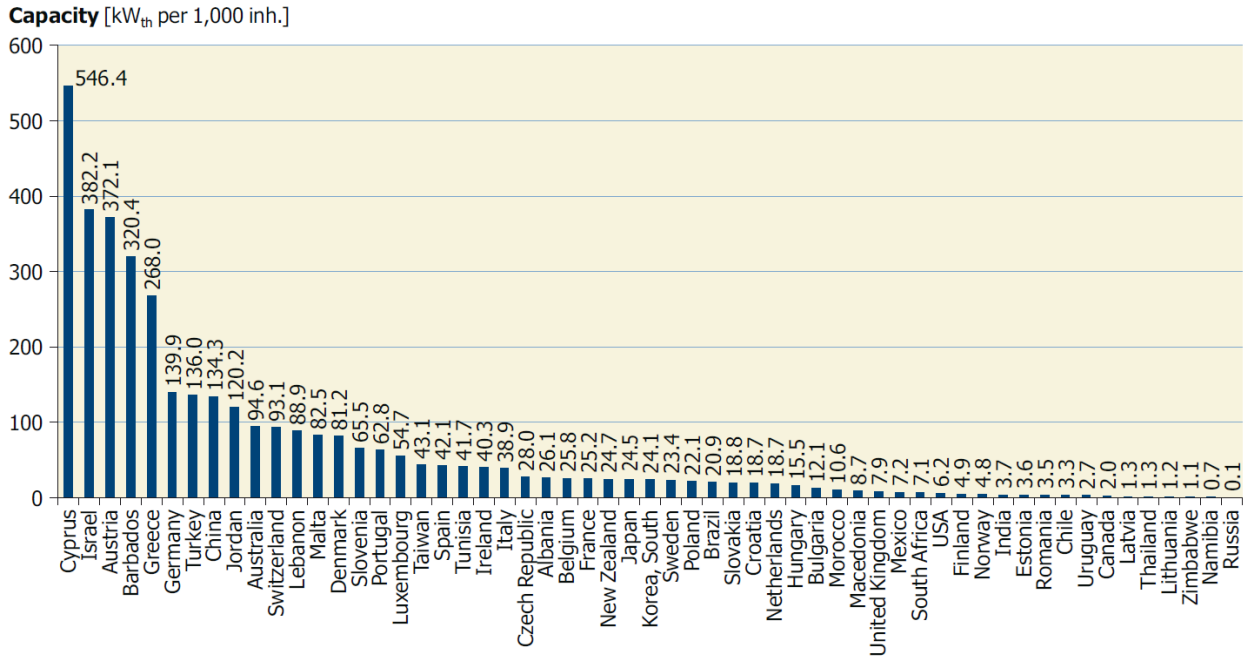
DALI 1,5MWp.

NISOU 1,5MWp.

FRENAROS 5MWp.

Solar Energy Potential

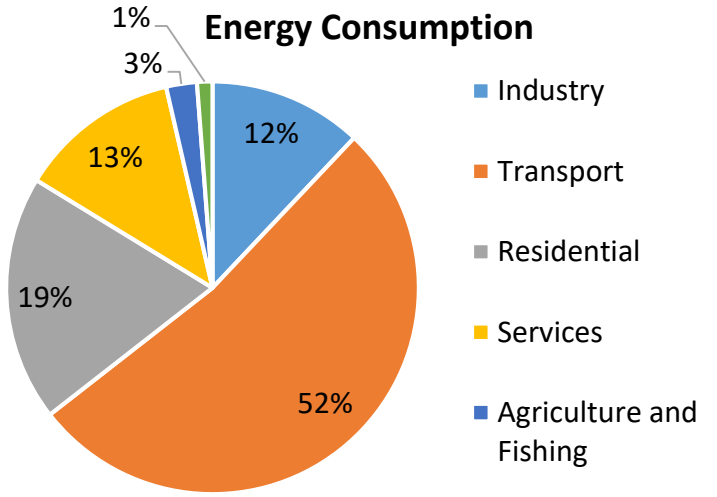
- Solar thermal collectors for hot water are widely used
- Worldwide leader country for the use of solar water heating systems per capita
- The total capacity of glazed water collectors in 2012 was 546.4 kW_{th} per 1000 inhabitants

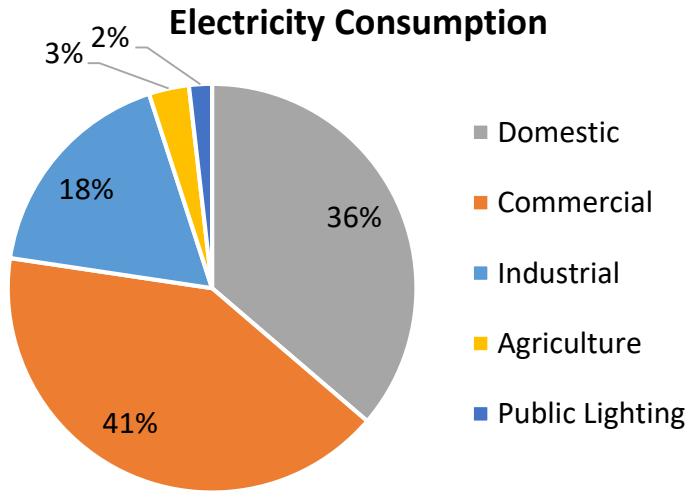


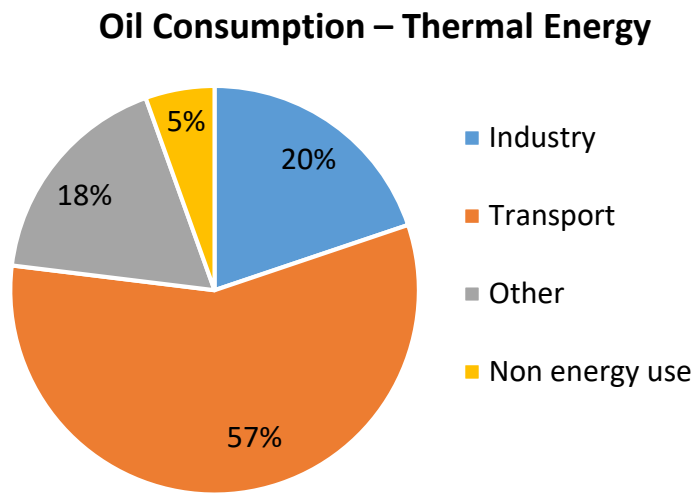
Energy for the Industrial Sector

- Industrial Sector:
  - 4th biggest energy consumer
  - 3rd biggest electricity consumer
  - 2nd biggest thermal energy consumer (oil consumption) →

Need to reduce oil consumption for thermal energy in the industrial sector

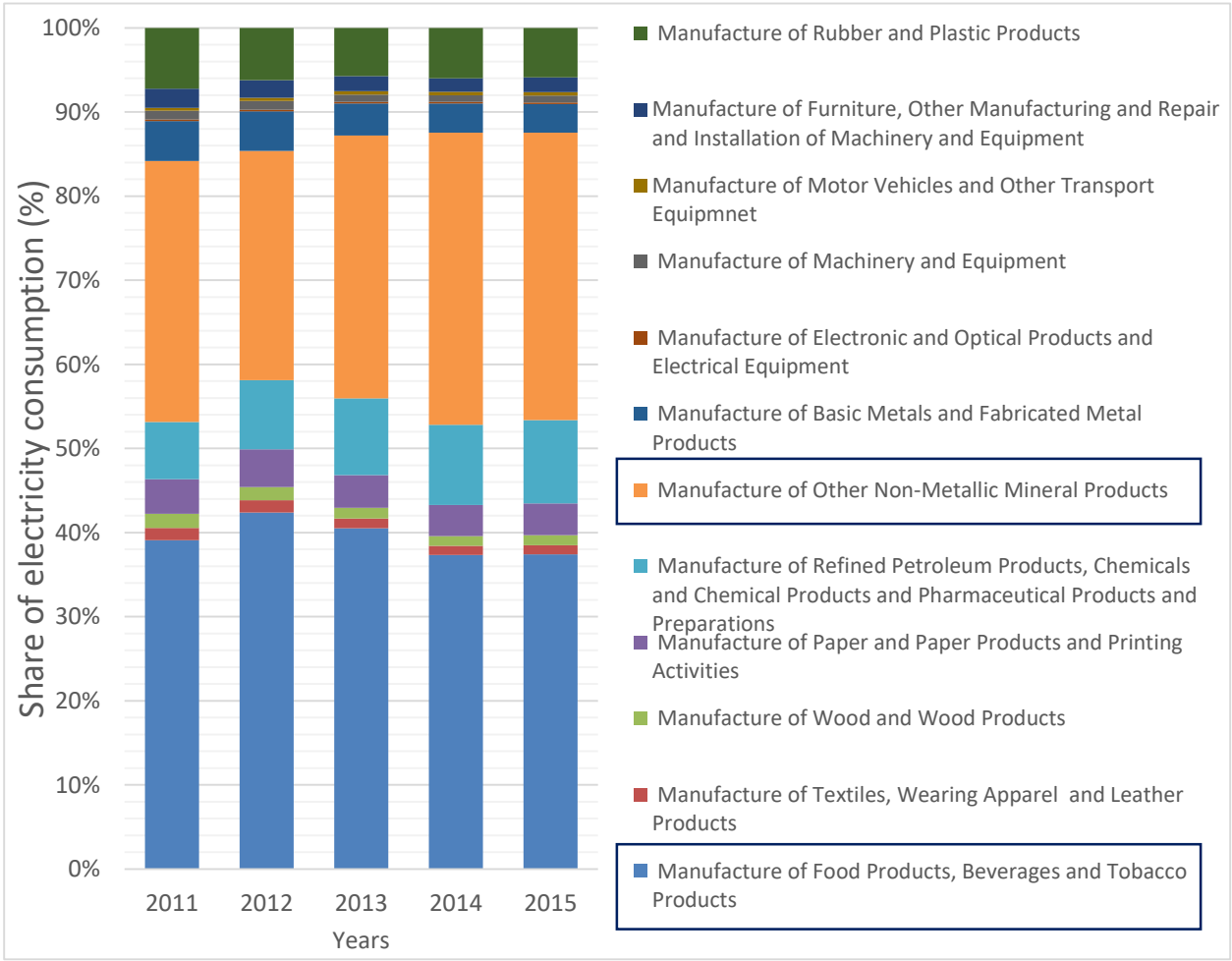




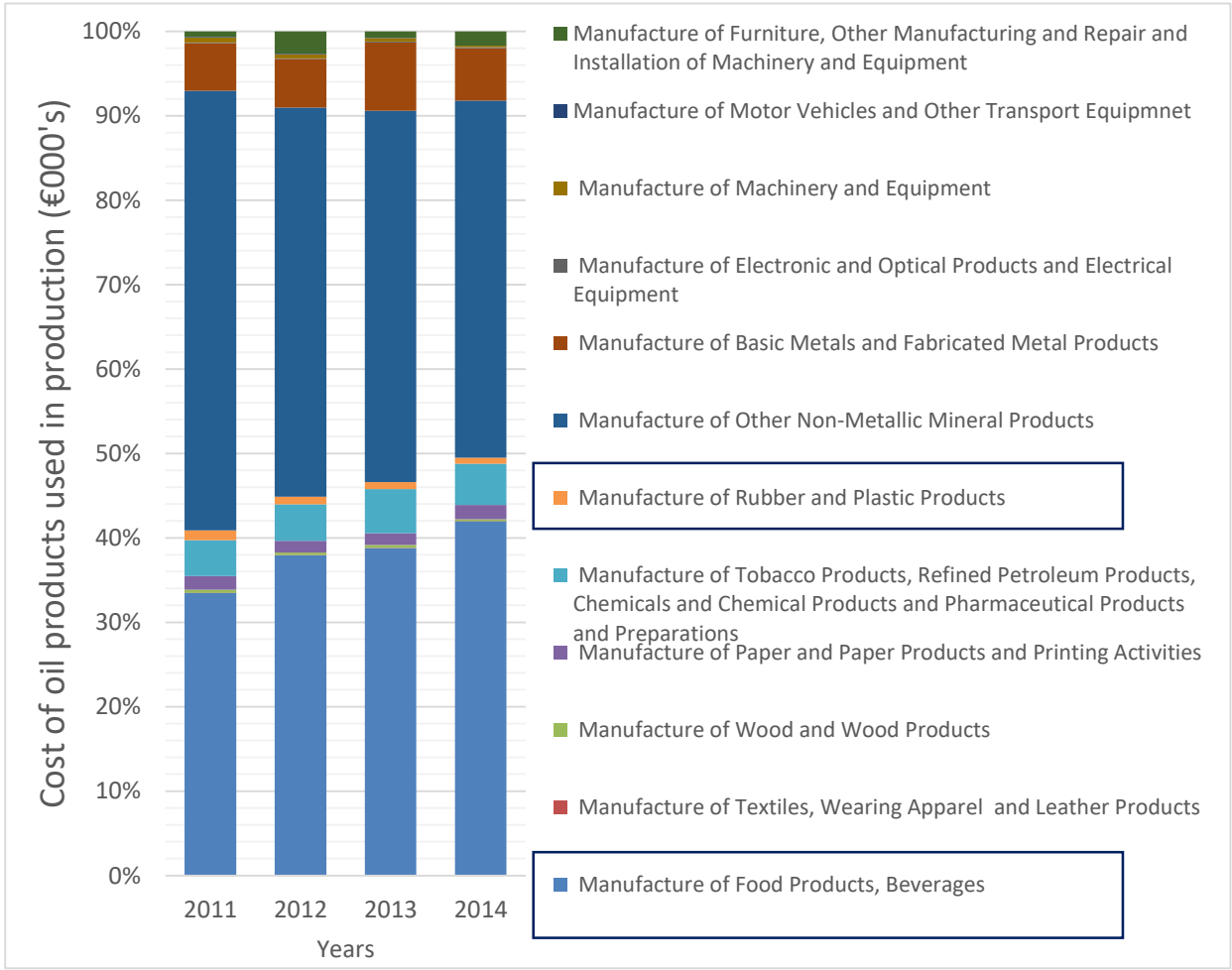


Energy for the Industrial Sector

Electricity consumption



Oil products for thermal energy production



Energy for the Industrial Sector

- The thermal load of the food industry and the non-metallic mineral products industry can be classified in relation to the required temperature range as follows:
  - Low temperature (<100^{o}C)
  - Medium temperature (100^{o}C – 300^{o}C)
  - High temperature (>300^{o}C)

Thermal demand of various factories from the food and beverage and non-metallic mineral products industries in Cyprus

Factory	Process	Temperature range (°C)	Hot water/ steam	Average load (tons/h)
Wine	Sterilization	90	Hot Water	1.5
Milk & Dairy products	Sterilization	120	Steam	2.2
	Drying			
Soft drinks	Pasteurization	95	Steam	3.5
	Cleaning / disinfecting process	150	Steam	
Meat	Cooking	90-100	Steam	1
Beer	Cleaning / disinfecting process/ hot water	80-90	Steam	5
Plastics	Separation	200-220	Steam	2
	Drying	180-200	Steam	
	Blending	120-140	Steam	
Bricks and blocks	Curing	60-140	Steam	4

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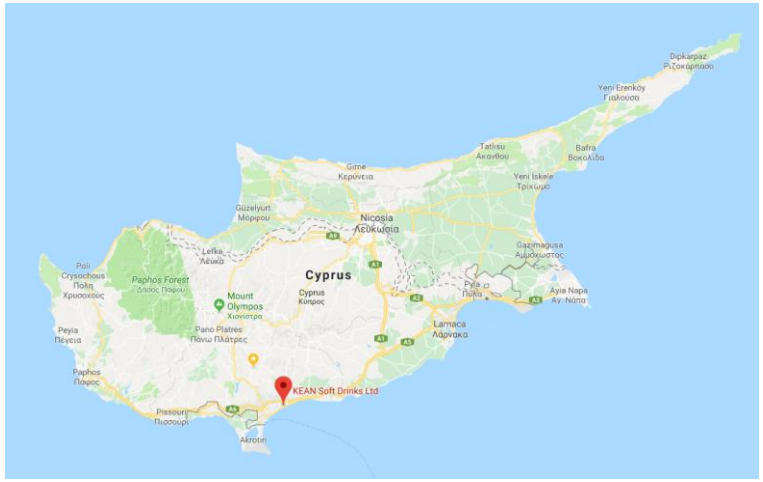
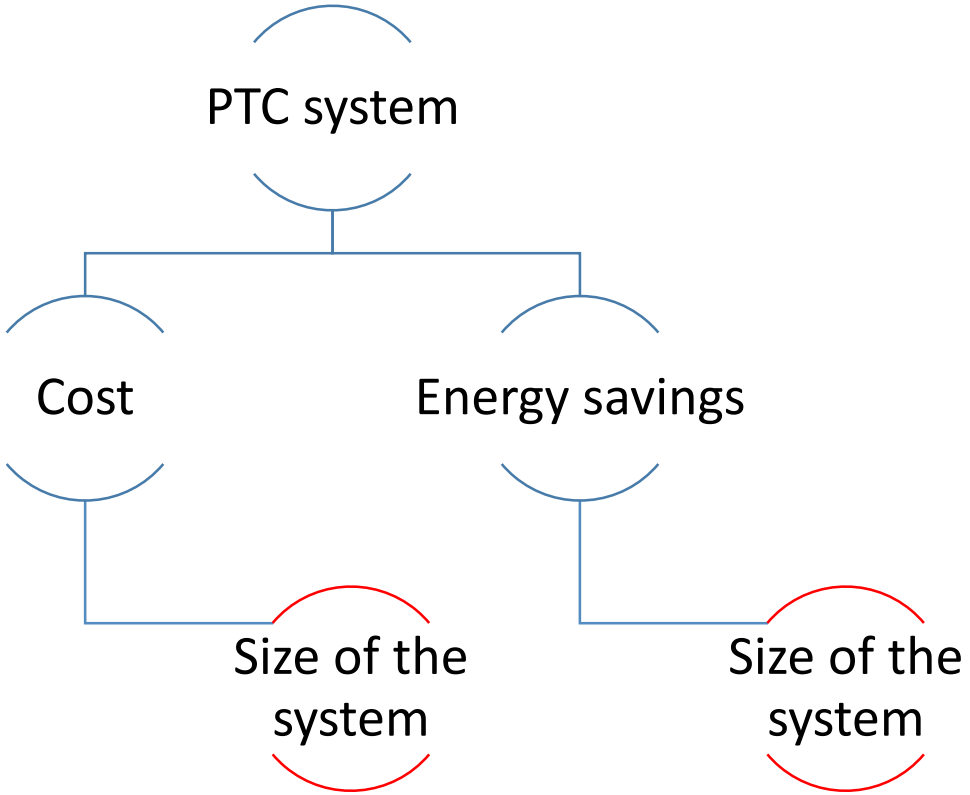
Case study

- Site/Factory scenario
  - Location: Limassol, Cyprus
  - Industry: Food and beverage industry
  - Factory: Soft Drinks
  - Thermal demand: 500 kW_{th}
  - Thermal needs: Steam, 150°C
  - Demand: 10 hours/day, 7 days/week



- System Selection



Simulation Dynamic Modeling

Software: TRNSYS

Weather data: TMY, Nicosia

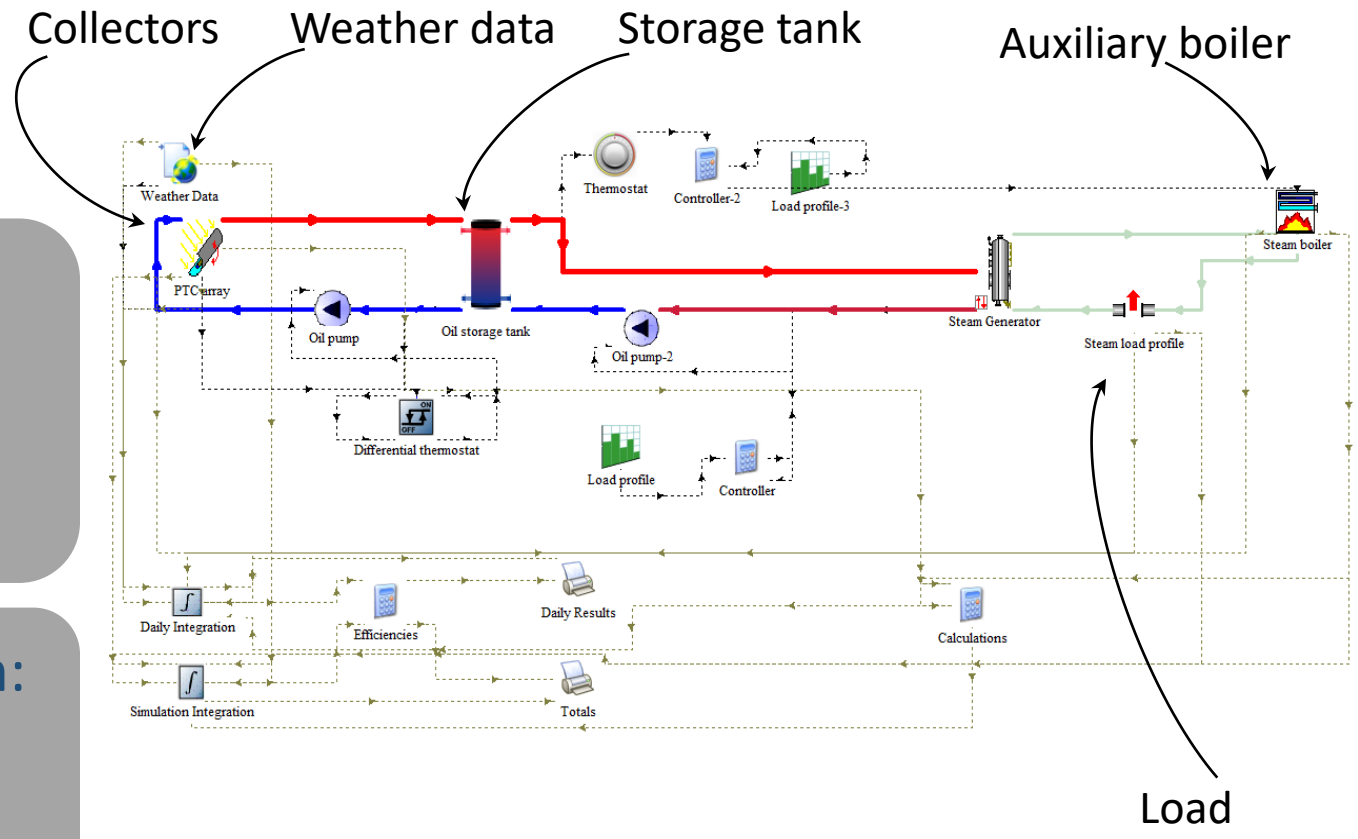
Parameters examined:

Storage tank size: 15, 20, 25, 30 and 35 m^3

Number of collectors: 100, 110, 120, 130, 140, 150, 160

Parameter Considered for system evaluation:

- Solar fraction
- System's energy cost (Solar Savings)



Life Cycle Cost Analysis

LCCA Assumptions:

System components & fuel	Cost
Collectors	270 €/m^2 (11.25 m^2/collector)
Steam generator, steam boiler, control system, pipes and pumps	€34,000
Fuel	20 €/GJ (+1% cost added per year)
Maintenance cost	7% (+1% cost added per year)
Storage tank cost	depending on the size (15, 20, 25, 30 and 35 m^3)

LCCA Method General Assumptions:

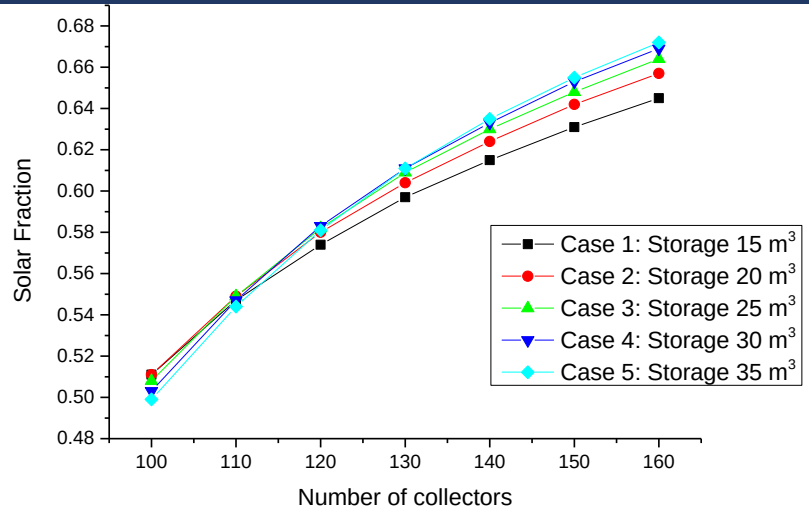
- Return of investment: 7%
- Pre-payment: 20%
- Loan interest rate: 7%
- Loan duration: 20 years

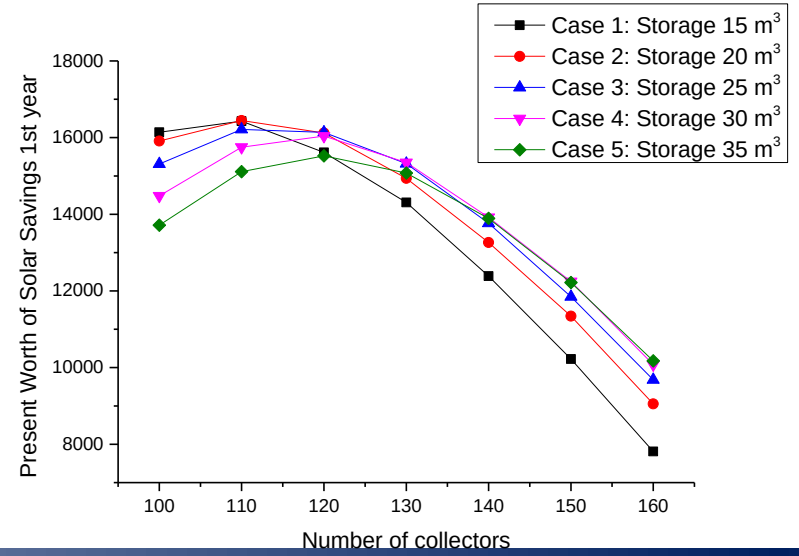
Feasibility analysis

Results of 35 simulation runs

Number of PTC	Case 1 Storage tank: 15m³		Case 2 Storage tank: 20m³		Case 3 Storage tank: 25m³		Case 4 Storage tank: 30m³		Case 5 Storage tank: 35m³	
	Solar fraction	Present worth of solar savings 1st year	Solar fraction	Present worth of solar savings 1st year	Solar fraction	Present worth of solar savings 1st year	Solar fraction	Present worth of solar savings 1st year	Solar fraction	Present worth of solar savings 1st year
100	0.511	16,140.52	0.511	15,909.33	0.508	15,309.73	0.503	14,478.12	0.499	13,714.92
110	**0.547**	**16,430.62**	**0.549**	**16,445.03**	**0.549**	**16,213.84**	0.547	15,750.64	0.544	15,110.24
120	0.574	15,615.48	0.58	16,121.11	**0.582**	**16,135.53**	**0.583**	**16,040.74**	**0.581**	**15,523.14**
130	0.597	14,309.13	0.604	14,937.56	0.609	15,320.39	0.611	15,348.41	0.611	15,076.42
140	0.615	12,388.75	0.624	13,262.80	0.63	13,768.43	0.633	13,919.25	0.635	13,892.87
150	0.631	10,222.78	0.642	11,342.43	0.648	11,848.06	0.653	12,244.48	0.655	12,218.10
160	0.645	7,811.19	0.657	9,053.64	0.664	9,682.08	0.669	10,078.50	0.672	10,174.93

Nu. of collectors	Storage tank volume m³	Overall cost €	Present worth value 1st year €	Solar fraction
110	15	373,125	16,430.62	0.547
110	20	374,825	16,445.03	0.549
110	25	376,525	16,213.84	0.549
120	25	406,900	16,135.53	0.582
120	**30**	**408,500**	**16,040.74**	**0.583**
120	35	410,500	15,523.14	0.581





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120	**30**	**408,500**	**16,040.74**	**0.583**
120	35	410,500	15,523.14	0.581

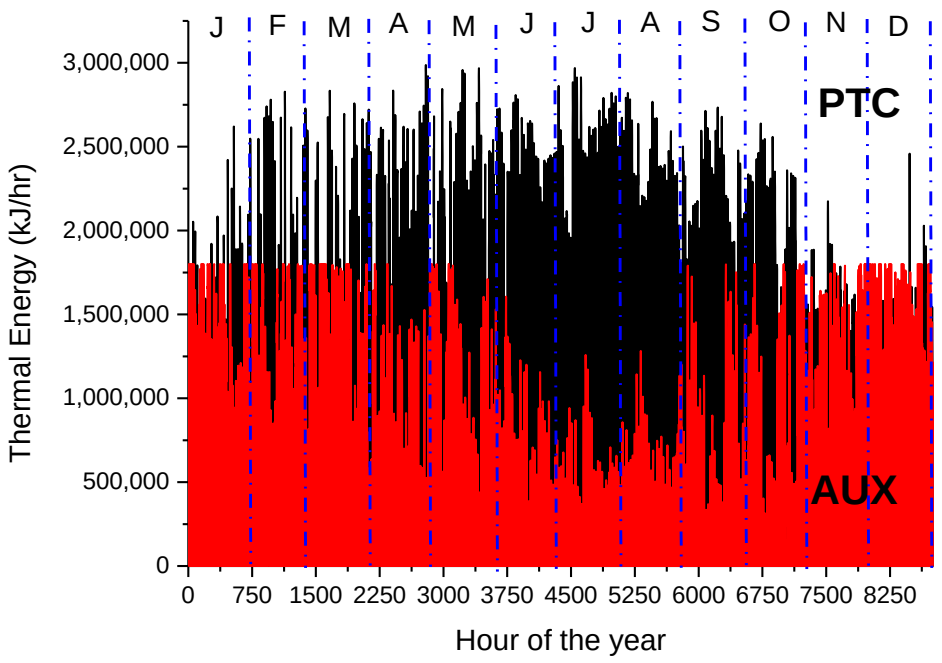
Final selected system:

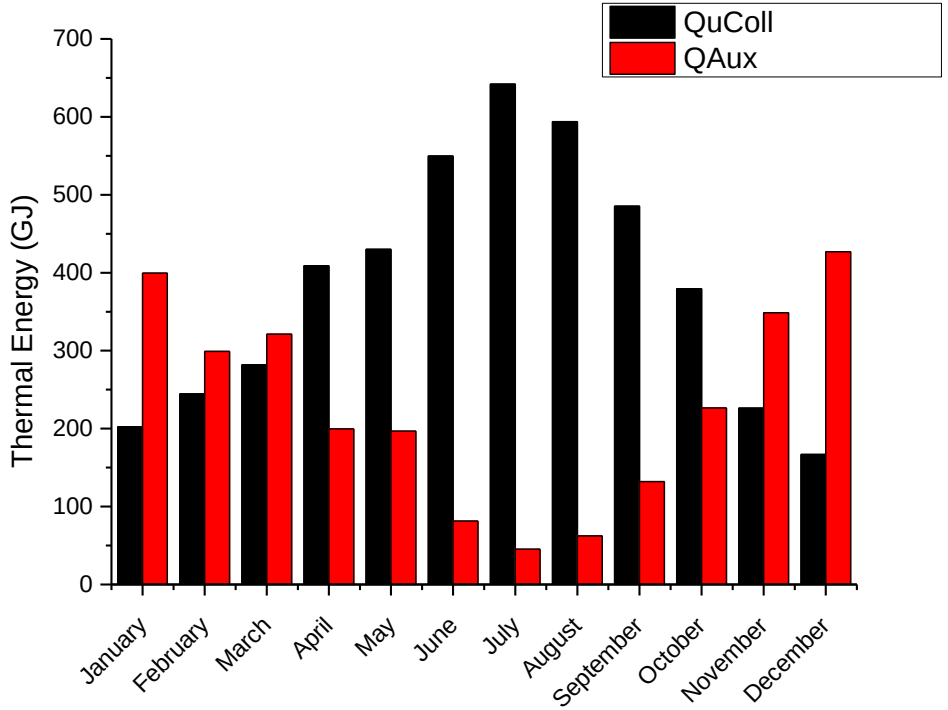
- Collectors: 120 (1350 m^2)
- Solar fraction: 0.583
- Storage tank: 30 m^2

Feasibility analysis

Annual thermal energy production of the selected system: 7420 GJ

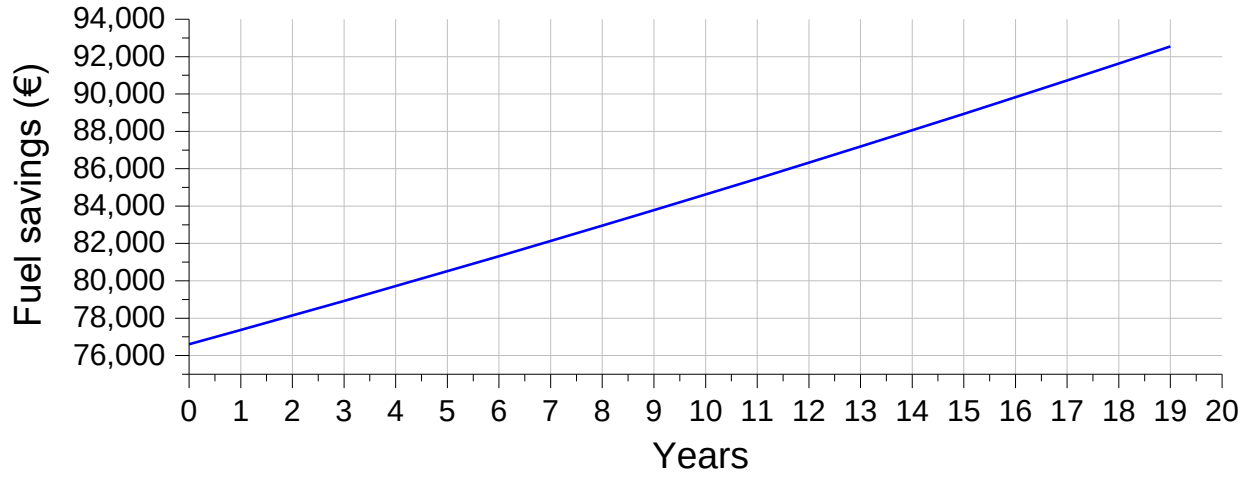
- 4700 GJ by the PTC system
- 2720 GJ from the auxiliary steam boiler

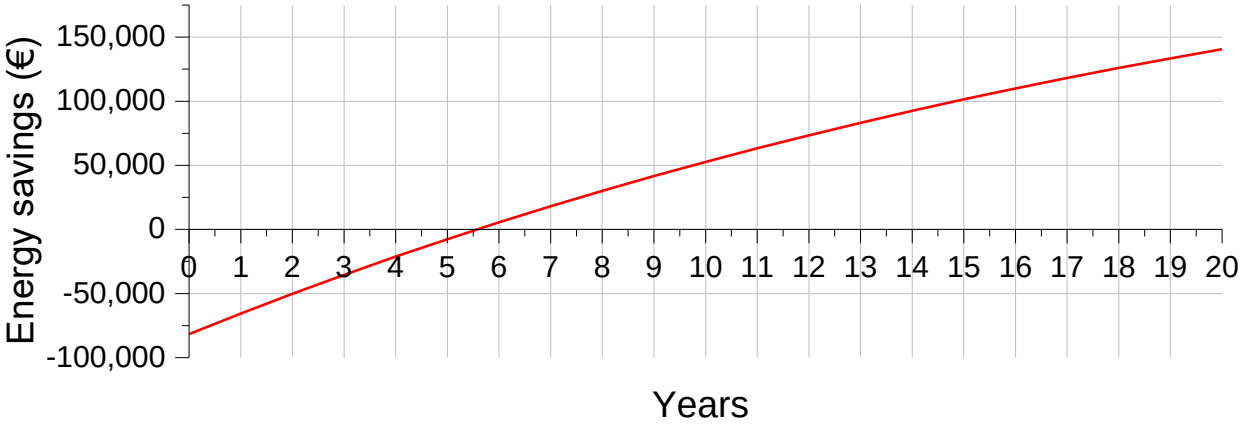




Cost Analysis

- Final selected system:
  - Total cost: €408,500.00
  - Payback period: 5-6 years
  - Overall savings: € 142,690.24





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Summary

- The climate of Cyprus has a great potential for solar energy systems
- The industrial sector has high thermal energy demand
- PTC is proposed for industrial process heat generation due to the temperature range
- Different storage tank sizes and collector's area are tested.
- The payback period is acceptable, 5-6 years.
- 58% of the thermal load is covered by the solar system.

Future work

- ✓**Validation:** On-site measurements from the first pilot PTC system on the island
- ✓**Storage:** Test the model with different storage types
- ✓**Scale-up:** Optimise the system for more industrial factories in different locations with different thermal needs
- ✓**Experimentation:** Build a pilot PTC system for performance monitoring




Acknowledgements

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Thank you for your attention..

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