

THE SO_PRO Project



*Greek Experiences with Solar Thermal
Process Heat Installations*

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***A synthesis of information from
3 EU projects
12 GSR projects
and 2 TPF contacts***

<i>in</i>	<i>8 industrial sectors</i>
<i>within</i>	<i>4 process types</i>
<i>to displace</i>	<i>5 types of fuel</i>

GSR= Guaranteed Solar Results

TPF=Third Party Financing

CIP=Cleaning in place

A synthesis of information from

3 EU projects = PROSESOL I, PROSESOL II, SACH

*10 GSR projects = Tyras, Alpino, Mandrerkas, Plektemboriki,
Tripou, Kastrinoyiannis, Alegro, Isto, Kozani,
Sarantis,*

2 TPF contacts = Achaia Clauss Winery, MEVGAL dairy

*in 8 industrial sectors= wine, dairies(milk, cheese, butter, yogurt),
olive processing, tanneries, dying-finishing,
cloth processing, greenhouses, cosmetics,
within 4 process types= CIP, boiler feeding preheating, cooling for
handling product, space heating*

to displace 5 types fuel=diesel, heavy oil, LPG, NG, electricity

Contents of the presentation

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Brief on 5 industrial sectors to match STPH into

Brief on 12 Greek projects with STPH

Selection of 3/12 projects and analysis

Details of the ACHAIA winery TPF contact and energy performance

Details of the MEVGAL dairy TPF contact and energy performance

Details SARANTIS cosmetics GSR contact and energy performance

Industrial Sectors

- Food Industry
- Agriculture
- Textiles
- Chemical industry
- Beverages

Solar thermal systems are particularly effective in industries which require relatively low water temperatures (i.e. 40 – 80 °C).

Food Industry

- Dairies
- Confectioneries
- Tinned goods
- Olive oil refineries
- Slaughter houses



Agriculture

- Drying
- Greenhouses
- Nurseries
- Farms
- Livestock landings



Textiles

- Tanneries
- Leather treatment
- Cloth refineries
- Dyeing/finishing
- Textile processing



Chemical industry

- Cosmetics
- Detergents
- Pharmaceuticals
- Wax
- Distilleries



Beverages

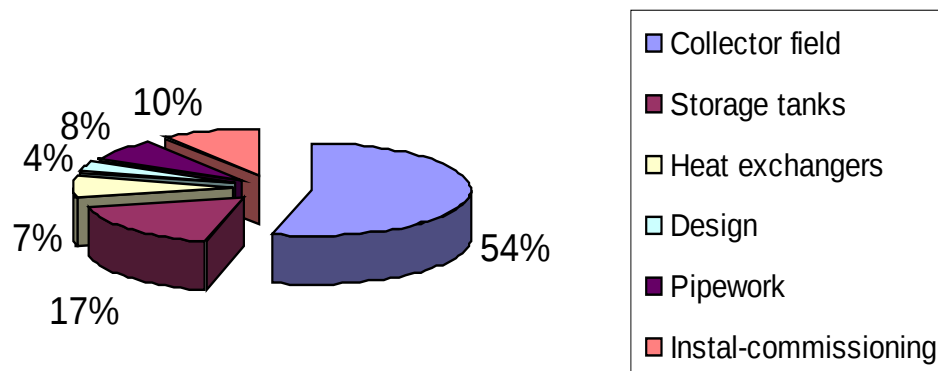
- Wineries
- Liquor distilleries
- Breweries
- Soft drinks
- Fruit juices



Economic Evaluation of Solar Systems (a Hellenic case study)

ALLOCATION OF COST BY SYSTEM COMPONENT

(based on an indicative system total cost 180 Euro/m²)



- Interest rate = 8%
- Boiler efficiency = 0.85
- Collector performance = 800 kWh/year/m²
- Coupling factor = 0.8
- Total cost = 180 €/m²

Table 1. Economic evaluation	Fuel	Fuel price 3/2000	Payback (years) 180 €/m ²	Payback (years) 90 €/m ²
	Diesel oil	0.628 €/kg	3.6	1.8
	LPG	0.540 €/kg	4.2	2.1
	fuel 1500	0.295 €/kg	7.7	3.8
	Natural gas	0.02 €/kWh	8.5**	4.2**

Achaia Clauss S.A. Winery, Patras (1993)

Use: Hot water for cleaning and sterilising bottles (60-85 °C)



- Collector area: 308 m² (black paint (sandwich) flat plate), closed loop water circuit, 6000 litre storage
- TPF financing (50% CRES (of which 50% SPA 1990), 50% SOLE S.A)
- Fuel replaced: Diesel

Allegro S.A. Clothes Processing, Athens (1993)

Use: Hot water for washing clothes (40-90 °C) and pre-heating of steam boiler (steam used in steam presses).



- Collector area: 55 m² (black paint (sandwich) flat plate) , closed loop water-glycol circuit, 1500 litre storage
- 50% public subsidy (SPA 1990)
- Fuel replaced: Diesel

Kastrinogiannis S.A. Textile Dyeing/Finishing, Heraklion (1993)

Use: Hot water for pre-heating steam boiler (Dyeing of textiles)



- Collector area: 180 m² (selective flat plate) , closed loop water-glycol circuit, 10000 litre storage
- 50% subsidy – SPA 1990
- Fuel replaced: Heavy oil

Mandrekas S.A., Dairy, Korinthos (1993)

Use: Hot water for yoghurt maturing process (40 °C)



- Collector area: 170 m² (black paint flat plate) , open loop water circuit, 2000 litre storage
- 50% public subsidy – SPA 1990
- Fuel replaced: Liquid Propane Gas (LPG)

Tripou-Katsouri S.A., Tannery, Athens (1993)

Use: Pre-heating of water entering steam boiler (40 – 90 °C).



- Collector area: 308 m² (black paint (sandwich) flat plate) , closed loop water circuit, 7500 litres storage
- 50% public subsidy – SPA 1990
- Fuel replaced: Natural gas

Kozani Greenhouses S.A., Kozani (1993)

Use: Hot water for under and over floor space heating (40-45 °C)



- Collector area: 80 m² (black paint flat plate) , closed loop water-glycol circuit, 4400 litre storage
- 50% public subsidy – SPA 1990
- Fuel replaced: Heavy oil

Plektemboriki S.A. Olive nets, Heraklion (2000)

Use: Hot water for olive net processing (90 °C).



- Collector area: 50 m² (black paint flat plate) , closed loop water-glycol circuit, 2500 litre storage
- Private investment
- Fuel replaced: Electrical resistance

Alpino S.A. – Dairy, Thessaloniki (2000)

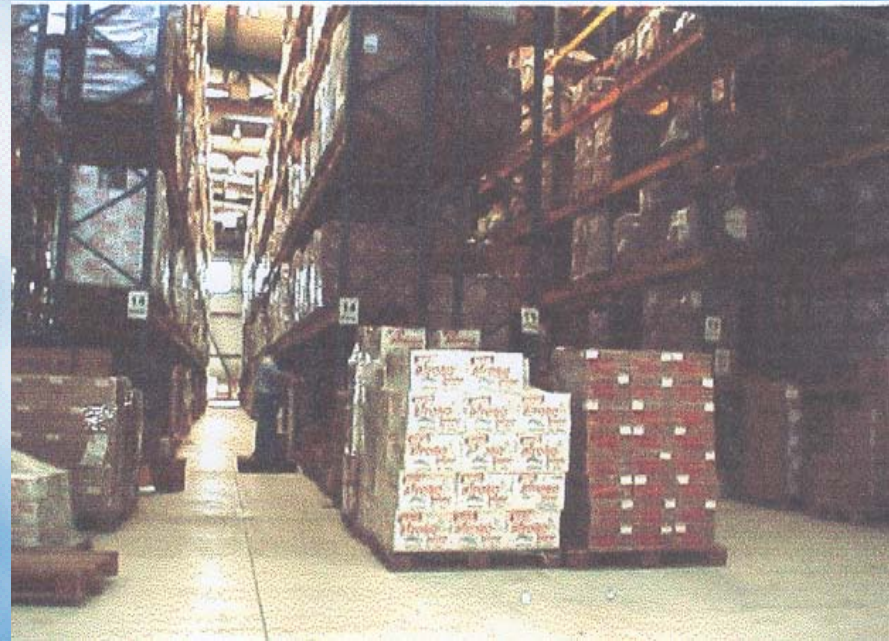
Use: Hot water for pre-heating of water entering the steam boiler
(steam used in CIP washing machine)



- Collector area: 576 m² (selective flat plate) , closed loop water-glycol circuit, 25000 litre storage
- 50% public subsidy (GSR contract) – O.P.E National
- Fuel replaced: Heavy oil

Sarantis S.A., Cosmetics, Oinofita (2000)

Use: Space cooling and heating for stock warehouse
(Cold water 7-12 °C, Hot water 40-45 °C)



- Collector area: 2700 m² (selective flat plate) , closed loop water-glycol circuit, 2500 litre storage
- GSR contract - 50% subsidy – O.P.E National
- Fuel replaced: Diesel

Tyras S.A., Dairy, Trikala (2001)

Use: Hot water for pre-heating of water entering the steam boiler
(steam used in CIP washing machine)



- Collector area: 1040 m² (selective flat plate) , closed loop water-glycol circuit, 80000 litre storage tanks
- 50% public subsidy (GSR contract) – O.P.E National
- Fuel replaced: Heavy oil

Mevgal S.A., Dairy, Thessaloniki (2002-2010)

Use: Hot water for CIP (**Clean in Place, 60-90 °C**) and pre-heating of water entering steam boiler



- Collector area: 727 m² (selective flat plate, black paint flat plate, CPC) , closed loop water-glycol circuit, 10000 litre storage
- TPF contract (CRES 73.5%, MEVGAL 20%, ATE 6.5%)
- Fuel replaced: Heavy oil

Selection of 3/12 projects and analysis

Details of the ACHAIA winery TPF contact and energy performance

Details SARANTIS cosmetics GSR contact and energy performance

Details of the MEVGAL dairy TPF contact and energy performance

***Details of the ACHAIA winery TPFcontact and
energy performance***

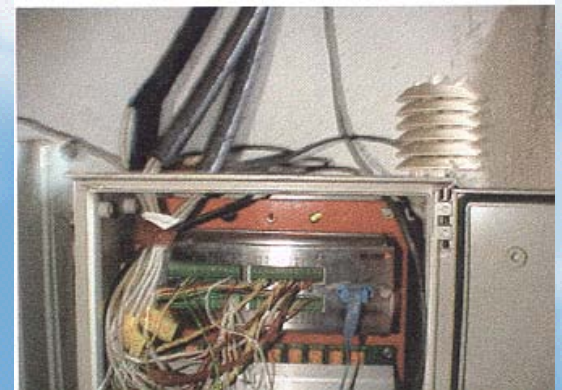
ACHAIA 1/6

Factory operation hours : 0600-1600 daily, closed on weekends
Hot water consumption : 80 m³/day
Temperature of process water: 20 - 80 °C

Description of solar system

Supplier : Sole S.A
Year of installation : 1993
Area of Collectors : 140 x 2.2 m² = 308 m² (Flat-plate collectors)
Tilt : 45 ° due South
Hydraulic circuit : Closed-loop distilled water
Connection : 20 parallel branches with 7 collectors in each branch
Volume of solar storage tank : 2 x 3000 litres (in parallel)

ACHAIA 2/6

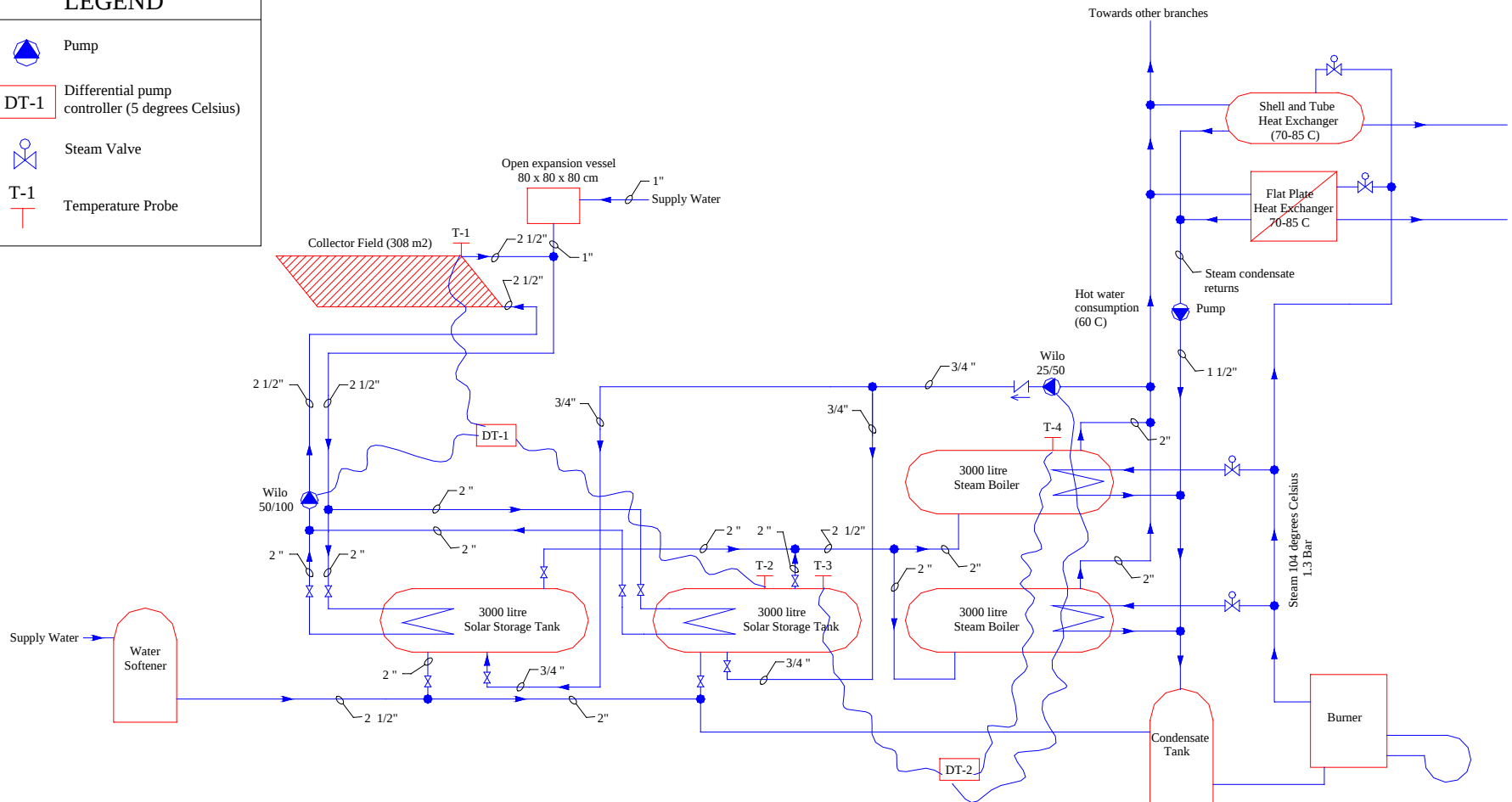
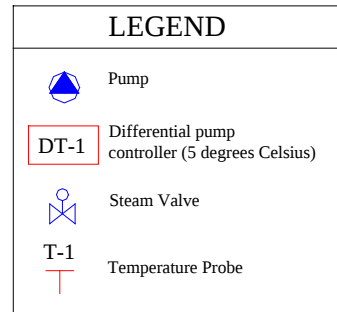


Brief description of whole system:

The hot water from the closed-loop hydraulic circuit of the solar collectors heats (via an internal heat exchanger) the water in two, closed 3000 litre solar storage tanks. The hot water leaving the solar storage tanks is then used to preheat the water in two 3000 litre storage tanks. Any auxiliary heating required is provided for via a submerged heat exchanger in the storage tanks. A re-circulation branch between the storage tanks and solar storage tanks was installed to increase the efficiency of the system.

Backup heating: Steam boiler – Diesel fuel

Achaia Clauss S.A. Case Study



Details from the TPF contract

The energy user pays the ESCO/ SOLE Ltd for the energy supplied, according to the following tariffs:

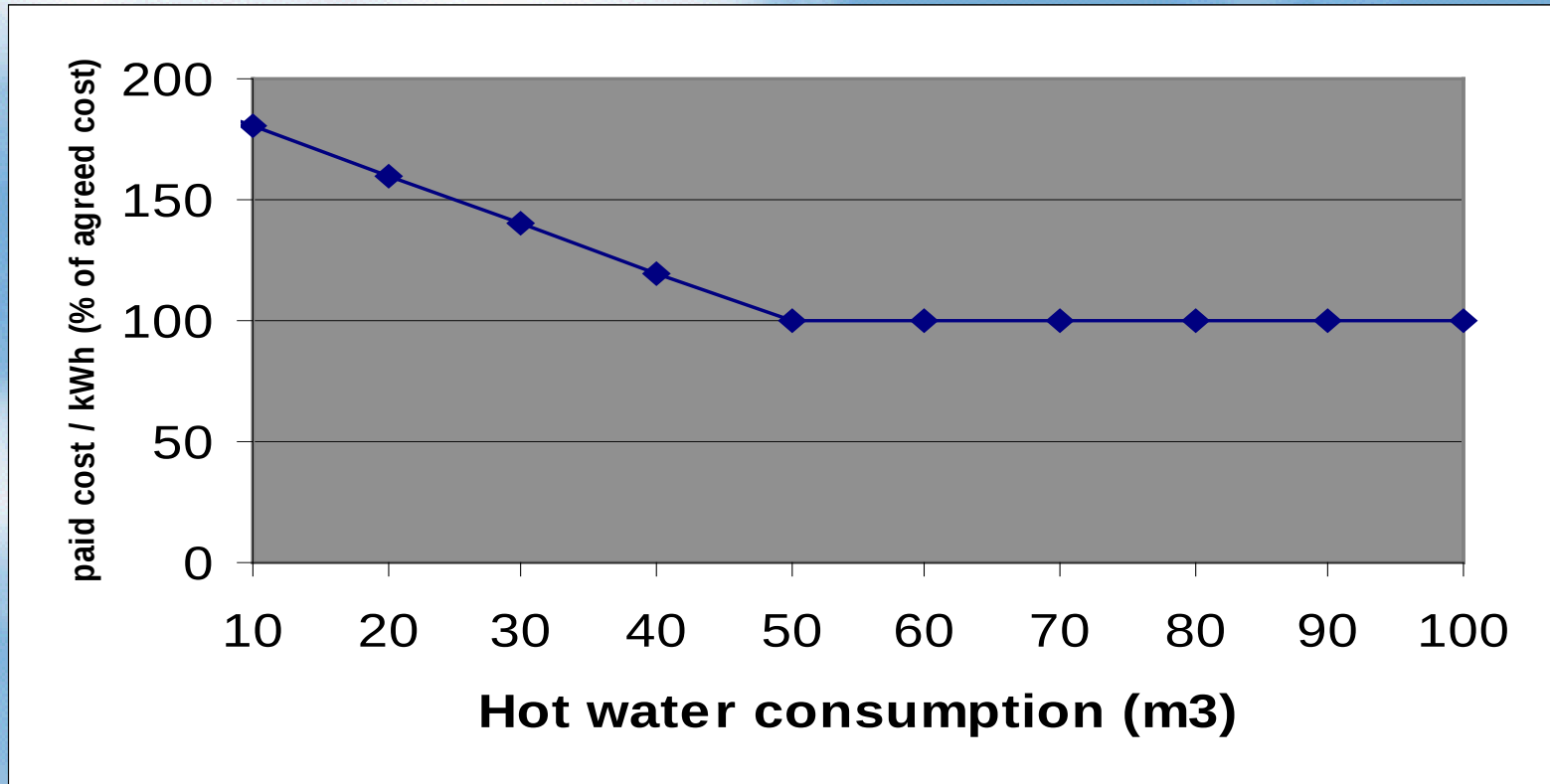
12 Drs. (0.043 €) / kWh during the six years.

the solar kWh price has been adapted according to the monthly mean oil price in order to keep the ratio (70%) constant

To insure both sides, two additional terms have been included in the TPF contract:

1. the consumption of hot water is taken equal to 50 m³ - 10%. If less water is consumed, the energy bill is leveled to 50 m³.
2. the installation of the equipment as well as the service works are to the charge of the user, except of the maintenance purpose spare parts, which are charged to the manufacturer.

Achaia Clauss S.A. – TPF Financing Scheme 1993



Price of kWh = 70% of current price of Diesel fuel

ACHAIA 6/6

Energy and operational results

The energy efficiency remained



Due to an insufficient maintenance program the collector field shouted down in year 1998, before amortization, following freezing damages.

Monthly performance of the solar system of the Achaia Clauss Winery in the year 1998

	Esun (kWh)
January	5884
February	7018
March	9067
April	6906
May	10868
June	10035
July	5925
August	7519
September	7554
October	5816
November	4099
December	1748
Total	82439



***Details SARANTIS cosmetics GSR contact
and energy performance***

SARANTIS 1/5

Function of solar system : Cooling of stock warehouse
+ heating of offices

Required temp. of warehouse : 27 °C dry bulb
19.5 °C wet bulb

Temperature of process water: 7/12 °C (summer)
45/40 °C (winter)

Description of solar system

Supplier	: Sole S.A
Year of installation	: 1999
Area of Collectors	: 2700 m ²
Tilt	: 30 °C due South
Hydraulic circuit	: Closed-loop water/ethylene glycol
Volume of solar storage tank	: 2500 litres

SARANTIS 2/5



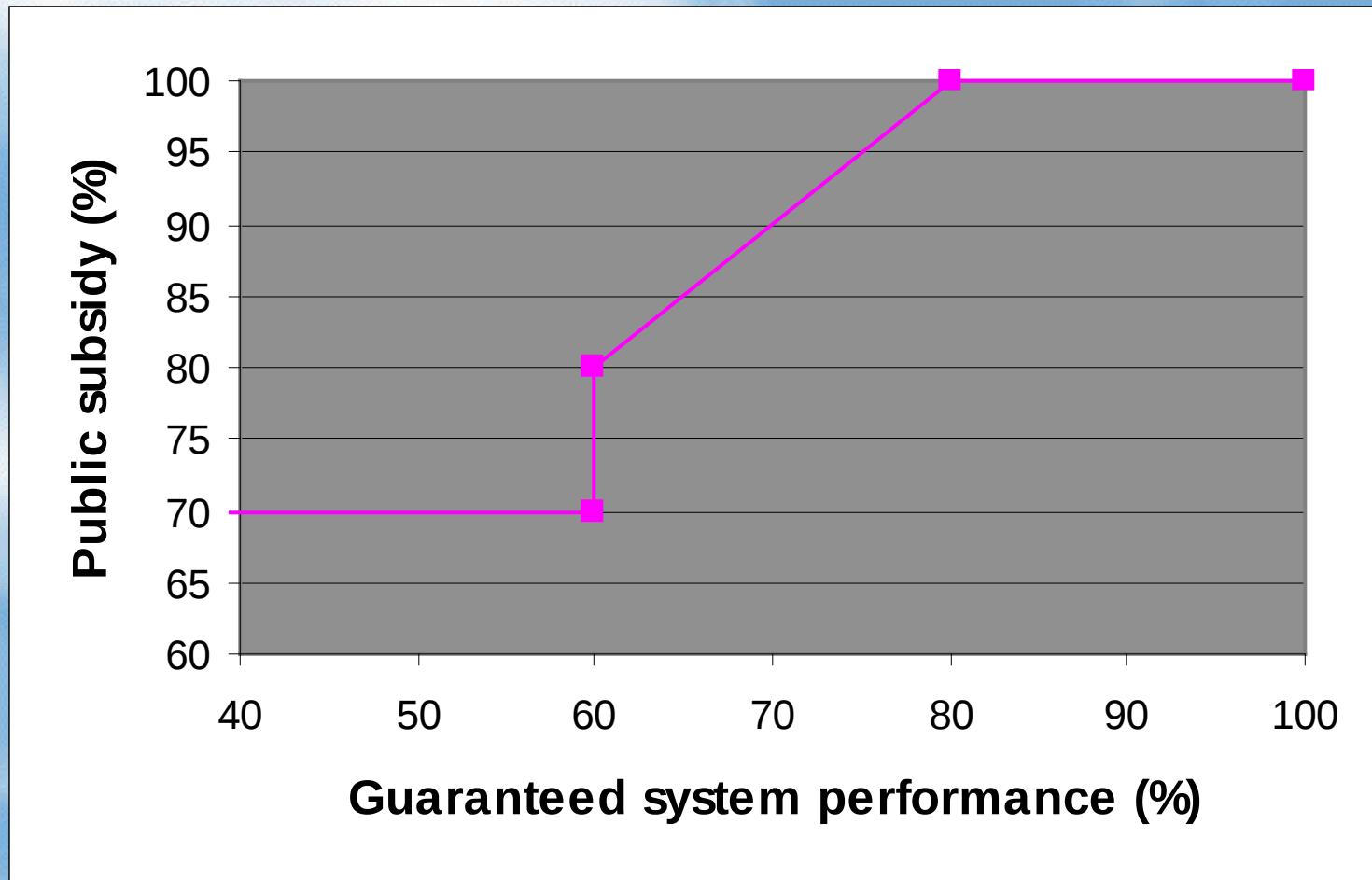
Brief description of whole system:

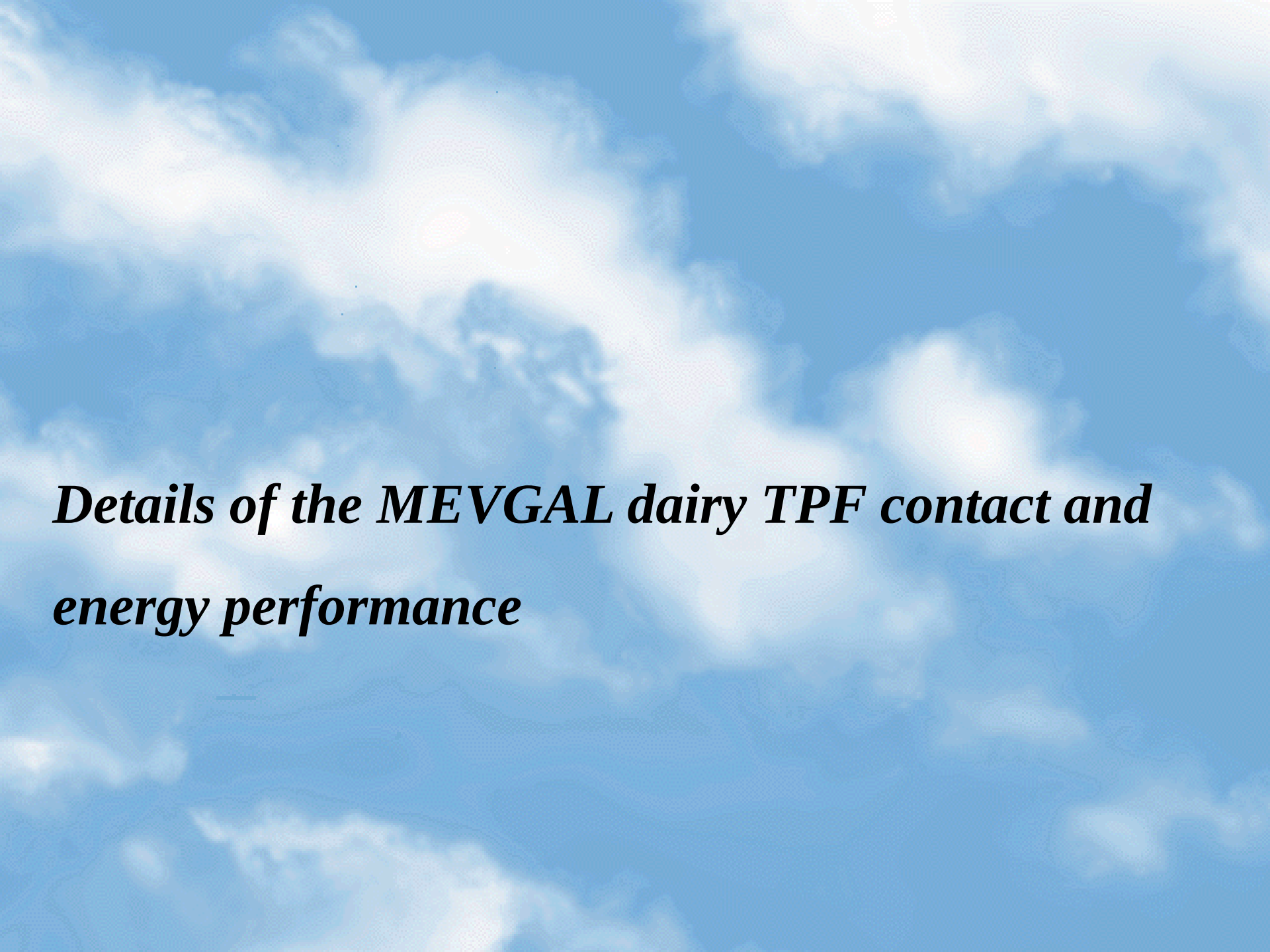
The hot water from the closed-loop hydraulic circuit of the solar collectors is used by two adsorption chillers (total refrigeration capacity, 668 kW) to provide cold water (7°C) to the air handling units of the warehouse. Hot water leaving the solar storage tanks is also used to heat the water in a 2500 litre closed storage tank via an internal heat exchanger. In the winter, the hot water from the solar collector field is used to preheat the water entering the steam boiler. Hot water in the winter is used for heating the office spaces and also for providing hot water for the bathrooms.

Backup cooling: 3 air-cooled chillers (1050 kW refrigeration capacity)

Backup heating: 2 steam boilers (1700 kW heating capacity)

O.P.E Funding Scheme (GSR 2000)





*Details of the MEVGAL dairy TPF contact and
energy performance*

Mevgal S.A 1/7

Factory operation hours : 24 hours a day, 7 days a week
Hot water consumption : 120-150 m³/day
Temperature of process water: a) washing machine: 20-80°C
b) Other processes: 20-130°C

Description of solar system

Supplier : Intersolar S.A
Year of installation : 1999
Area of Collectors : a) 168 x 2.4 m² = 403.2 m² (selective coll
b) 108 x 2m² = 216 m² (flat plate collectors)
c) 40 x 2.7m² = 108 m² (CPC collectors)
Tilt of flat-plate collector : 45 ° due South
Hydraulic circuit : Closed-loop water/propylene glycol
Connection (selective) : 14 parallel branches with 12 col/branch
Connection (CPC) : 8 collectors in parallel
Connection (flat plate) : 9 parallel branches with 12 col/branch
Volume of solar storage tanks : 2 x 2.5 m³ (in series) – selective collectors
2 x 2.5 m³ (in parallel) – CPC + flat plate col

Mevgal S.A 2/7



Brief description of whole system

The hot water from the closed-loop hydraulic circuit of the selective flat plate solar collectors heats (via an internal heat exchanger) the water in two, closed 2500 litre solar storage tanks.

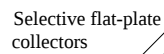
The hot water leaving the solar storage tanks is then used for the washing machine.

Any auxiliary heating required is provided for by the steam boilers.

The hot water from the closed-loop hydraulic circuit of the CPC and flat plate solar collectors heats (via an internal heat exchanger) the water in two, closed 2500 litre solar storage tanks.

The hot water leaving the solar storage tanks is used for preheating the water entering the steam boiler.

Backup heating: 3 steam boilers (total power capacity = 12MW) – heavy oil



Mevgal S.A 4/7

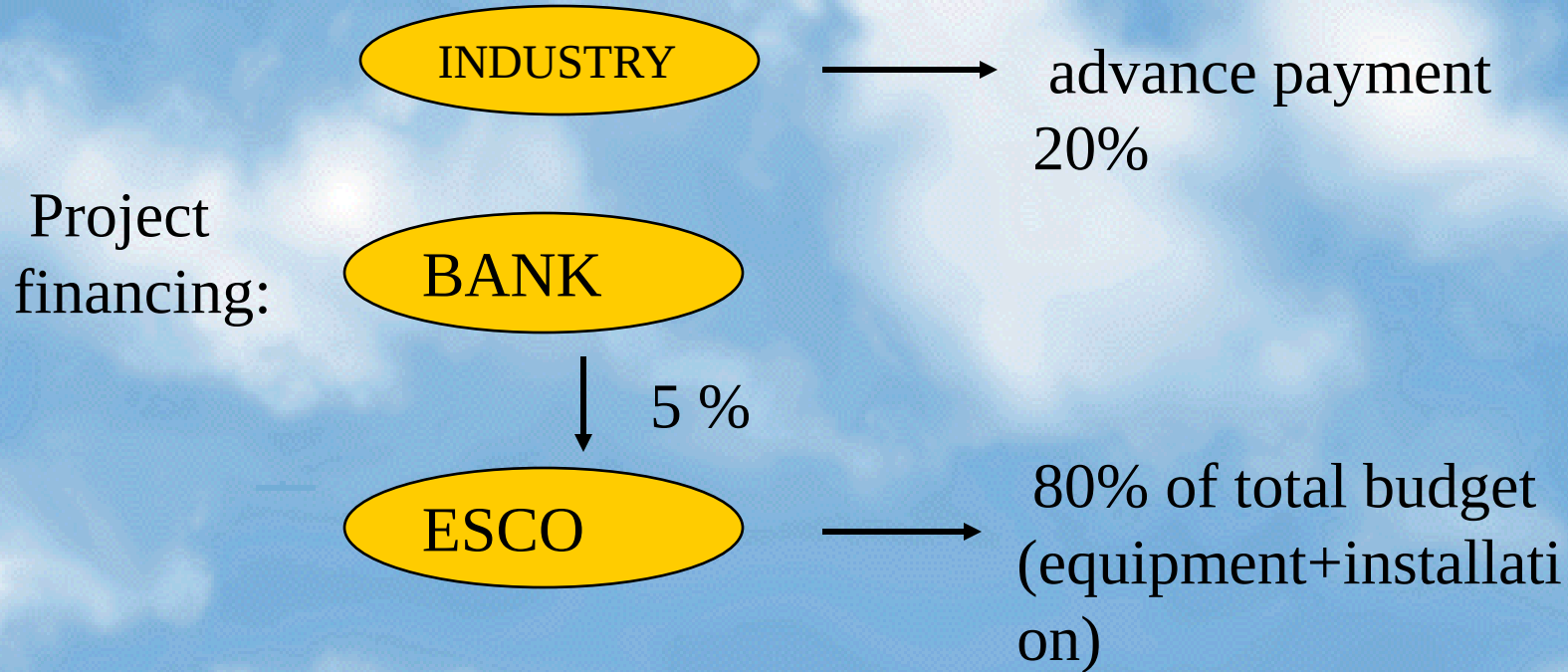
Details from the TPF contract of MEVGAL SA

Three Contracts have been implemented:

- ☞ 1st Contract : Agreement between ESCO and Industry
- ☞ 2nd Contract : Agreement between ESCO and System Producer
- ☞ 3rd Contract : Contract for Technical Auditing and System Maintenance

Performed TPF for solar water heating in MEVGAL SA

1st Contract's Main Articles



Performed TPF for solar water heating in MEVGAL SA

Dairy Industry - 1st Contract's Main Articles

👉 Budget : ~ 180,000 €

👉 Duration : until pay-back

👉 ESCO/Bank will be paid through the solar bills, issued every 4 months through telemonitoring

👉 Payments will be based on 1997 prices

👉 Originally agreed price for the «solar kWh» ~ 0.03 € for heavy oil fuel. This price will be readjusted proportionally to heavy oil fuel price changes

👉 Prices will be renegotiated in the case of heavy oil replacement according to the lower calorific value and the prices relation of the two fuels

👉 Metering equipment will be installed by and at ESCO's expenses

Energy and operational results

The energy efficiency reaches the 447 kWh/m²/a. This value remain low (far from reaching at 600kWh/m²/a as designed) because of the low coupling factor against the tank volume design

Subsystem	Technology	Surface (m²)	Useful measured value of energy (MWh/a)	Specific energy (kWh/m²/a)
Cheese shop	Flat plate selective collectors Intersolar K21C	403,2	186,00	461,54
Machine shop	Flat black paint Intersolar P20K-4 CPC Solar Focus	216 108	153,72	474,44
Blow down	Plate H/X		508,89	
TOTAL		727,2	848,61	