Combined cold, heat and power system, based on an organic Rankine cycle, using biomass as renewable heat source for energy saving and emissions reduction in a supermarket

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Research group ***ISTENER***

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EXPANDER TECH S.L.

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14th September 2017 | Milan

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CONTEXT

LIFEZEROSTORE PROJECT

LIFE ZERO STORE

Supermarket retrofit for zero energy consumption (LIFEZEROSTORE)

Life

EROSKI contigo

LSOLÉ

CENER

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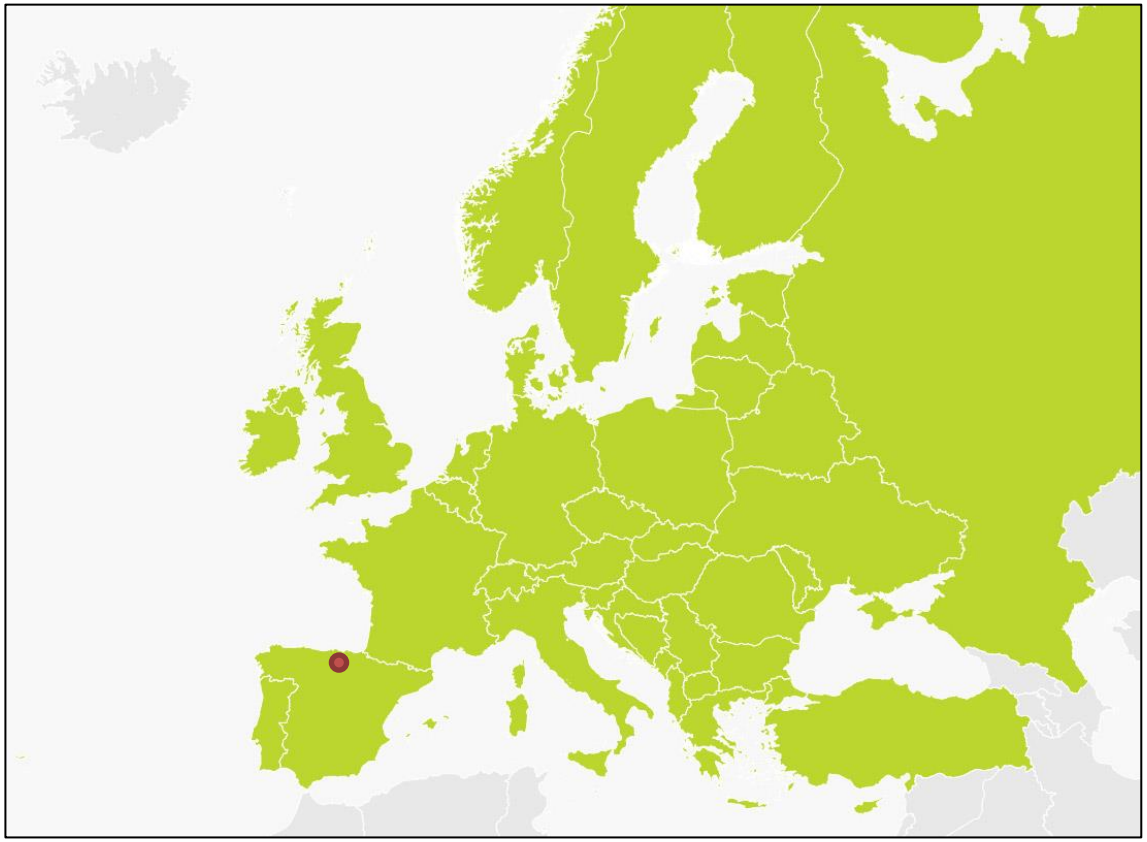
Iparfrío
frío industrial y comercial

CONTEXT

LIFEZEROSTORE PROJECT



EROSKI supermarket in Vitoria (Spain)

Combined cold, heat and power system, based on an organic Rankine cycle, using biomass as renewable heat source for energy saving and emissions reduction in a supermarket

CONTEXT

LIFEZEROSTORE PROJECT

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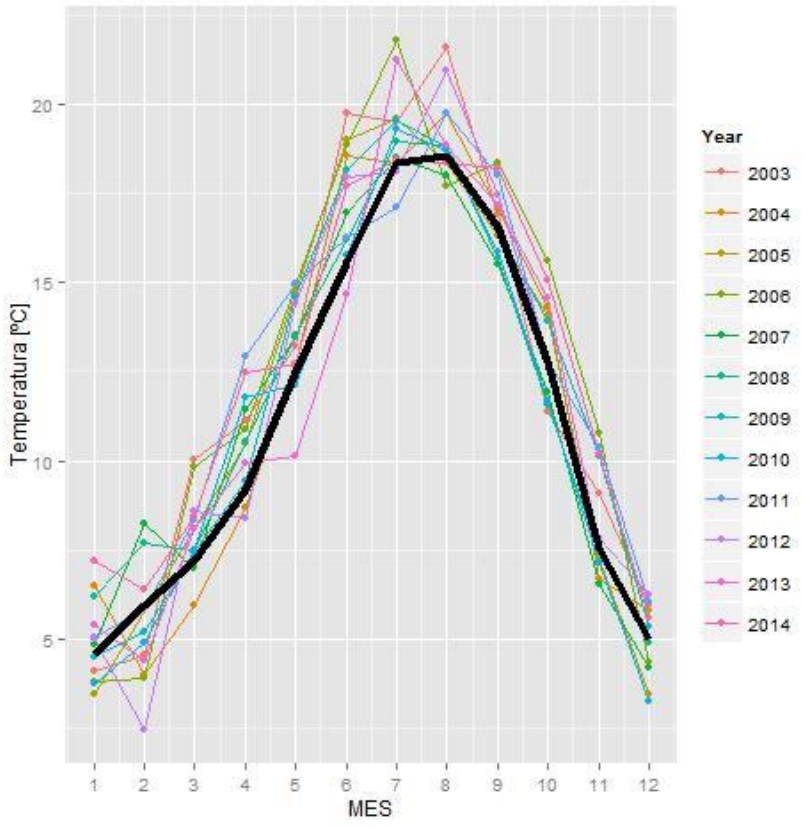
CONTEXT

ENERGY STUDY



Climatic conditions:

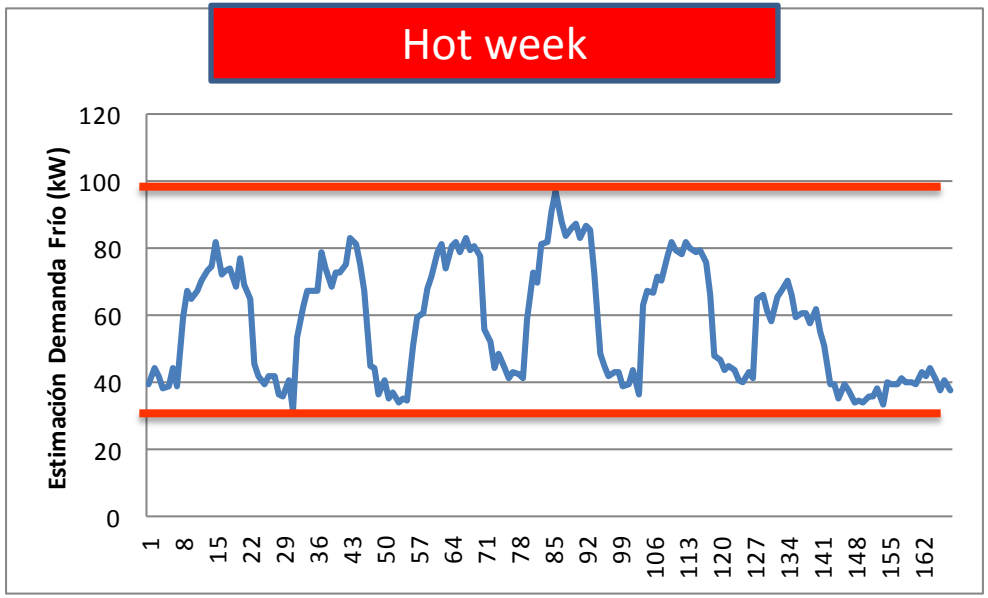
- HOT WEEK: August 19-25
- COOLD WEEK: November 25-30
- NORMAL WEEK: October 7-13

CONTEXT

ENERGY STUDY

Cooling demand:

30-100 kW



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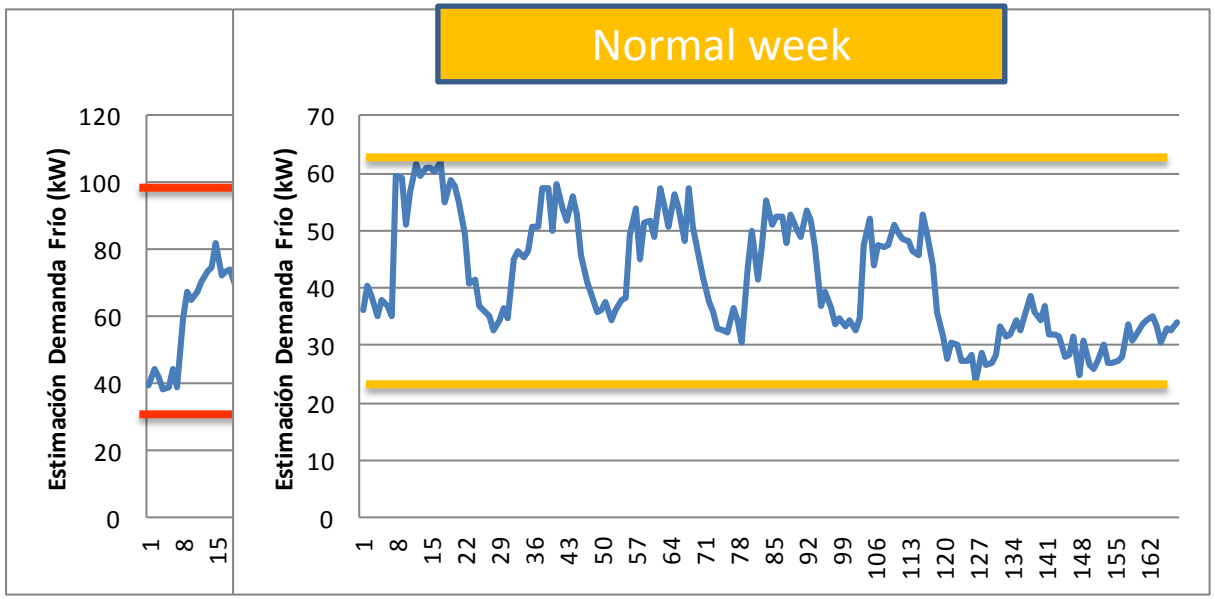
CONTEXT

ENERGY STUDY

Cooling demand:

30-100 kW

22-63 kW



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CONTEXT

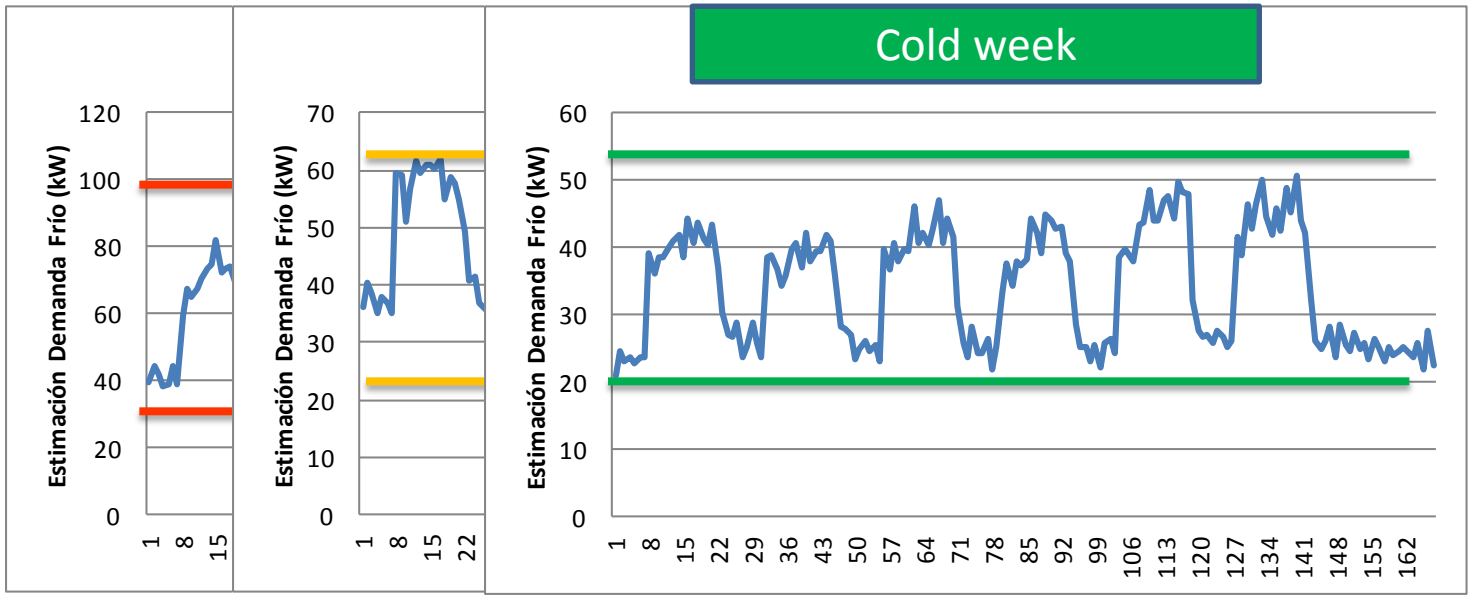
ENERGY STUDY

Cooling demand: 20-30 kW base

30-100 kW

22-63 kW

20-50 kW



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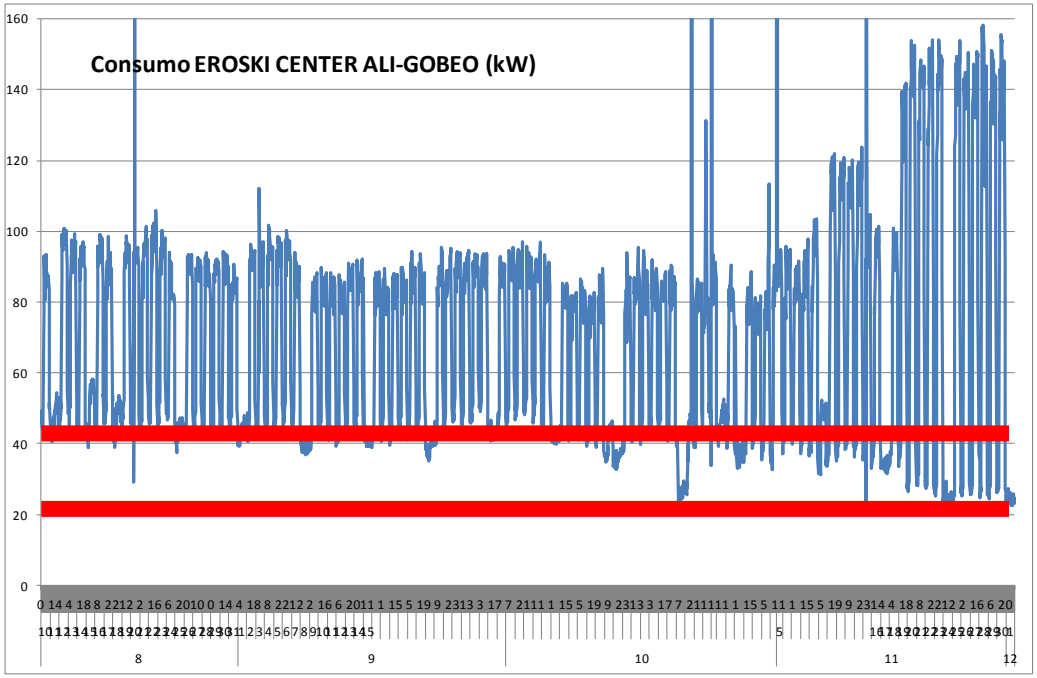
CONTEXT

ENERGY STUDY

Electricity demand: 20-40 kW base

20-40 kW



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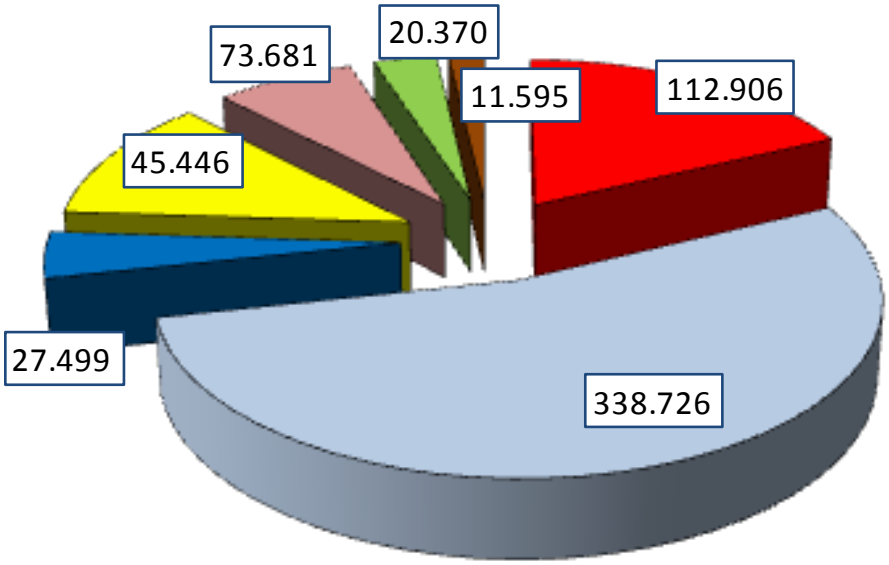
CONTEXT

ENERGY STUDY

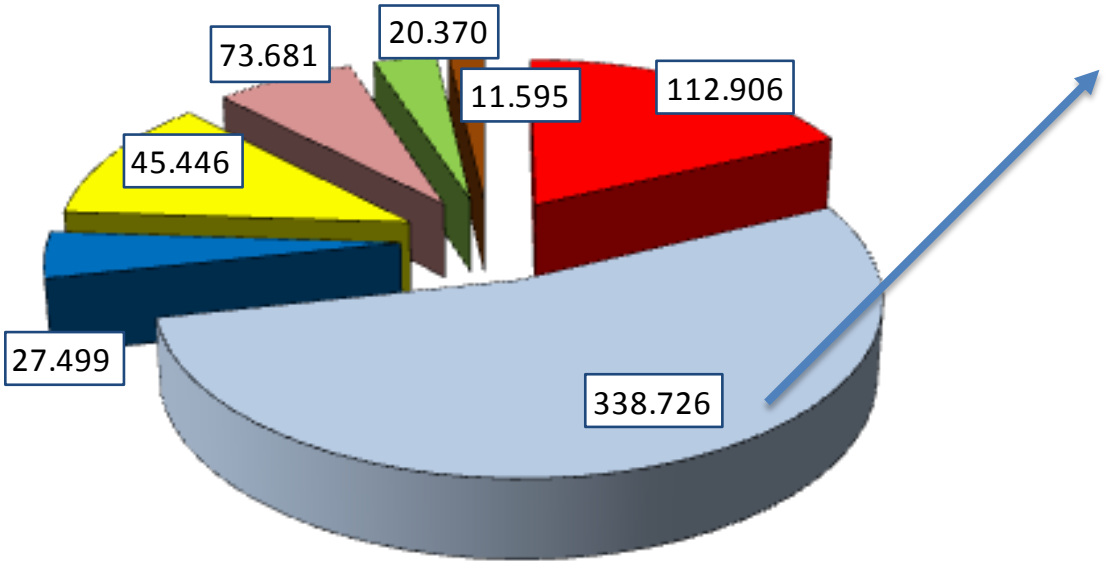
Electricity demand: annual kWh



CONTEXT

ENERGY STUDY

Electricity demand: annual kWh

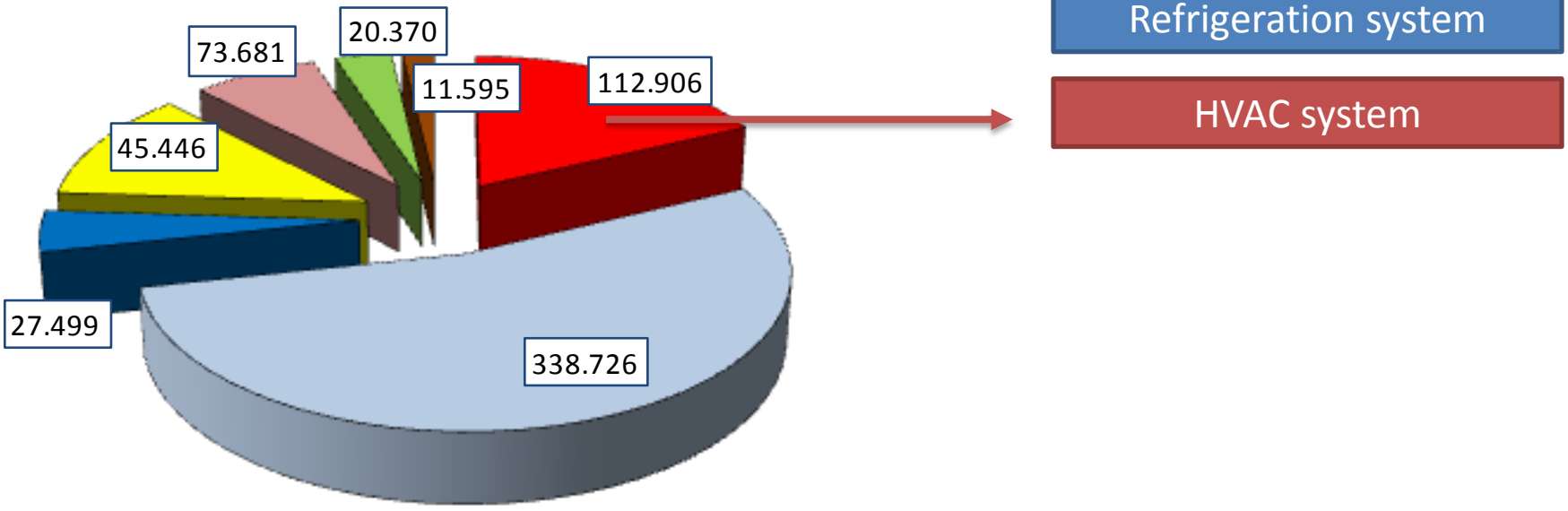


Refrigeration system

CONTEXT

ENERGY STUDY

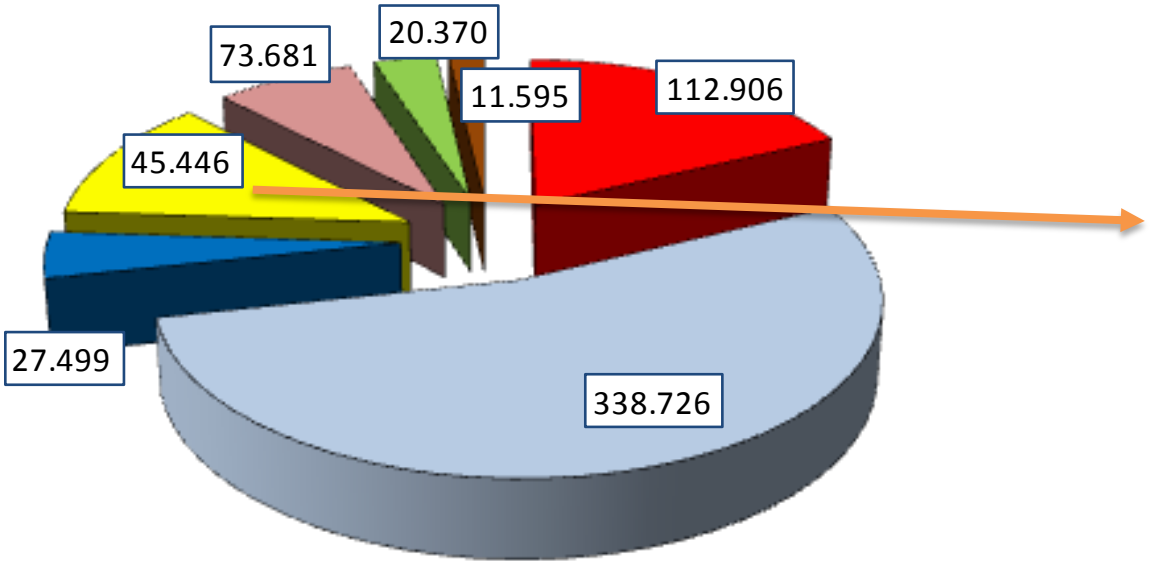
Electricity demand: annual kWh



CONTEXT

ENERGY STUDY

Electricity demand: annual kWh



- Refrigeration system
- Air-conditioning system
- Lighting system

CONTEXT

ENERGY SAVING MEASURES

Refrigeration system

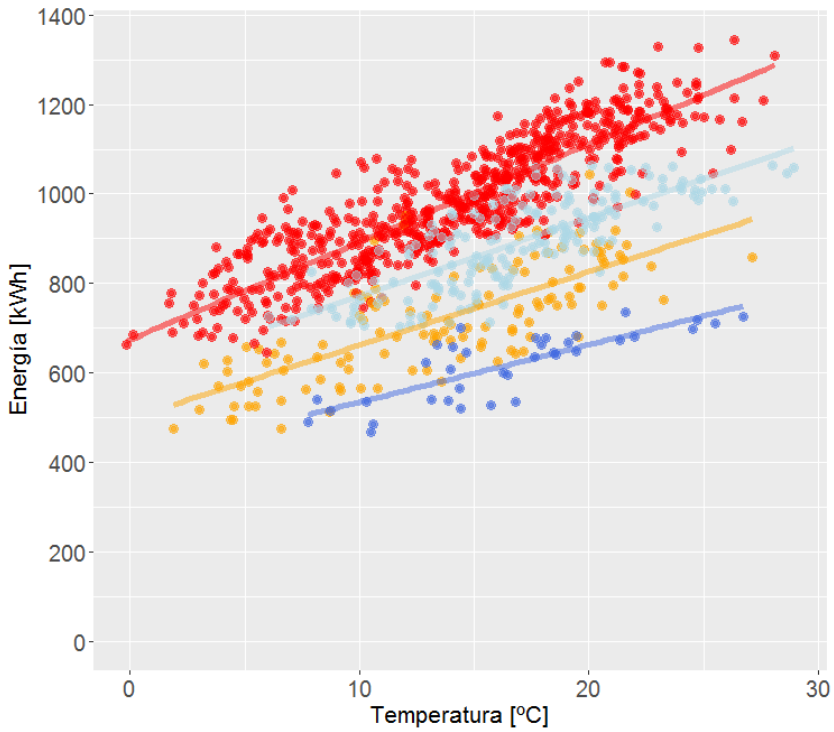
Simple cycle with R404A

Simple cycle with R404A

Cascade cycle with R450A / CO2

CONTEXT

ENERGY SAVING MEASURES



Refrigeration system

18%

CONTEXT

ENERGY SAVING MEASURES

Air-conditioning system

~10%

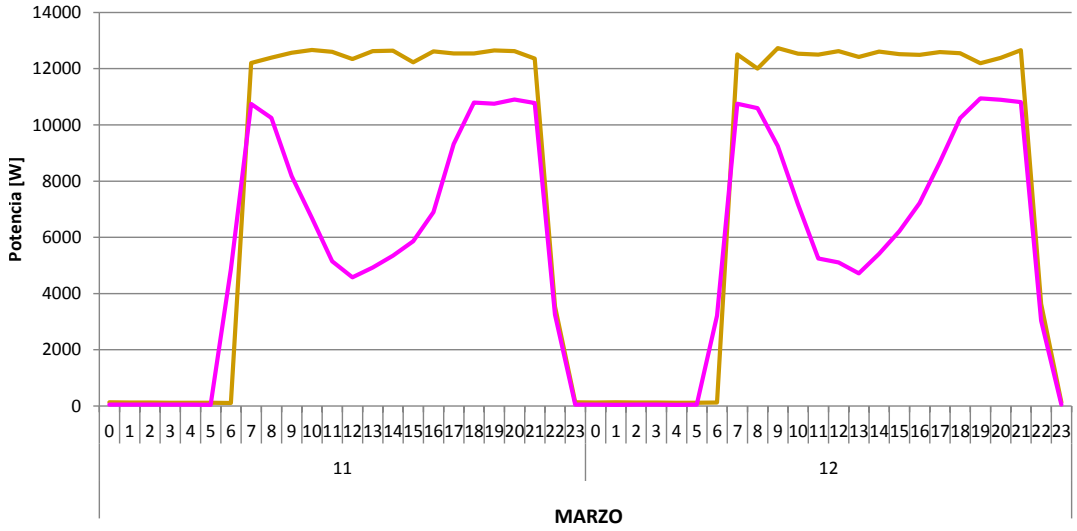
CONTEXT

ENERGY SAVING MEASURES

Lighting system

CONTEXT

ENERGY SAVING MEASURES



Lighting system

22%

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CONTEXT

ENERGY SAVING MEASURES

Cooling demand: 20-30 kW base

Electricity demand: 20-40 kW base

Combined cold, heat and power system

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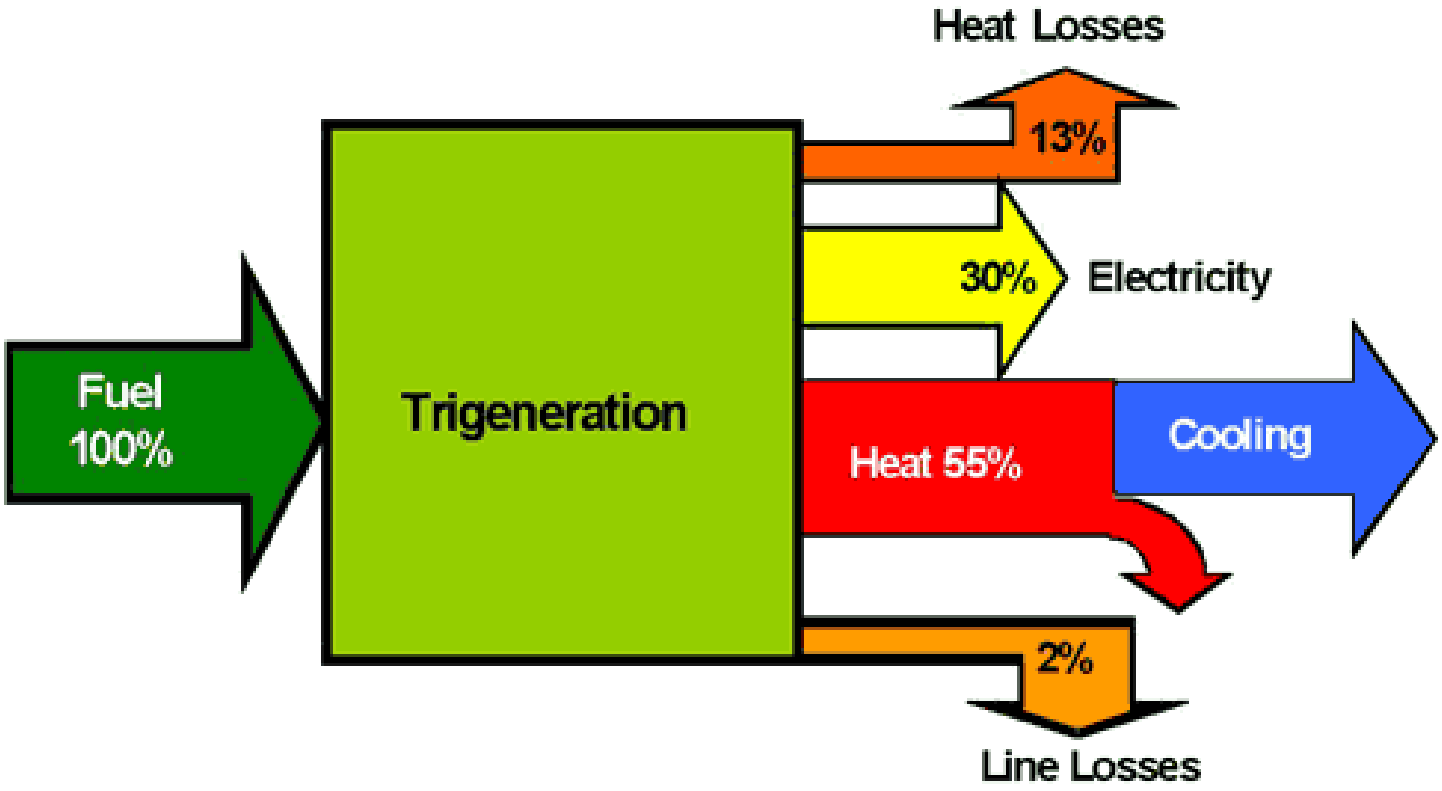
CCHP SYSTEM

CONCEPT



CCHP SYSTEM

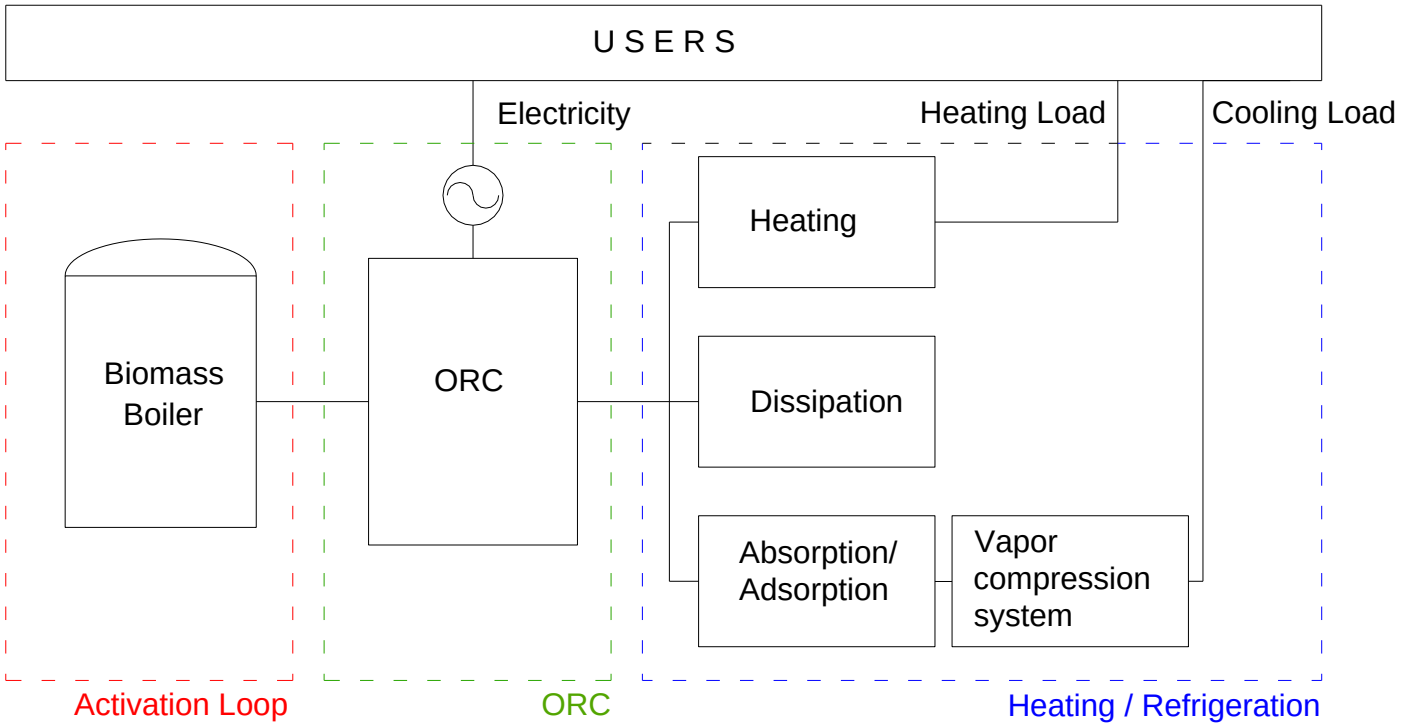
CONCEPT

Fuel
100%

Combined cold, heat and power system, based on an organic Rankine cycle, using biomass as renewable heat source for energy saving and emissions reduction in a supermarket

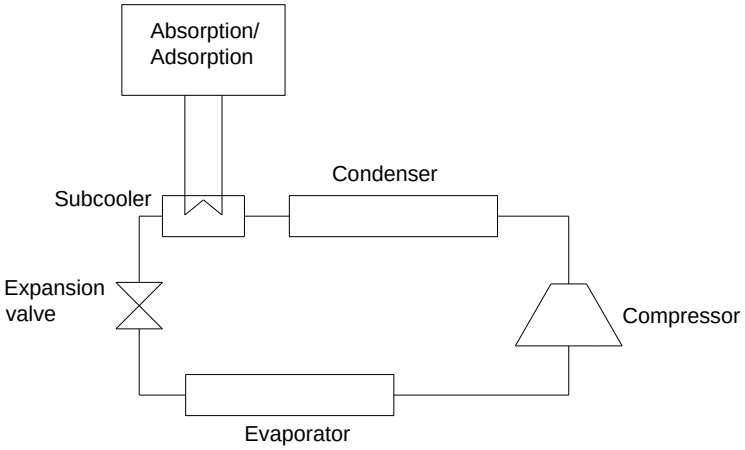
CCHP SYSTEM

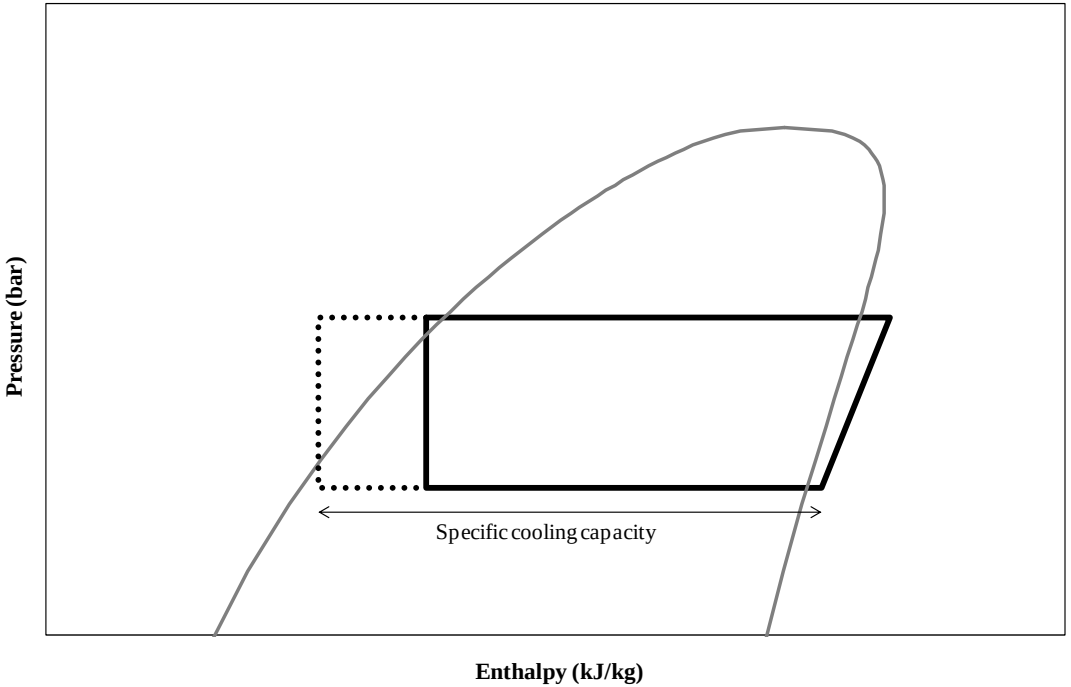
CONCEPT



CCHP SYSTEM

CONCEPT





250 kWt
(205ºC)

Biomass boiler

ORC module

180 kWt
(50ºC)

27.5 kWe

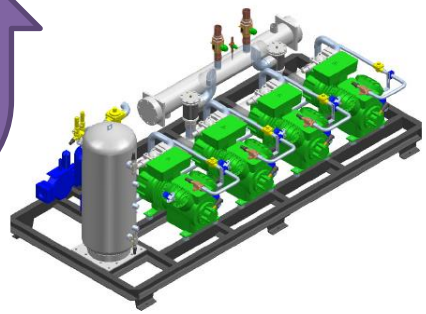
25 kWt
(88ºC)

EROSKI

Eroski

Absorption module

17.5 kWt
(7ºC)



CCHP SYSTEM

BIOMASS BOILER

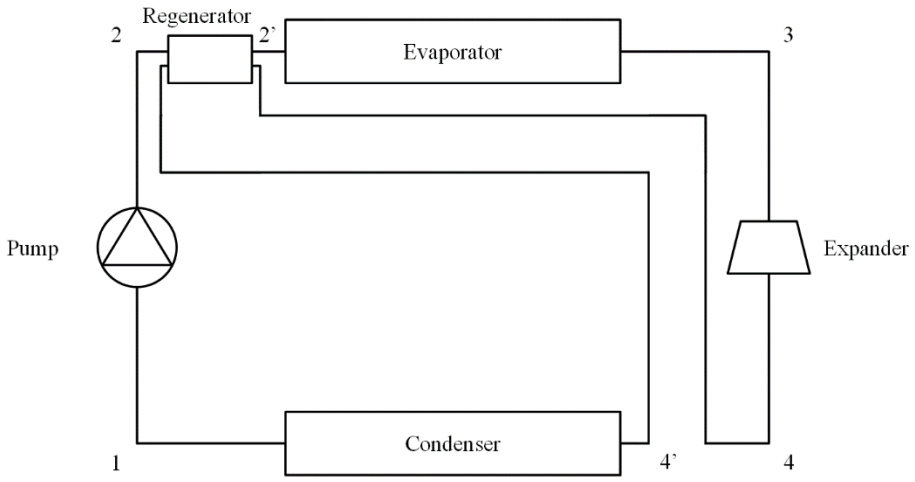
Thermal oil

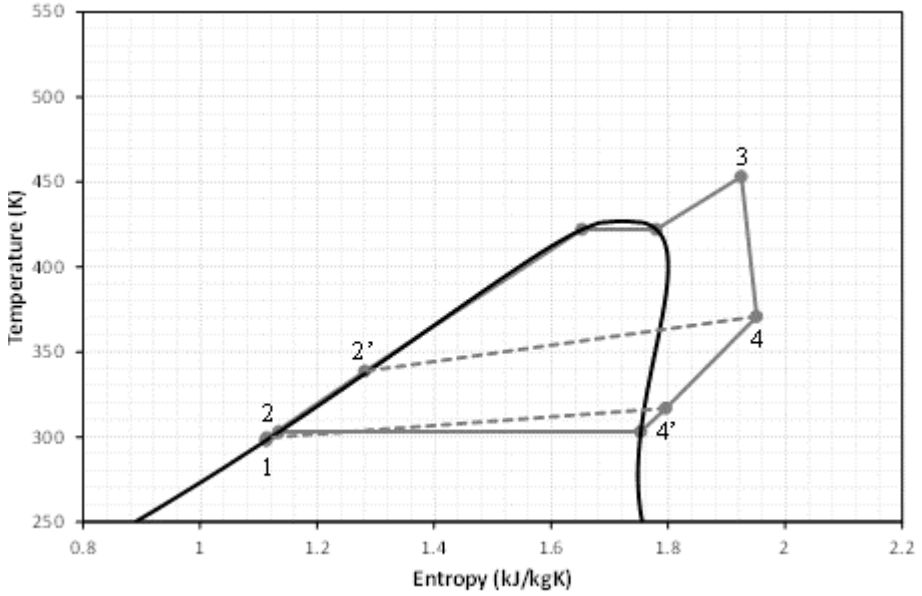
Heat production
250 kWt – 205ºC

CCHP SYSTEM

ORGANIC RANKINE CYCLE

Regenerative cycle





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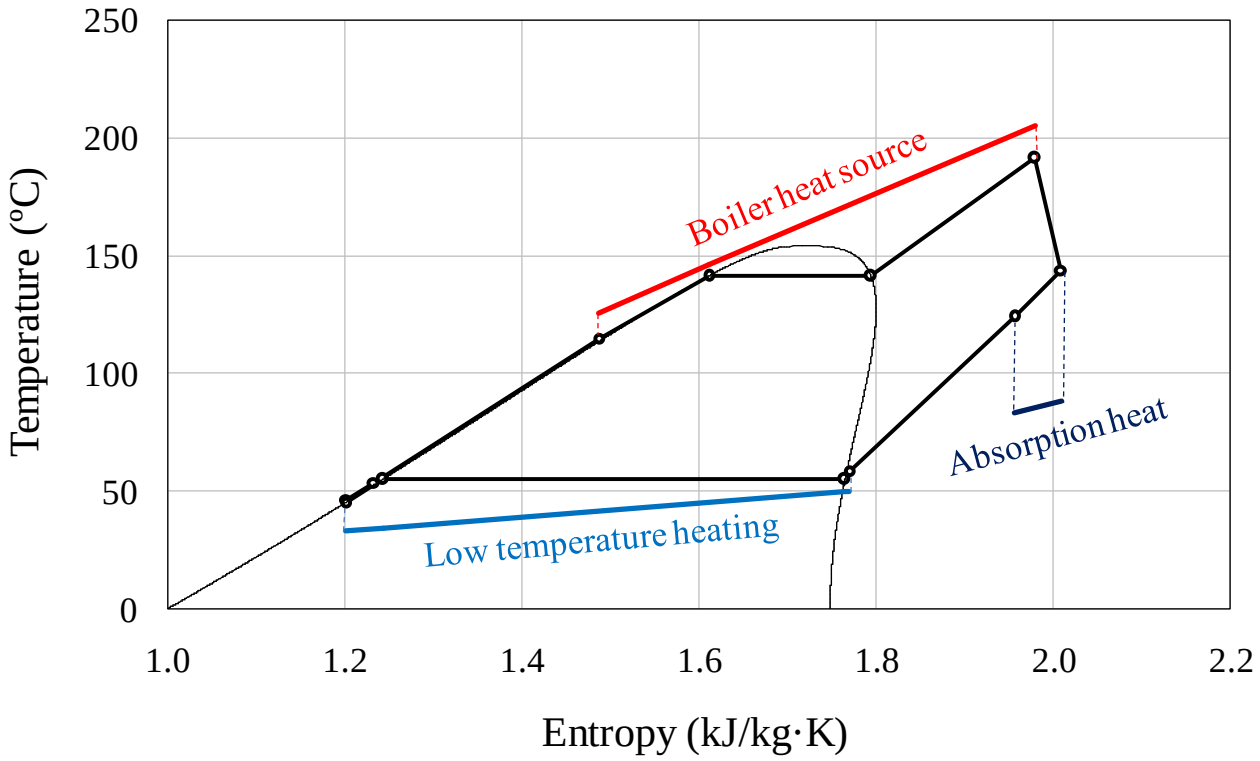
CCHP SYSTEM

ORGANIC RANKINE CYCLE



CCHP SYSTEM

ORGANIC RANKINE CYCLE

Heat source:
250 kWt – 205ºC

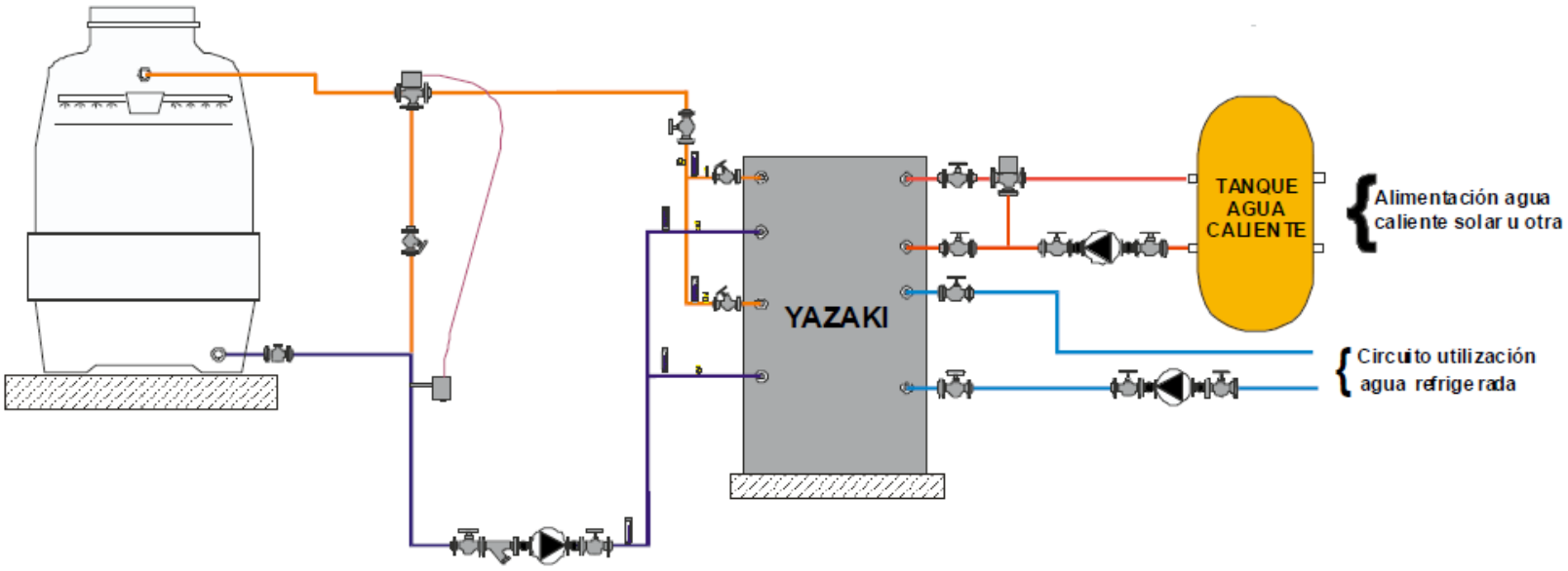
Heat sink:
180 kWt – 50ºC

Heat sink:
25 kWt – 88ºC

Electricity:
27.5 kWe

CCHP SYSTEM

ABSORTION



CCHP SYSTEM

ABSORTION

LiBr - Water

Heat source:
25 kWt – 88ºC

Heat rejection:
43 kWt – 35ºC

Cooling production:
18 kWt – 7ºC

CCHP SYSTEM

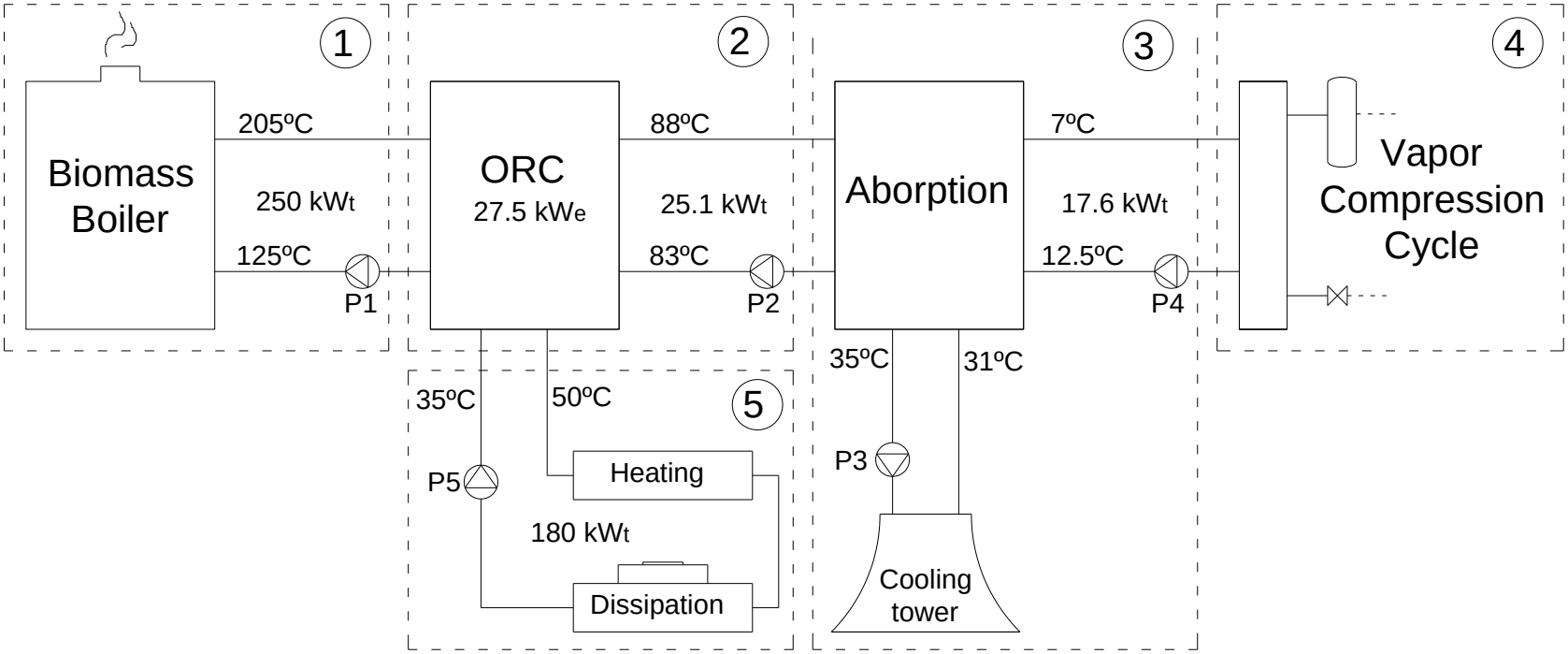
EVAPORATION TOWER

Heat rejection:
43 kWt – 35ºC

Combined cold, heat and power system, based on an organic Rankine cycle, using biomass as renewable heat source for energy saving and emissions reduction in a supermarket

CCHP SYSTEM

SCHEME



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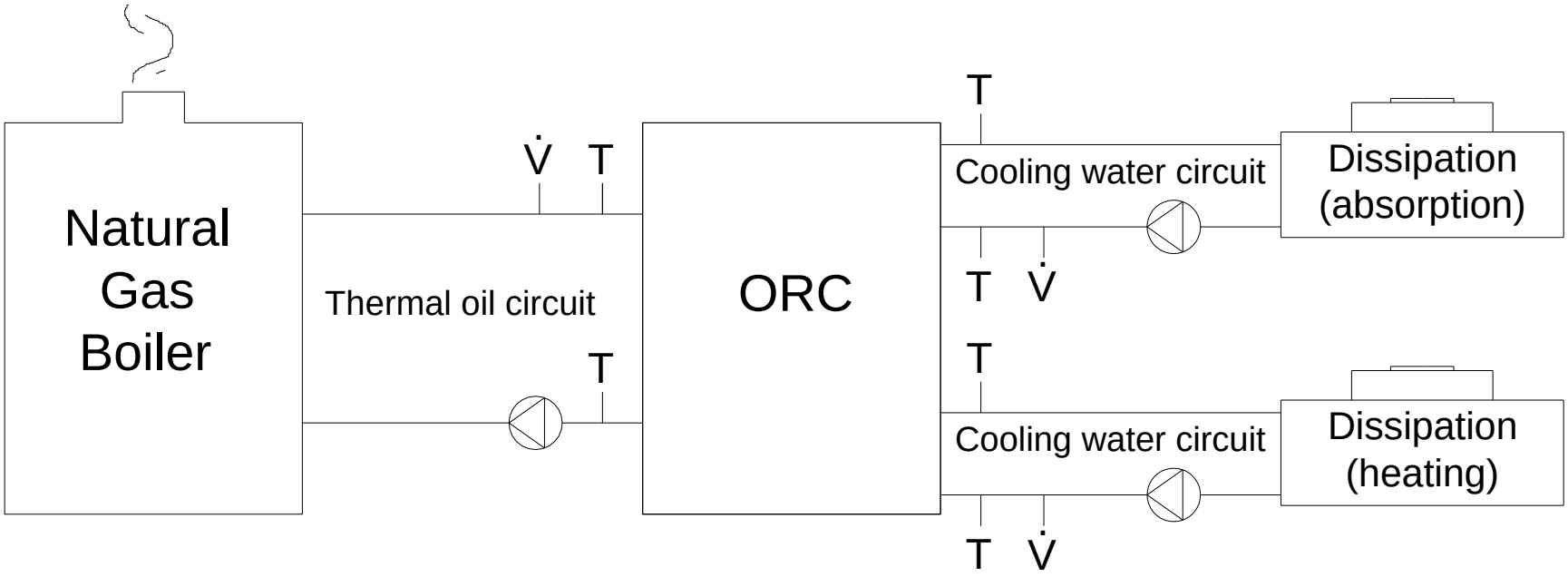
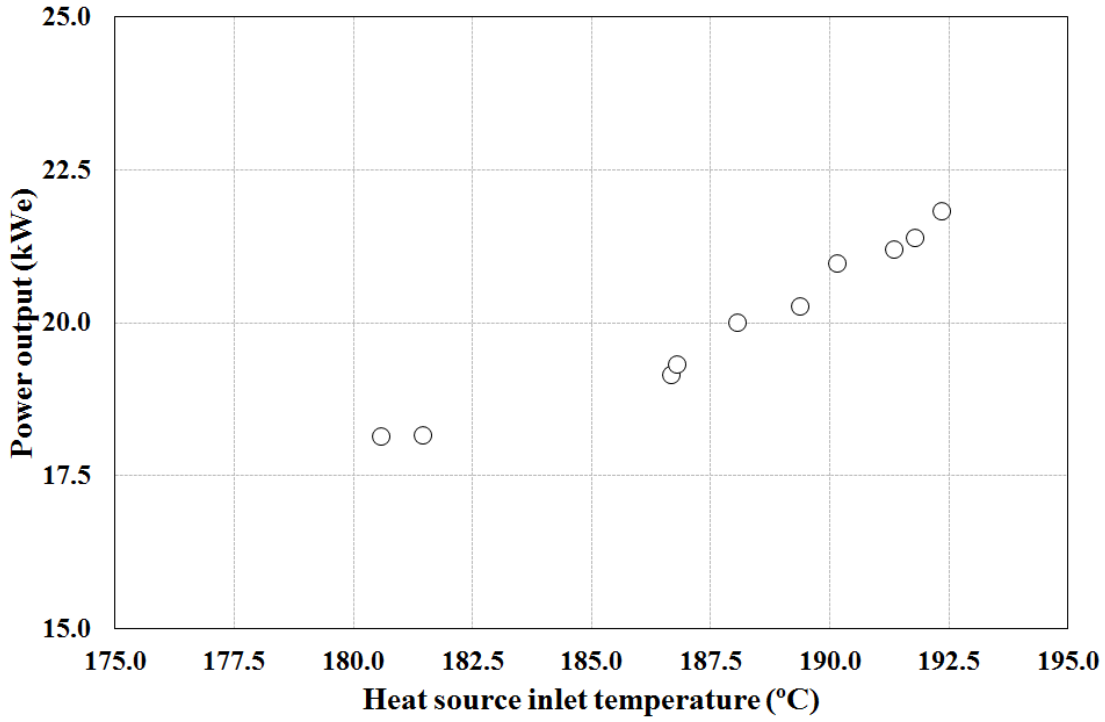
ORC CHARACTERIZATION

TEST BENCH



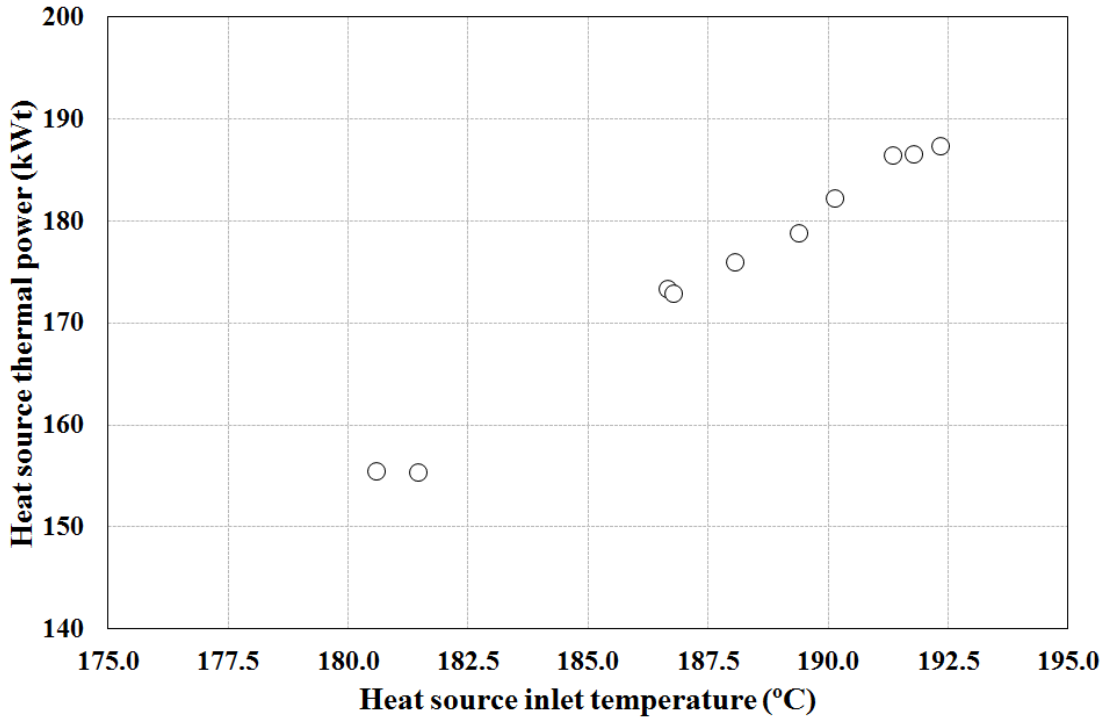
ORC CHARACTERIZATION

RESULTS



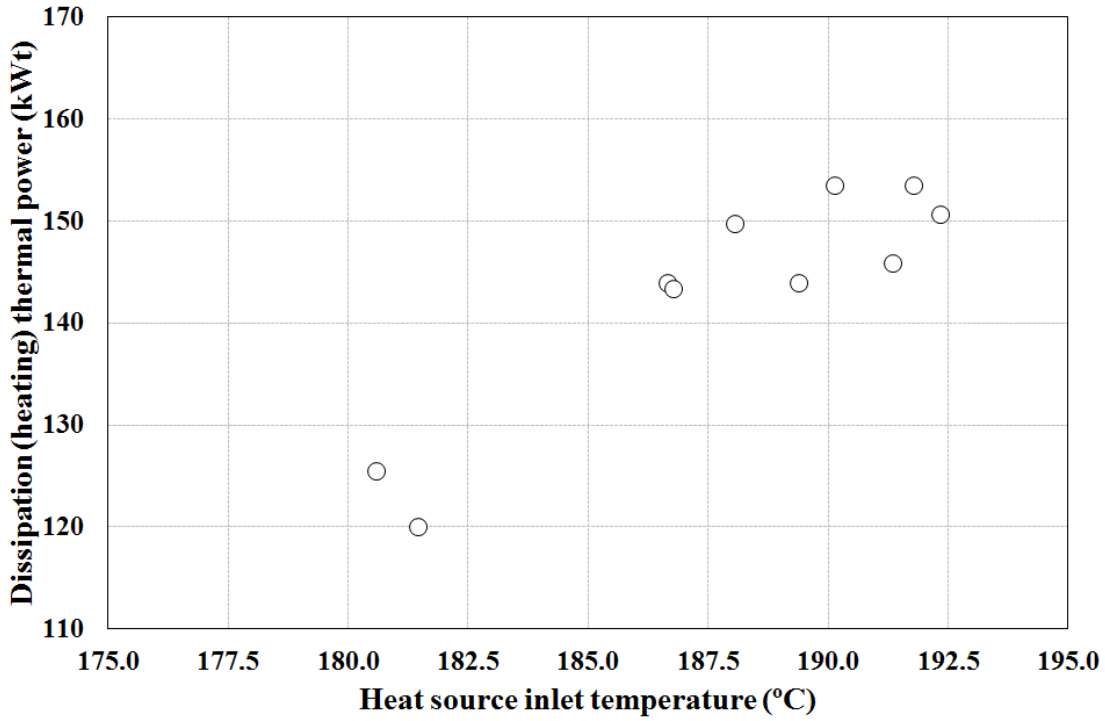
ORC CHARACTERIZATION

RESULTS



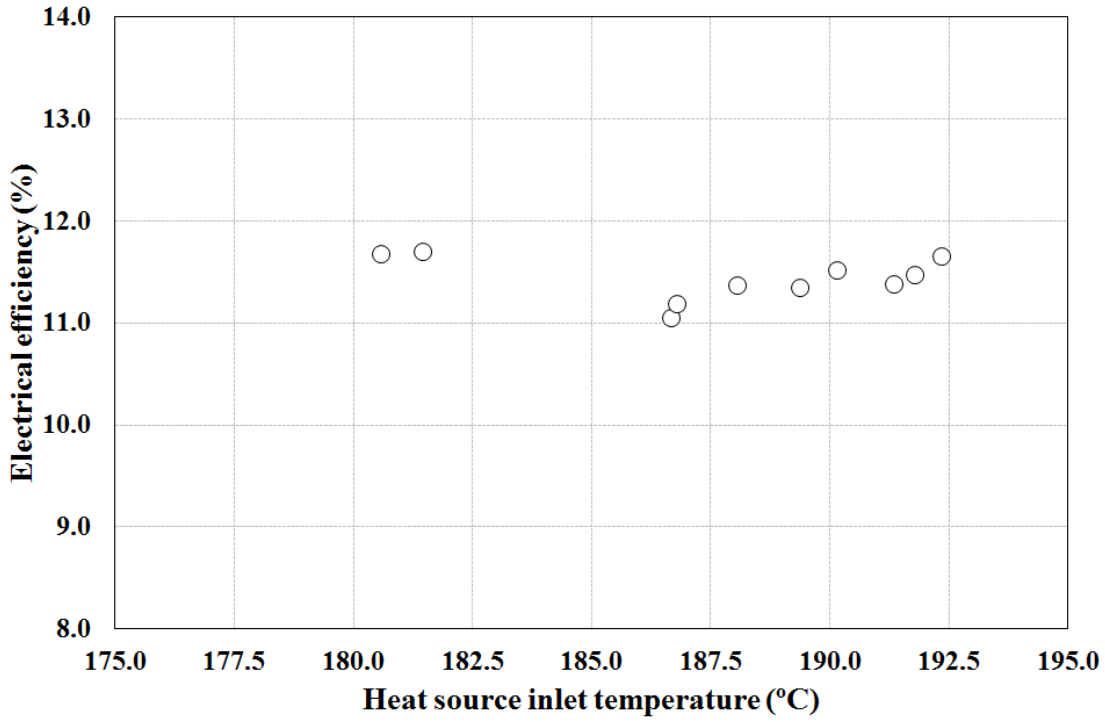
ORC CHARACTERIZATION

RESULTS



ORC CHARACTERIZATION

RESULTS



ORC CHARACTERIZATION

EXPECTED PERFORMANCE

Thermal oil inlet temperature (ºC)	205
Thermal oil outlet temperature (ºC)	125
Thermal oil flow rate (m^3/h)	5.75
Thermal oil thermal power (kW)	250
Water inlet temperature (heating) (ºC)	32.5
Water outlet temperature (heating) (ºC)	50
Water flow rate (heating) (m^3/h))	10.75
Water thermal power (heating) (kW)	180
Water inlet temperature (absorption) (ºC)	83
Water outlet temperature (absorption) (ºC)	88
Water flow rate (absorption) (m^3/h)	9
Water thermal power (absorption) (kW)	26
Gross electrical power (kW)	28.5
Gross electrical efficiency (%)	11.5%
Net electrical efficiency (%)	10%

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SYSTEM ANALYSIS

ENERGY ANALYSIS

Electricity power (kWe)	25
Heat source thermal power (kWt)	250
Heat sink (heating) thermal power (kWt)	180
Heat sink (absorption) thermal power (kWt)	26
Absorption cooling capacity (kWt)	19.5
Operating time (with heating usage) (h)	4000
Operating time (without heating usage) (h)	4000

SYSTEM ANALYSIS

ENERGY ANALYSIS

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Absorption cooling capacity (kWt)	19.5
Operating time (with heating usage) (h)	4000
Operating time (without heating usage) (h)	4000
Electricity generation (kWh)	200000
Biomass consumption (kWh)	2000000
Cooling energy (kWh)	156000
Heating energy (kWh)	720000

SYSTEM ANALYSIS

ECONOMIC ANALYSIS

Electricity power (kWe)	25
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Operating time (without heating usage) (h)	4000
Electricity generation (kWh)	200000
Biomass consumption (kWh)	2000000
Cooling energy (kWh)	156000
Heating energy (kWh)	720000
Electricity price (€/kWh)	0.115
Cooling price (€/kWh)	0.055
Heating price (€/kWh)	0.065
Biomass cost (€/kWh)	0.025

SYSTEM ANALYSIS

ECONOMIC ANALYSIS

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Cooling price (€/kWh)	0.055
Heating price (€/kWh)	0.065
Biomass cost (€/kWh)	0.025
Net cash flow (€)	28380

SYSTEM ANALYSIS

ENVIRONMENTAL ANALYSIS

Electricity power (kWe)	25
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Biomass cost (€/kWh)	0.025
Net cash flow (€)	28380
Biomass consumption emission rate ($kgCO_2$/kWh)	0.018
Electricity production emission rate ($kgCO_2$/kWh)	0.339
Cooling energy emission rate ($kgCO_2$/kWh)	0.192
Heating energy emission rate ($kgCO_2$/kWh)	0.311

SYSTEM ANALYSIS

ENVIRONMENTAL ANALYSIS

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Electricity production emission rate ($kgCO_2$/kWh)	0.339
Cooling energy emission rate ($kgCO_2$/kWh)	0.192
Heating energy emission rate ($kgCO_2$/kWh)	0.311
Emission reduction ($kgCO_2$)	285610

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CONCLUSIONS

- Energy study and energy saving measures in a supermarket
- Combined cold, heat and power system
- Biomass as used fuel: RENEWABLE ENERGY
- ORC experimental characterized
- Energy, economic and environmental analysed

CONCLUSIONS

CONCLUSIONS

END OF THE PRESENTATION

THANKS FOR YOUR ATTENTION

Any question?