SHIP2FAIR

Solar Heat for Industrial Processes towards Food and Agro Industries commitment in Renewables

Solar Heat for Industrial Processes

EMRE 2022, 19/05/2022

EUROPEAN MASTER IN RENEWABLE ENERGY
Coordinated by EUREC

cea

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General context of the energy policy

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Global warming

- In order to limit the Global Warming at 1.5°C, the IEA recommends:
  - No new investment in fossil fuel supply by 2021
  - Ban the selling of new fossil fuel boiler from 2025
  - Zero emission electricity by 2035 for OECD and 2040 for the rest of the world

- In 2018 EU define a roadmap for being neutral carbon by 2050:
  - Reduce the GHG by 45% in 2030 et by 60% in 2050
  - Reduce the fossil fuel dependency from 55% nowadays to 20% by 2050
  - Increase the Renewable Energy share (83% of electricity should be renewable by 2050)

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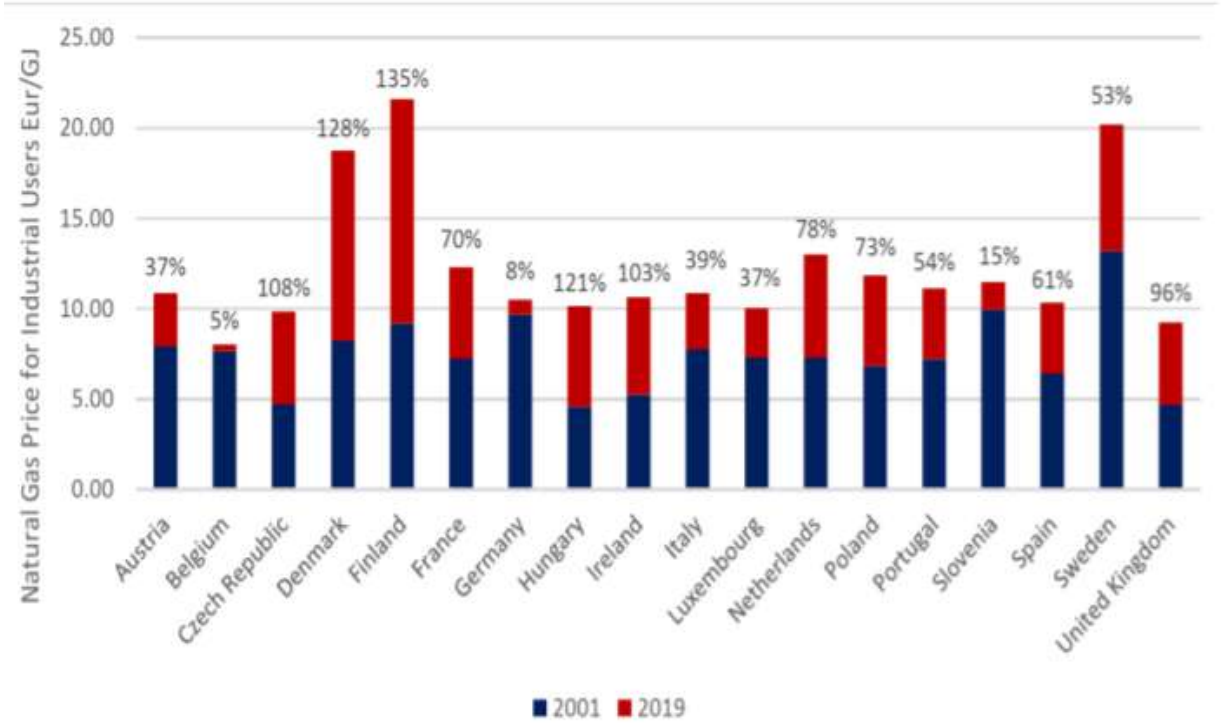
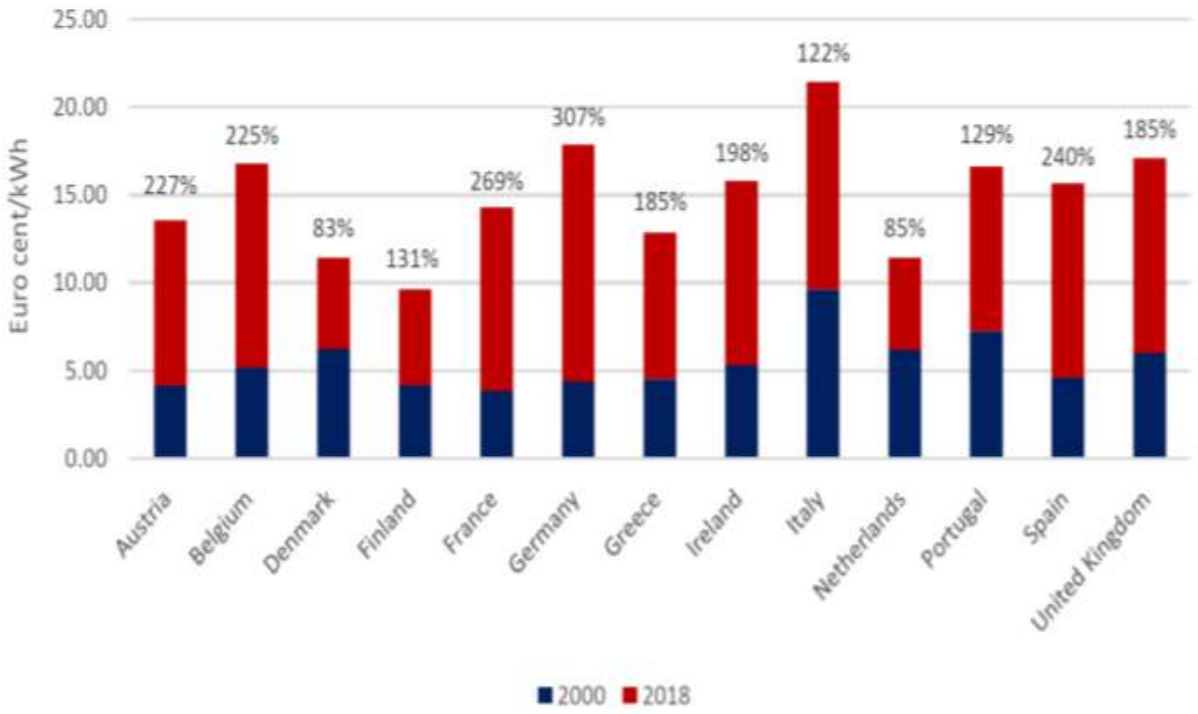
The price of energy is dramatically increasing (1/2)



Natural gas Price evolution



Electricity Price evolution

The price of energy is dramatically increasing (2/2)

- The energy needs due to the economic recovery from the pandemic has increased the energy price:
  - During the 3rd quarter of 2021: The largest year-on-year price increases were registered in Ireland (+323%), Portugal (+215%) and Spain (+214%), triggered by rising gas prices.
  - Wholesale gas prices in Europe continued their sharp increase in the 3rd quarter of 2021, as spot contracts rose from 37 €/MWh to 85 €/MWh

The new geopolitical deal (1/4)

- Due to the economic sanctions against Russia, the EU has decided to reduce by 2/3 the import of Russian oil & gas by the end of year and end reliance by 2027:
  - Diversification of the providers,
  - Reducing the consumption,
  - Increase the renewable energy share.

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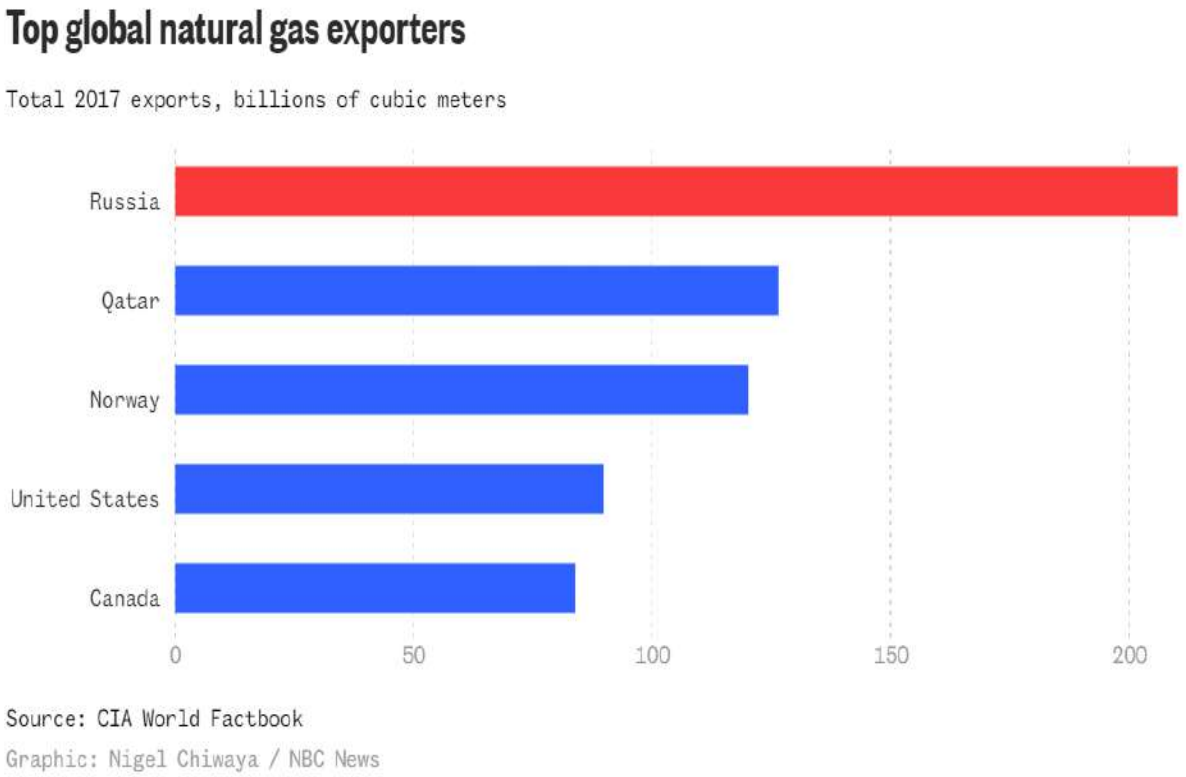
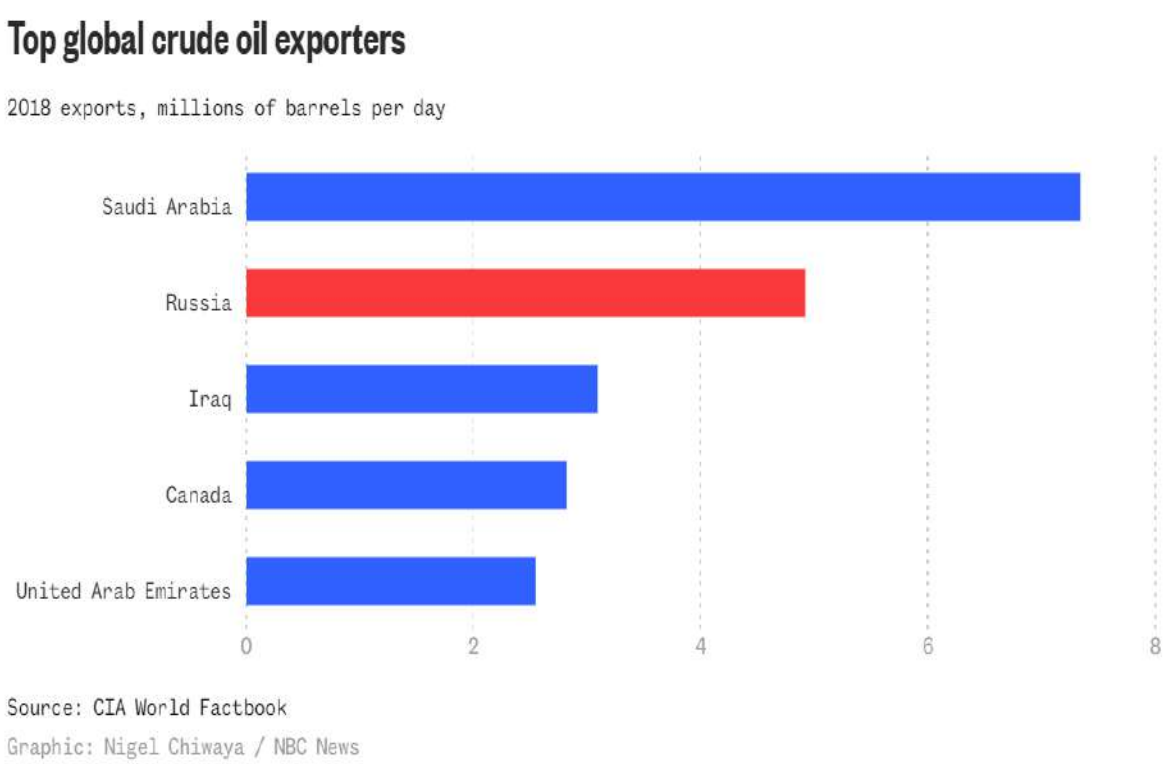
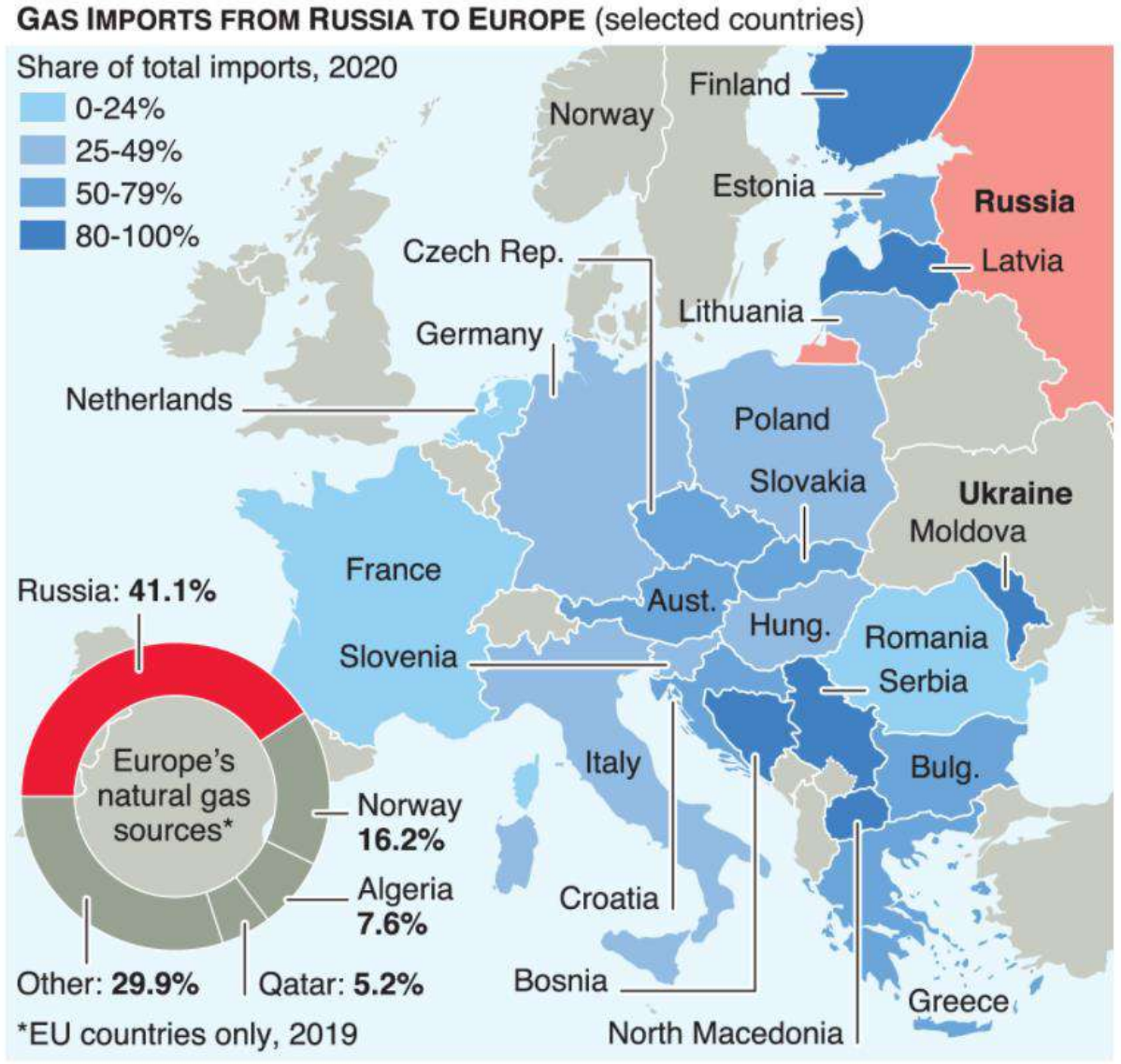
The new geopolitical deal (2/4)





The new geopolitical deal (3/4)



The new geopolitical deal (4/4)

- The Ukraine war will have a major and durable impact on the energy price:
  - Oil:
    - In Feb 2022 90$ per barrel, the 7th March it was about 130 $
    - With the Russian embargo it will rise up to 160-200 $ per barrel
  - Gas:
    - In Nov 2021 the price was about 50 €/MWh. On 7th March it raised briefly up to 345 €/MWh then fall to 130 €/MWh

Resume

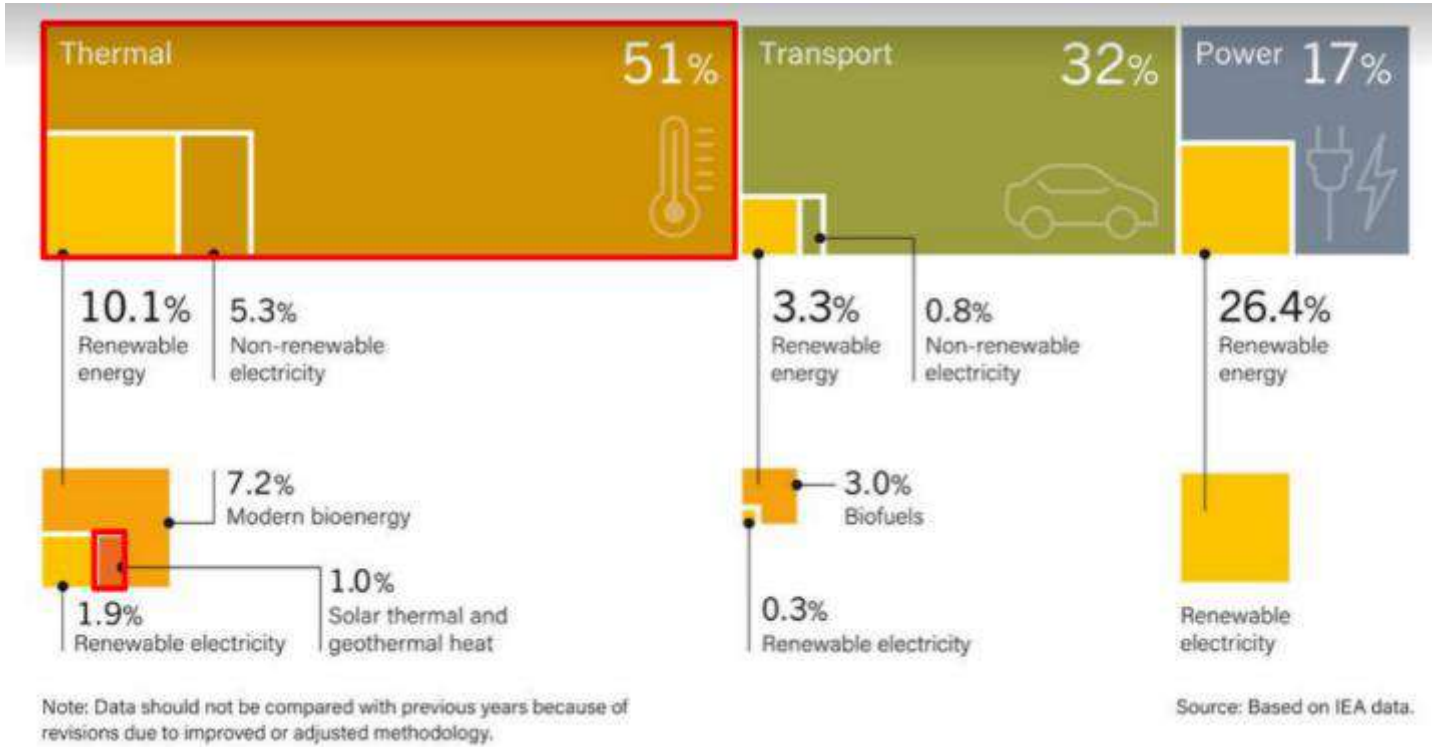
- Need to increase the Renewable Energy share
- The energy price will be durably very high
- The energy price has a strong tendency to rise
- Industrials need to control on long term the energy price

Can SHIP be a solution?

The Energy Needs in Industry

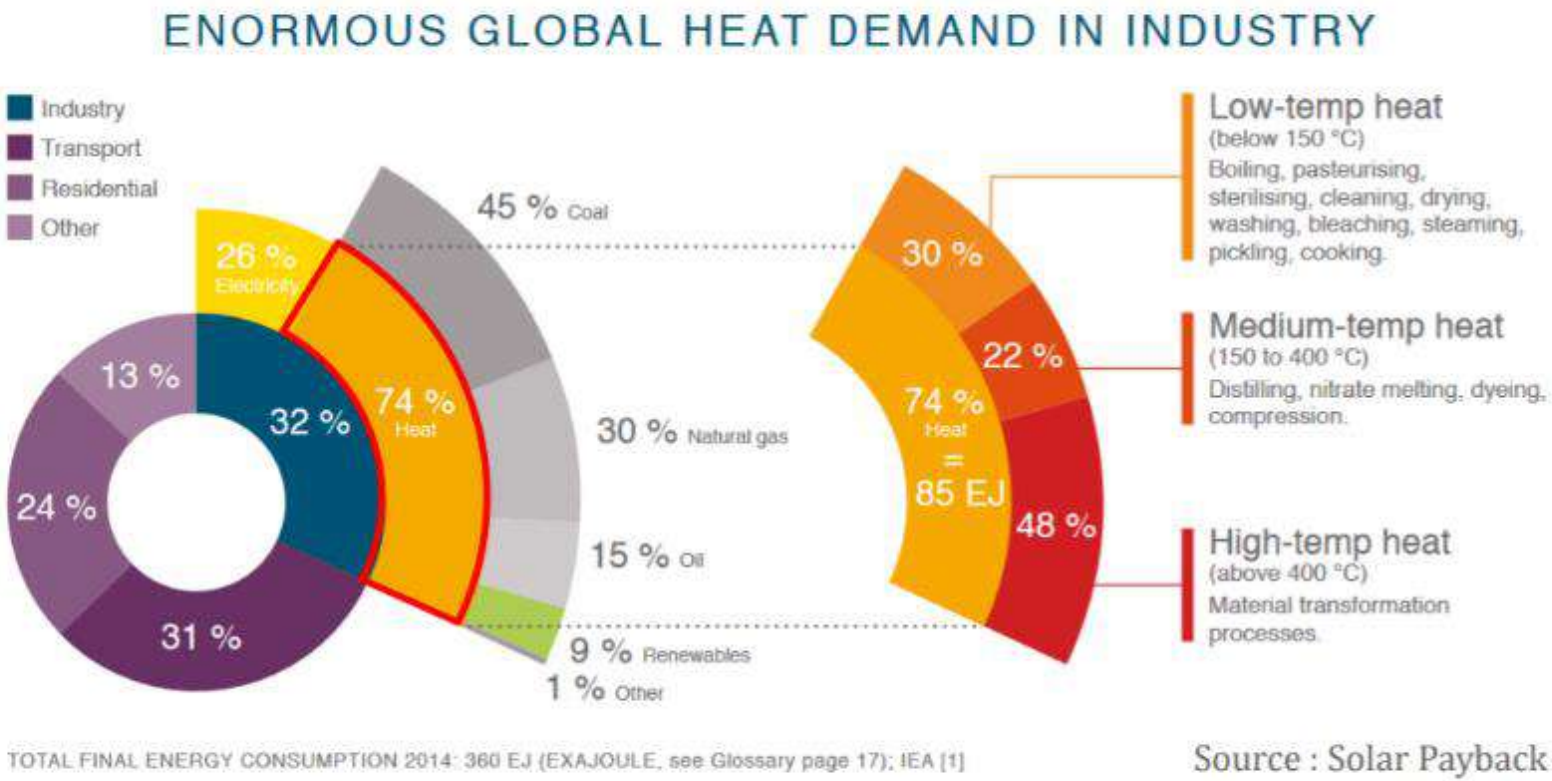
The energy needs in industry

The global trend has been for electricity to transform the energy sector, while:



With strong growth in demand for cooling

The energy needs in industry



INDUSTRIAL HEAT DEMAND ON THE RISE

1.7 %

Average annual growth of industrial heat demand until 2030 [4]

90 %

Met by coal, oil and gas

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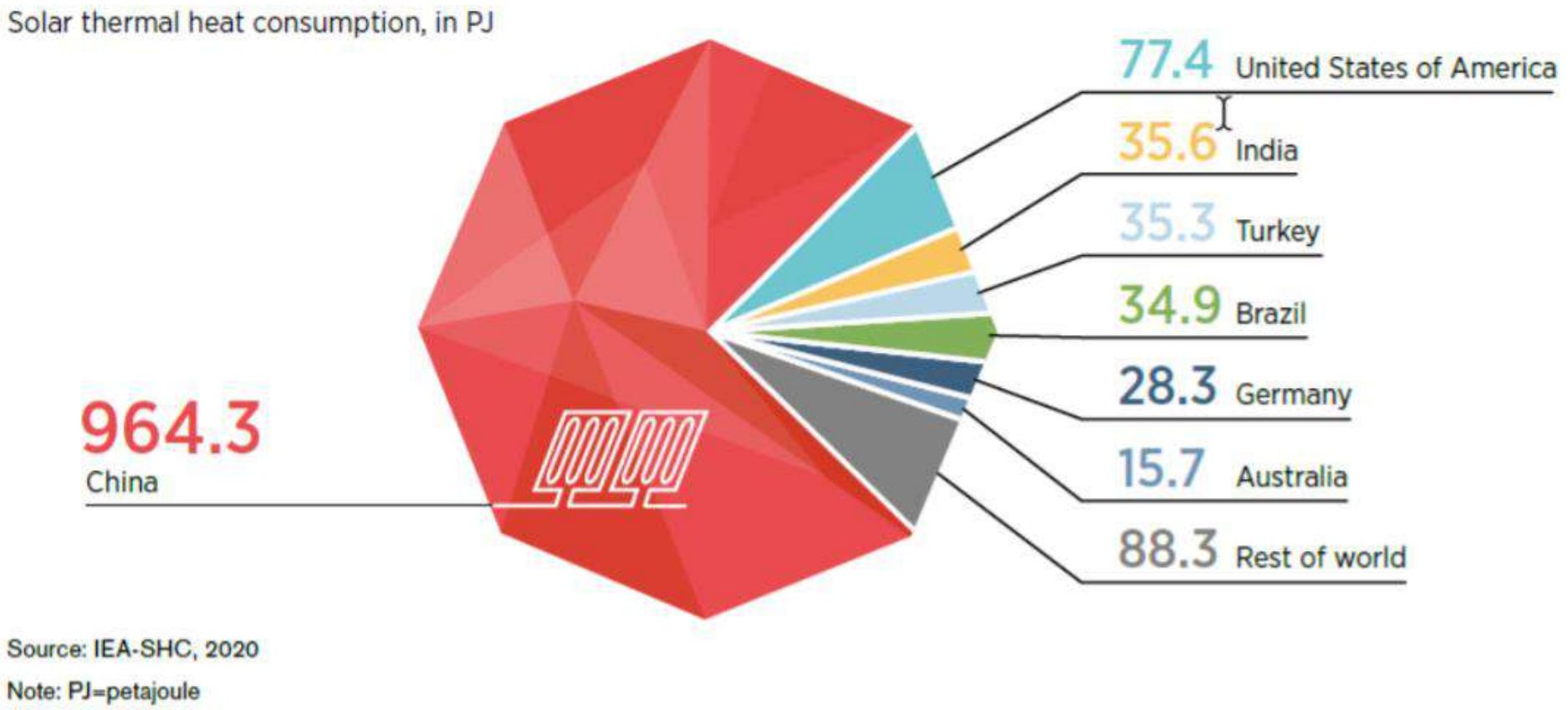
The Solar Thermal Heat Consumption



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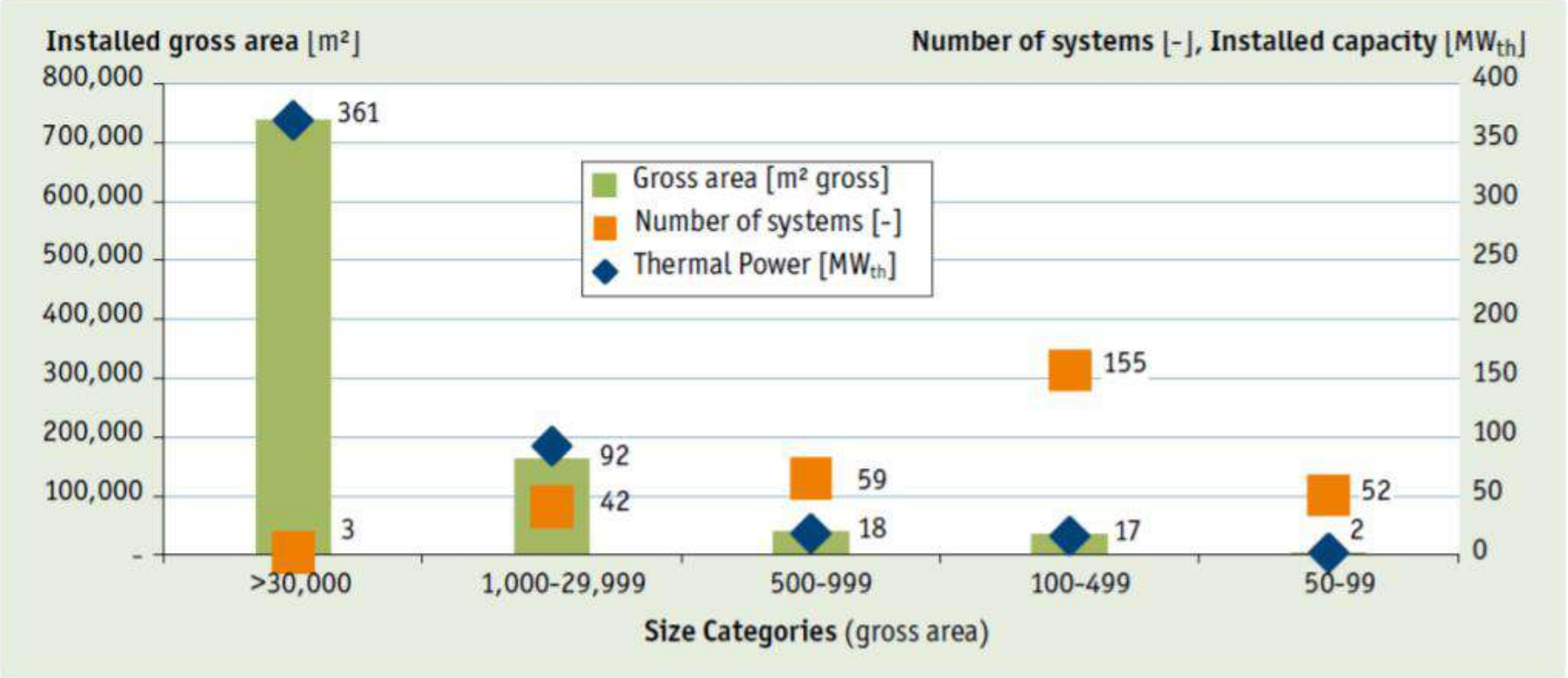
SHIP sizes



- The world's largest SHIP plant, the Miraah in Oman (300 MWth), produce steam for the extraction of heavy oil from the ground.
- The second largest SHIP application is for a green house in Australia (36.6 MWth).
- The third largest system is installed in Chile (27.5 MWth) for a copper mining process.

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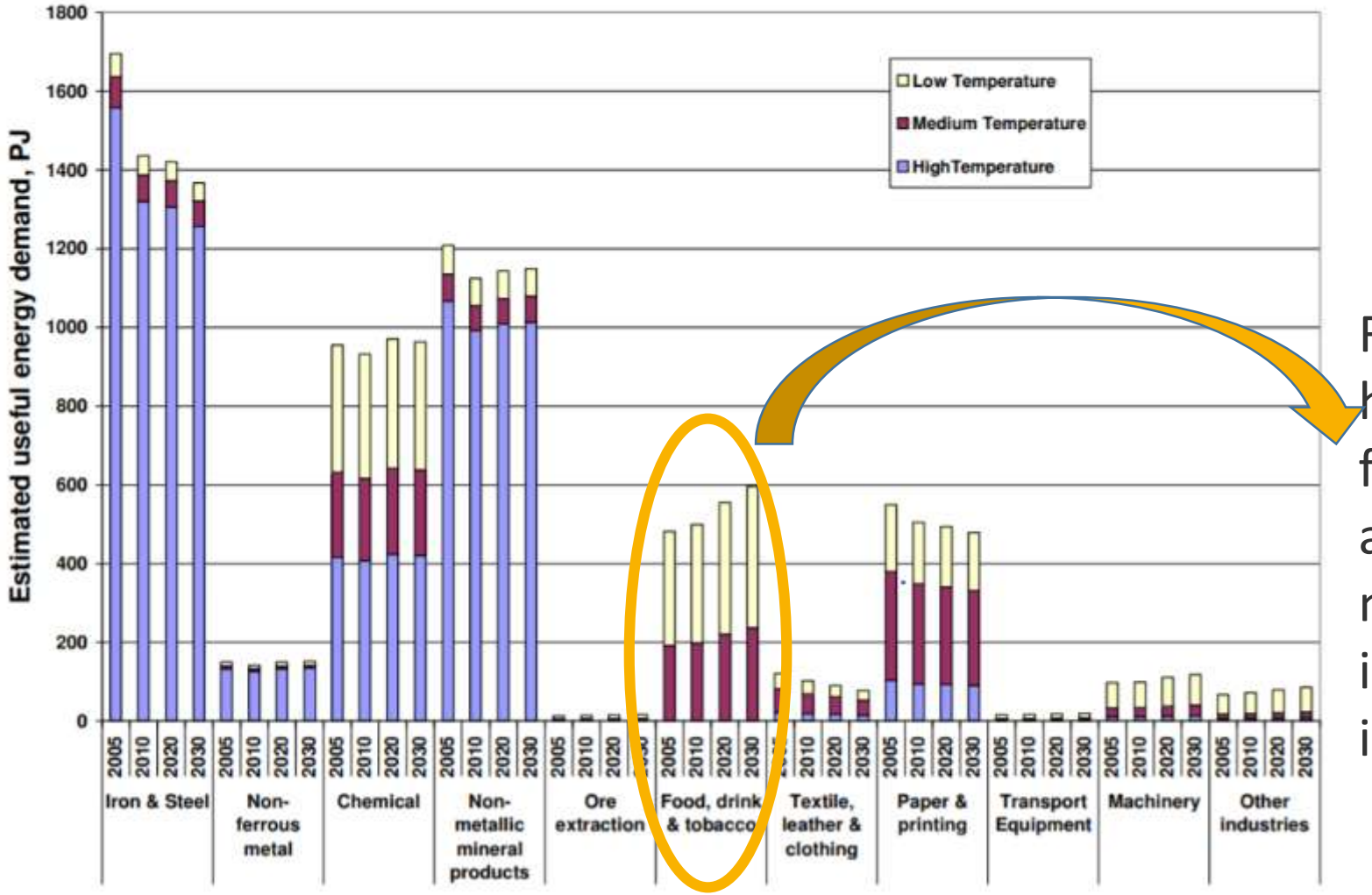
Targeting the right industries



Fostering the integration of solar heat in industrial processes - **SHIP** from agro-food sector, by developing and demonstrating a set of tools and methods for the development of industrial solar heat projects during its whole life-cycle.

Industrial processes and temperature levels

Industrial Sector	Unit operation	Temperature range (°C)
Food	Drying	30-90
	Washing	60-90
	Pasteurising	60-80
	Boiling	95-105
	Sterilising	110-120
	Heat Treatment	40-60
Beverages	Washing	60-80
	Sterilising	60-90
	Pasteurising	60-70
Paper Industry	Cooking and Drying	60-80
	Boiler feed water	60-90
	Bleaching	130-150
Metal Surface Treatment	Treatment, electro-plating, etc.	30-80
Bricks and Blocks	Curing	60-140

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Industrial processes and temperature levels

Industrial Sector	Unit operation	Temperature range (°C)
Textile Industry	Bleaching	60-100
	Dyeing	70-90
	Drying, De-greasing	100-130
	Washing	40-80
	Fixing	160-180
	Pressing	80-100
Chemical Industry	Soaps	200-260
	Synthetic rubber	150-200
	Processing heat	120-180
	Pre-heating water	60-90
Plastic Industry	Preparation	120-140
	Distillation	140-150
	Separation	200-220
	Extension	140-160
	Drying	180-200
	Blending	120-140
Flour By-products	Sterilising	60-90
All Industrial Sectors	Pre-heating of boiler feed water	30-100
	Industrial solar cooling	55-180
	Heating of factory buildings	30-80

The Solar technologies vs temperature level

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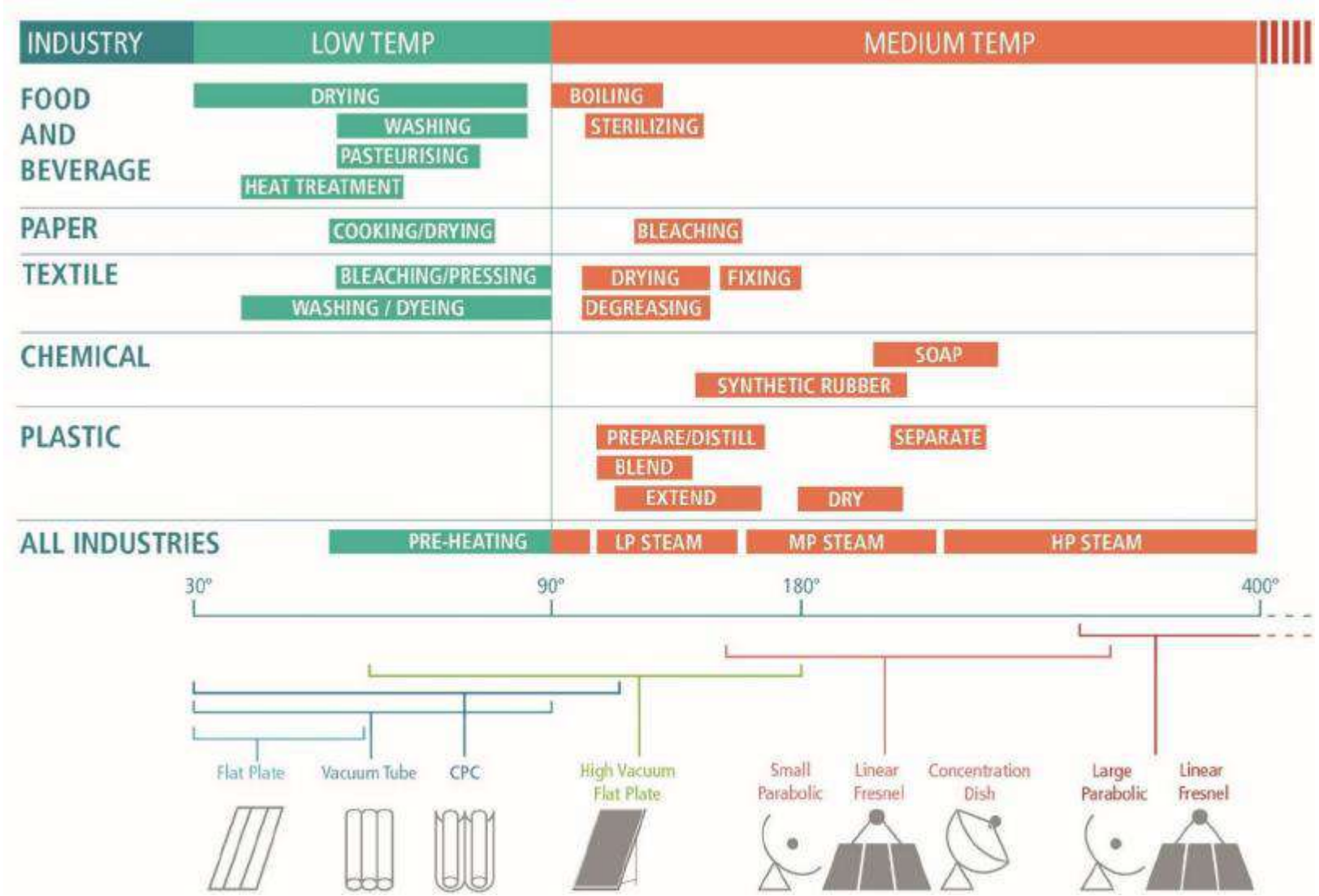
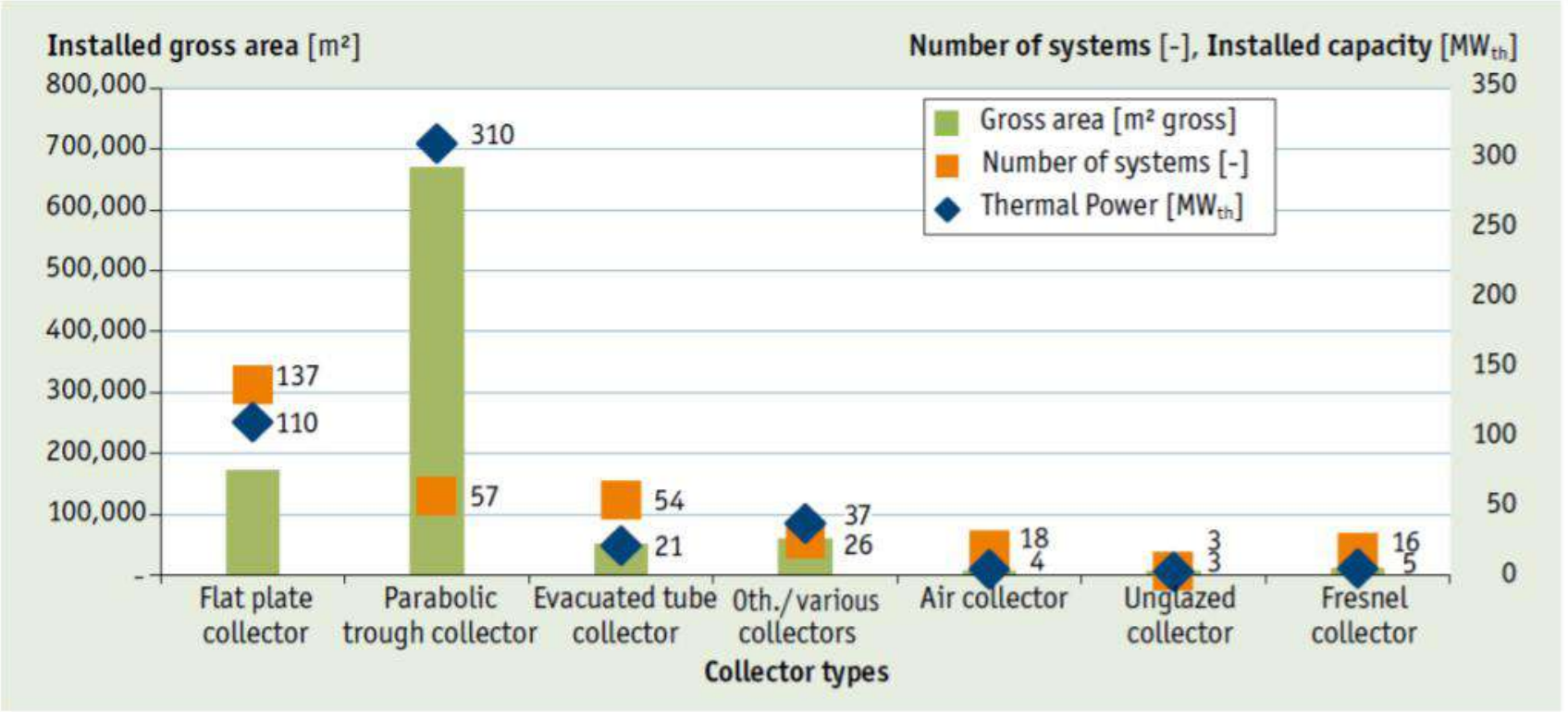


The plants by technology



The majority of the systems use **flat-plate collectors** to produce solar process heat, followed by **parabolic trough collectors** and **evacuated tube collectors**.

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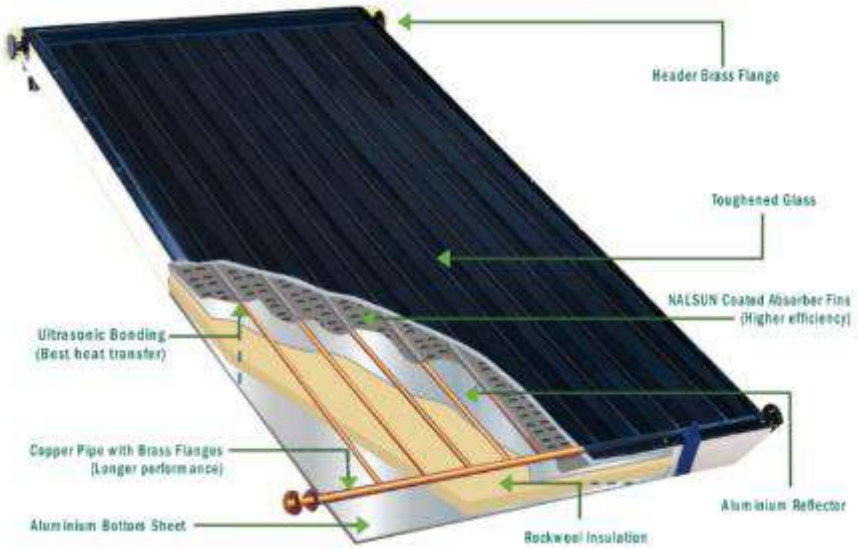
Flat Plate



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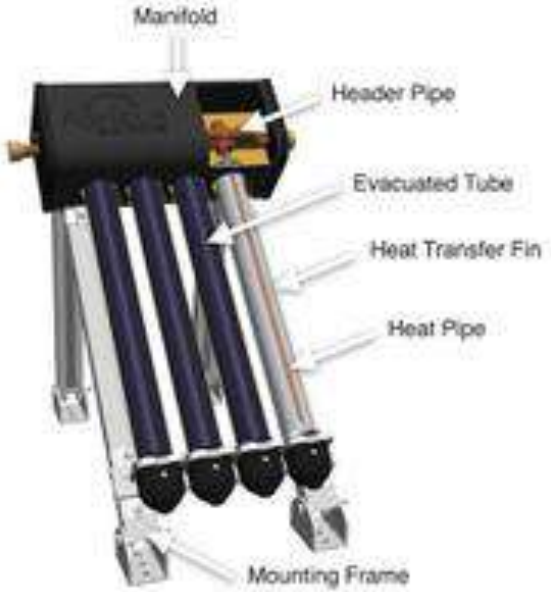
Vacuum tube



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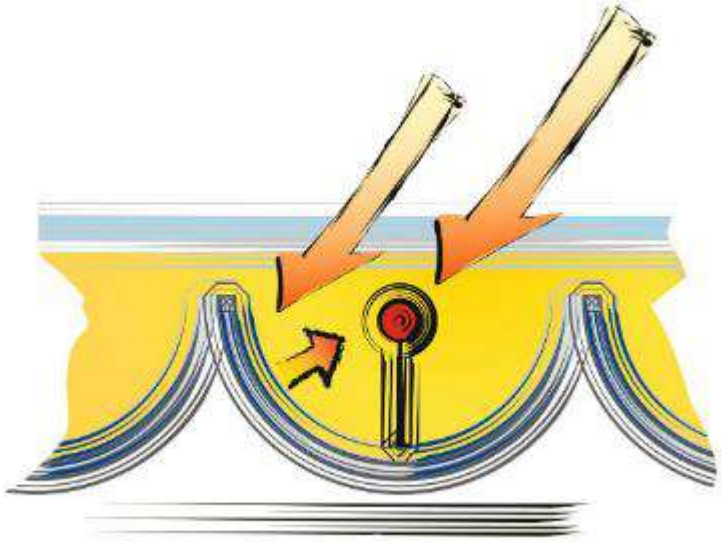
CPC



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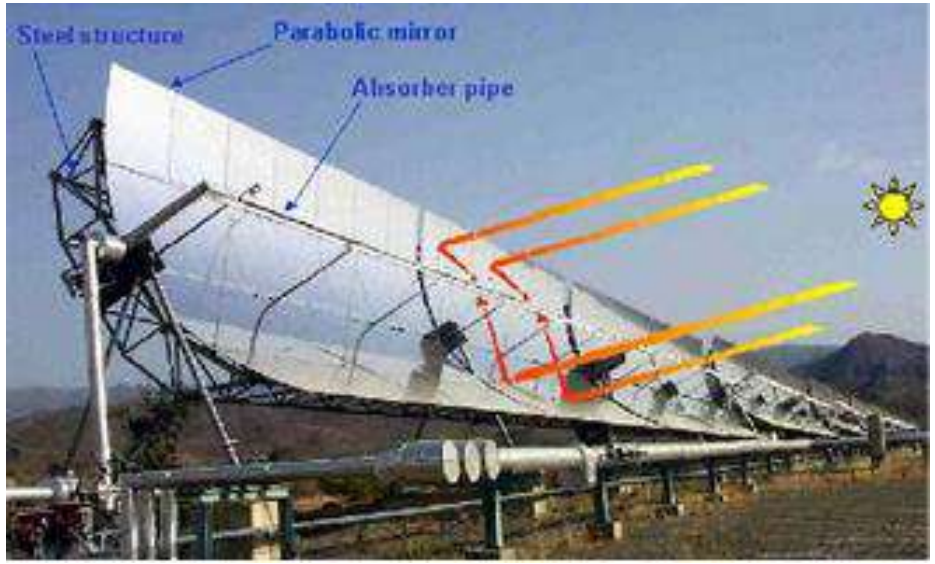
High Vacuum Flat Panel

Parabolic Through



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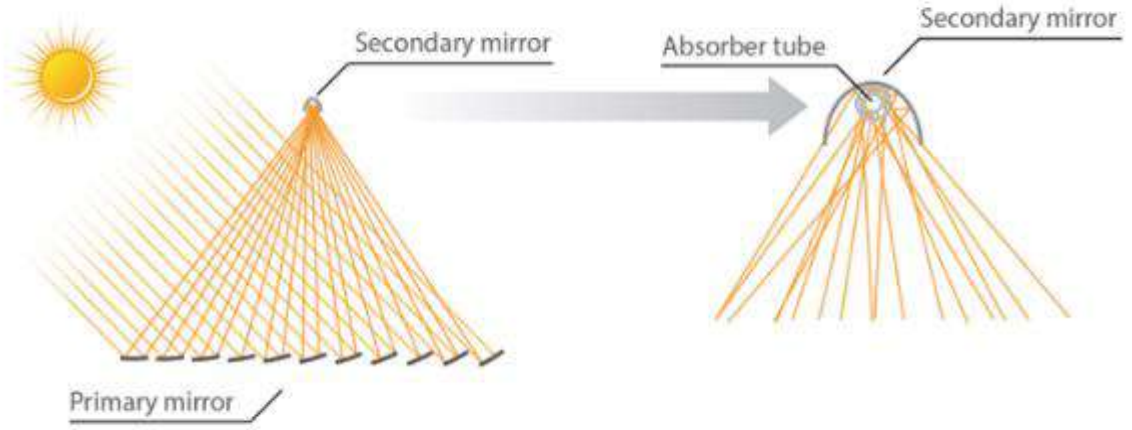
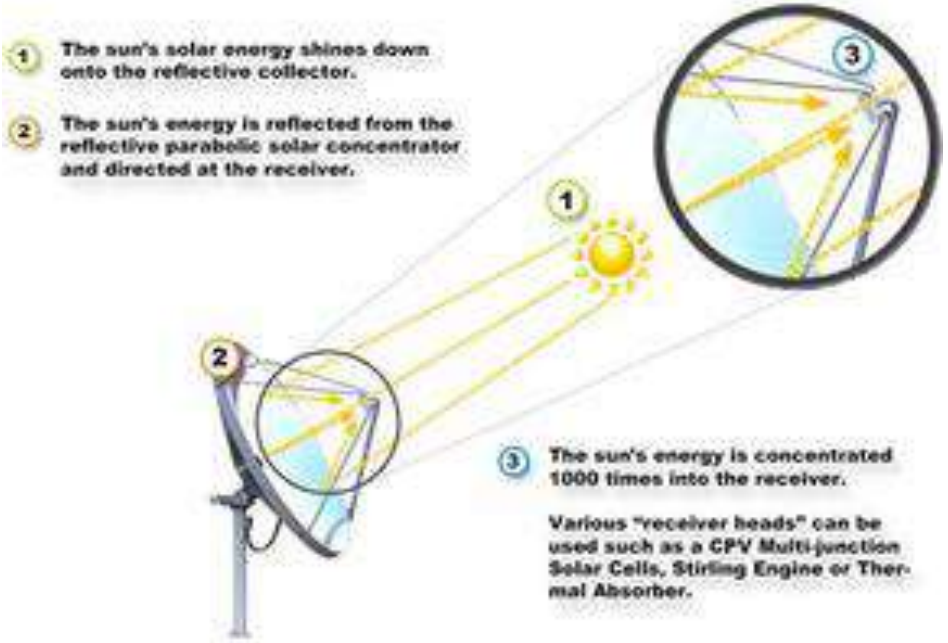
Linear Fresnel



INDUSTRIAL SOLAR
renewables onsite

Dishes



Dish requires dual axis tracking

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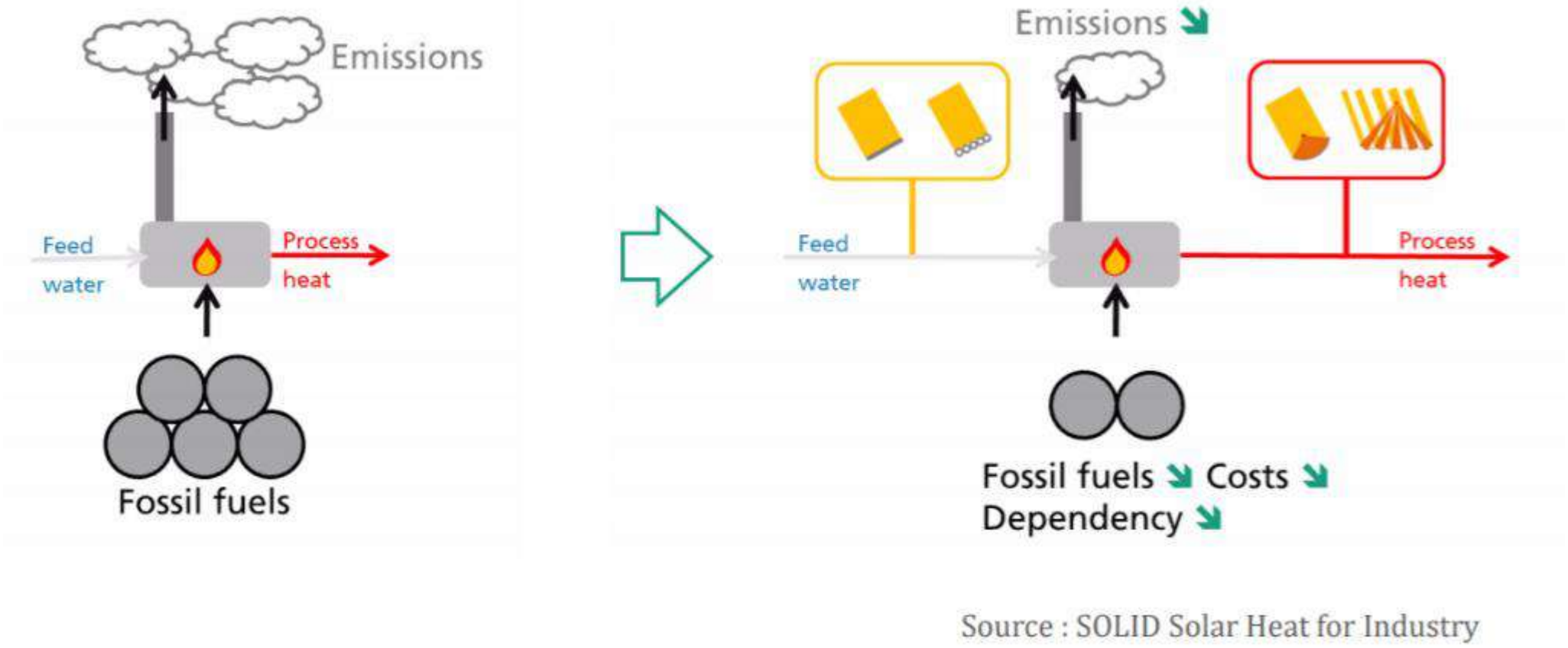
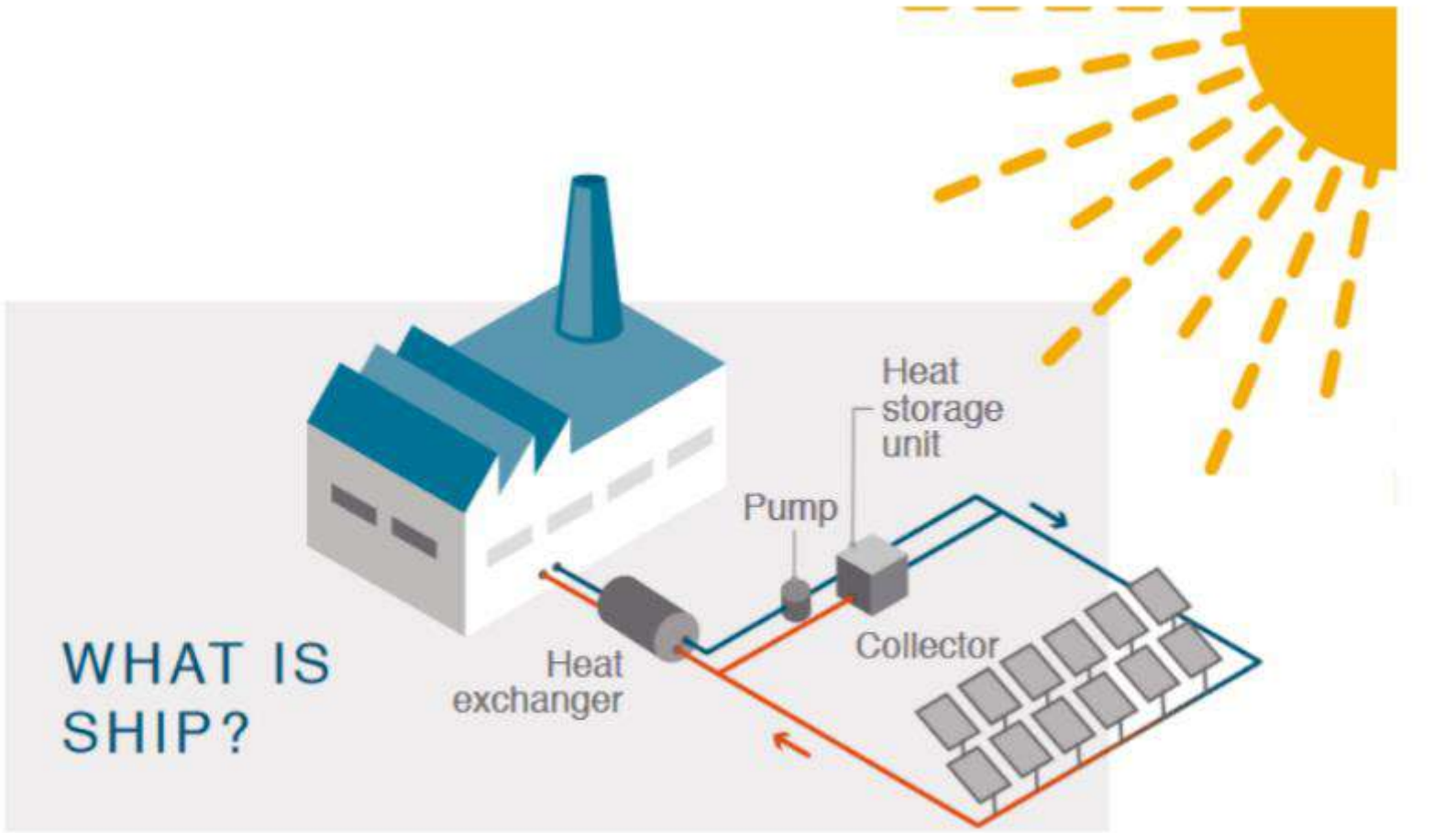
Why SHIP?



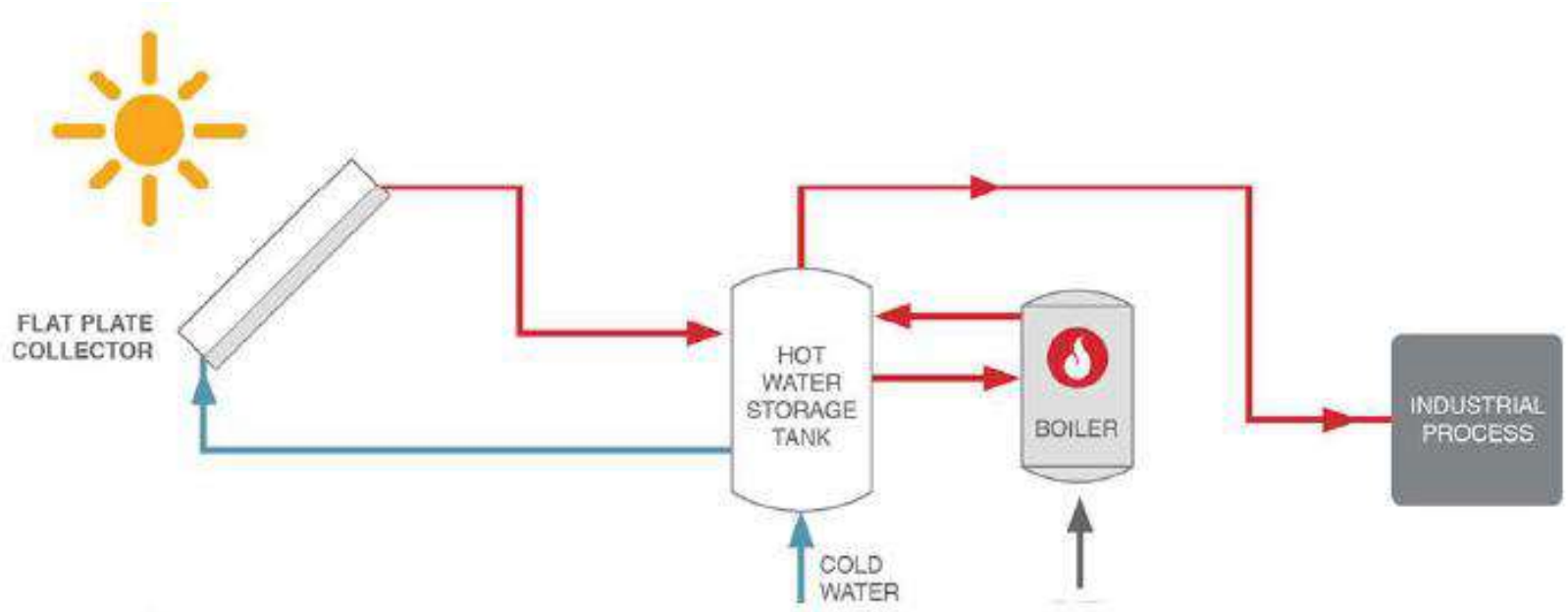
Source : SOLID Solar Heat for Industry

How?



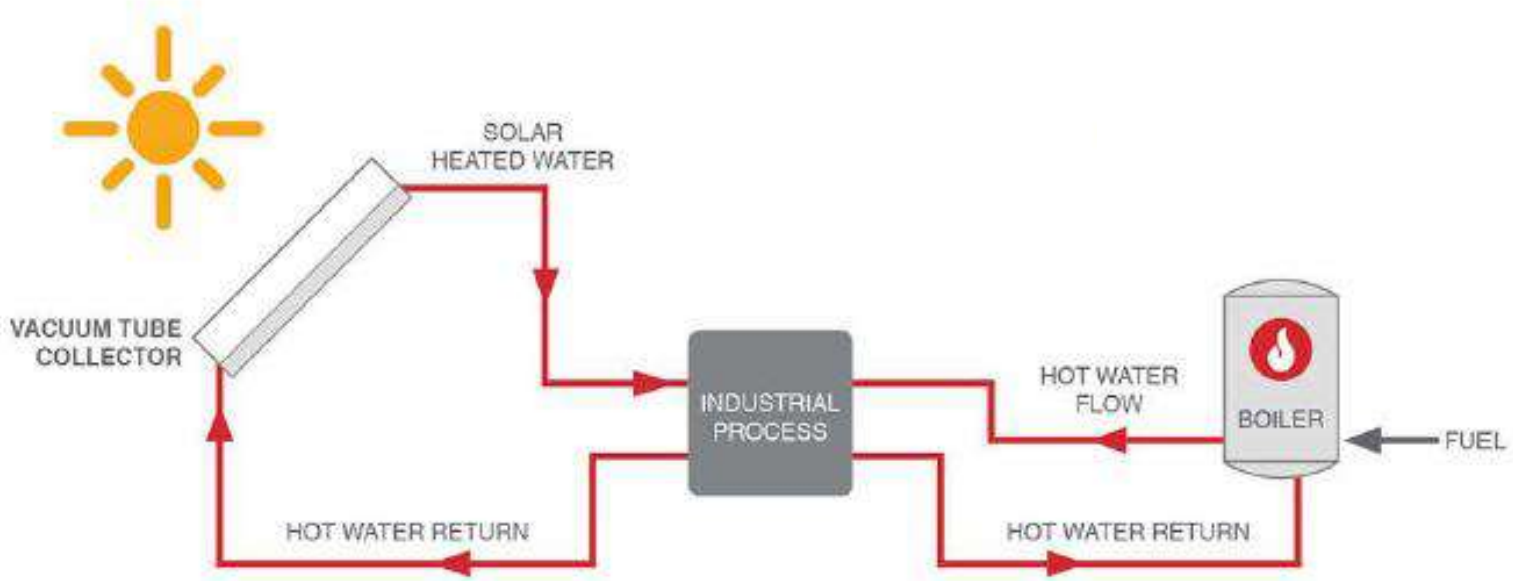
Source : SOLID Solar Heat for Industry

The different ways of integration in an existing process



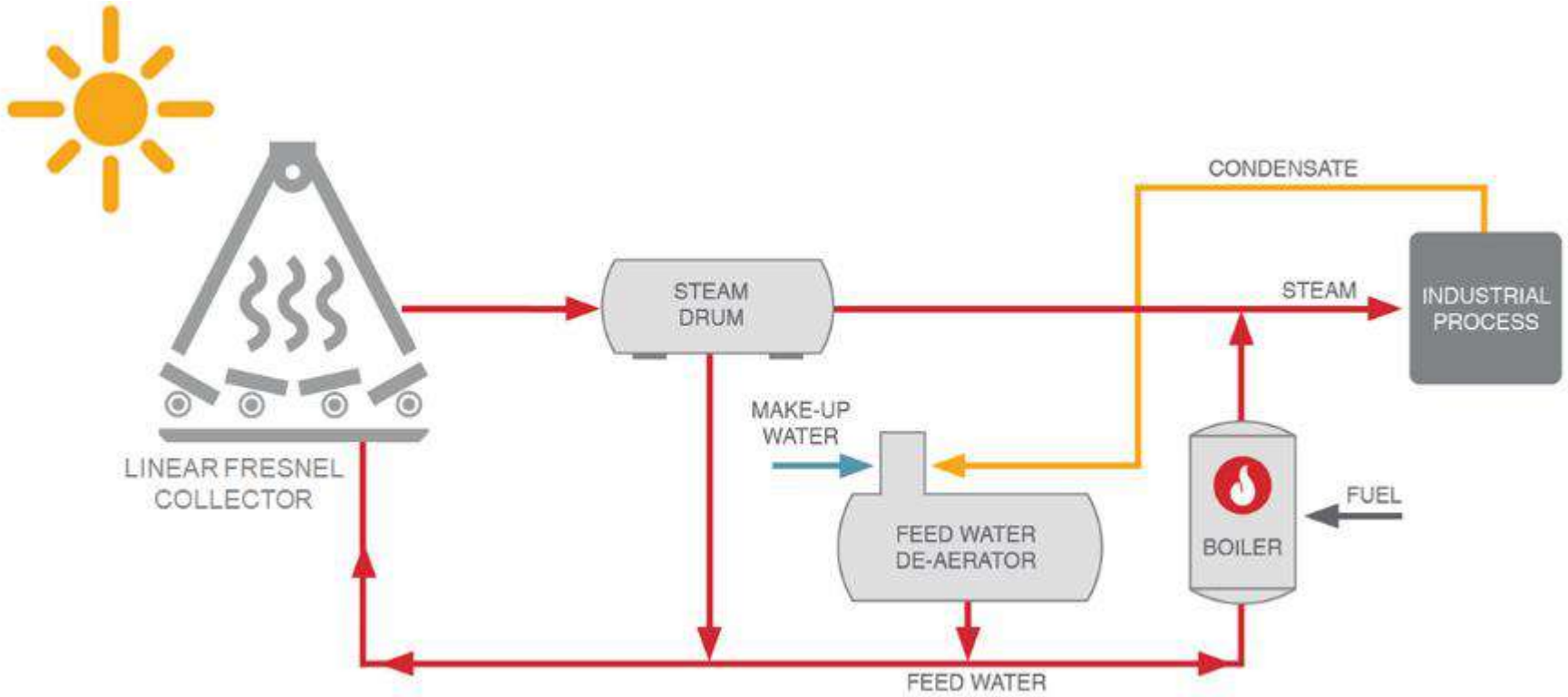
Water Preheating

The different ways of integration in an existing process



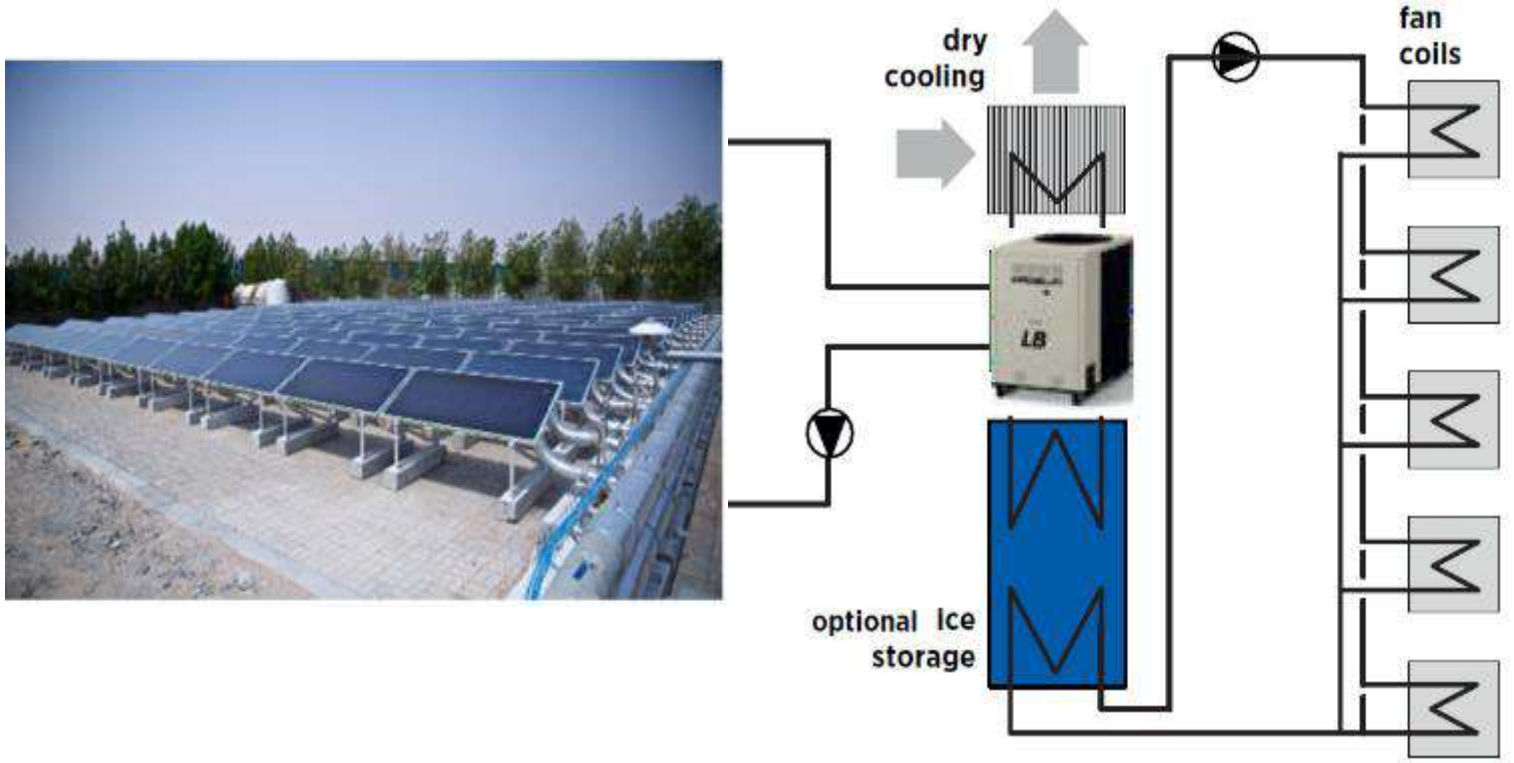
Process Heating

The different ways of integration in an existing process



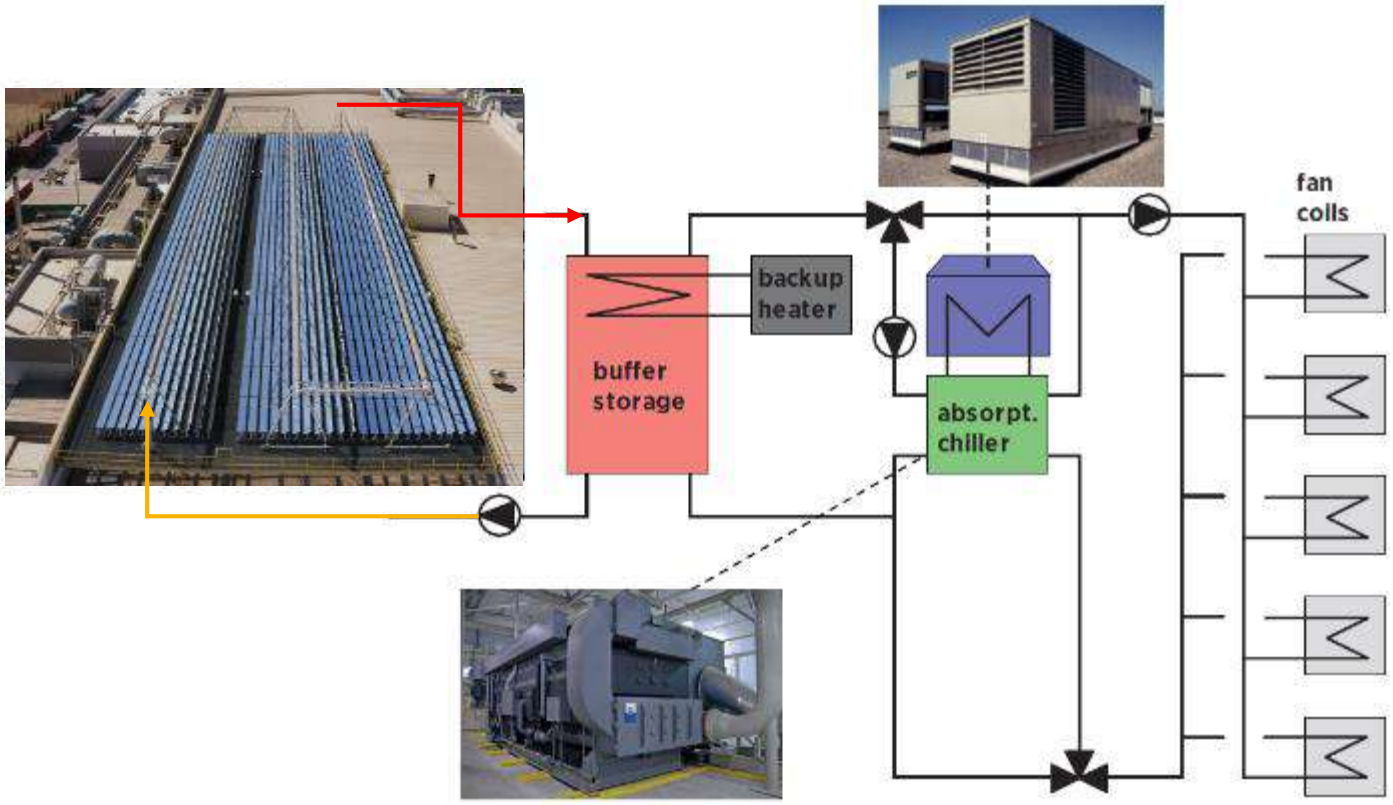
Direct Steam Generation

The different ways of integration in an existing process



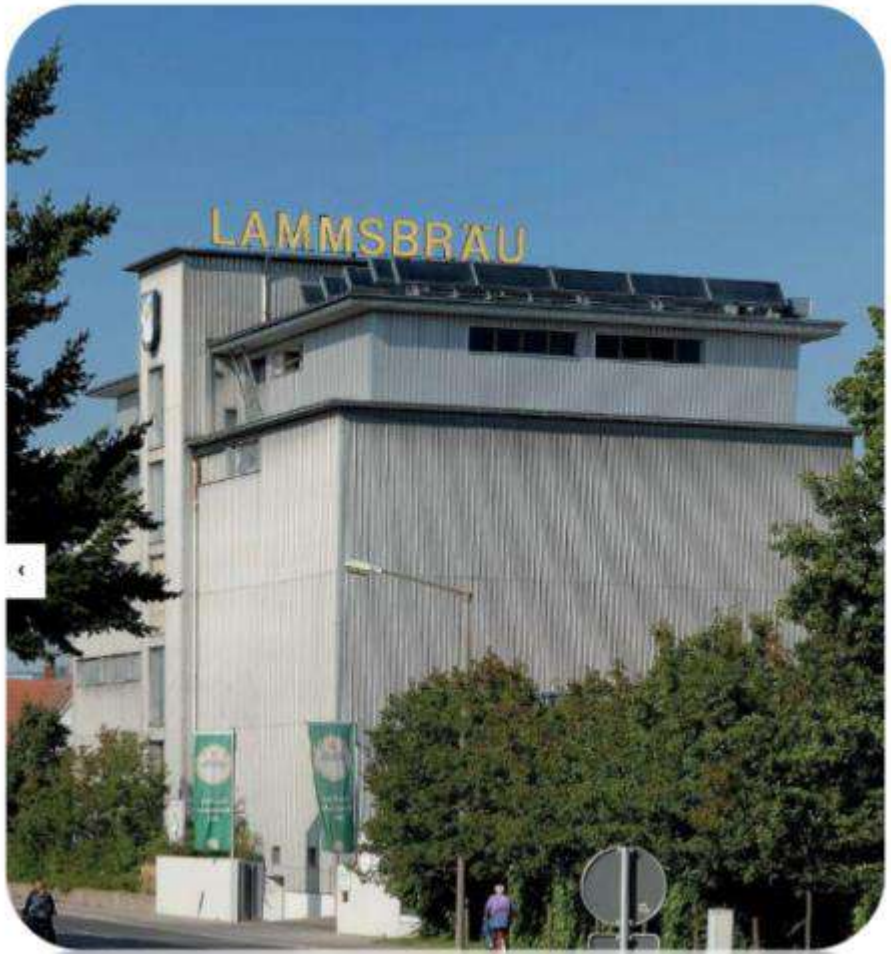
Solar thermal cooling (ammonia-water chiller)

The different ways of integration in an existing process



Solar thermal cooling (lithium-bromide-water chiller)

Example

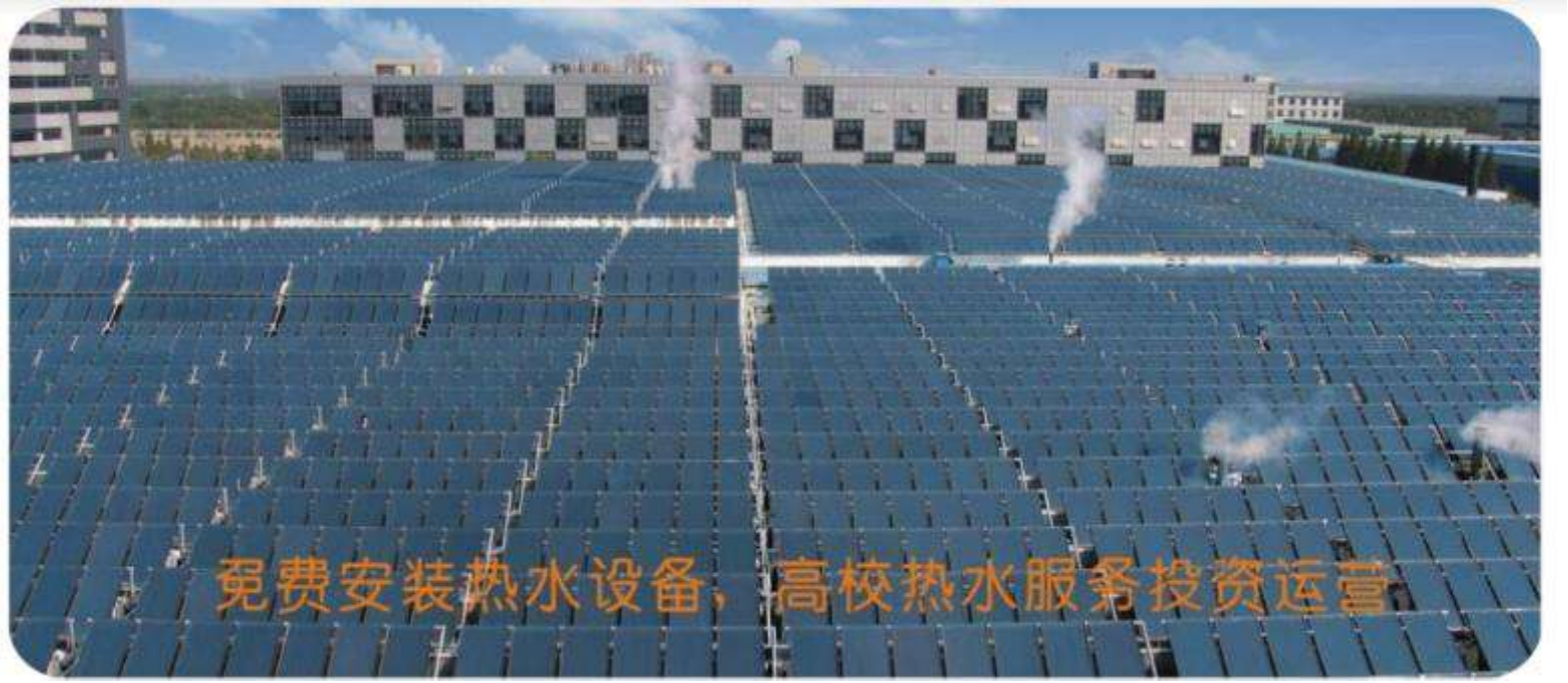


Brewery – Germany (2000)

- 51 kWth
- 72 m² Flat Plate panels (air)
- Pre-heating air for drying process
- T=60°C
- Investment 32 000 € => 441€/m²

Textile Factory – China (2007)

Example



- 9 MWth
- 13 000 m² Flat Plate panels
- 900 m³ storage
- Pre-heating water for dyeing process
- T=55°C
- Investment 1 100 000 € => 84,62€/m²

Greenhouses– Netherland (2019)

Example

- 6,5 MWth
- 9 300 m² Flat Plate panels
- 1 400 m³ storage

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Example

Oil recovery– Oman (under construction)

- 1 GWth
- 3 km² (360 soccer field) Parabolic through
- 6 000 tons of steam / day

Manufacture of Tobacco– Jordan (2017)

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Example

- 705 kWth Steam generation
- 1254 m² Linear Fresnel
- Cooling and heating process
- Feeding the steam network
- T = 225°C, 25 bars

More informations

http://ship-plants.info/

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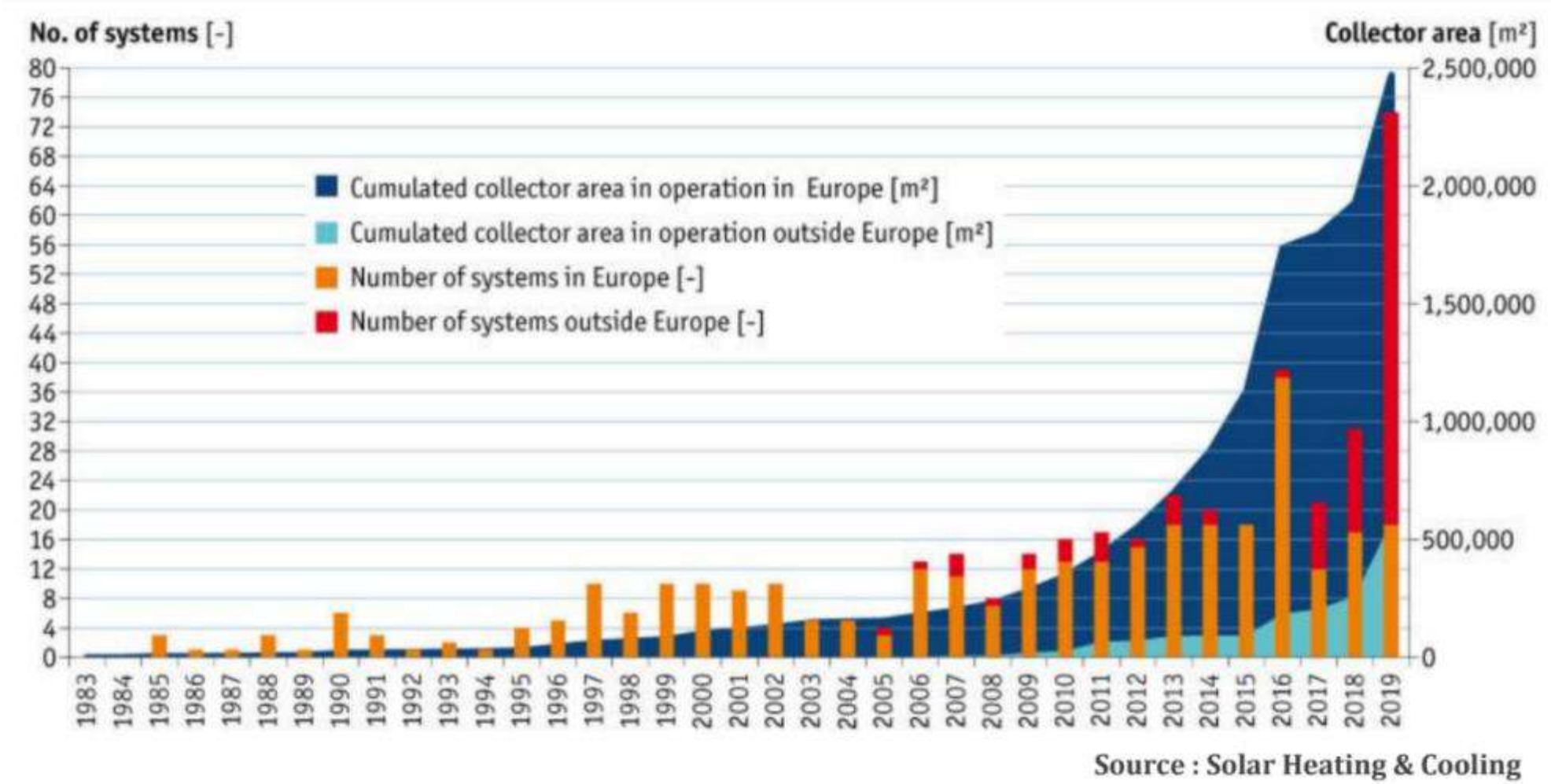
Large Solar Plants (2019)



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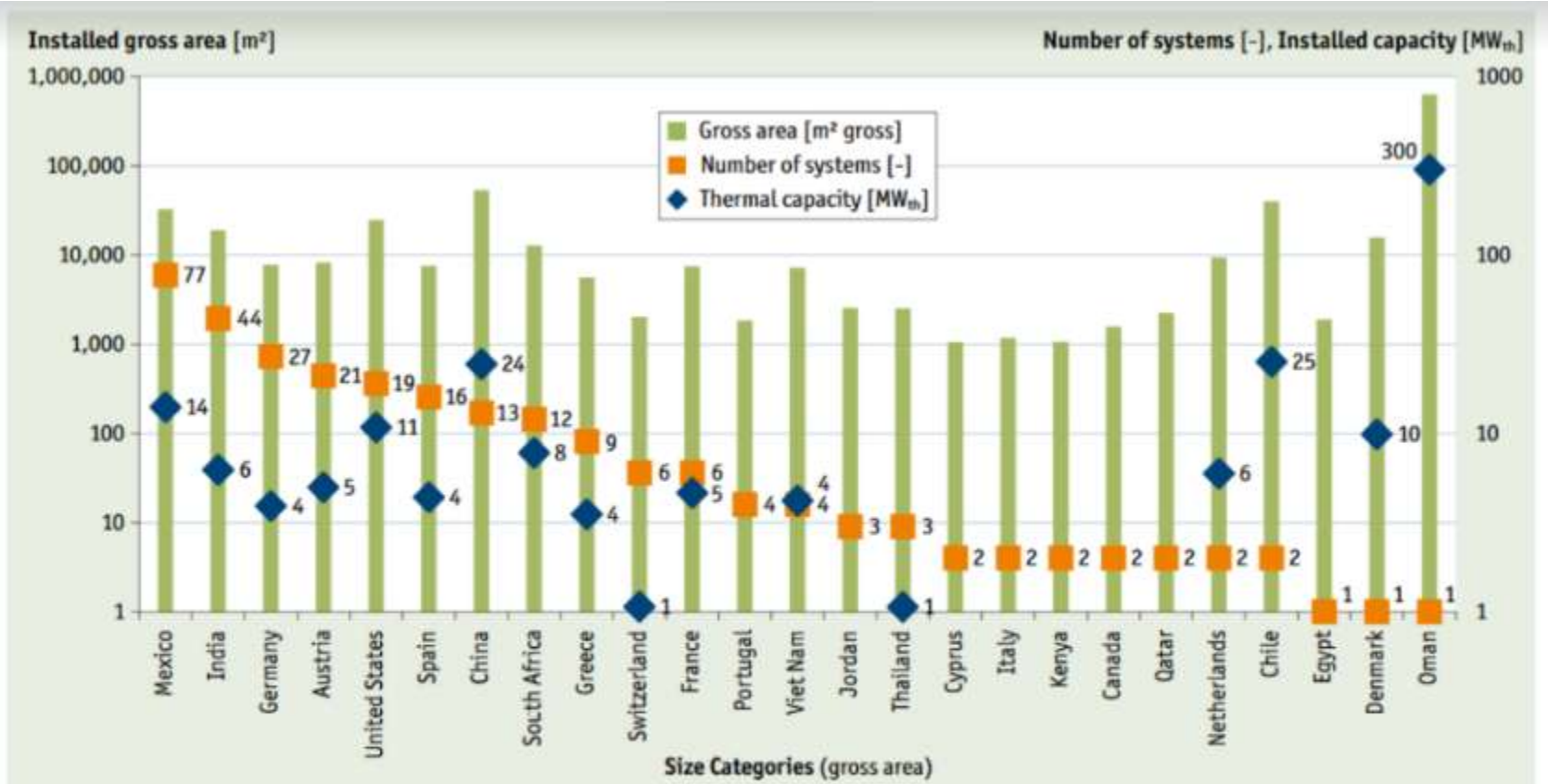
Large Solar Plants by Country (2020)



ıre 11: Solar process heat applications in operation worldwide end of March 2020 by country. (Only countries with at least 0.7 MWth (1,000 m² gross area) are shown, which is 281 of 301 systems, accounting for >99 % of installed thermal capacity).

(Source: IEA SHC Task49 / IV SHIP database)

Source : AIE

- 635 SHIP operating
- 905 000 m² collectors
- 441 MWth

Barriers to overcome

- High investment costs and lack of finance options
- Fossil fuel pricing (subsidized)
- Public awareness
- Scaling Issues
- Lack of suitable design guidelines and tools

FOCUS ON SHIP2FAIR PROJECT

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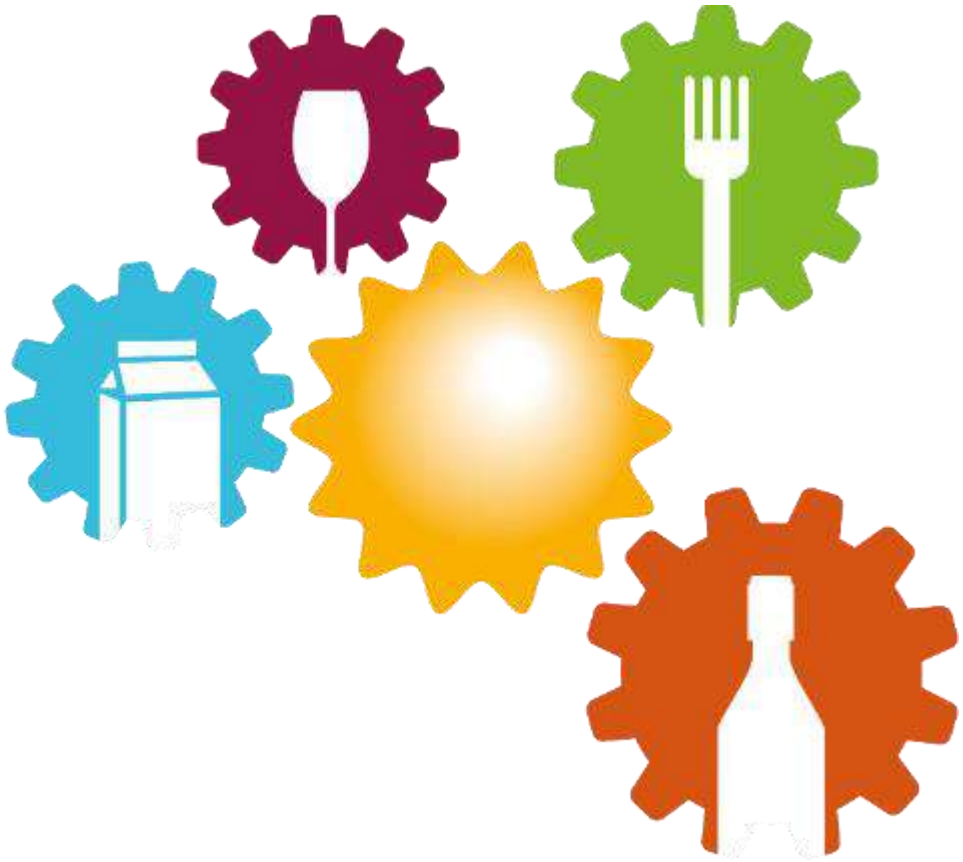
Concept



Fostering the integration of solar heat in industrial processes - **SHIP** from agro-food sector, by developing and demonstrating a set of tools and methods for the development of industrial solar heat projects during its whole life-cycle.

BUDGET: 7.996.793,25 €
DURATION: 2018-2022

SHIP2FAIR Project

Challenges

Economic competitiveness

Integration of SHIP in existing industrial processes

Solutions

- **Development of easily replicable solutions** to increase energy efficiency and lower process heat temperature.
- Development of **suitable control strategies** taking into account inertia effects, delays, influence of radiation fluctuations and susceptibility to oscillations.
- Tools validation by continuous feedback from **real-operating systems**.
- Development of **training from a practical methodology**, making large use of ***use-cases***, letting users utilize the software directly within their local environment, thus achieving a **tailored solution to users' local challenges**.

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Partners

Coordination

Solar technologies providers

R&D and consulting

Agro-food field experts

Dissemination & Training

SHIP2FAIR
Expected results

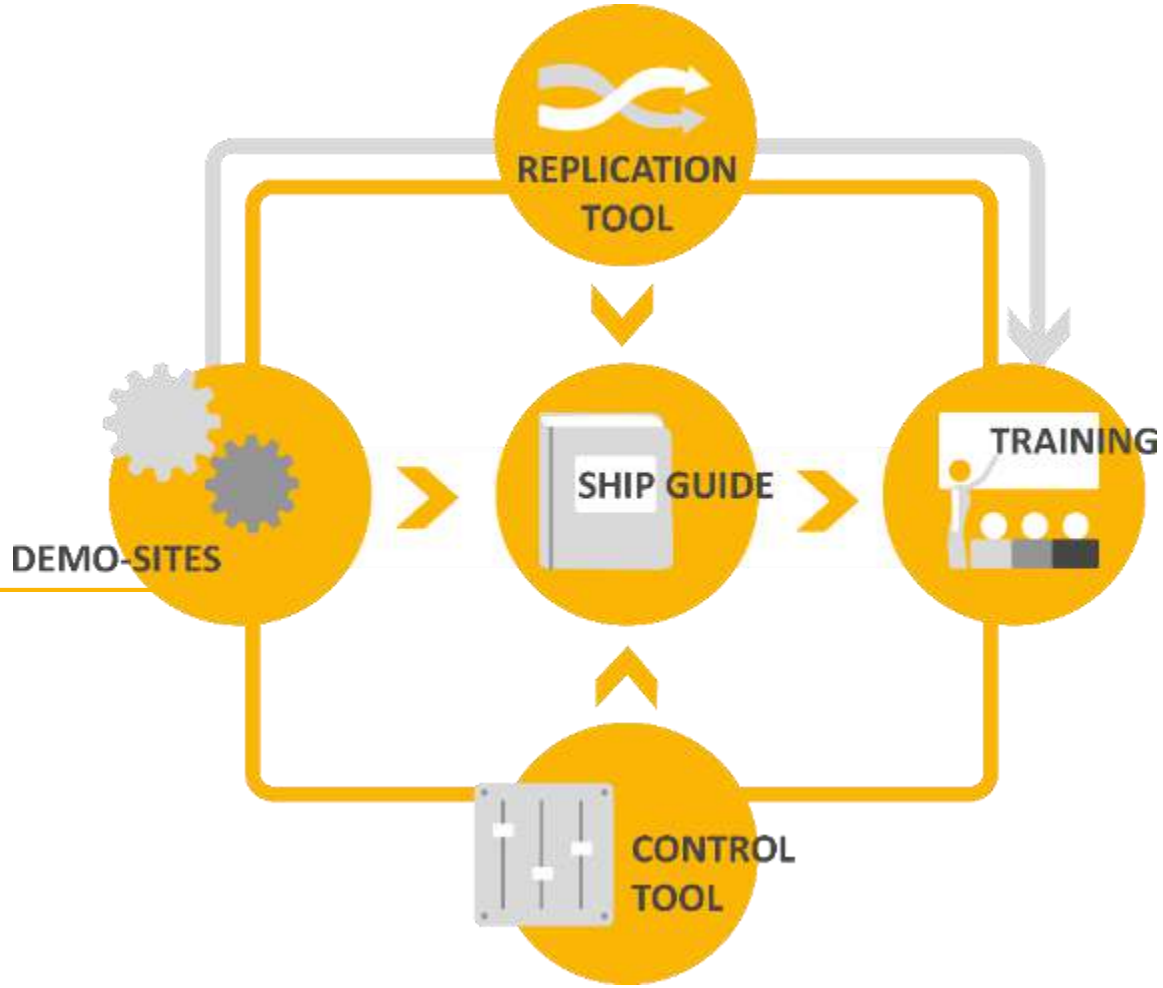
SHIP2FAIR will develop & demonstrate, in a minimum of 4 real industrial sites - **demo-sites**, a set of **tools & methods** for the development of industrial solar heat projects during their whole life-cycle.

Sugar boiling
Porto, Portugal

Foie-gras production
Castelnaudary, France

Spirits distillitation
Pessione, Italy

Wine fermentation & stabilization
La Rioja, Spain



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The demo-sites & the flagship projects

A minimum of 4 SHIP systems fully validated in real processes: new demo-sites joining in 2020

Novel solar collectors demonstrated in average irradiance areas through a 18-month demonstration campaign

- **Total capacity:** 2.9 MWth
- **Solar fraction:**
  11.2% (RAR)-39% (RODA)
- **Yearly average solar efficiency:**
  37% (M&R)-54% (RODA)

- **Primary energy savings:**
  - 4 GWh/year
  - 1145 tCO_2/year avoided
  - 5.4 GWh/year increase of RES in industrial heating

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First demo-site installed

Wine fermentation & stabilization
La Rioja, Spain

BODEGAS RODA
Haro . Rioja Alta . España

NEEDS

Heating

- Radiant floor heating for malolactic fermentation
- Heat for adsorption process
- Pipe cleaning & desinfecting
- High-pressure cleaning

Cooling

- Fermentation process
- Ageing

SHIP2FAIR'S EXPECTATIONS

Wine fermentation & stabilization
La Rioja, Spain

- BRING RENEWABLE ENERGY
- USE OF SOLAR-THERMAL ENERGY TO GENERATE HEAT and COLD
- INTEGRATION OF VACUUM TUBES IN THE WAREHOUSE ARCHITECTURE: CARING FOR THE AESTHETIC OF THE FACILITIES
- DECREASE IN ENERGY EXPENDITURE

Winemaking flow diagram

Wine fermentation & stabilization
La Rioja, Spain
BODEGAS RODA

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RODA: General overview

Wine fermentation & stabilization
La Rioja, Spain
BODEGAS RODA

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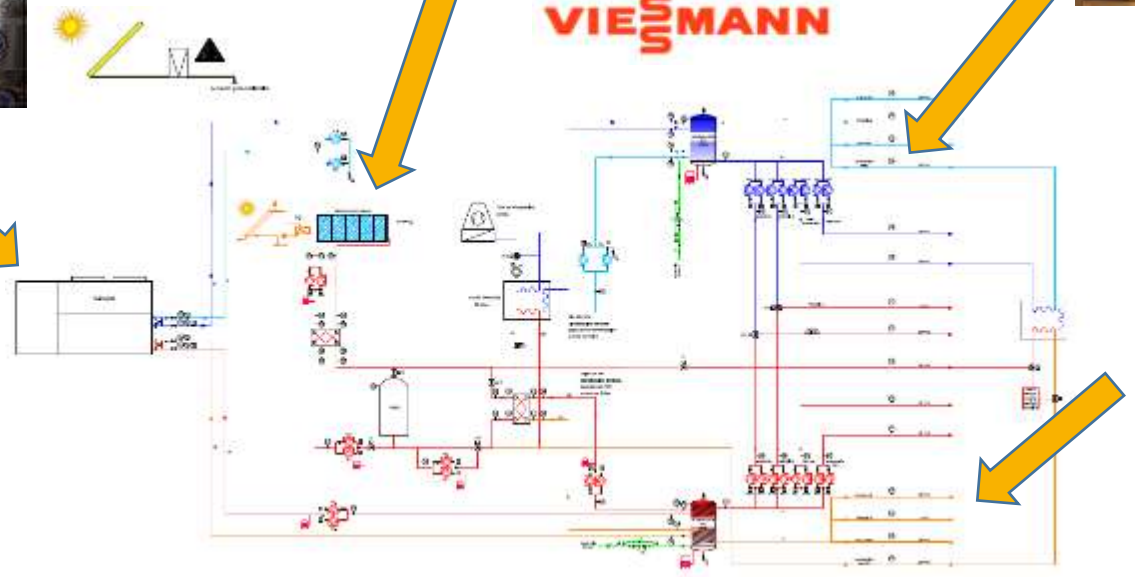
Solar thermal to provide heating & cooling Viessman Vitosol 200TM 100m^2 area + Absorption chiller (YASAKI)

VIESMANN



Solar Plant Features

- Hot Water T=70°C
- 75 MWh/an
- 100 m²
- 5 c€/kWh
- Absorption Chiller: 35kW
- Cold Storage: 4m3
- Hot Storage: 4m3

Wine fermentation & stabilization
La Rioja, Spain

BODEGAS RODA

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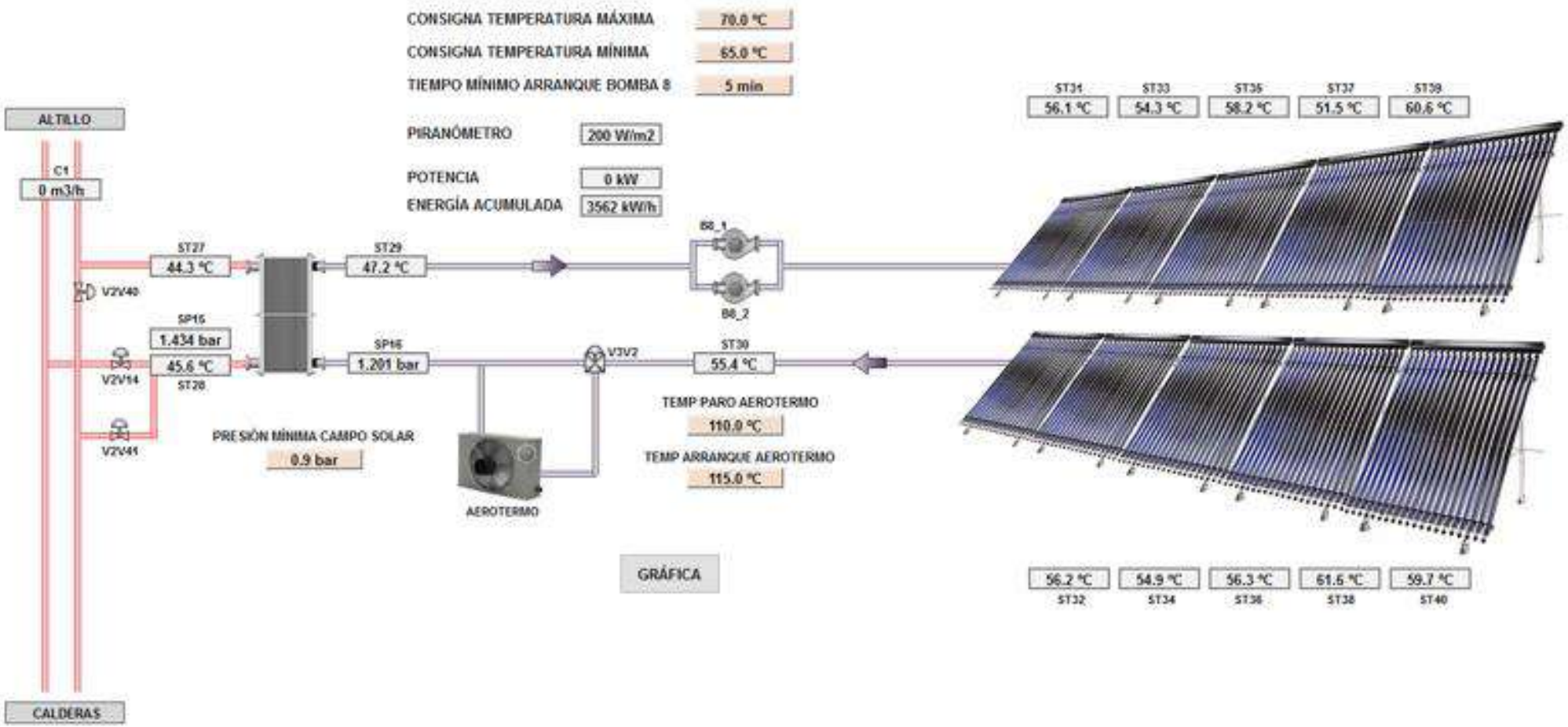
SOLAR PRODUCTION



Wine fermentation & stabilization
La Rioja, Spain

BODEGAS RODA

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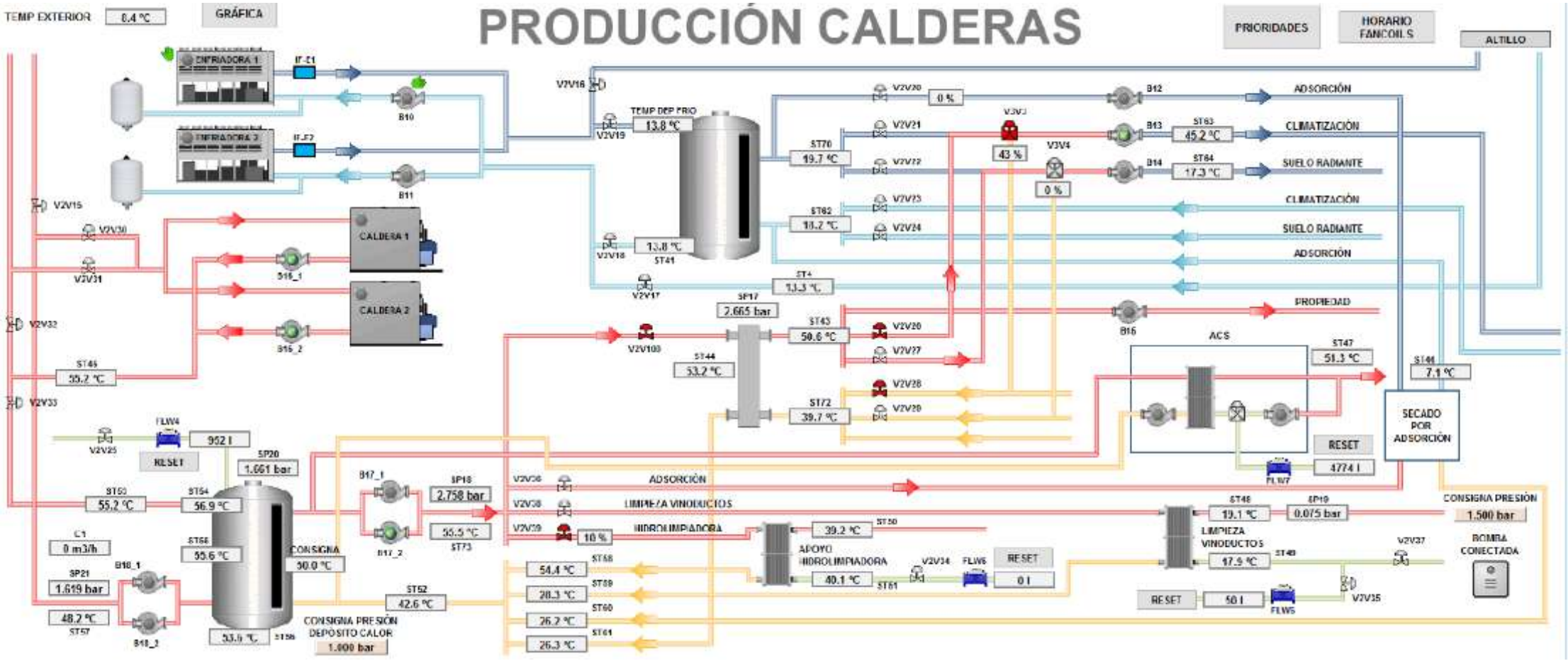
SOLAR USE



RODA´S SOLAR FIELD

Wine fermentation & stabilization
La Rioja, Spain

BODEGAS RODA

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- info@ship2fair-h2020.eu

INDUSTRIAL SOLAR
renewables onsite

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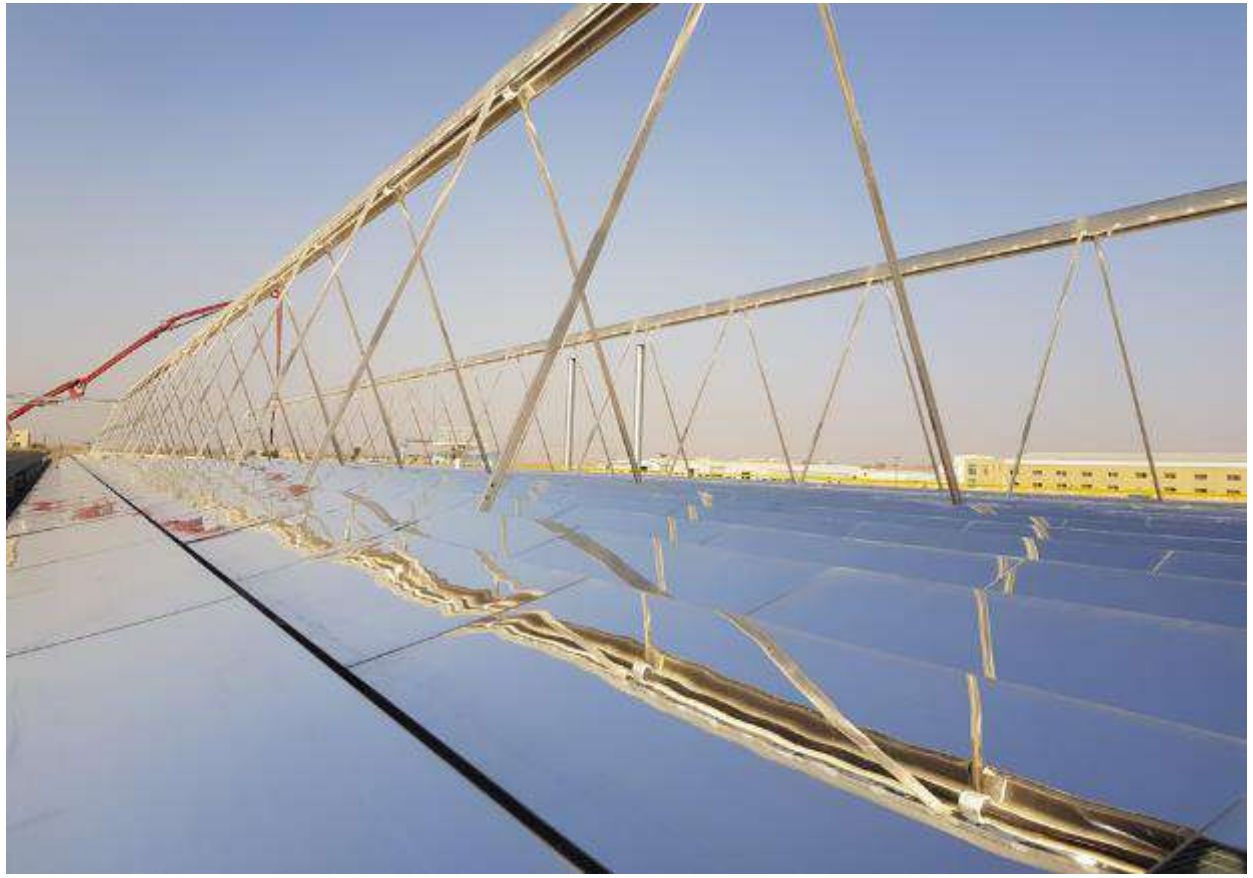
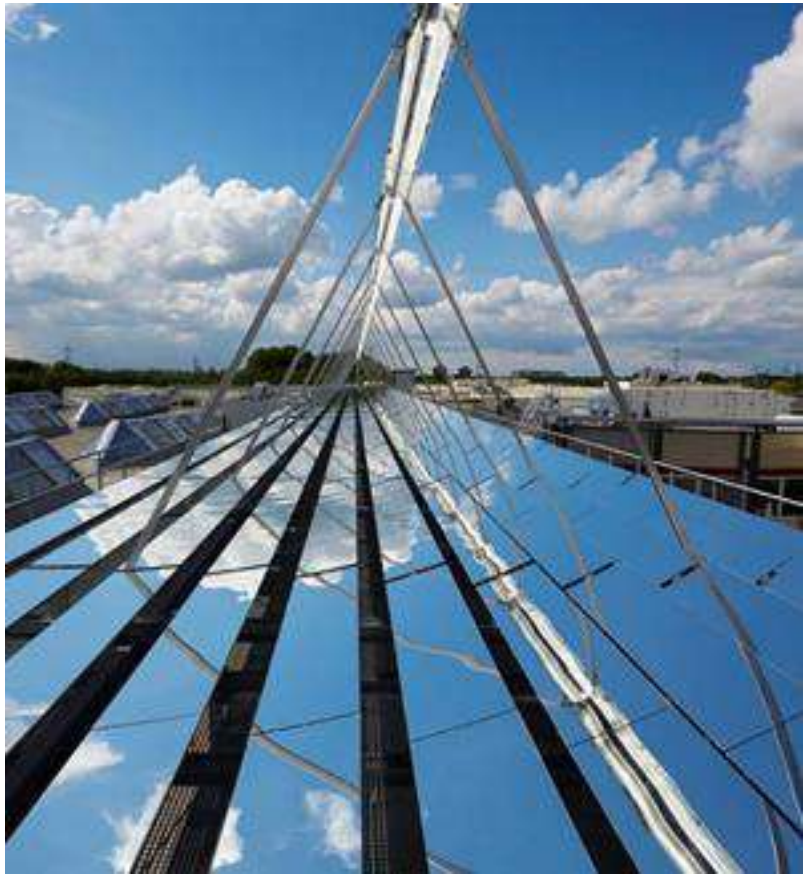
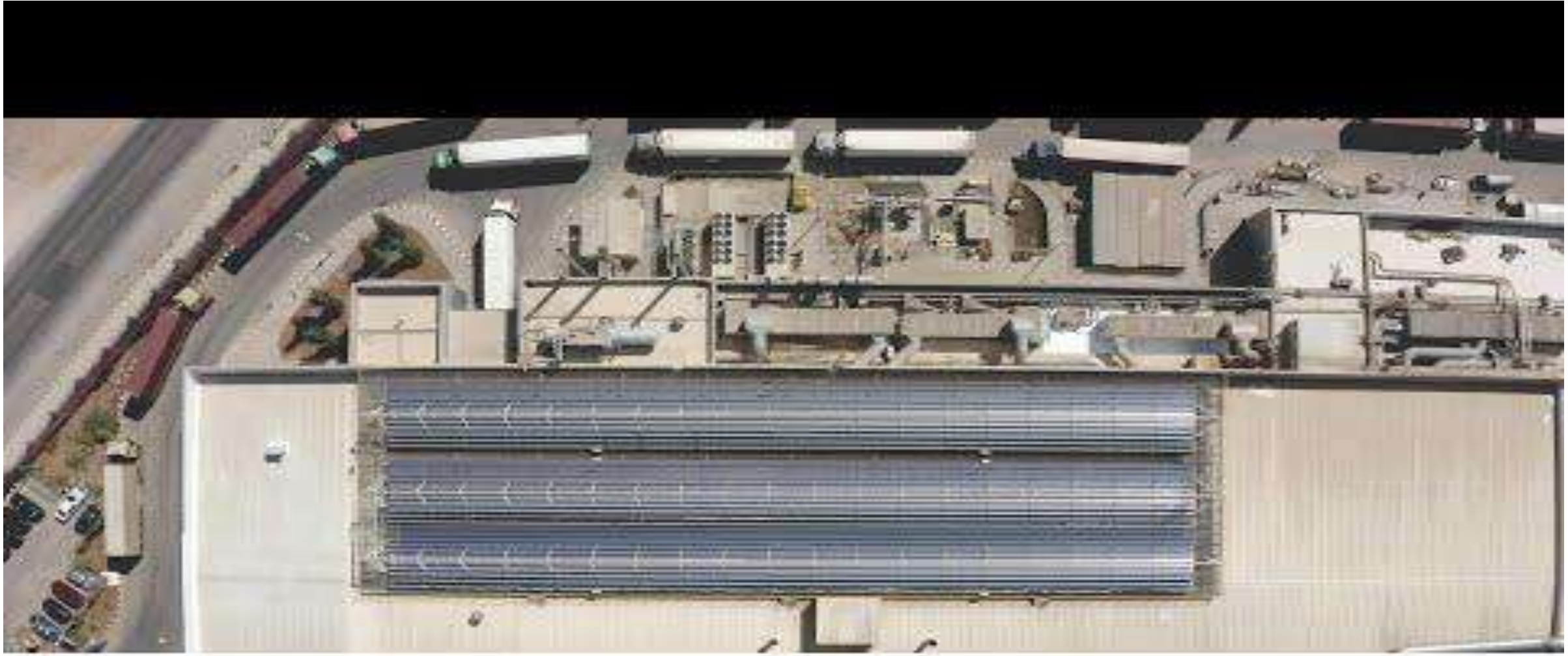
Fresnel Collector technology







Fresnel Solar Steam Generator

- System Overview -

INDUSTRIAL SOLAR
renewables onsite

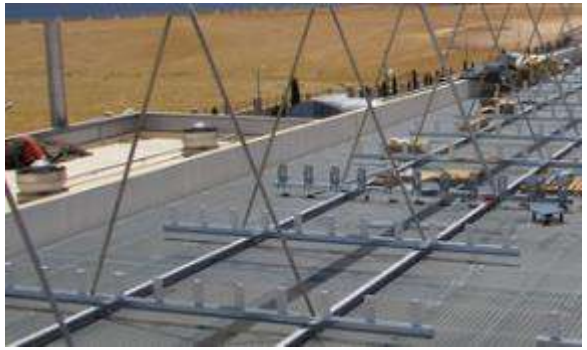
SHIP2FAIR

Fresnel Collector – Components

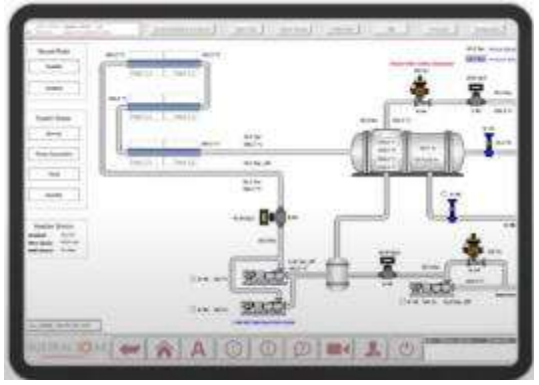
Mirror system (robust)

Absorber tube (high efficiency)

Support Structure (lightweight)



Control system (smart control)



INDUSTRIAL SOLAR
renewables onsite

SHIP2FAIR

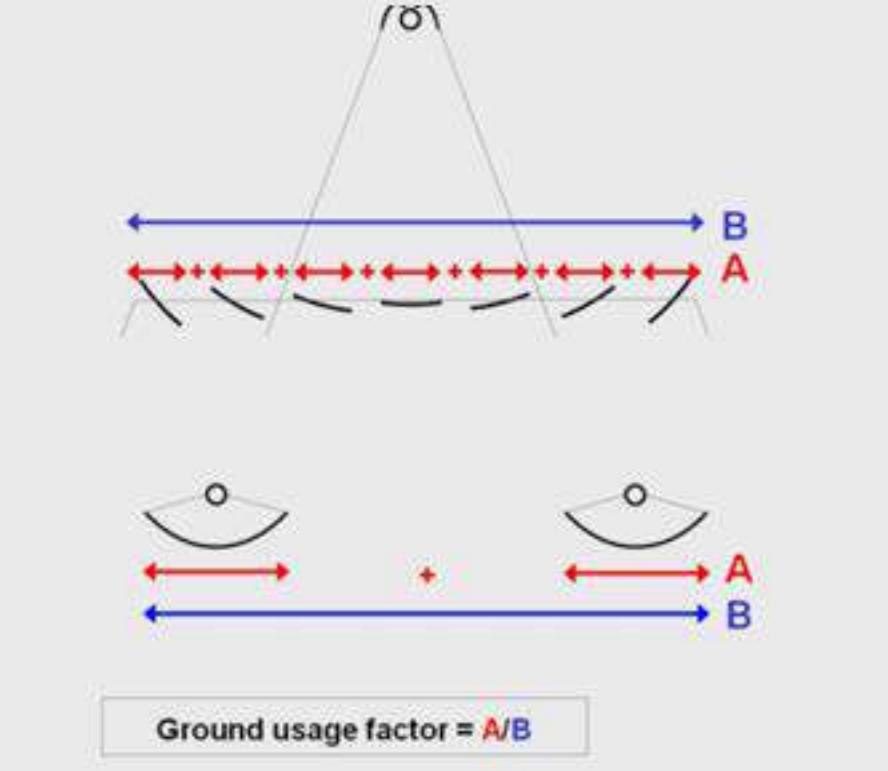
Fresnel Collector – Technology overview

Higher ground usage factor
~65% higher space efficiency
(aperture area / used ground area) Reference: 1
MW = ~ 2500 – 3000 m²

Low wind load
Low exposure to wind

Good weight distribution
Even distribution of the weight on the ground

Flexible design temperature/pressure
up to 400°C, 120 bar



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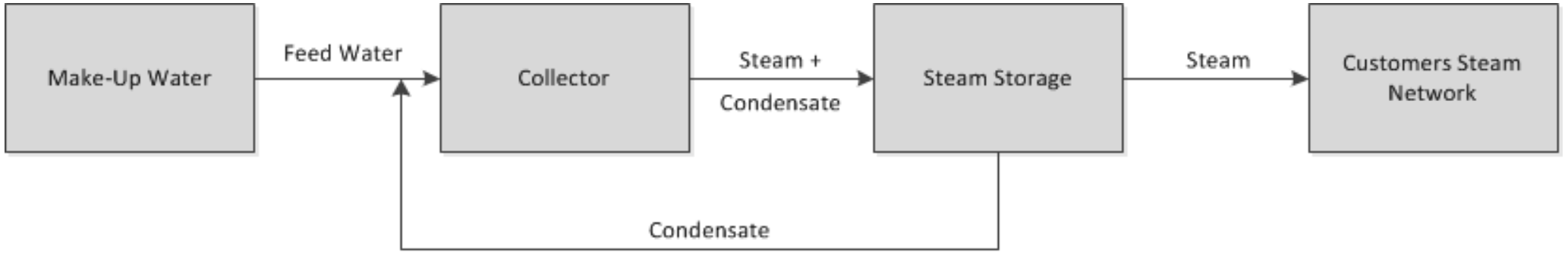
renewables onsite

SHIP2FAIR

Fresnel Collector – Steam generation concept



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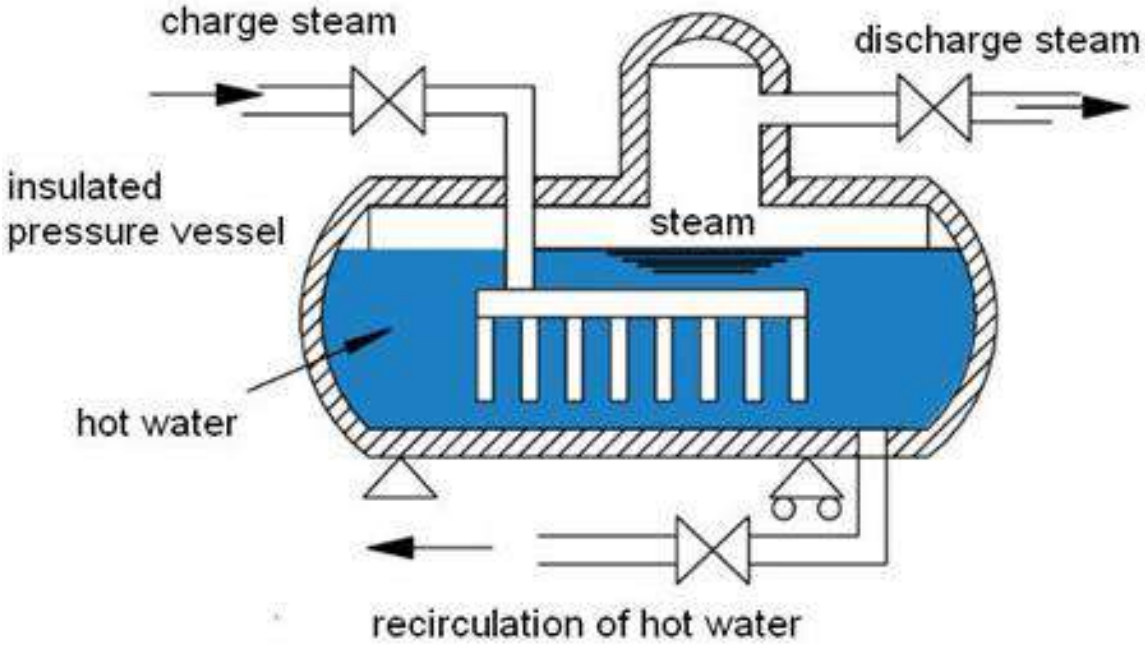
renewables onsite

Fresnel Collector – Steam drum

Large pressure vessel

mainly filled with liquid water (80% of volume)

partly filled with steam (20% of volume)



Additional Functions of Storage

- Two-phase separation
- Expansion Vessel
- Steam pressurization
- Blow-down
- De-Aeration
- Anti-Freeze protection

INDUSTRIAL SOLAR
renewables onsite

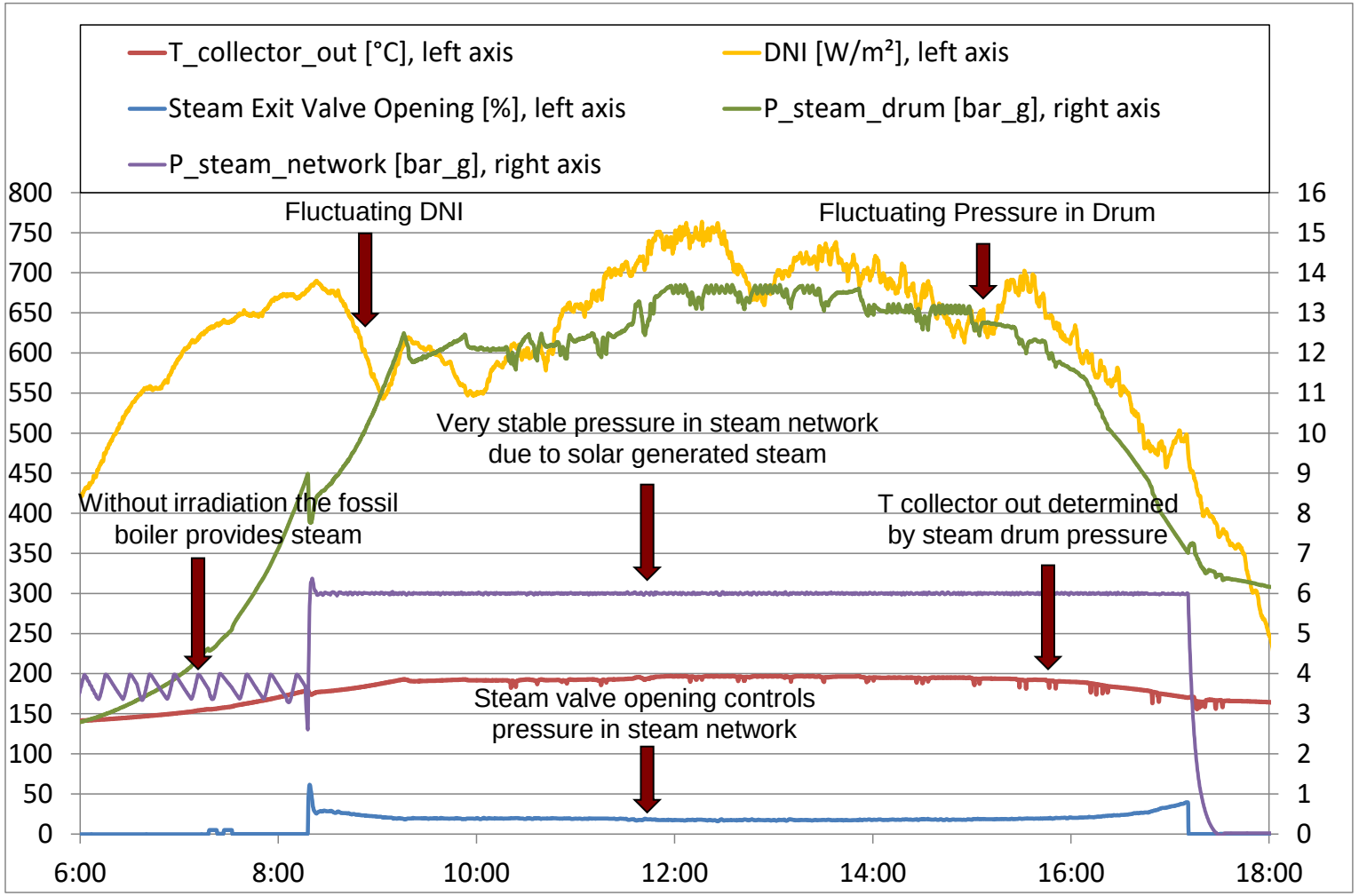
SHIP2FAIR

Fresnel Collector – Steam drum

INDUSTRIAL SOLAR
renewables onsite

SHIP2FAIR

Fresnel Collector – control performance



Sugar boiling
Porto, Portugal

SHIP2FAIR

Demo site at RAR

RAR Açúcar is a company dedicated to the refining and selling of sugar

Solar steam will reduce fuel consumption and avoid emissions from burning fuel oil and natural gas

NEEDS

Heating

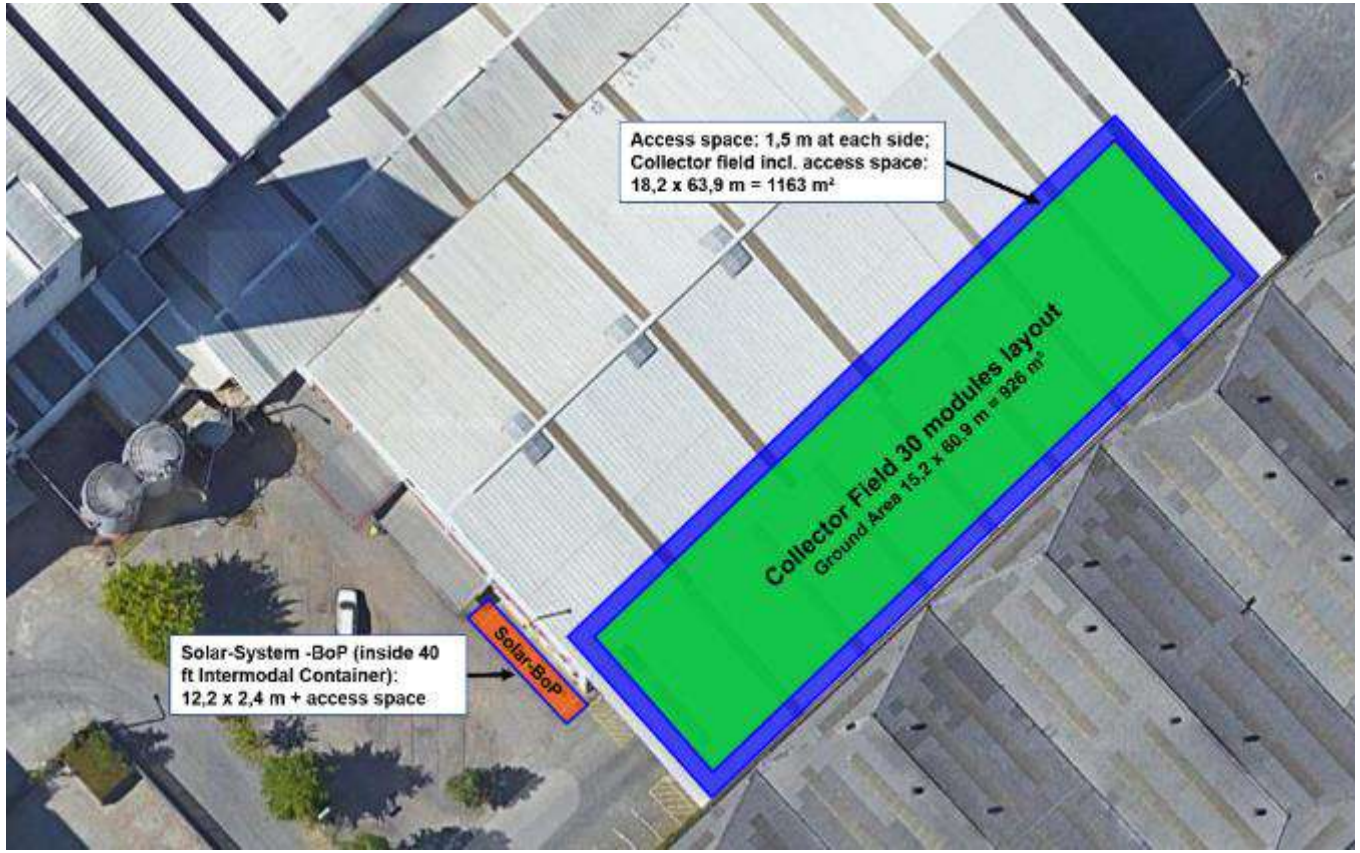
- Sugar crystallization process: 125°C
- Solar steam operation modes:
- Main use: 1 bar(g) grid for all major processes and the degasser
- Optional: 5 bar(g) grid used for cleaning (in continuous process)

Sugar boiling
Porto, Portugal

SHIP2FAIR

Demo site at RAR

Technology: Solar Fresnel Concentrators
Solar field: 30 modules
Orientation: 47° from the N-S-axis
660 m² aperture area
Production: steam @10 bar
Under execution



INDUSTRIAL SOLAR
renewables onsite

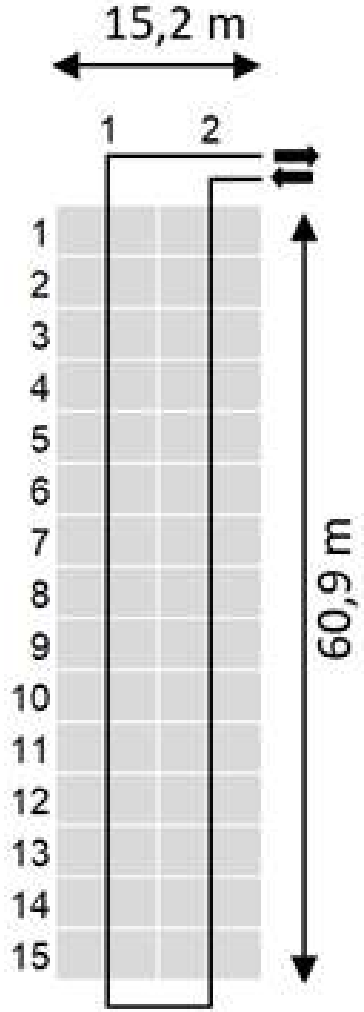
Sugar boiling
Porto, Portugal

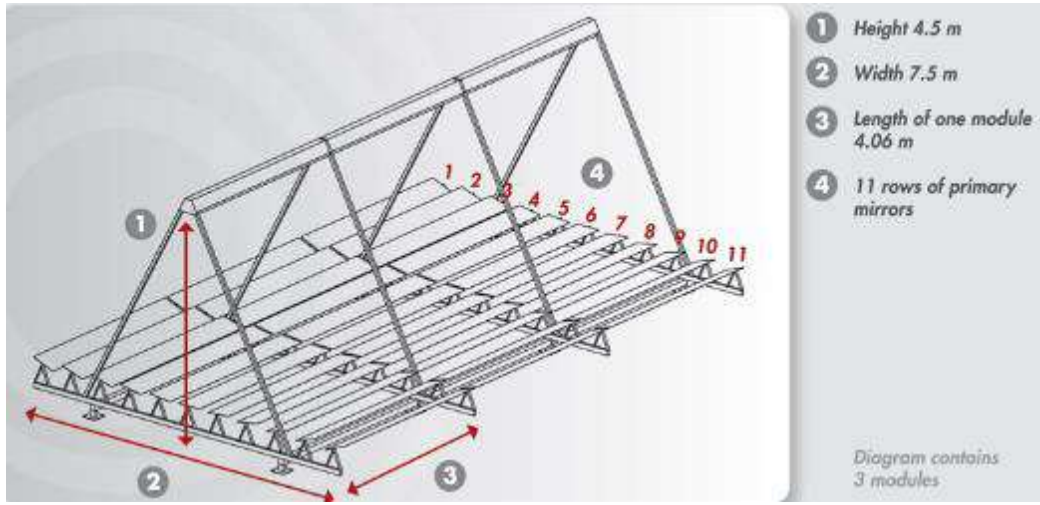
SHIP2FAIR

Demo site at RAR – System layout

30 modules (15 strings of 2 modules each)
690 m² aperture area
415 kW thermal power at reference conditions
926 m² ground space (15,2m x 60,9m)
+ access space of 1,5 m each side
75 % ground space efficiency

465 kWh/an
3 c€/kwh



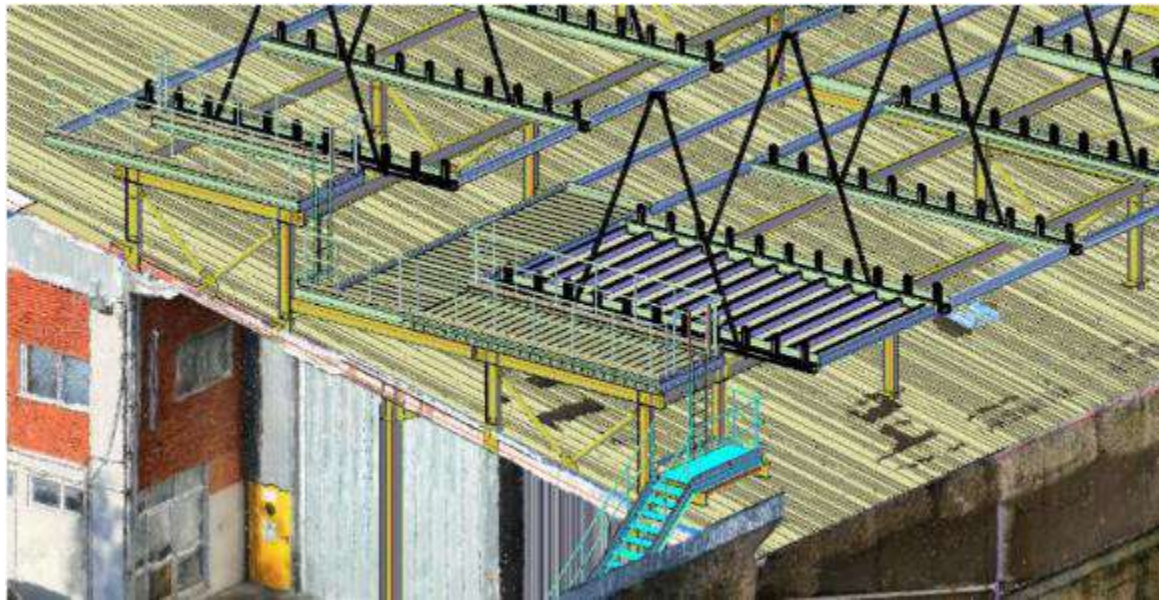


INDUSTRIAL SOLAR
renewables onsite

Sugar boiling
Porto, Portugal

SHIP2FAIR

Demo site at RAR – Roof installation



Sugar boiling
Porto, Portugal

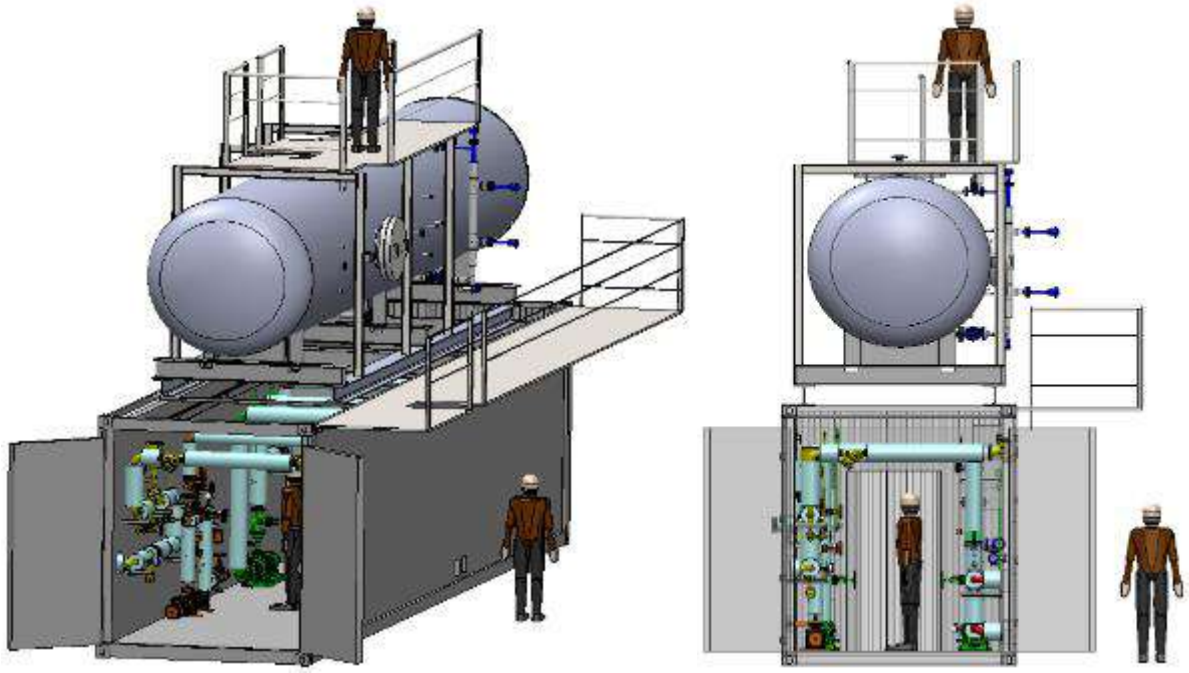
Demo site at RAR – BOP container

INDUSTRIAL SOLAR
renewables onsite

Technology: Solar Fresnel Concentrators
Steam storage and BOP Container

- Replicability
- Reduced engineering efforts
- Reduced planning cost
- Acceleration of engineering
- Pre-manufacturing & tests before shipping
- Reduced installation time onsite
- Short pipe ways from solar field to solar BoP
- Clear definition of solar system interfaces

Storage capacity: **60 minutes and 415 kWh (1,5 GJ)**

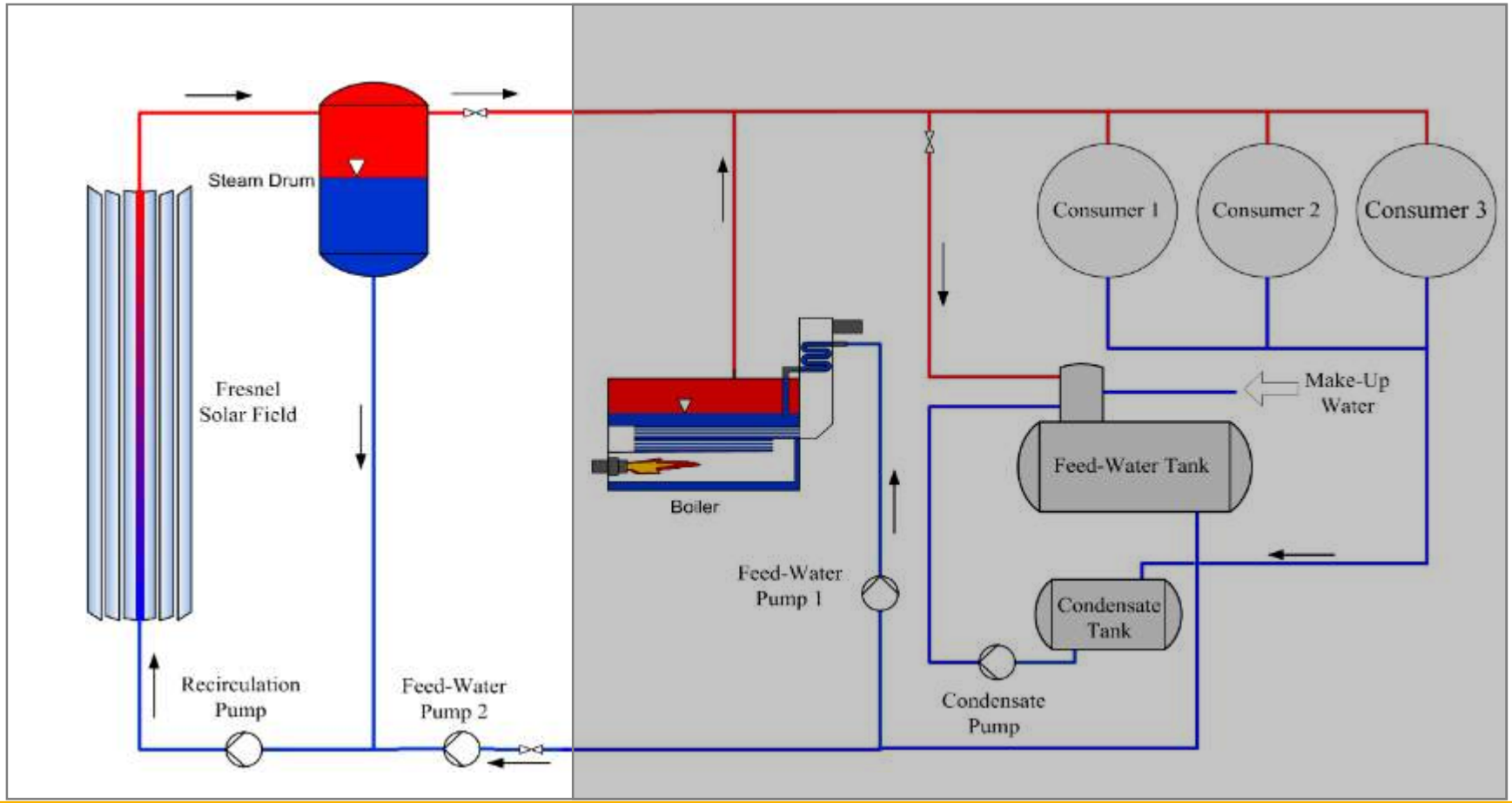


Demo site at RAR – Steam integration

Solar Steam Boiler

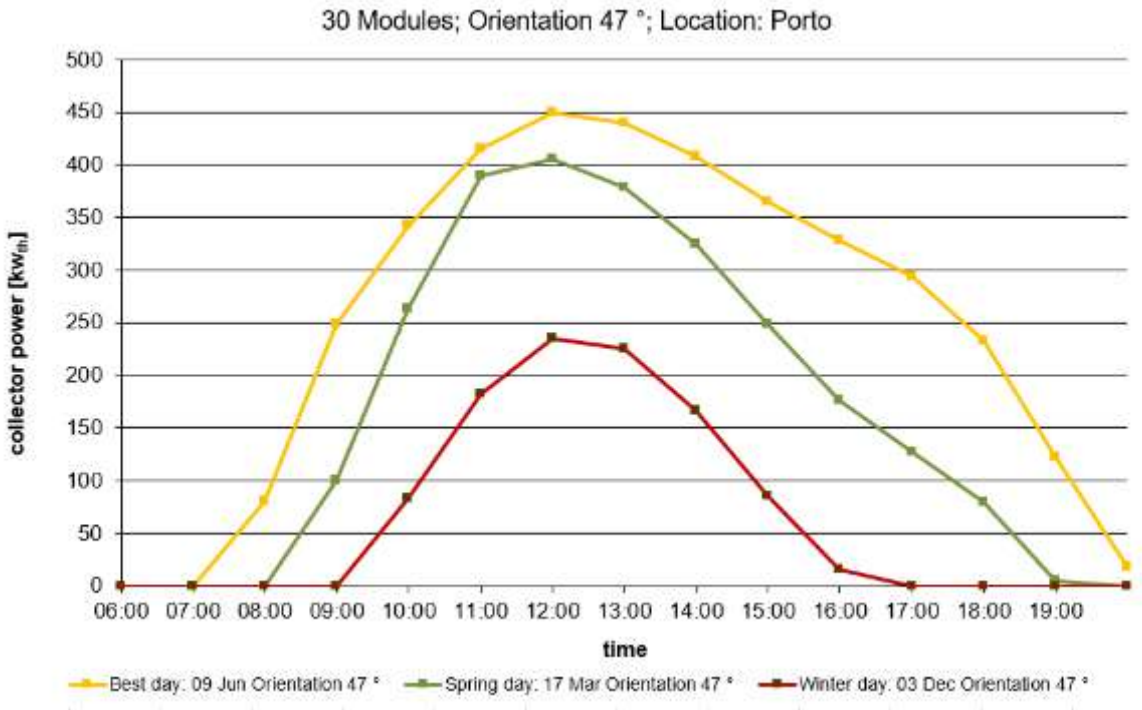
Existing Steam Network

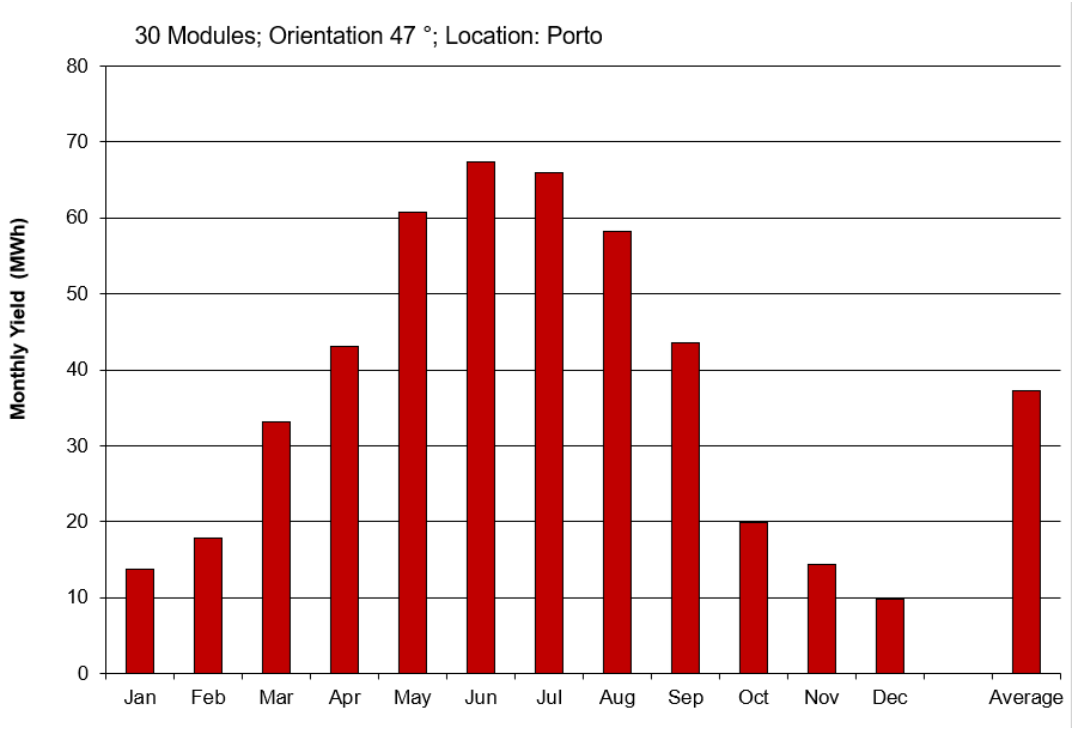
INDUSTRIAL SOLAR
renewables onsite

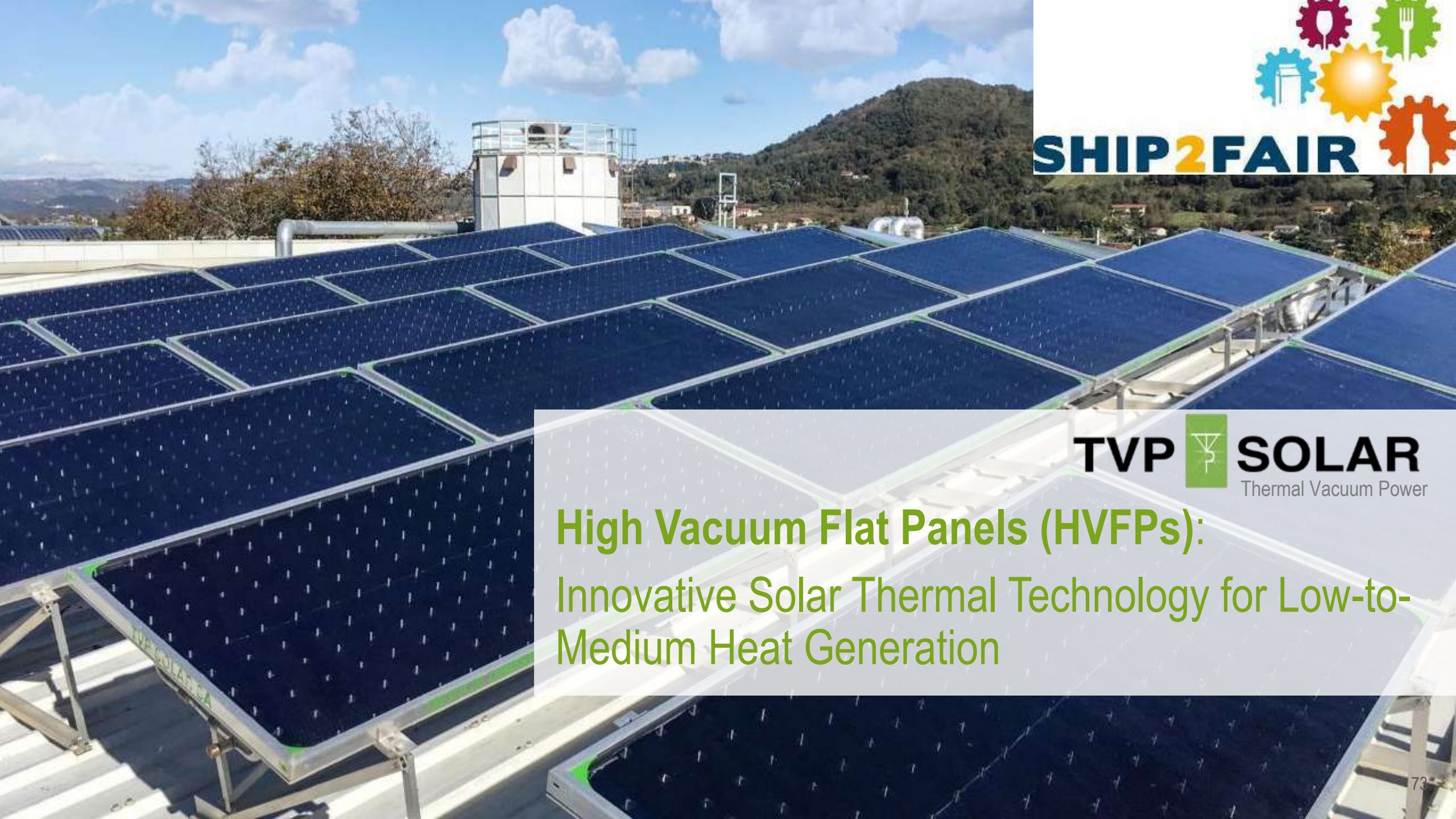


Sugar boiling
Porto, Portugal

Demo site at RAR – Gross energy yield







SHIP2FAIR

TVP SOLAR
Thermal Vacuum Power

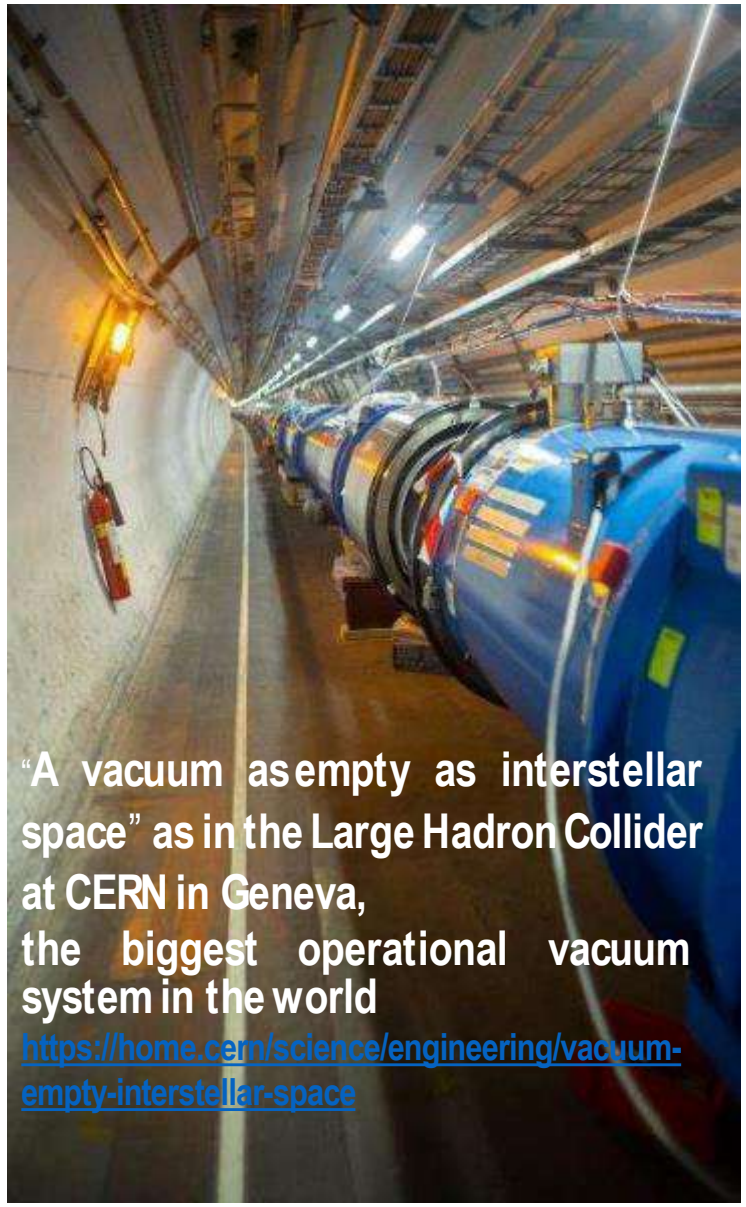
High Vacuum Flat Panels (HVFPs):

Innovative Solar Thermal Technology for Low-to-Medium Heat Generation

The World Best Solar Thermal Collector (1/2)

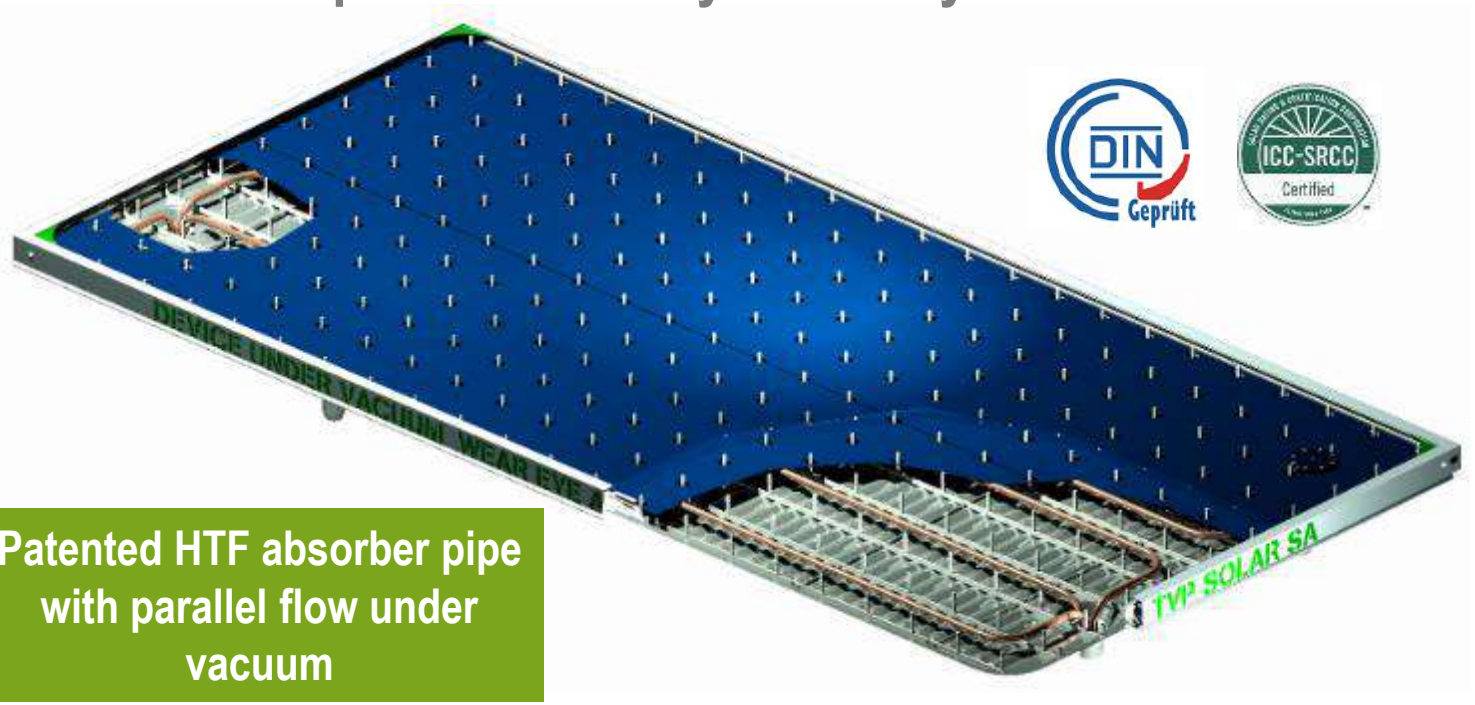
TVP SOLAR

SHIP2FAIR



"A vacuum as empty as interstellar space" as in the Large Hadron Collider at CERN in Geneva,
the biggest operational vacuum system in the world
https://home.cern/science/engineering/vacuum-empty-interstellar-space

Certified best performance by SolarKeyMark 65˚C to 200˚C

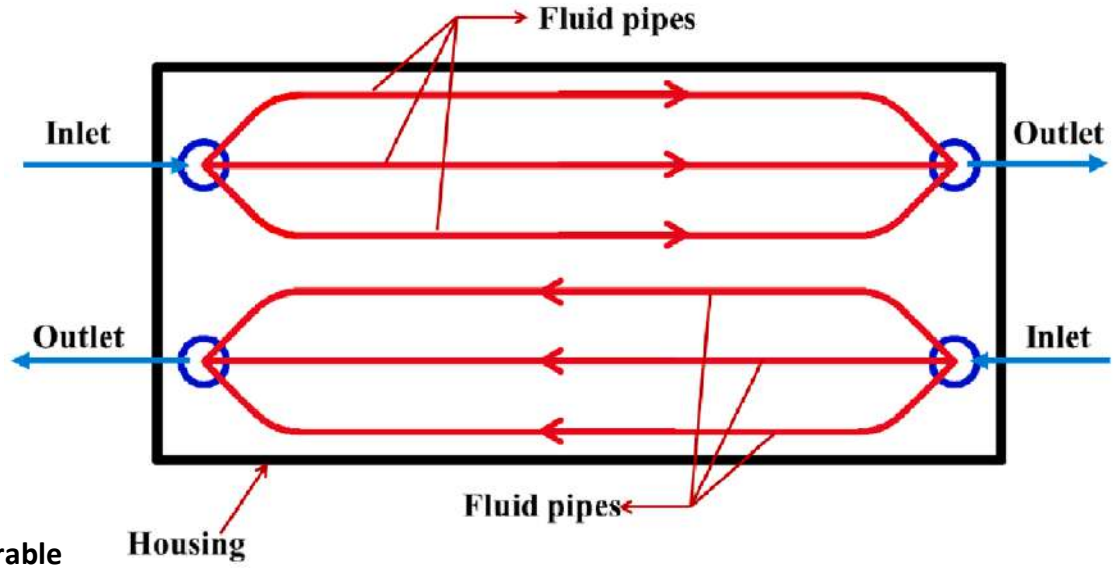


- Patented HTF absorber pipe with parallel flow under vacuum
- Patented internal pressure indicator
- Patented auto-regenerative getter
- Patented glass-to-metal seal
- Patented lightweight support structure

The World Best Solar Thermal Collector (2/2)

TVP SOLAR
SHIP2FAIR

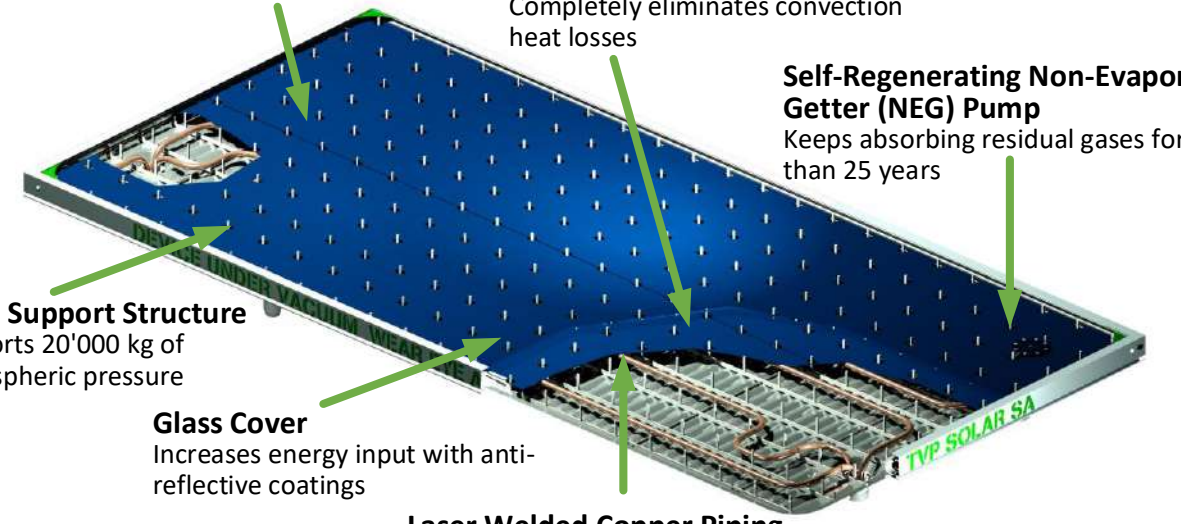
- High-vacuum insulation suppresses thermal losses
- Best efficiency and highest energy production at any operating temperature, with any ambient temperature, in any climate condition



Aluminium Absorber Plate with Advanced Selective Coating Technology
Converts sunlight to usable heat

High Vacuum Insulation <0.1Pa
Completely eliminates convection heat losses

Self-Regenerating Non-Evaporable Getter (NEG) Pump
Keeps absorbing residual gases for more than 25 years



Glass Support Structure
Supports 20'000 kg of atmospheric pressure

Glass Cover
Increases energy input with anti-reflective coatings

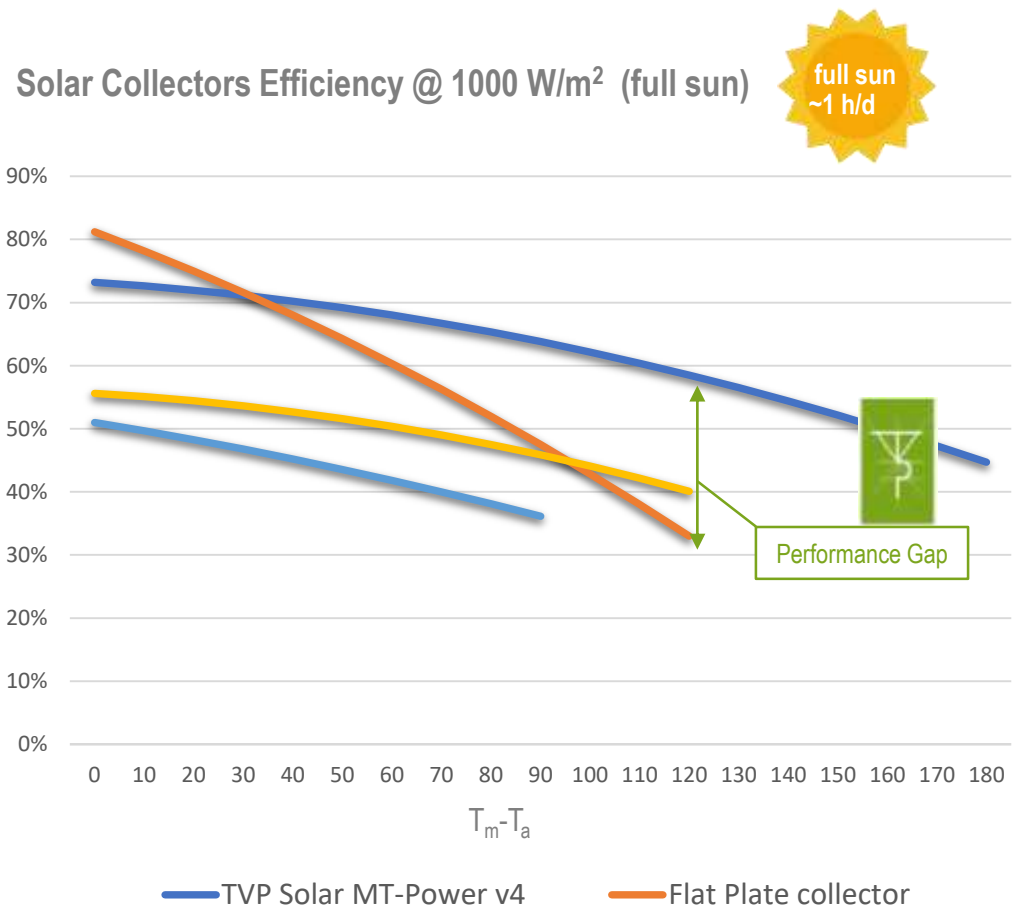
Laser Welded Copper Piping
Circulates fluid to extract heat (2 inlets and 2 outlets to maximize panel string efficiency)

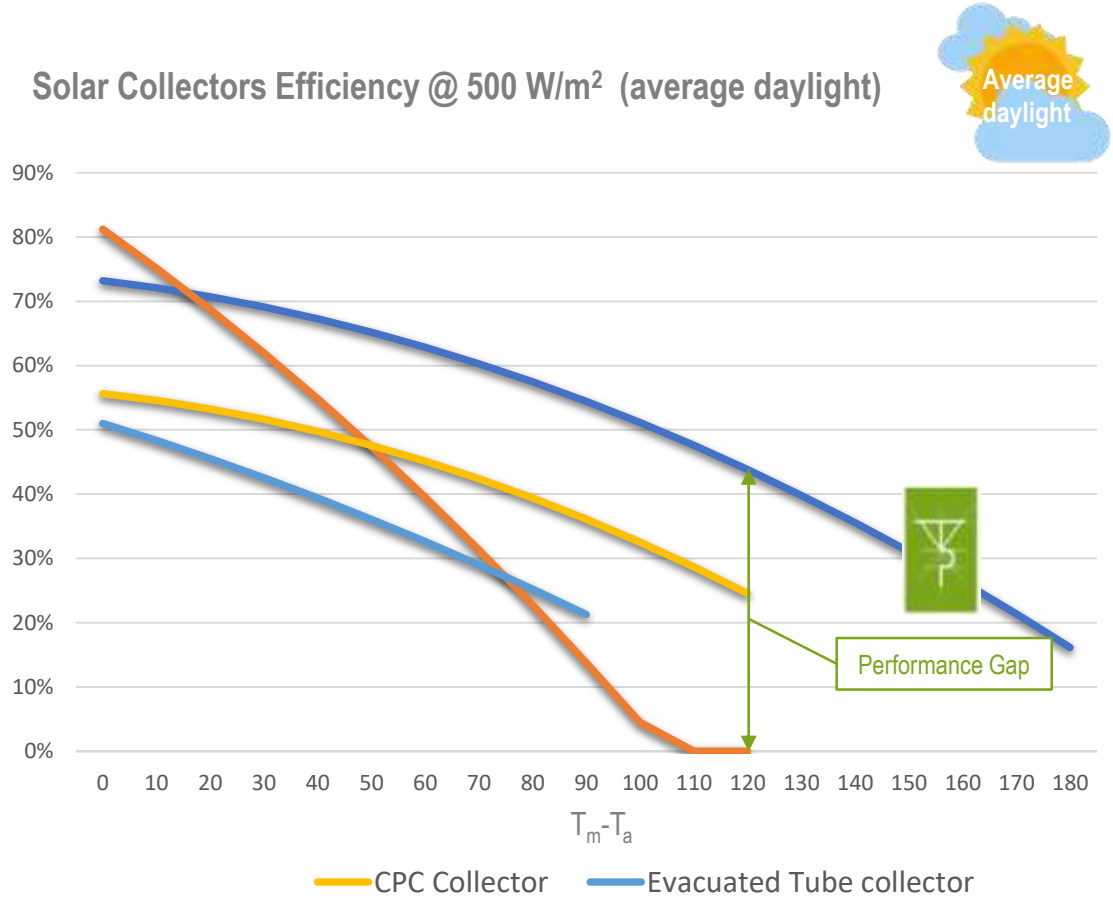
- 20 years consistent & predictable performance without any degradation
- Designed for industrial-scale applications

Best Solar Thermal

TVP SOLAR
SHIP2FAIR

Best efficiency and energy output in any climate conditions,
with any irradiance, at any operating temperature up to 200C



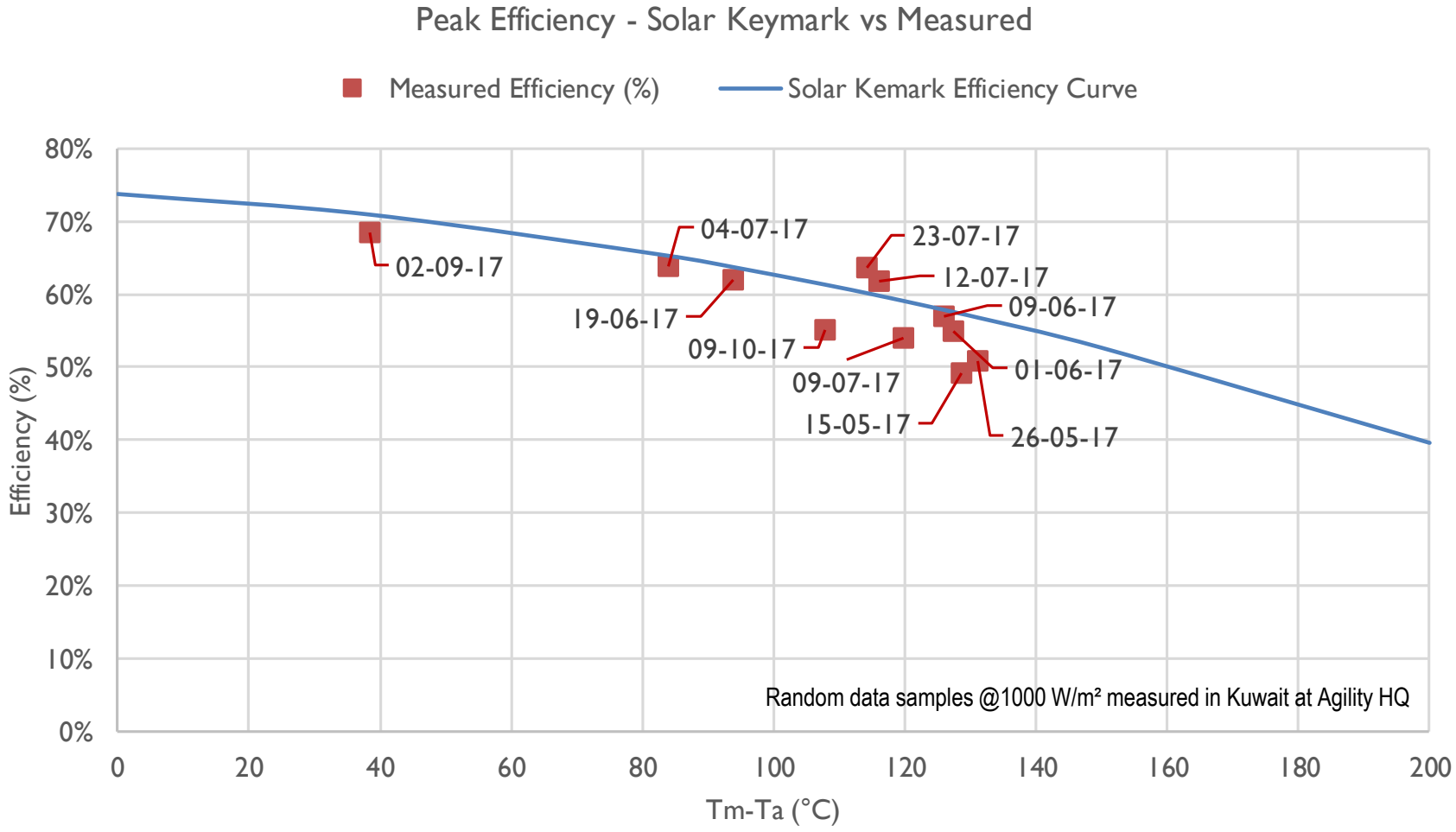


In-Field Results Verified Certification Values

TVP SOLAR

SHIP2FAIR

MT demonstrated in-field as world's best performing solar thermal collector up to 180˚C




DIN CERTCO

CERTIFICATE

TVP Solar SA
Place du Bourg-de-Four 36
1204 Geneva
SWITZERLAND

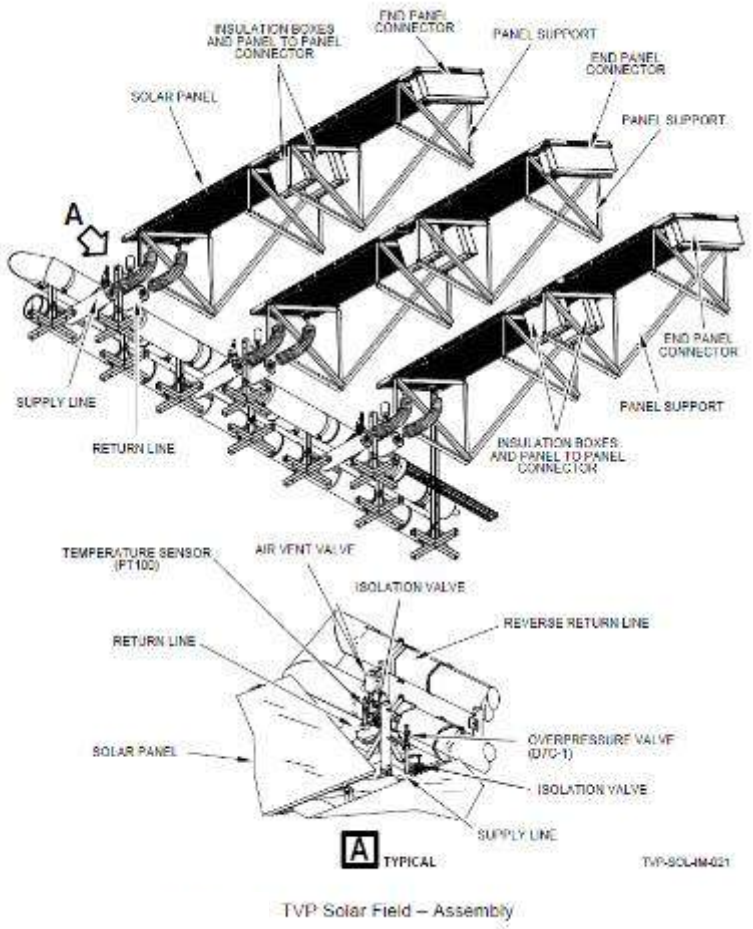
Standardized and Modular Solar System

TVP SOLAR

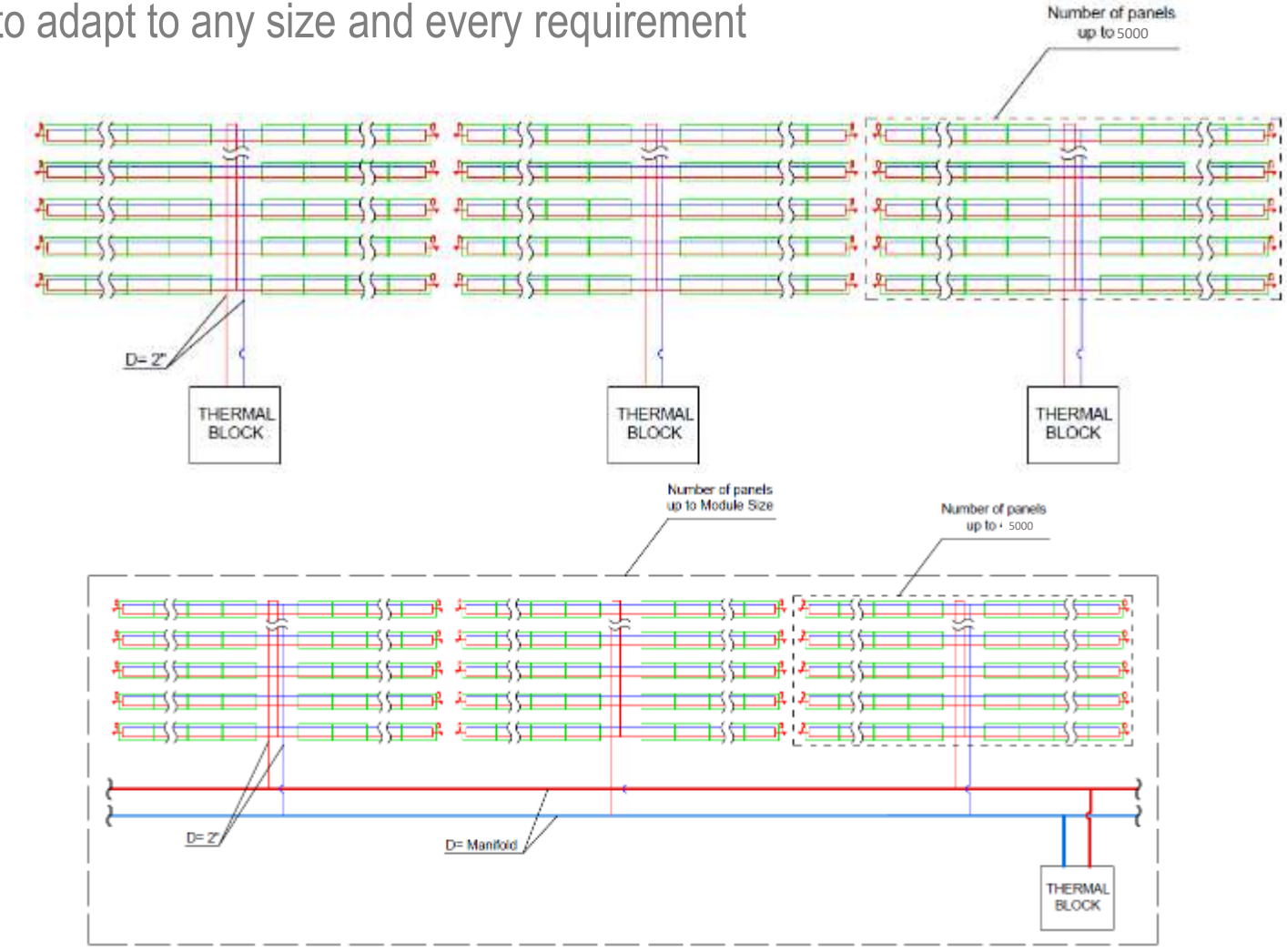
SHIP2FAIR

Standardized solar system components ease installation and maintenance

Modularity to adapt to any size and every requirement



TVP Solar Field – Assembly



HVFPs for oil processing

TVP SOLAR

SHIP2FAIR

أرامكو السعودية
saudi aramco

End-client:	Saudi Aramco
Location:	Qurayyah Seawater Treatment Plant, KSA Diesel
Application:	Boiler Feedwater Pre-Heating 1.8 MW; 93 to 164 °C [5,520 lb/h; 24/7]
Project:	1,020 m^2 solar field; 0.6 MW; 3,410 MMBtu/y
Savings:	138,269 liter/y of diesel and 372 ton/y of CO_2
Energy Cost:	8.5 $/MMBtu
TVP role:	single source contractor, EPC

Commissioned December 26th 2020

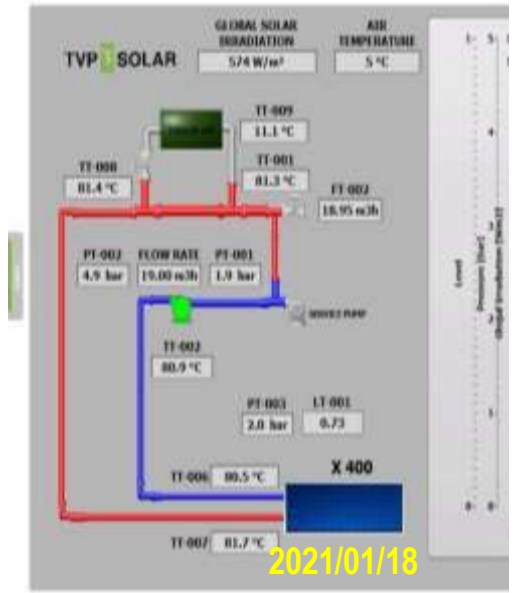
HVFPs for district heating

TVP SOLAR

SHIP2FAIR

End-client:	Service Industriels de Geneve
Location:	Le Lignon DH Thermal Plant (GE), Switzerland
Application:	District network return flow heating 0.5MW; 45 to 85 °C [20 m^3/h; 10 h/d 365 d/y]
Project:	816 m^2 solar field; 0.55 MW; 517 MWh/y
Savings:	59,900 m^3/y of NG and 119 ton/y of CO_2
Energy Cost:	38 CHF/MWh
TVP role:	EPC

Commissioned December 16th 2020



HVFPs for industrial process heat

TVP SOLAR
SHIP2FAIR

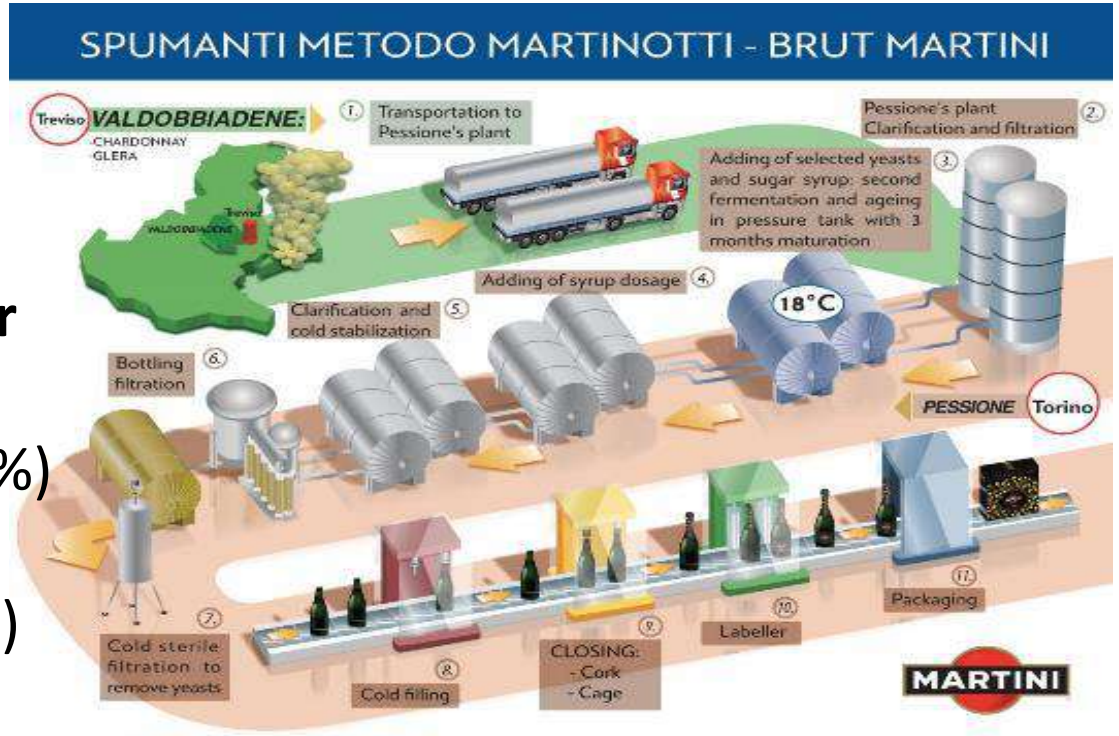
End-client:	Martini & Rossi Pessione/Chieri
Location:	(TO), Italy
Application:	Indirect steam generation (4 bar) 165°C to 175°C
Project:	600 m^2 solar field; 0.4 MW; 400 MWh/y
Savings:	49,070 m^3/y of NG and 96 ton/y of CO_2
Energy Cost:	34 €/MWh
TVP role:	EPC

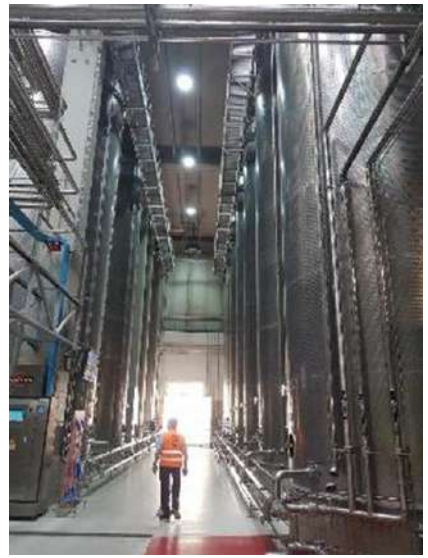
End-client:	PesiCo do Brasil
Location:	Sete Lagoas Plant (MG), Brazil
Application:	Process hot water 50° C to 65°C
Project:	400 m^2 solar field; 0.3 MW; 517 MWh/y
Savings:	144,544 m^3/y of NG and 287 ton/y of CO_2
Energy Cost:	18 $/MWh
TVP role:	tender winner, EPC

Second demo-site installed

Spirits distillitation
Pessione, Italy

MARTINI





Heat need : 5 542 MWh/year

- Bottling process 1 (81%)
- Bottling process 2 (7%)
- Distillation (12%),

- which is fed by 759 526 m^3 of natural gas per year.

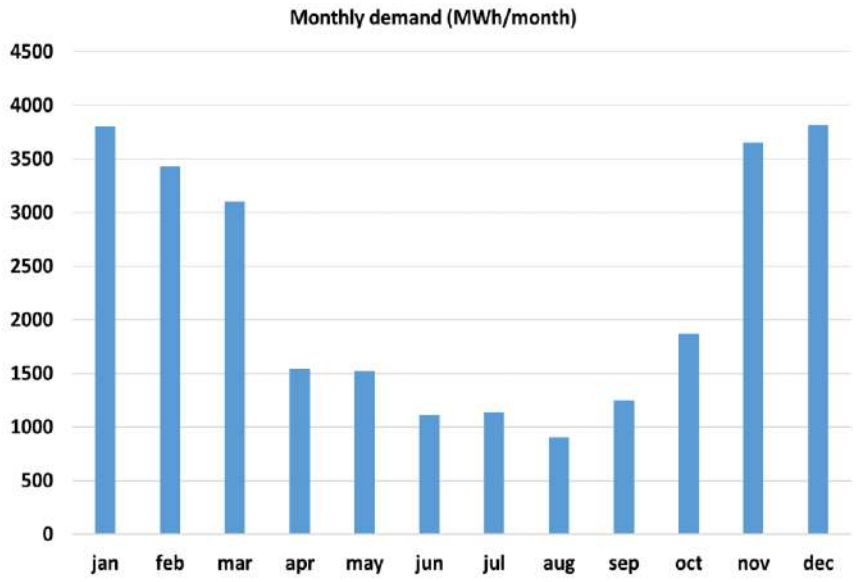
SHIP2FAIR

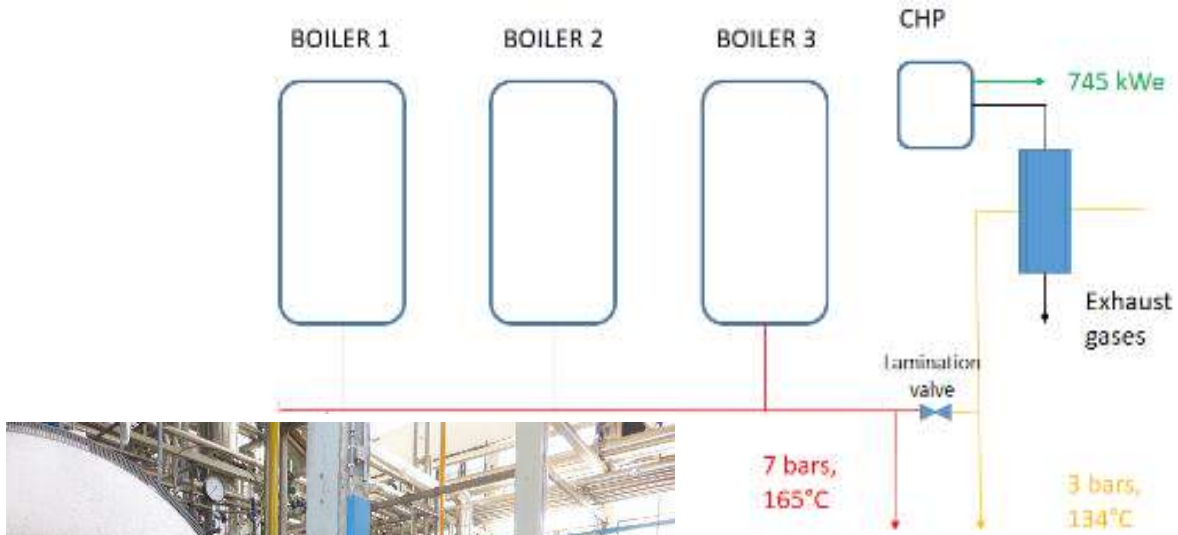
Second demo-site installed

Spirits distillitation
Pessione, Italy

MARTINI

Consumption: 759 526 m³ /year of natural gas





SHIP2FAIR

Second demo-site installed

Spirits distillitation
Pessione, Italy

MARTINI

600 m2 gross area **350 kWth peak power**

- *Dual use* of solar heat
  - Summer -> Steam at 3.7 bar – 150C
  - Winter -> Space heating at 70C
- Maximization of solar output -> 0.6MWh/m^2/y

- A well designed integration with users thermo-hydraulic circuit
- Reduction of the environmental impact of the entire production

- Technology: High Vacuum Flat Panels

TVP SOLAR

Solar Process Heat at M&R: Overview

- **Context:** Demonstration site under the H2020 **SHIP2FAIR** project
- **Solar thermal technology:** High Vacuum Flat Panels (HVFPs)
- **Site & Location:** Alcoholic beverage plant – Pessione, Turin, Italy
- **Global Horizontal Irradiance**: 1332 kWh/m²
- **Installation**: Rooftop
- **Collector surface**: 596 m2
- **Installed Power:** 327 kWp
- **Energy production**: 349,403 kWh/y (586 kWh/m2/y)
- **Configuration:** Oct-Mar: Hot water. Operating T: 90ºC (outlet)
  Apr-Sep: Steam. Operating T: 170ºC (outlet)
- **Installation completed:** Dec 2020; **Commissioning**: Feb 2021

3,4 c€/kwh

SHIP2FAIR project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 792276.

M&R solar system: Expected performance

SHIP2FAIR

Martini & Rossi - Italy

Fuel savings: 48.579 m^3/year
Solar system efficiency: 45 % (average)
56% (peak)

Budget of the solar system: 500K€ (approx.)
Financial model: CAPEX; EU funding

M&R solar system: feasibility

SHIP2FAIR

Objective: To maximise usable energy production all year round

Actions and results:

- ❖ Sizing of solar system: rooftop surface availability
- ❖ Energy generation: calculations – simulation on TRNSYS
- ❖ Dual operating mode: Hot water during winter period; Steam during summer period
- ❖ Sizing of indirect steam generator: calculating summer peak generation and max steam flowrate; 10% safety factor

M&R solar system: construction

SHIP2FAIR

1

Rooftop surface preparation

2

Beams for substructure

5

Indirect steam generator

3

Substructure for panel installation

4

Solar field installation completed

M&R solar system: Control & monitoring

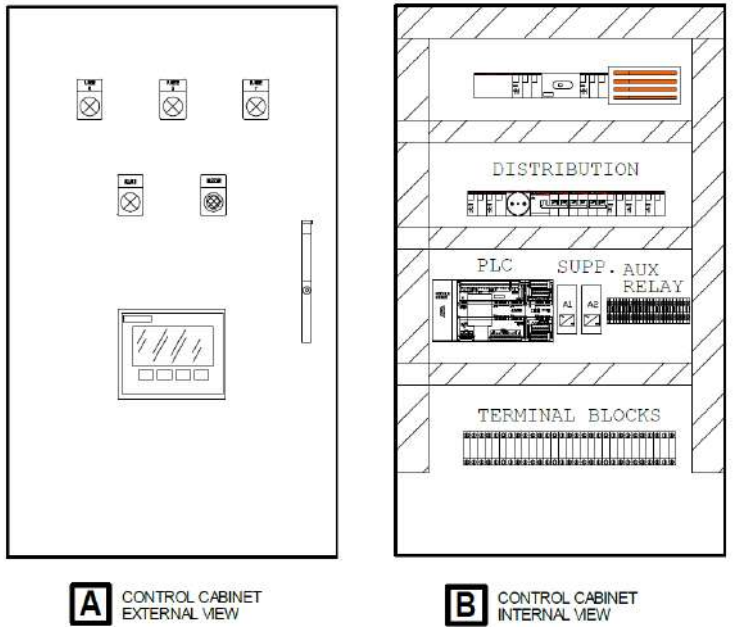
SHIP2FAIR

Control & monitoring system of the solar field:

- To achieve a stable and desired set point despite fluctuations in solar radiation
- To optimize solar system operation for maximum heat generation meeting thermal demand
- To monitor performance and key operational parameters of the solar system

Hybrid operation - hot water or steam generation: Options for system configuration:

- **Pre-set:** Oct-Mar: Hot water. Operating T 90ºC (outlet)
  Apr-Sep: Steam. Operating T 170ºC (outlet)
- **Advanced:** Dynamically adjusting configuration based on weather forecast



A CONTROL CABINET EXTERNAL VIEW

B CONTROL CABINET INTERNAL VIEW

Upcoming Demo

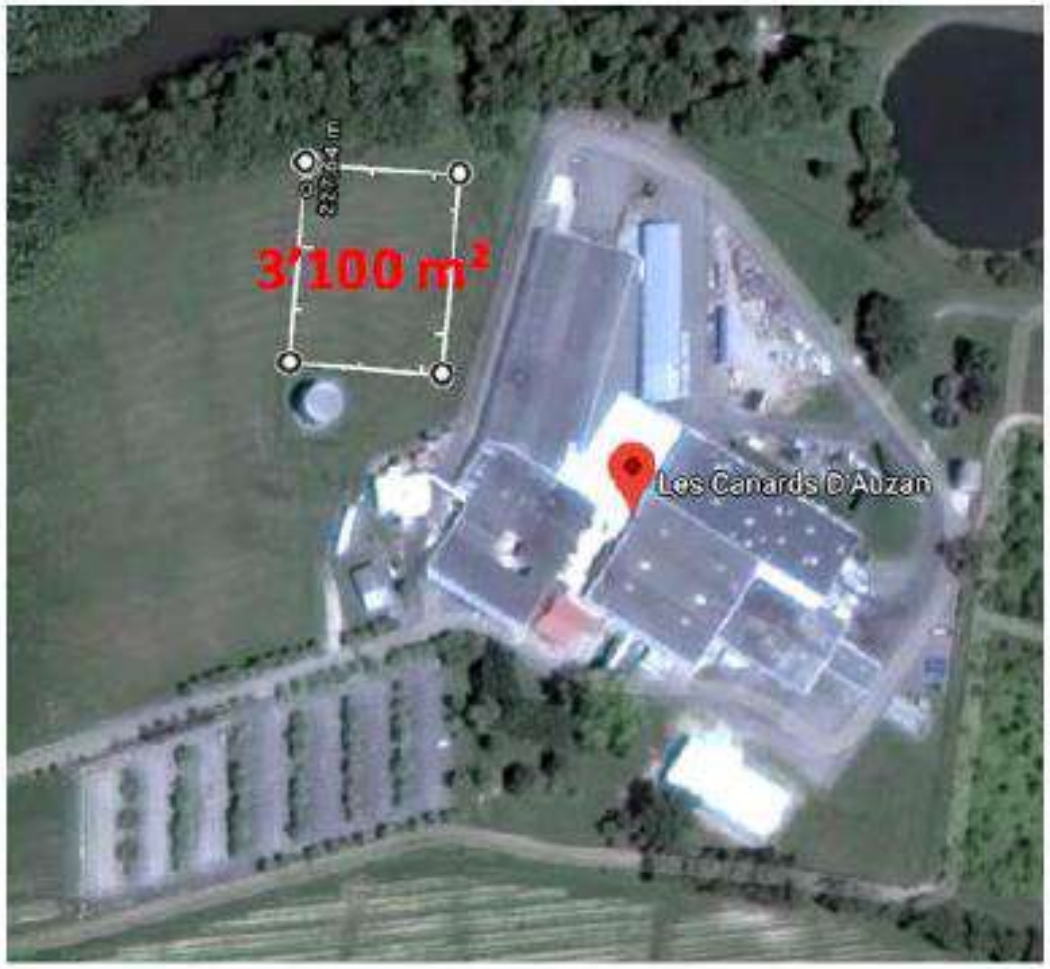
SHIP2FAIR

TVP SOLAR

Foie-gras production
Castelnaudary, France

Technology: HVFP
Solar Field size: 1600 m² – 1MW$_{th}$
1069 MWh/an
4 c€/kWh
Cascade application:

- Boiler feed water pre-heating @140C
- Water tank heating @65C

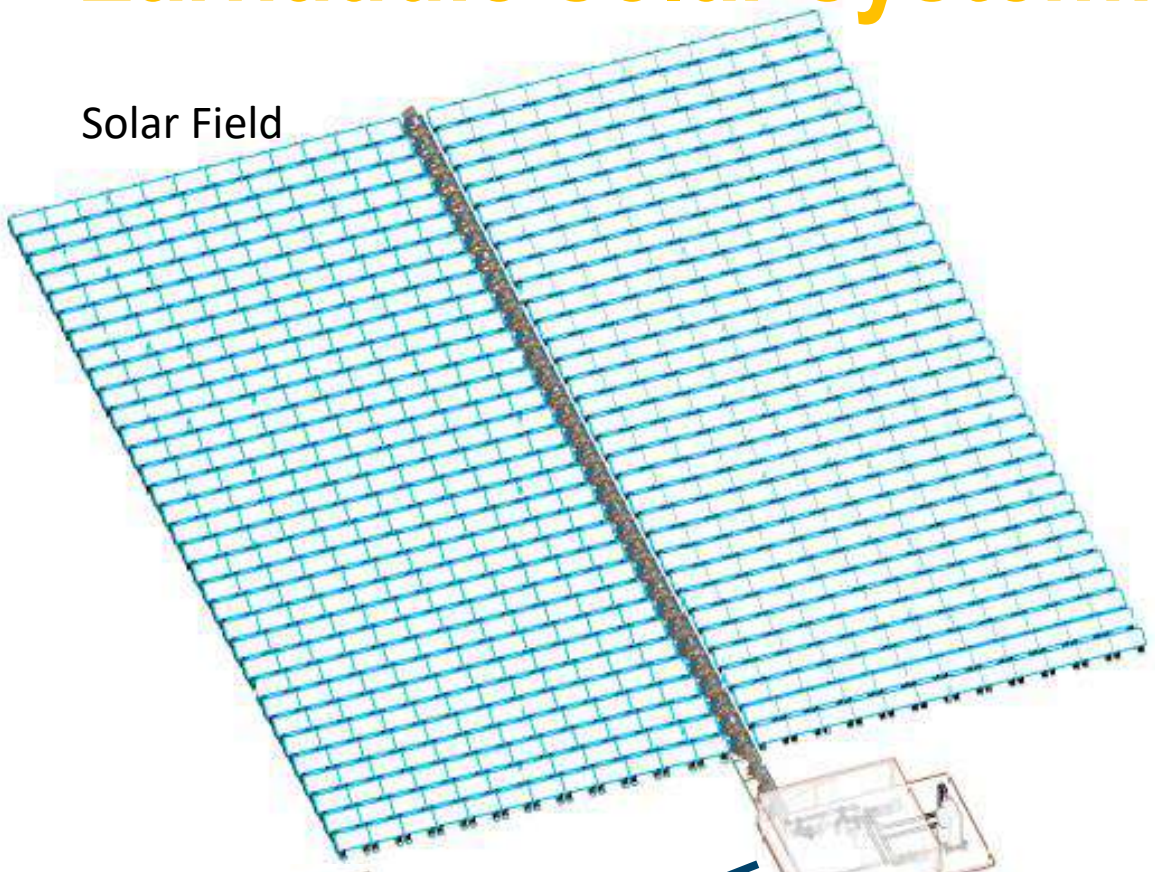


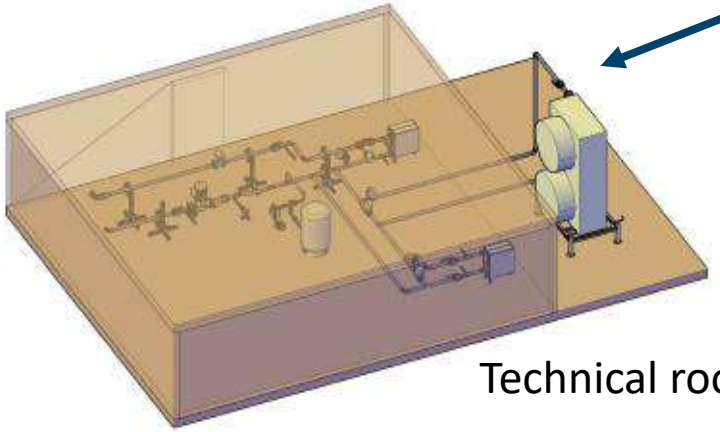
Larnaudie solar system: engineering

SHIP2FAIR

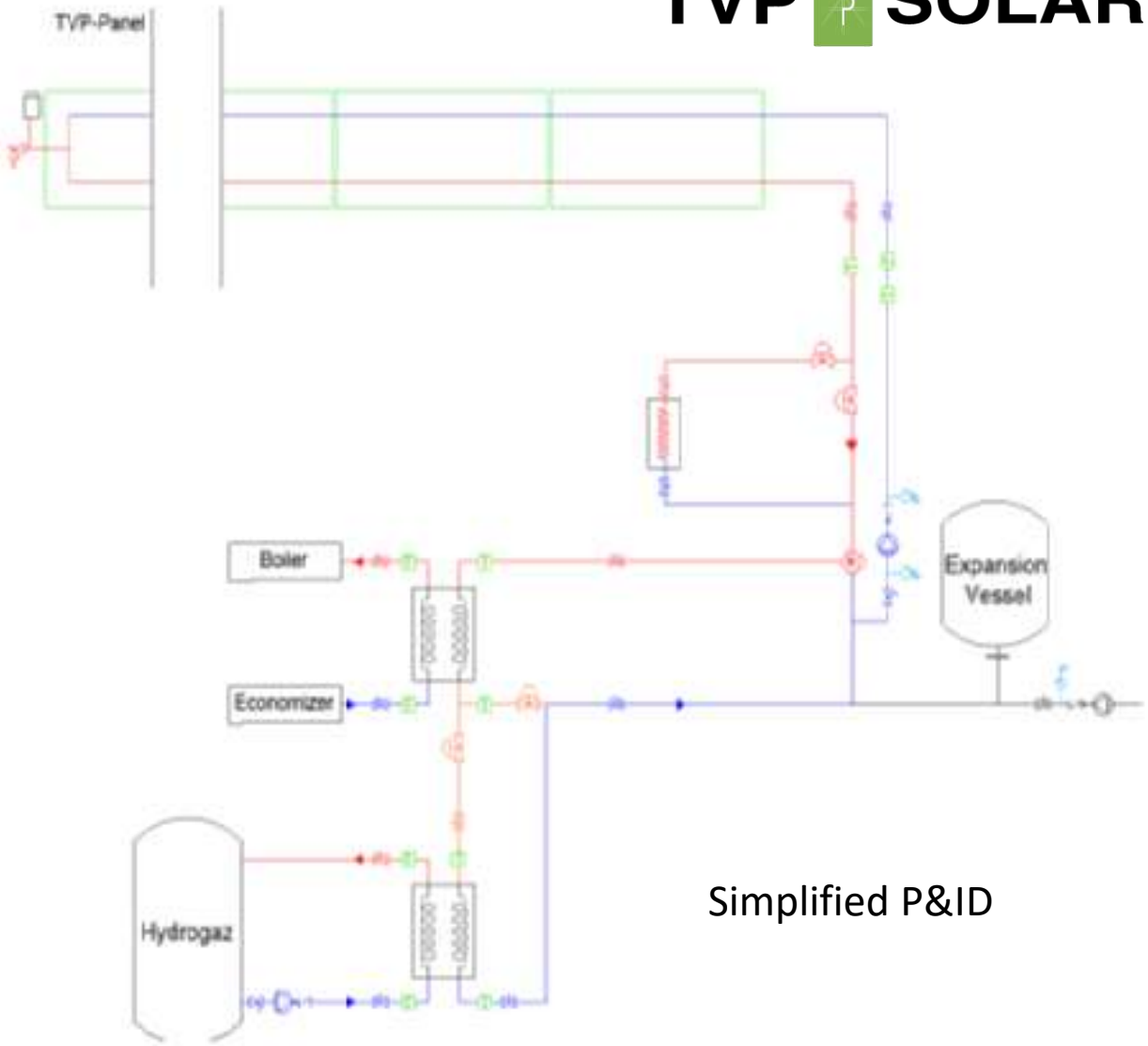
TVP SOLAR

Solar Field





Technical room



Simplified P&ID

Larnaudie experience: Issues to pay attention to Regulatory requirements

SHIP2FAIR

- Authorities not familiarized with industrial-scale solar systems
- Time consuming process with some uncertainty

SHIP2FAIR
Replication Tool

The Replication Tool is a software able to evaluate the **techno-economic potential** of SHIP solution, starting from **local solar potential** and current **process heat demand**.

This tool is able to provide a first outlook on the SHIP **integration within the process** and to **optimise the system** according to the user's needs.

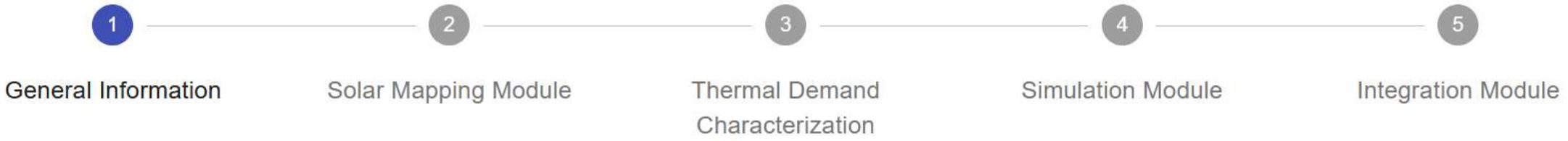
It provides:

- Evaluation of **solar field parameters** (sizing, technology, thermal storage requirements, etc.)
- Expected **energetic and environmental results** (solar fraction, energy savings, avoided emissions, etc.)
- Preliminary **economic figures**.

How does the RT work?

The Replication Tool (RT) is a **web tool**, which allows registered users to **run 5 modules** in sequence:

- General Information Module
- Solar Mapping Module
- Industrial Process Demand Characterization Module
- Simulation Module
- Solar Integration Module



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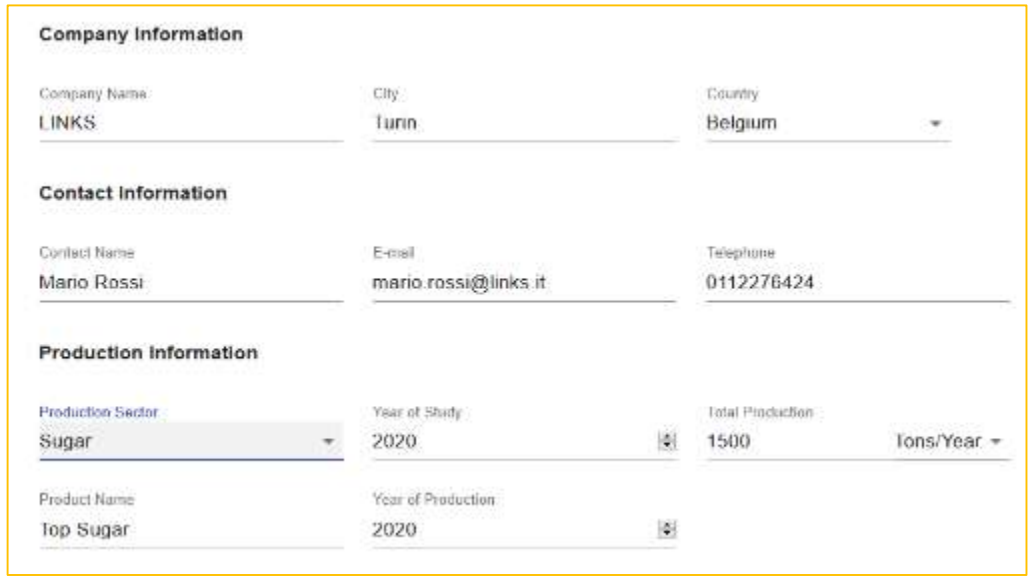
Module 1/5

General information

By using this module, the user can insert:

- **Company information**
  Company name, city and country.
- **Contact information**
  Contact name, email, phone.
- **Production information**
  Product name, Production Sector, Year of production, Total production (Tons/Year).



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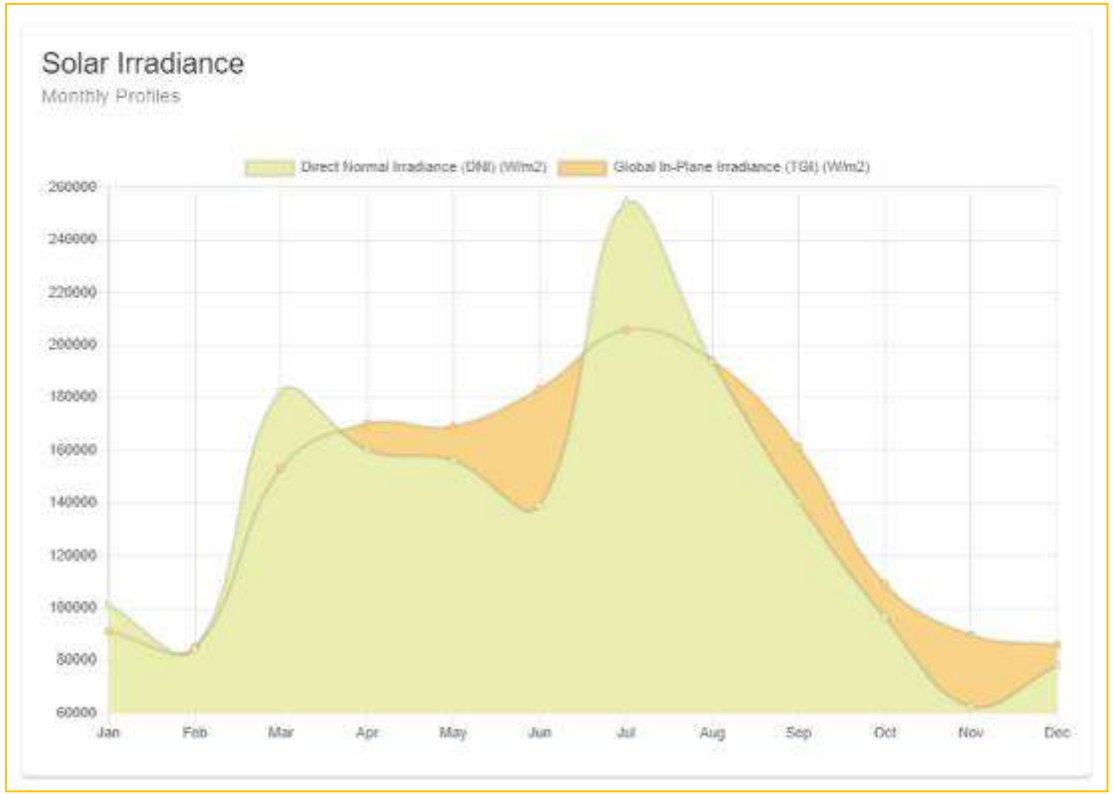
Module 2/5

Solar Mapping Module

This module estimates the solar thermal theoretical potential according to local conditions in terms of **solar irradiance** and usable **area** for installing solar thermal collectors.



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Module 2/5

The user inserts inputs in 3 sections:

- **Location of the industrial site**
  Latitude and longitude
- **Assessment of Solar Radiation and Sun Position**
  Panel's Azimuth and panel's Slope [optional]
  Reference period
- **Solar Field Characterization**
  Area for the collectors
  Type of installation (roof/ground, roof typology, roof orientation…)
  Corrective factors to reduce the area (Obstacles? Shading? Maintenance space?)

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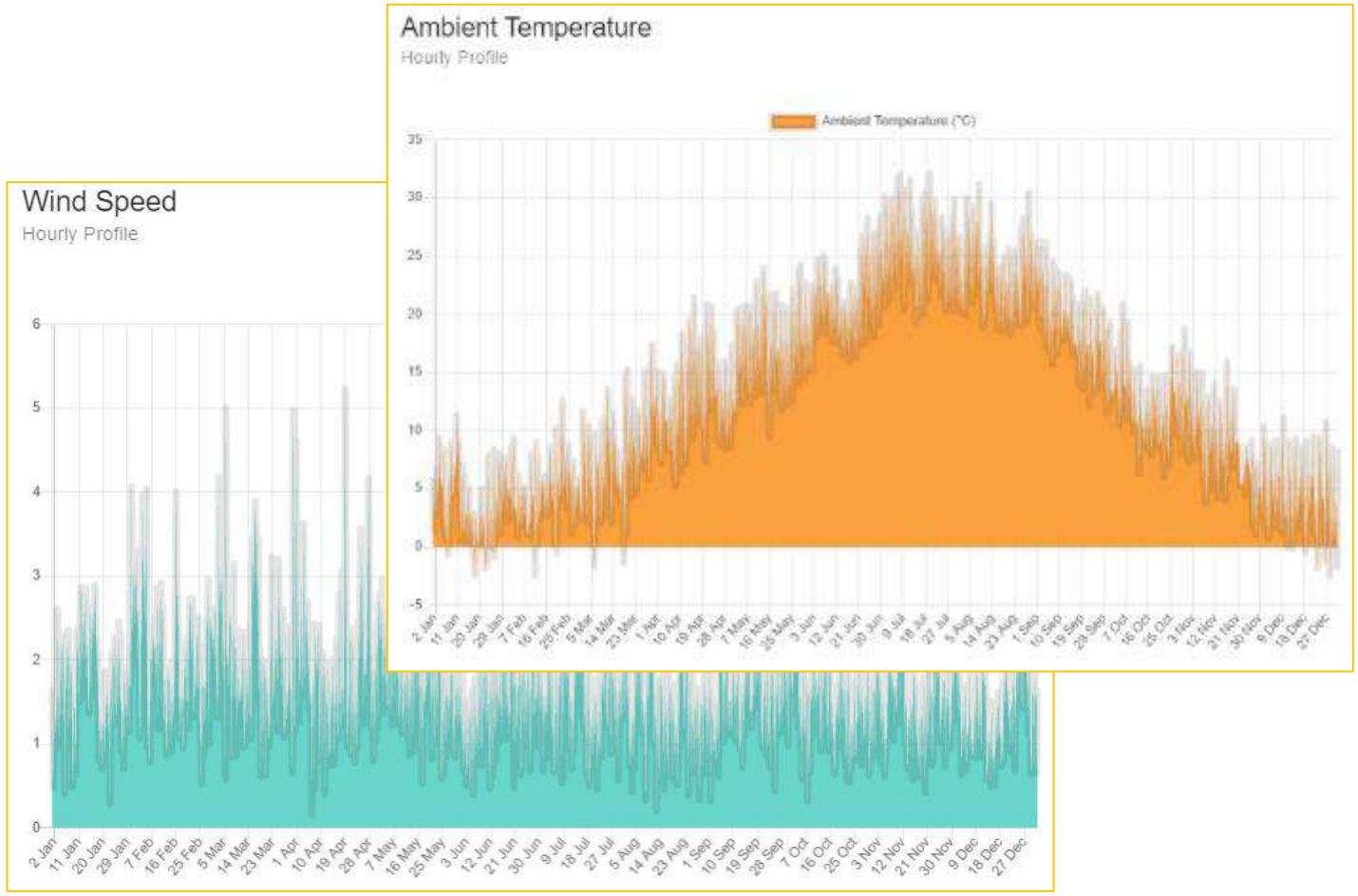
Module 2/5

Outputs:

- Solar irradiance (hourly profile)
- Optimized angles (slope and azimuth)
- Usable area
- Total corrective factor
- Ambient temperature (hourly profile)
- Wind speed (hourly profile)



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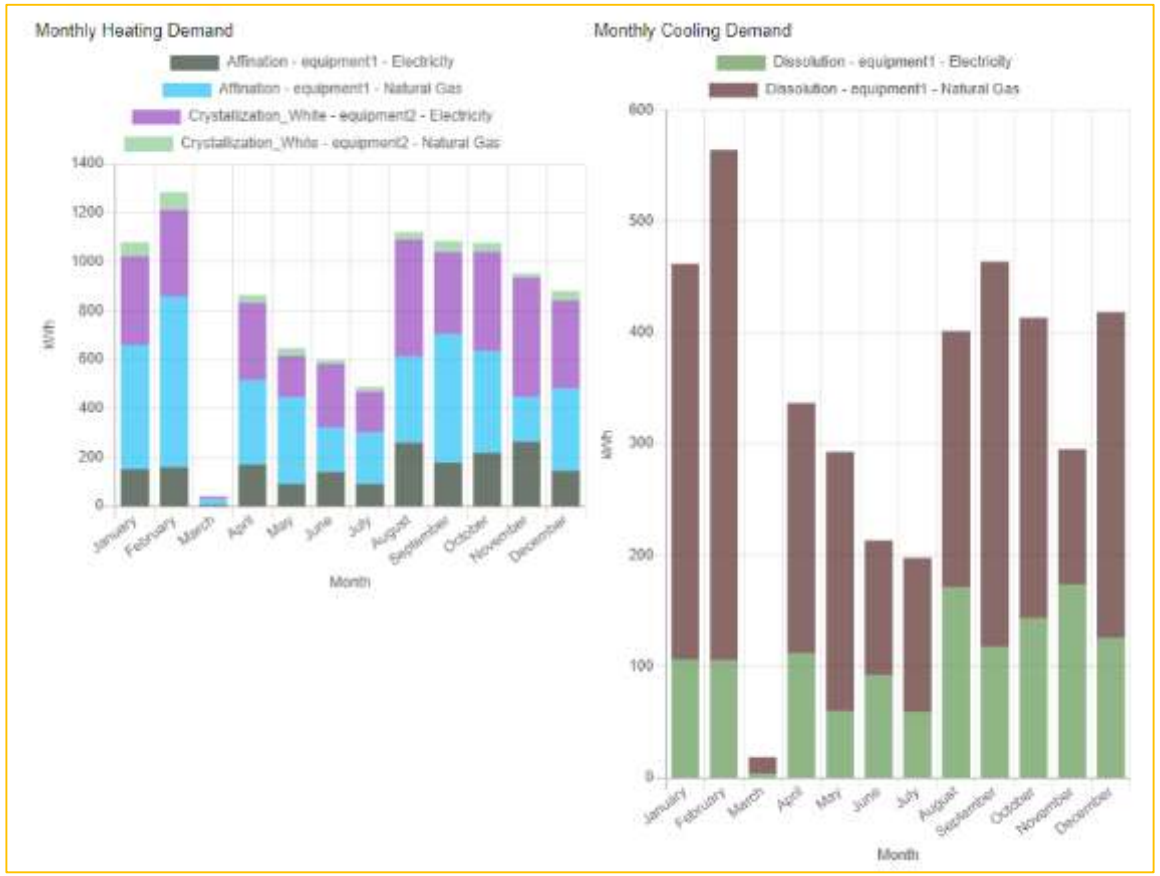
Module 3/5

Thermal Demand Characterization Module

This module estimates the **thermal demand** of the **industrial processes** selected by the user, using user's inputs about:

- the **energy sources consumption**
- the **equipment** involved
- the operating **schedule** of the different processes



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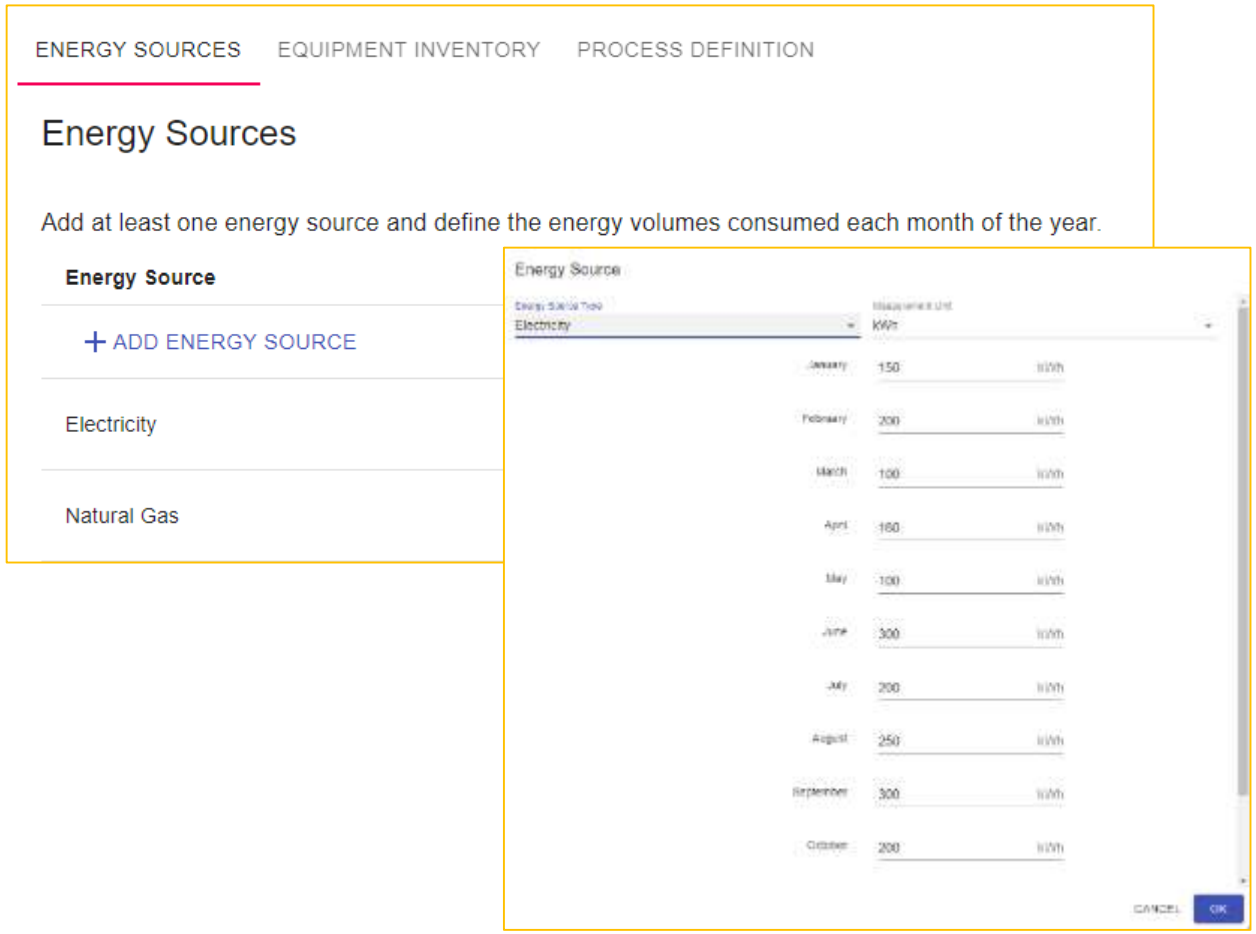
Module 3/5

The user inserts inputs in 3 sections:

- **Energy sources**
  Type (Electricity, Natural Gas, Diesel…)
  Consumption data from bills
- **Equipment inventory**
  Equipment name; type (boiler, chiller…); simultaneous units; energy source distribution; nominal power & load factor; efficiency; production processes supplied & nominal power.
- **Process definition**
  Thermal use (heating/cooling); working fluid (water/steam); operating temperature; consumption profiles to find the process schedule, loading and working hours (typical daily/weekly/yearly profiles).



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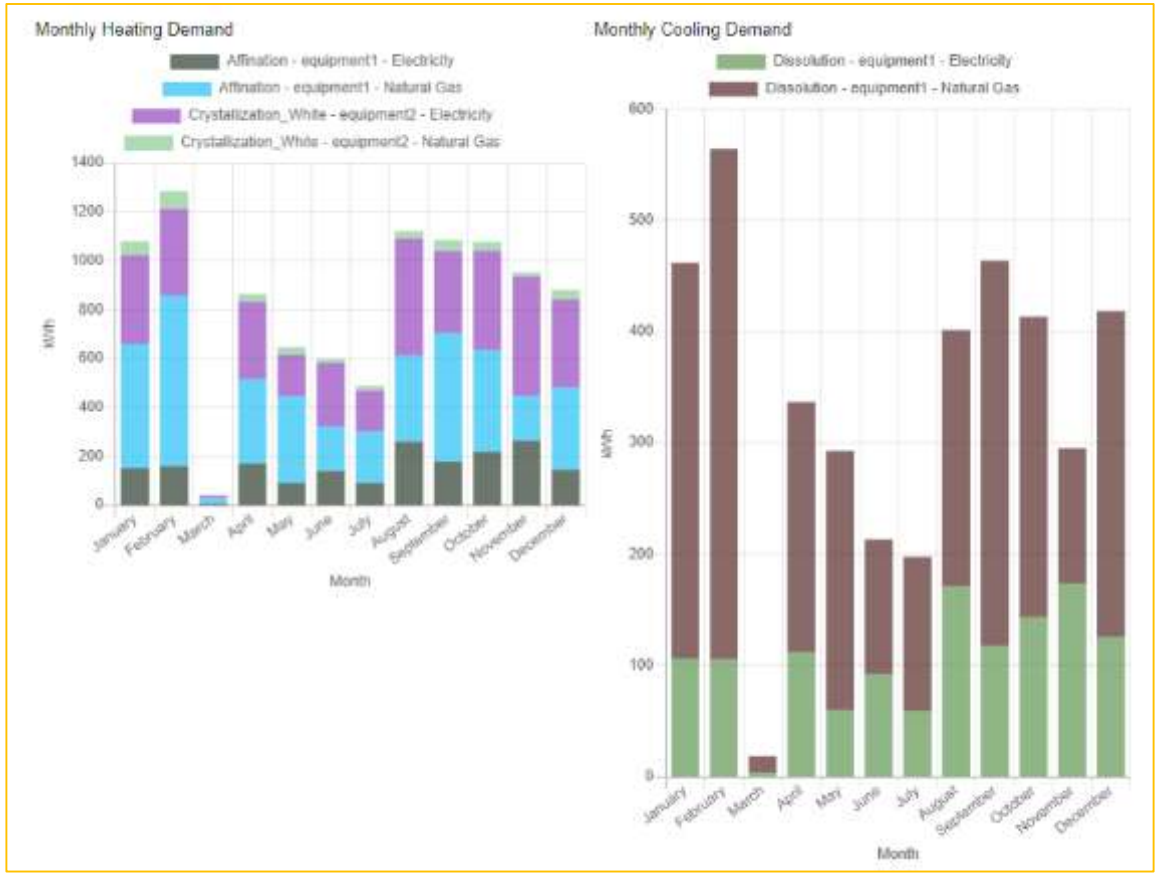
Module 3/5

Outputs:

- Total thermal demand
- Heating demand & Cooling demand
- Monthly demand distribution
- Process operating temperature
- Details of the thermal demand for each single process



Simulation Module

This module provides the **yearly solar heat** delivered to the process by **the user-defined solar plant** (solar field and thermal storage).

Several **Key Performance Indicators** are calculated to help the user evaluate the benefit of the solar plant from a **technical**, **environmental** or **economic** point of view.

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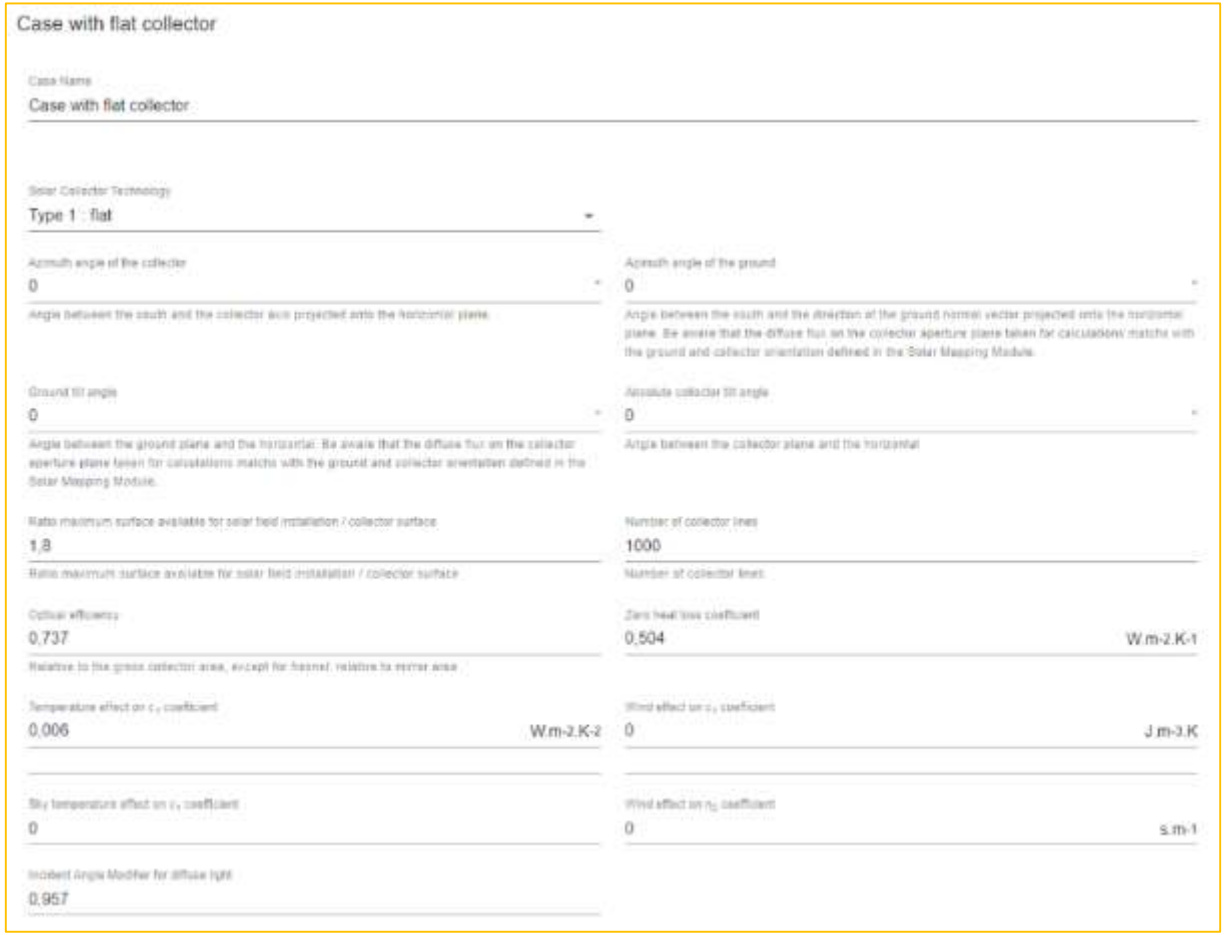
Module 4/5

The user inserts inputs in 2 sections:

- **Specific section for each case study**
  Solar collector technology; Azimuth angle (Collector/Ground); Tilt angle (Collector/Ground); Ratio collector surface/maximum surface available for solar field installation; Solar plant electricity consumption, lifetime, etc.
- **Shared section (common for all cases)**
  Storage type; storage fluid density; boiler efficiency; electricity cost; fossil energy cost, etc.



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Module 4/5

Outputs:

- Yearly solar energy production
- Entire collector surface
- Optical efficiency
  Relative to the available ground/collector surface
- Thermal efficiency
- Optical efficiency
- Solar plant overall efficiency relative to the collector
- Solar field outlet temperature reached ratio
- Thermal storage diameter
- Energy saving rate
- Return on Investment
- Payback period
- Energy inside the storage tank
- …

Solar integration Module

This module **identifies** and **ranks** which is the best **solar integration point** within the different process in the industry.

It aims to solve one of the most critical issues of solar technology, which concerns the evaluation of the dynamic **integration** within an industrial process.

It uses a **multi-optimization algorithm** approach based on:

- minimize the energy loss
- maximize the use of solar energy or maximize the ratio energy/losses

As a result, in a yearly and monthly basis, the **best combination of processes** to be fed by the solar energy is presented, with the **optimal area** and **volume** for the solar design.

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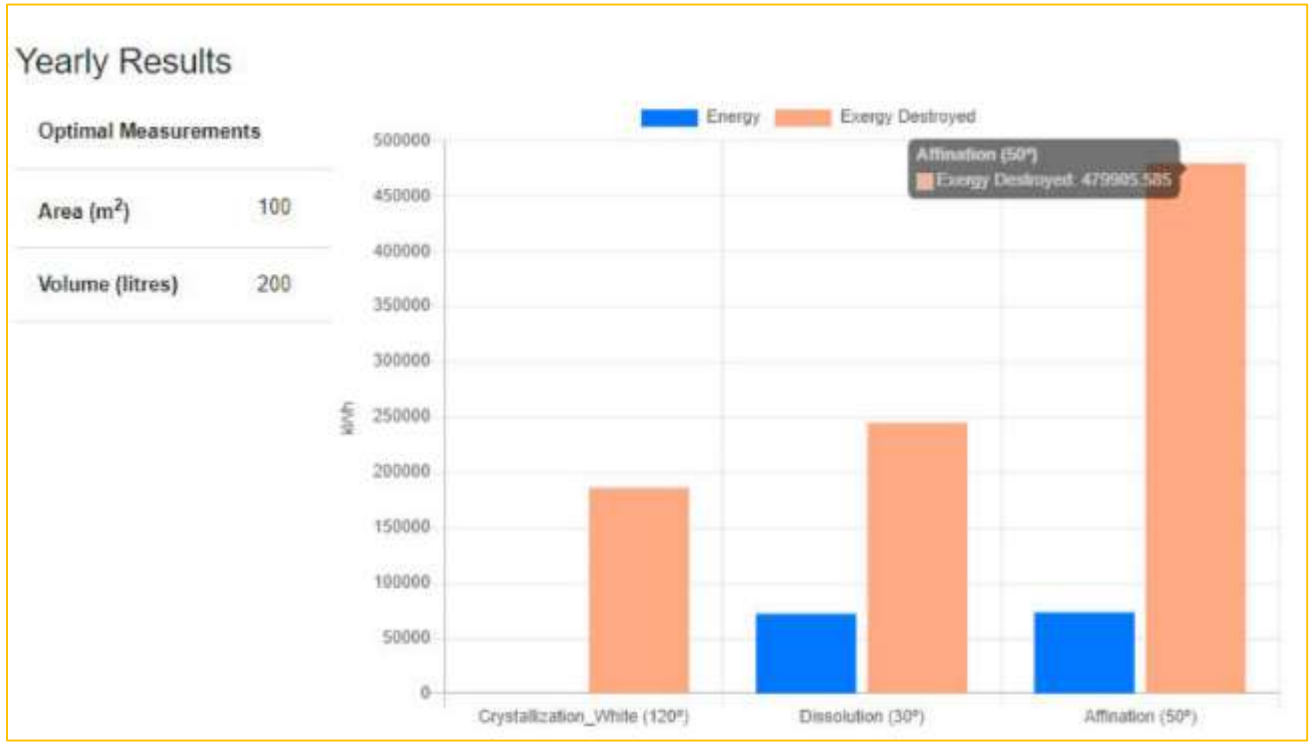
Module 5/5

Outputs:

- Yearly results
- Optimal area and volume for the solar design
- Monthly results
- The best combination of processes to be fed by the solar energy (in monthly basis)



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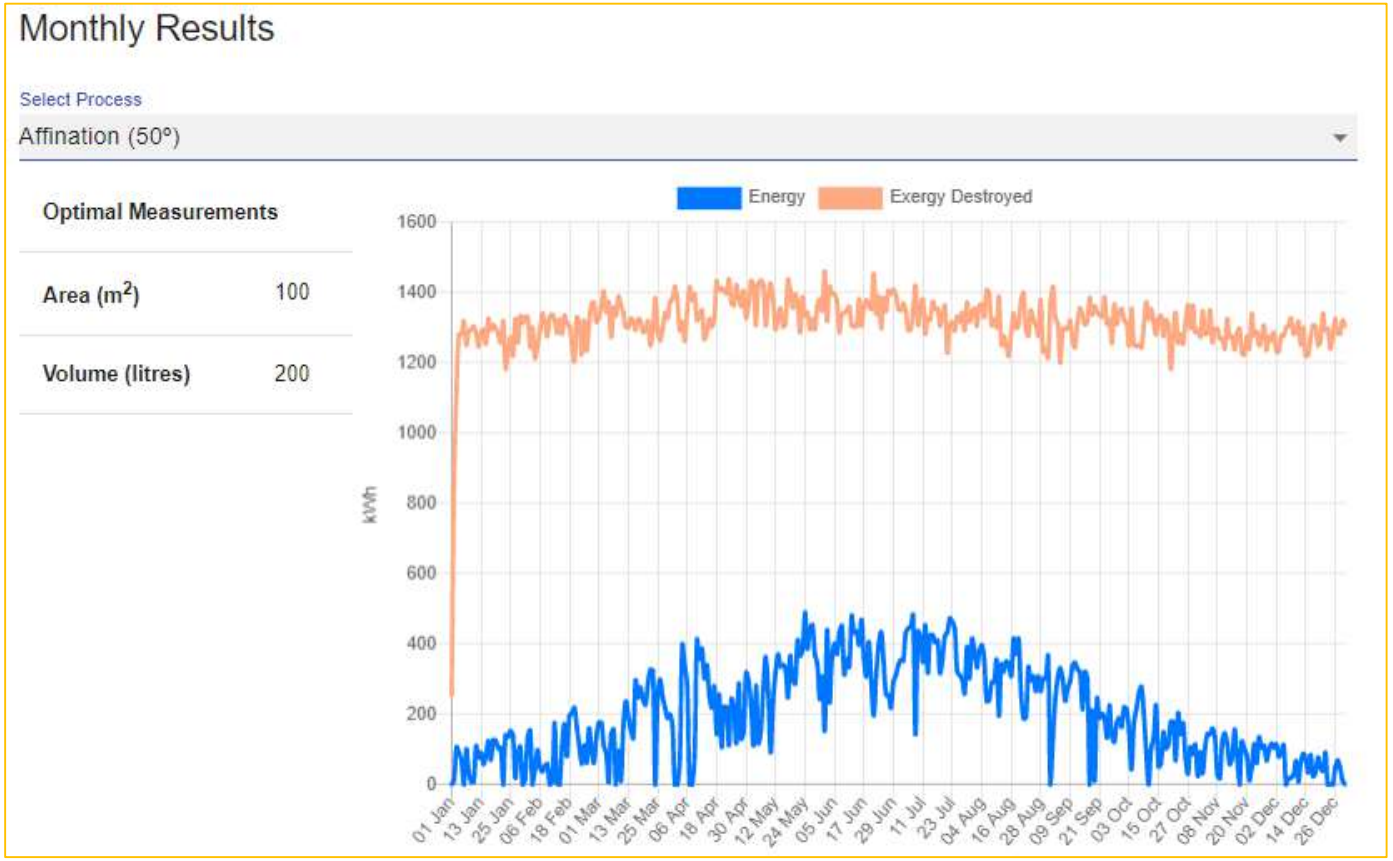
Module 5/5

Outputs:

- Yearly results
- Optimal area and volume for the solar design
- Monthly results
- The best combination of processes to be fed by the solar energy (in monthly basis)



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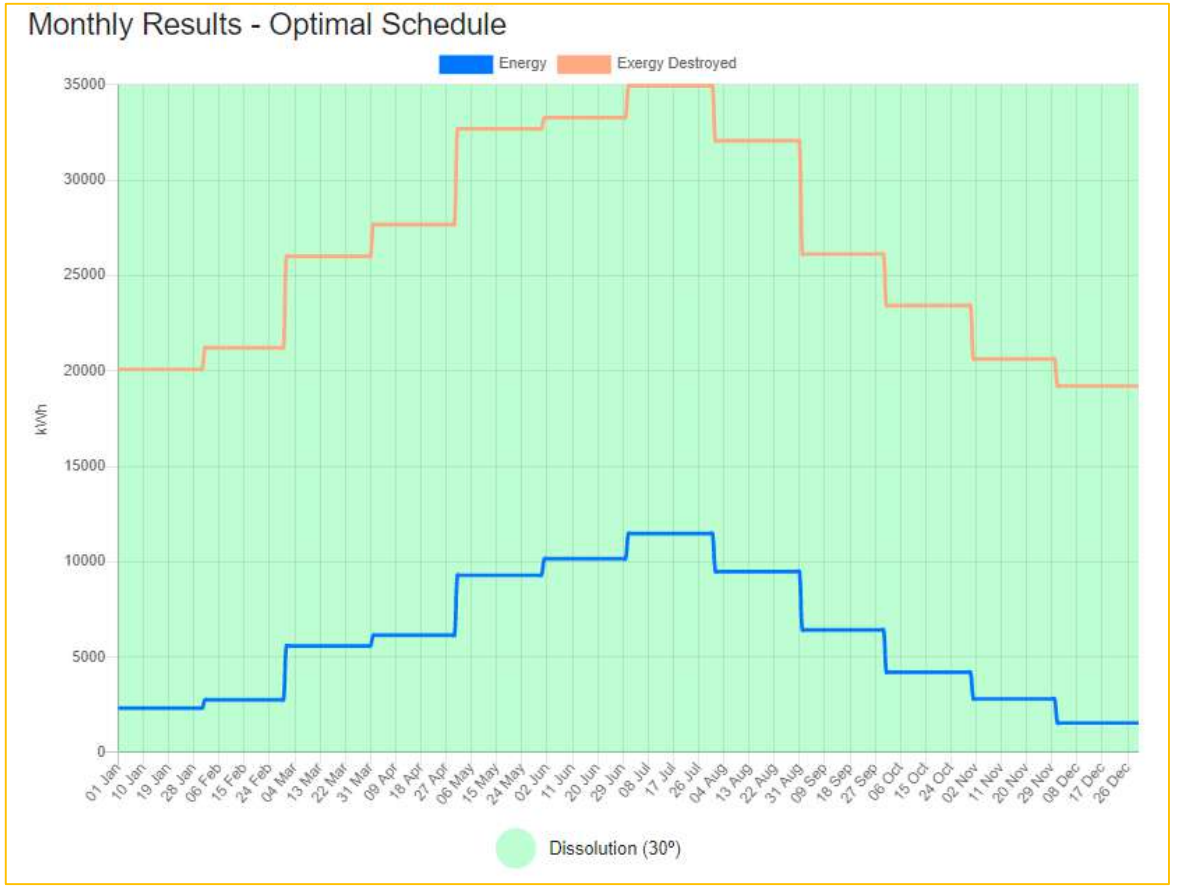
Module 5/5

Outputs:

- Yearly results
- Optimal area and volume for the solar design
- Monthly results
- The best combination of processes to be fed by the solar energy (in monthly basis)



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Where do I find the Replication Tool?

https://replicationtool.ship2fair.cloud

(Currently in Beta testing)

Motivation of the Control Tool

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1. **Coordinate, monitor and management of the solar heat flow** in a production environment, according with the SHIP2FAIR philosophy of **flexibility** / **simplicity** /**scalability** / **replicability** / business appealing.
2. To **identify** the **most convenient control strategies** allowing to **make the most** of the **solar production**.
3. To **develop** a **model predictive control (MPC)** to **optimize the management** of **solar production** integrated **with thermal energy storages** (TES), already installed **process heating** and **combined heat and power** (CHP) generators.

Structure of the Control Tool

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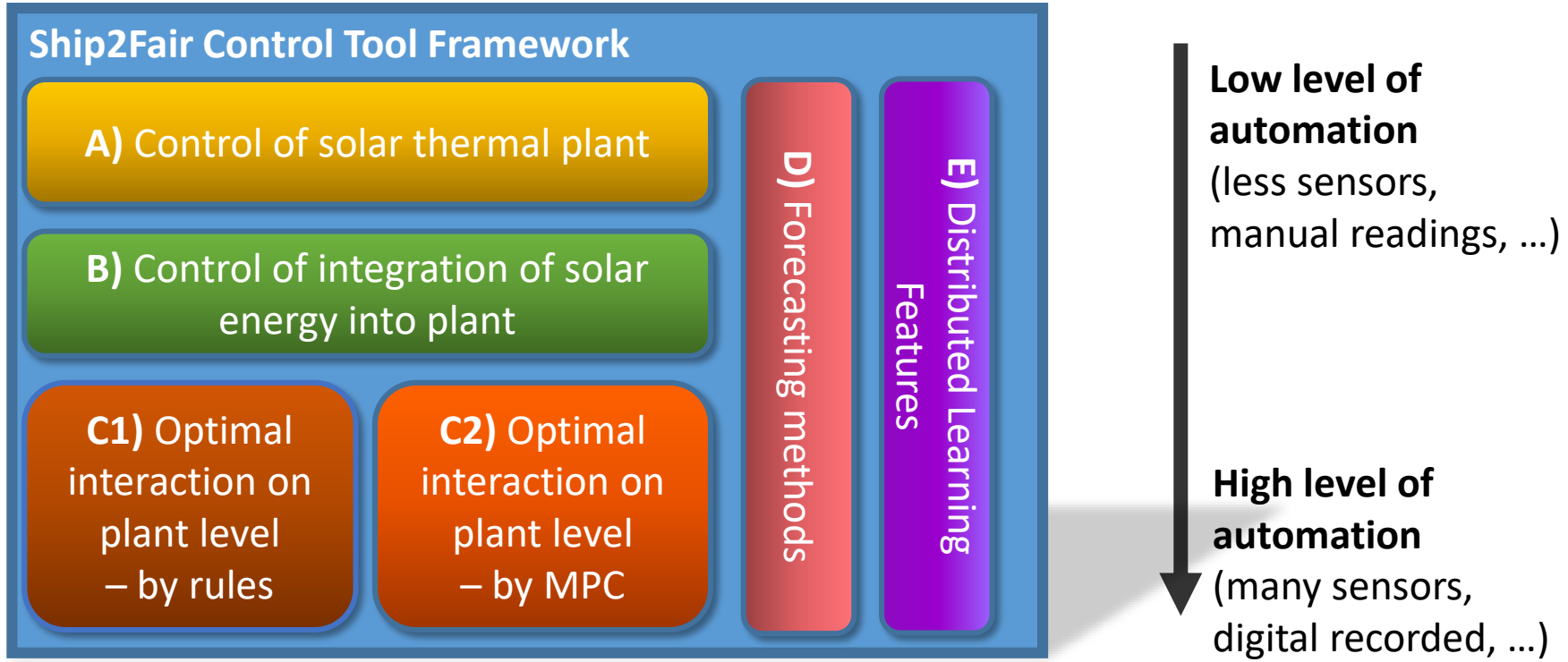
- **Consists of a Framework of 5 MODULES which allow to make the most of the solar production.**

- MODULES are chosen based on the possibilities available on-site
- Chosen MODULES form specific CONTROL TOOL for a plant



Control Tool Framework modules related to plant

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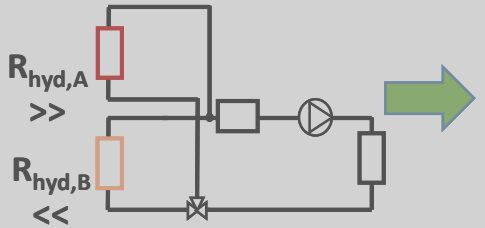
B) Control of integration of solar energy into plant

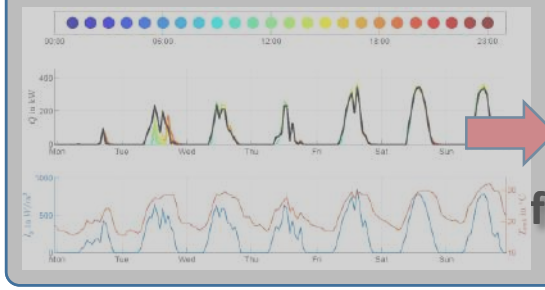


Goal: stable hydraulic condition

E) Distributed Learning Features

Goal: efficient & smart monitoring

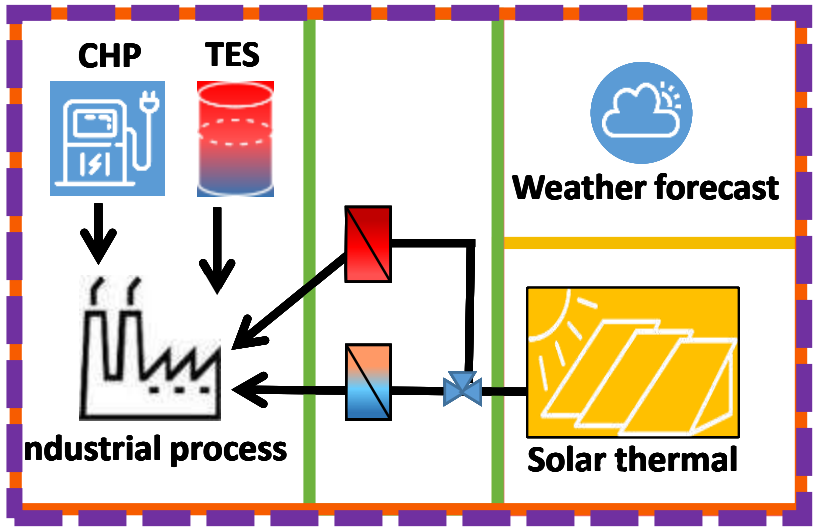
D) Forecasting methods



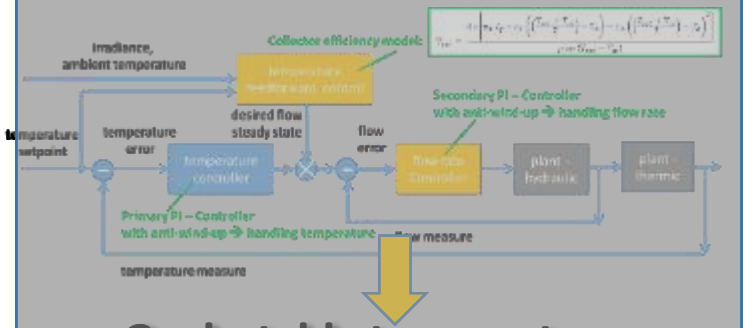
Goal: future heat forecast

C2) Optimal interaction on plant level

Goal: optimal overall control



A) Control of solar thermal plant



Goal: stable temperature

Exemplarily application of the MPC

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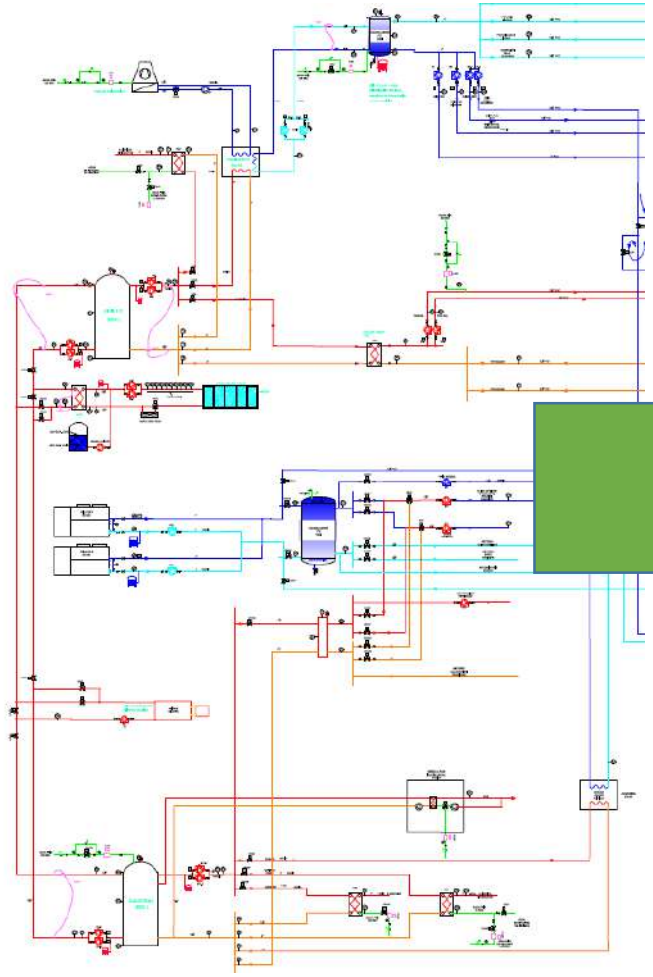
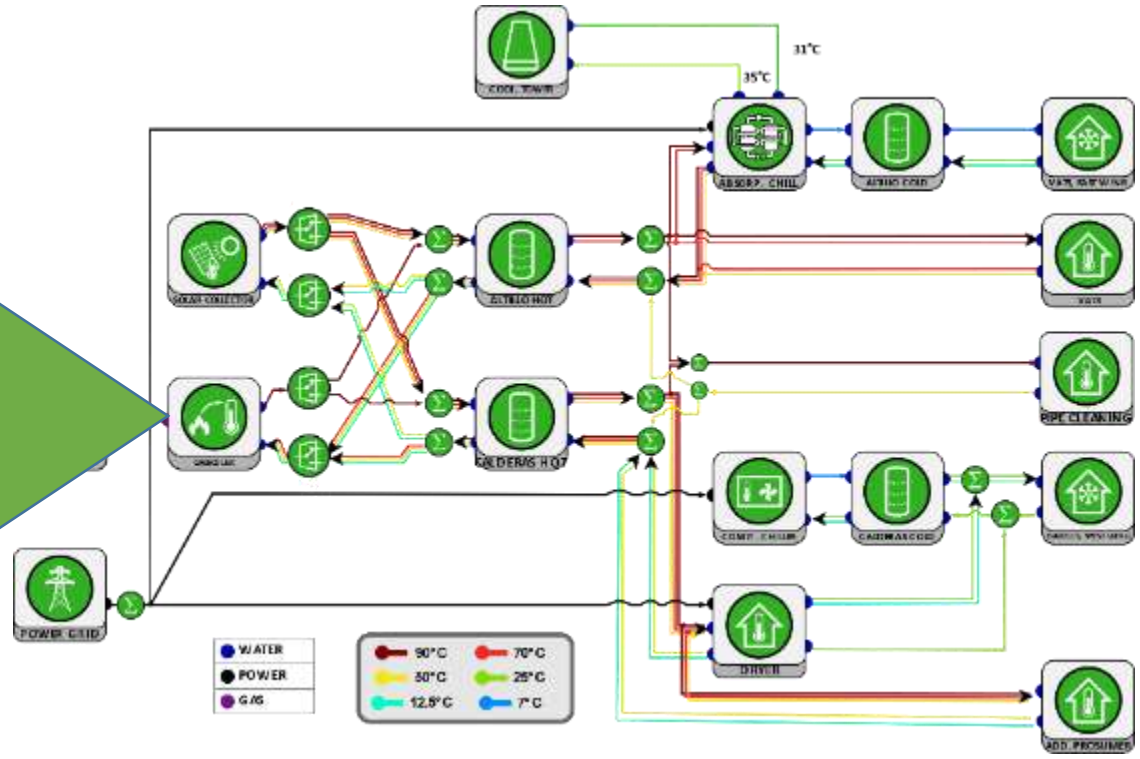
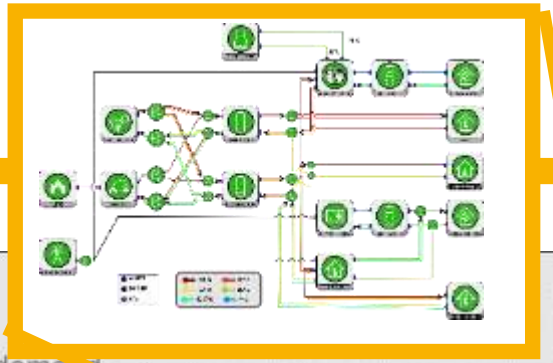


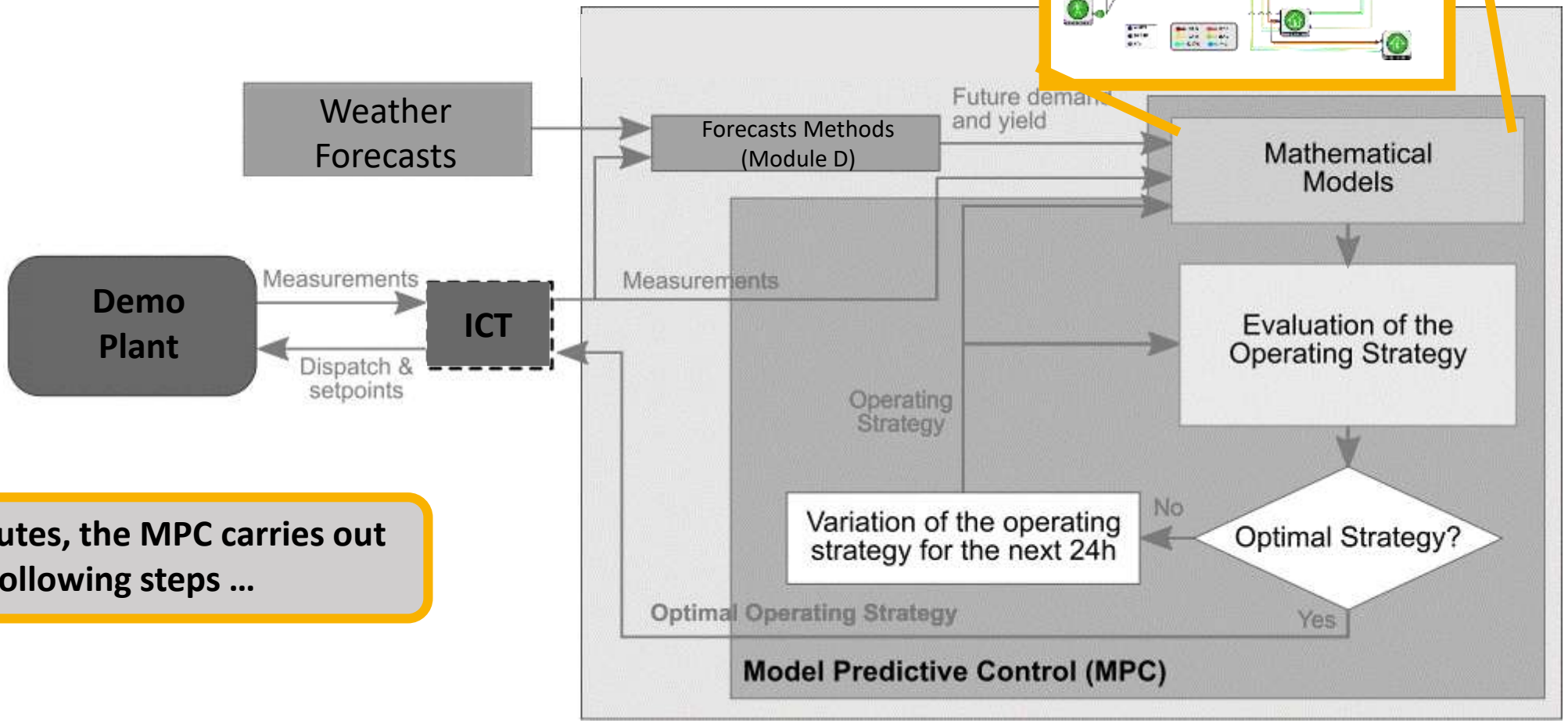
Based on the real structure of the system, the right models are combined



Model represents the whole system and its connections and considers prices for heat, gas, electricity, …

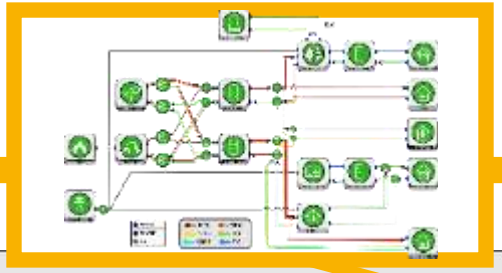
Simulation of MPC for RODA





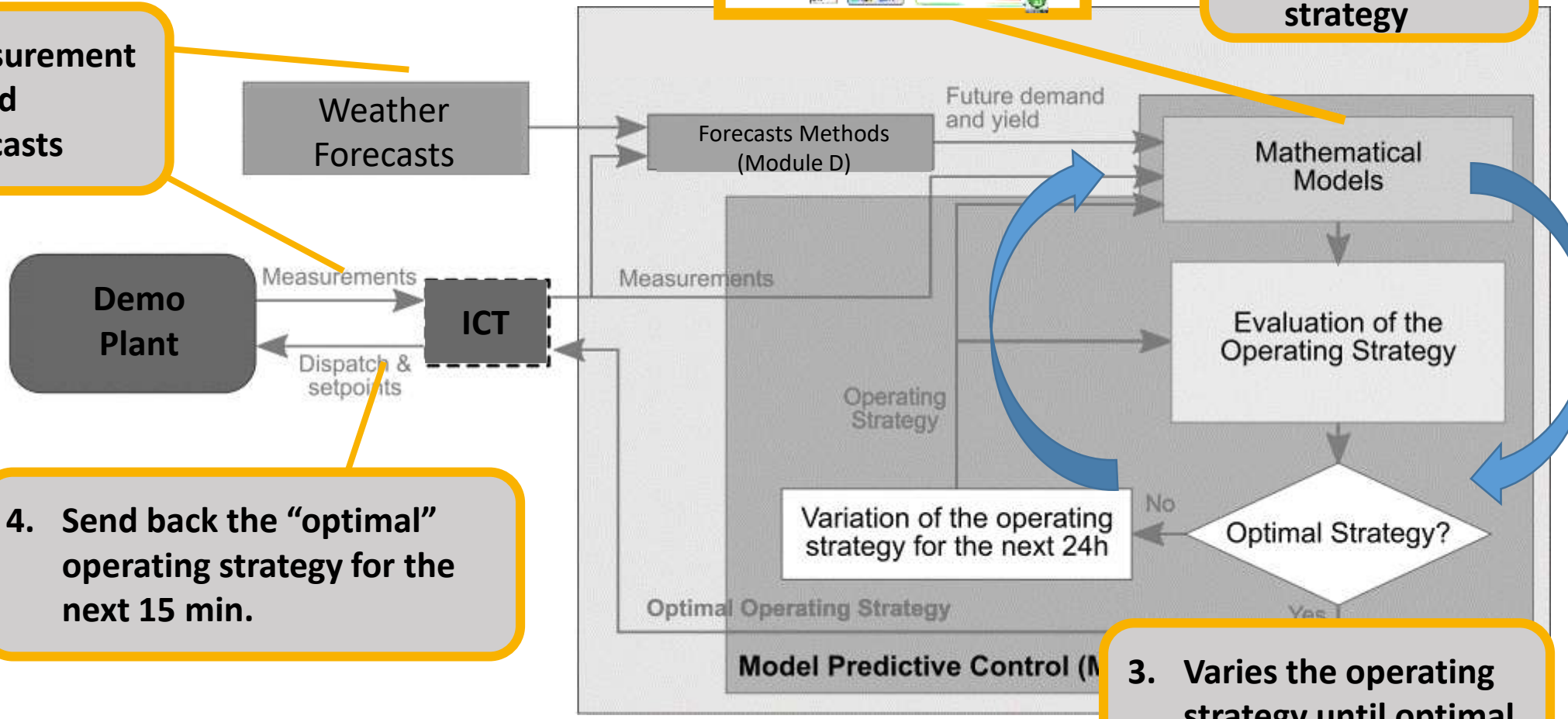
Every 15 minutes, the MPC carries out the following steps …

Simulation of MPC



1. receives measurement from plant and weather forecasts

2. Initialize the model and tries operating strategy



4. Send back the "optimal" operating strategy for the next 15 min.

3. Varies the operating strategy until optimal one is found

Implementation and Integration of the Control Tool

Planned integration of Control Tool

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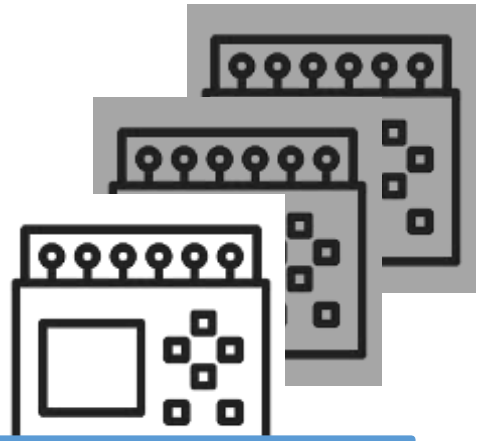
Frontend (=Browser)
Representation of Data for User



Server
Conn. Weather forecasts

MODULE C)Opt. whole plant by MPC

MODULE D) Forecasts solar prod.

Server
Data handling/ICT

MODULE E) Distributed Learning Features

Plant Level (programmable logic controller =PLC)
Control of plant in real time

MODULE A) Control of Solar thermal plant

MODULE B) Control solar plant integration.

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The Capacity Building Program

- 500 professionals
- 400 undergraduates
- 100 Master students

Will be trained via master classes and visits to the demo-sites with the double benefit of a more prepared workforce & a good number of potential users

Will contribute to create

Feasibility studies in 10 additional sites **by the end of the project**

Will help to set the ground for

- 75 EU agro-food industries
- 25 plants from other industrial sectors **after SHIP2FAIR**

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Thank you!

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www.ship2fair-h2020.eu

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