The Gaby project

Large scale solar plant for Chilean copper mines

Leo Holm, Sunmark Solutions

Leo Holm

- Engineer
- Working with District Heating and alternative energy sources since 1988
- 1991 – 2013 Manager Marstal District Heating
- 1. of April 2013, Engineer at the company SUNMARK Solutions

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Sunmark Solutions A/S

Sunmark Solutions in head lines

- Established in 2014, after a reconstruction of the SUNMARK company, and changed ownership.
- Owned by Hans Grydehøj.
- The company is based on more than 20 years of experience and knowhow.
- Experience from installations totaling, more than 200,000 m².
- Collector production in Vietnam, certified according ISO 9001, Solar Keymark and EN 12975.
- Highest efficiency flat plate collector in the market without Teflon.
- Production of heat exchange stations in Denmark.
- Product development in Denmark..

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Selection of References

Country	Project	Type of delivery	Area	MWh/year1	Max load2
Denmark	Rise District Heating	Turn-key	3,600 m²	1,692	2.66 MW
	Marstal District Heating I+II	Turn-key	16,295 m²	7,659	12.06 MW
	Sønderborg District Heating I+II+III	Panels	7,779 m²	3,656	5.76 MW
	Tørring CHP	Turn-key	7,500 m²	3,525	5.55 MW
	Ærøskøbing District Heating	Panels	2,195 m²	1,032	1.62 MW
	Oksbøl District Heating	Turn-key	10,000 m²	4,700	7.40 MW
	Jægerspris CHP I+II	Turn-key	13,300 m²	6,251	9.84 MW
	Hejnsvig District Heating I+II	Turn-key	5,766 m²	2,710	4.27 MW
	Vojens District Heating	Turn-key	17,500 m²	8,225	12.95 MW
	Sæby District Heating	Turn-key	11,921 m²	5,603	8.82 MW
	Ejstrupholm District Heating	Panels	6,243 m²	2,934	4.62 MW
	Skovlund District Heating	Panels	2,970 m²	1,396	2.20 MW
	Toftlund District Heating	Turn-key	11,000 m²	5,170	8.14 MW
	Sydlangeland District Heating	Turn-key	12,500 m²	5,875	9.25 MW
	Tim District Heating	Turn-key	4,235 m²	1,990	3.13 MW
Norway	Akershus Energi	Panels	12,810 m²	4,223	9,61 MW
Netherlands	Almere	Panels	7,134 m²	3,353	5.28 MW
Chile	Minera Gaby SpA	Turn-key	36,000 m²	51,800	32 MW
Vietnam	Sheraton Hotel	Panels	112 m²	123	88 kW
	Perrin Tannery	Panels	238 m²	262	188 kW
Thailand	Thai Union Manudacturing Co. Ltd.	Panels	462 m²	508	365 kW
	Shangri-La Hotel, Bangkok	Panels	921 m²	1,013	728 kW

1 Calculation based on average of 470 kWh/year in Nothern Europe and 1100 kWh/year in Asia.
2 Calculation based on average of 740 w/m² in Nothern Europe and 790 w/m² in Asia.

CODELCO

Main copper producer in the world

- Chilean state-owned Codelco – the world's largest copper mining company
- Controls around **10% of the world reserves.**
- More than **US$30 billions** in assets.
- In 2012, produced **1.75 million metric tons** of refined copper (10% of world production).
- **8 operations** throughout Chile.

CODELCO

Gabriela Mistral

Minera Gaby

- Placed in the northern Chile in the midd

  The Atacama Desert
- **150 km** from nearest city and **2,660 m.a.s.l.**
- **120.000 metrics tons** of copper produced in 2012.
- First operation using only **autonomous trucks to haul mineral.**
- Women account for **23% of the staff** (Mining industry average: 6%).

Pampa Elvira Solar project
Gabriela Mistral, Codelco.

One of the World largest thermal solar pla

Installation & performance data

- Collectors area : 36.025 m^2 .
- 2.620 13,75 m^2 panels.
- Annual production: 51.800 MWh.
- Share in annual heat demand: 85%.
- Tank capacity : 4.300 m^3 .

Key figures

- Diesel savings: 6.500 ton/year + 250 truck travels/year.
- Reduction CO_2 : 15.000 ton/year.
- Start-up: August 2013.

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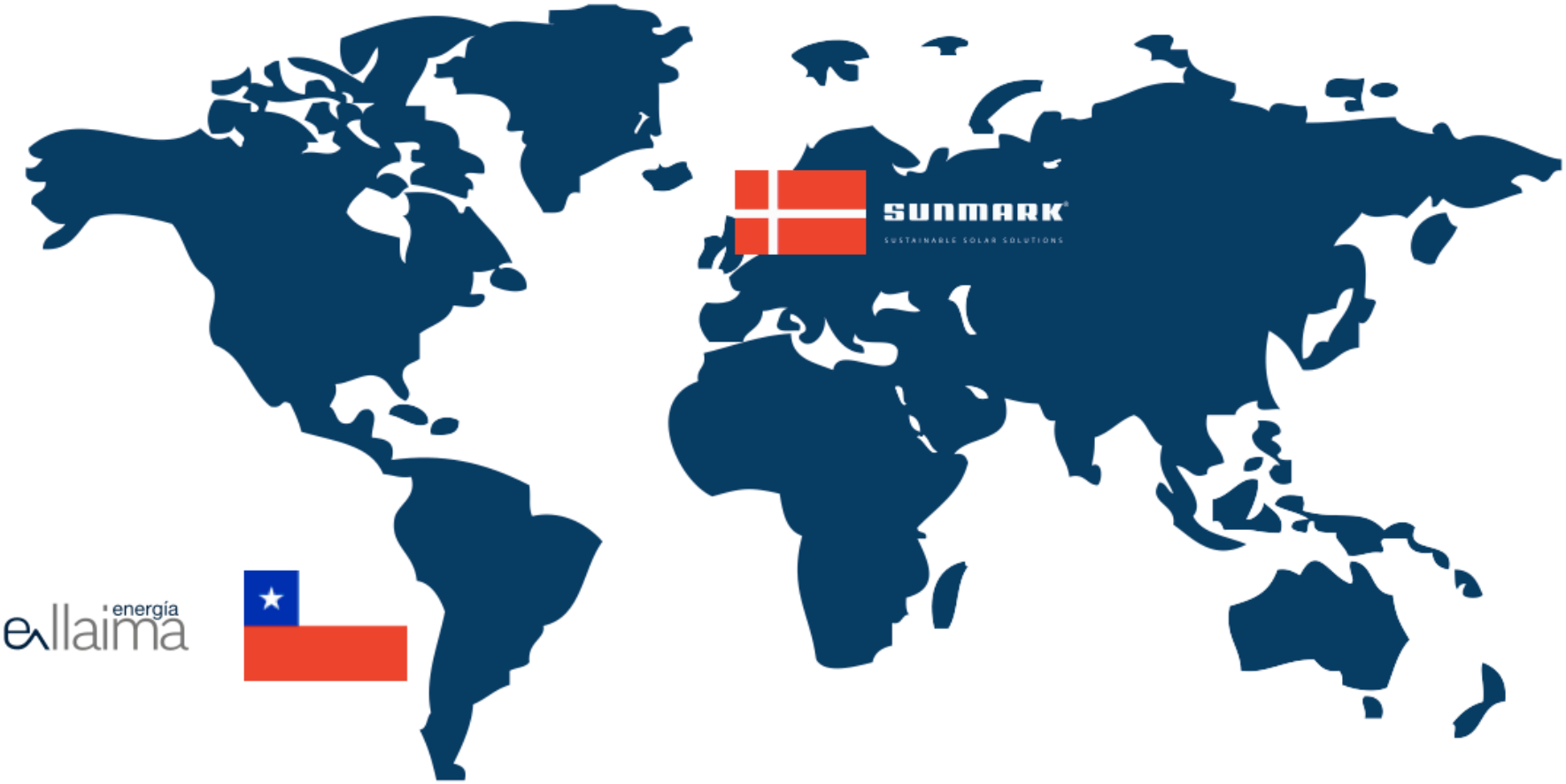
SUNMARK® SUSTAINABLE SOLAR SOLUTIONS

energía ellaima SUNMARK®

Pampa Elvira Solar



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Thermal Power Purchase Agreement:

- Agreement on minimum monthly amount of solar energy delivered.
- We operate and maintain heaters as backup as well as Heat Exchangers
- 24/7 heat supply.
- Covenants on heat supply quality (Electrolyte Temperature) and safety.
- Contract length: 10 years.
- Stable energy tariff US$/MWh + Fixed charge heaters O&M.




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How Pampa Elvira Solar works

FLAT PLATE SOLAR COLLECTORS

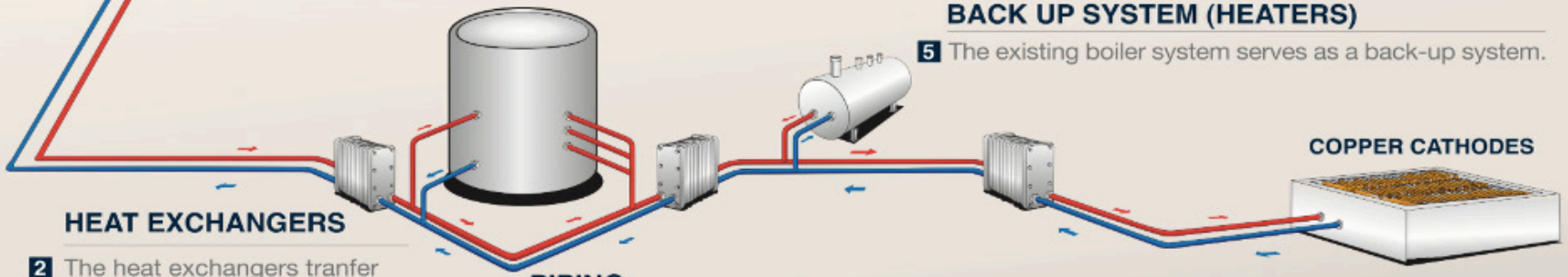
1 The thermal solar plant consists of 2,620 flat plate collectors and covers a total area of 39,300 m², becoming the largest of its kind in the world. The plant receives the solar radiation and heats a water-anticoolant mix, transforming the radiation into themal energy (heat).

Solar Thermal Battery

4 The tank is 17 meters high and 17 meters of diameter, having a total storage capacity of 4,300 m³. It is thermally insulated and its design allows to stratify the water at different temperatures. Additionally, an automatic control system allows the plant to steadily supply heat 24 hours per day.

BACK UP SYSTEM (HEATERS)

5 The existing boiler system serves as a back-up system.



HEAT EXCHANGERS

2 The heat exchangers tranfer the heat to the different stages of the system

PIPING

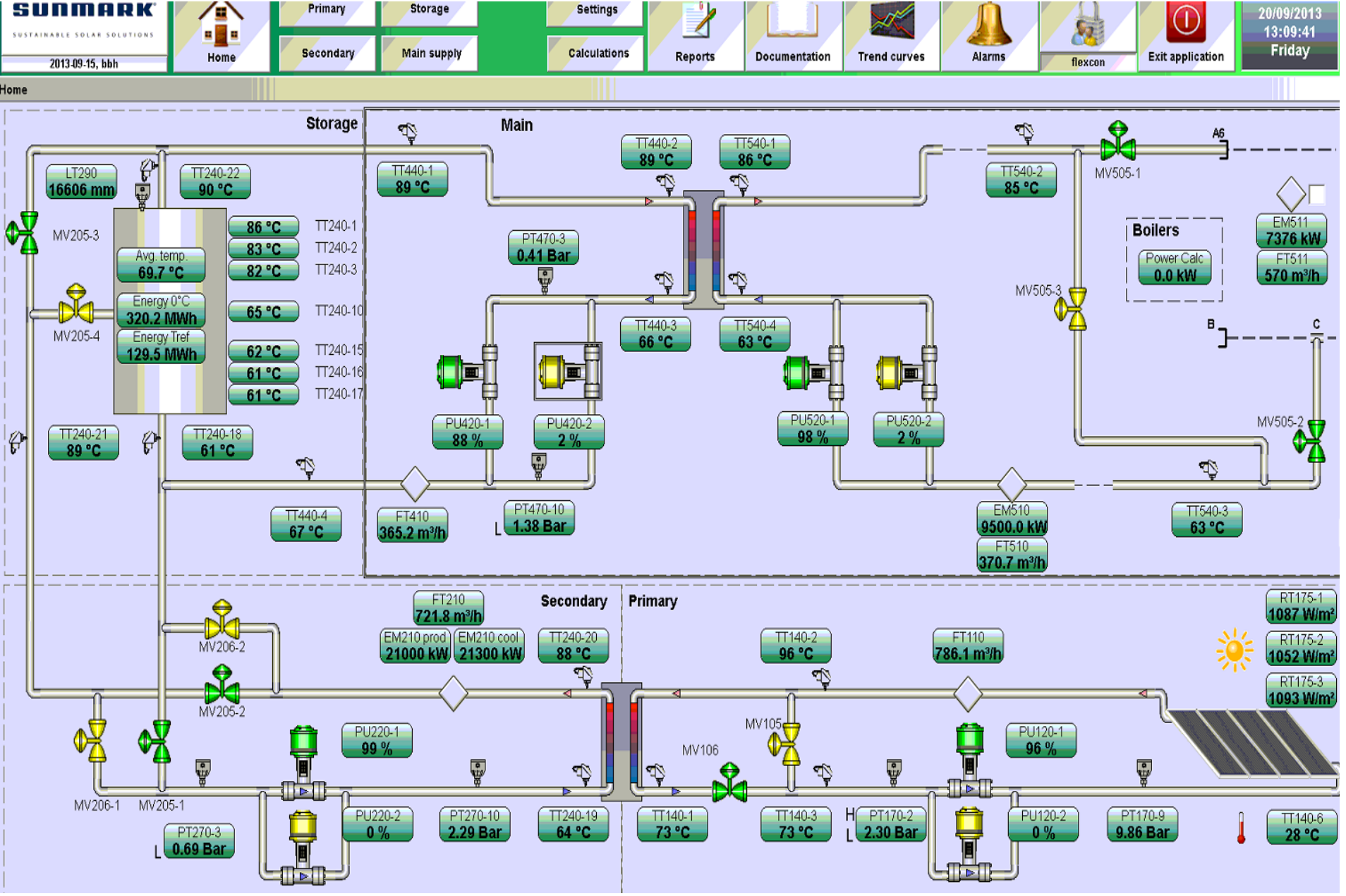
3 3,500 meters of thermally insulated pipes transport the fluid at different temperatures to the stages of the plant and points in the metallurgical process.

Colder Hotter

ELECTRO WINNING PROCESS

6 The process to obtain copper requires heat at different demand points: keeping the electrolyte at a steady temperature of 50°C as well as for the washing of the copper cathodes, among others.

Through the thermo solar plant we are able to provide the neccesary heat at the right temperatures to allow our client to get high purity copper cathodes.



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Very harsh weather conditions

- Desert conditions.
- 140 kmh (87 mph) - Swirling winds.
- Dust.
- Hails / Snow.
- Extreme night/day Temperature variations:
  - -15° C / 30 ° C
- Earthquakes.
- No water.

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Very harsh weather conditions

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Very harsh weather conditions

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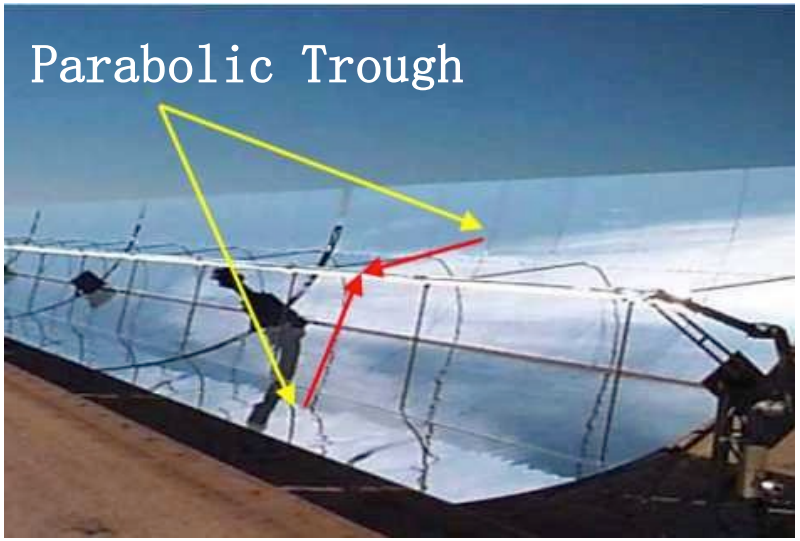
Not any solar technology fits well in mining



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Not any solar technology fits well in mining

Technology	Sunmark	Parabolic	Fresnel
CAPEX	optimal	high	high
OPEX	optimal	high	high
Working Pressure	low	high	high
Moving Parts	no	yes	yes
Operational life	over 20 years	no track record	no track record
Storms (wind, dust, hailstones)	high resistance	limited	limited
Earthquakes	proven resistance	not proven	not proven

Sunmark: simple & robust
The best fit for mining

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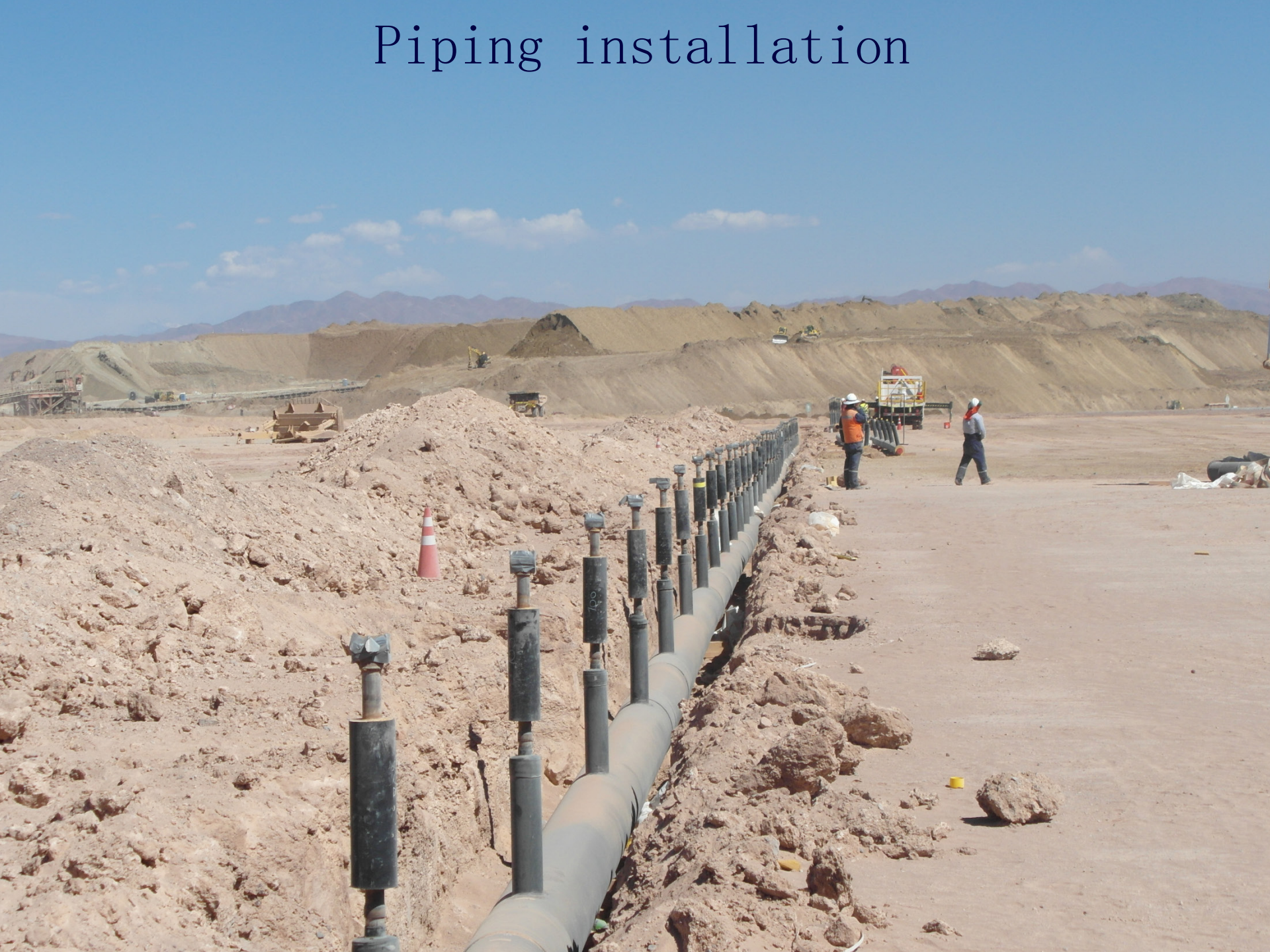
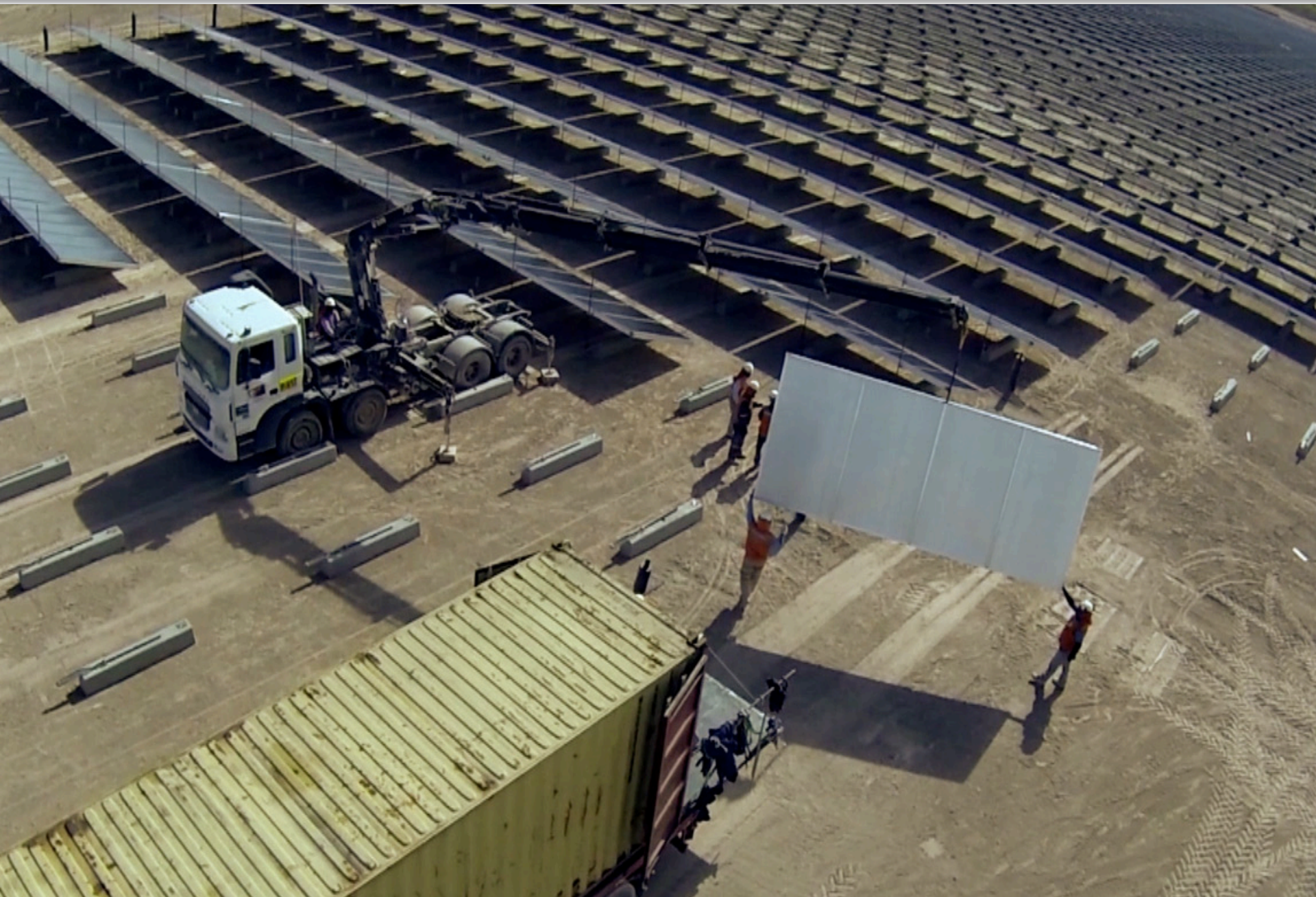
Preparing the land

Piping installation



Placing concrete blocks

Mounting the panels

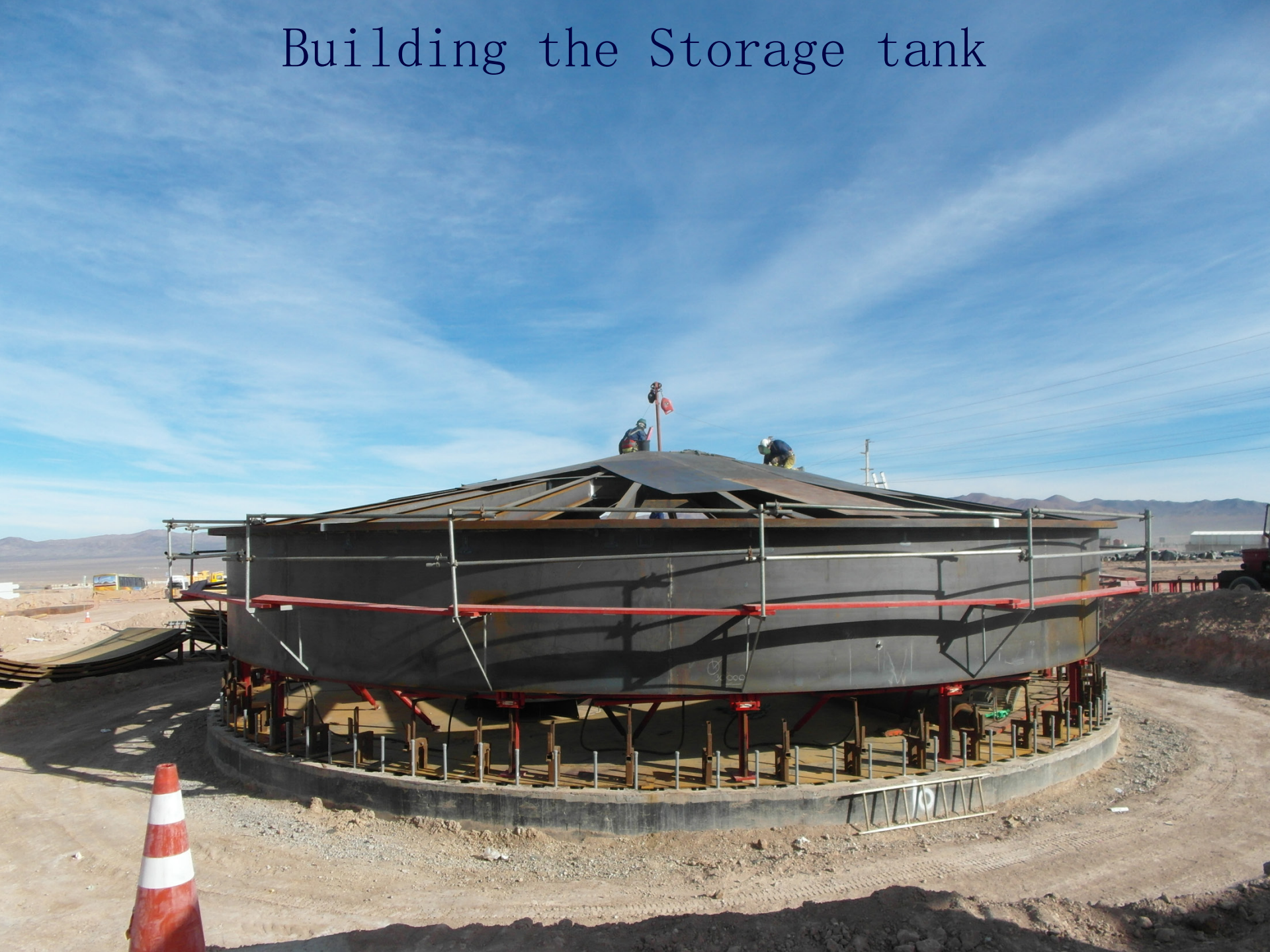


Building the heat exchangers room

Building the heat exchangers room

Building the heat exchangers room

Building the Storage tank

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Pampa Elvira
SOLAR

How it looks like from the air

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Dust

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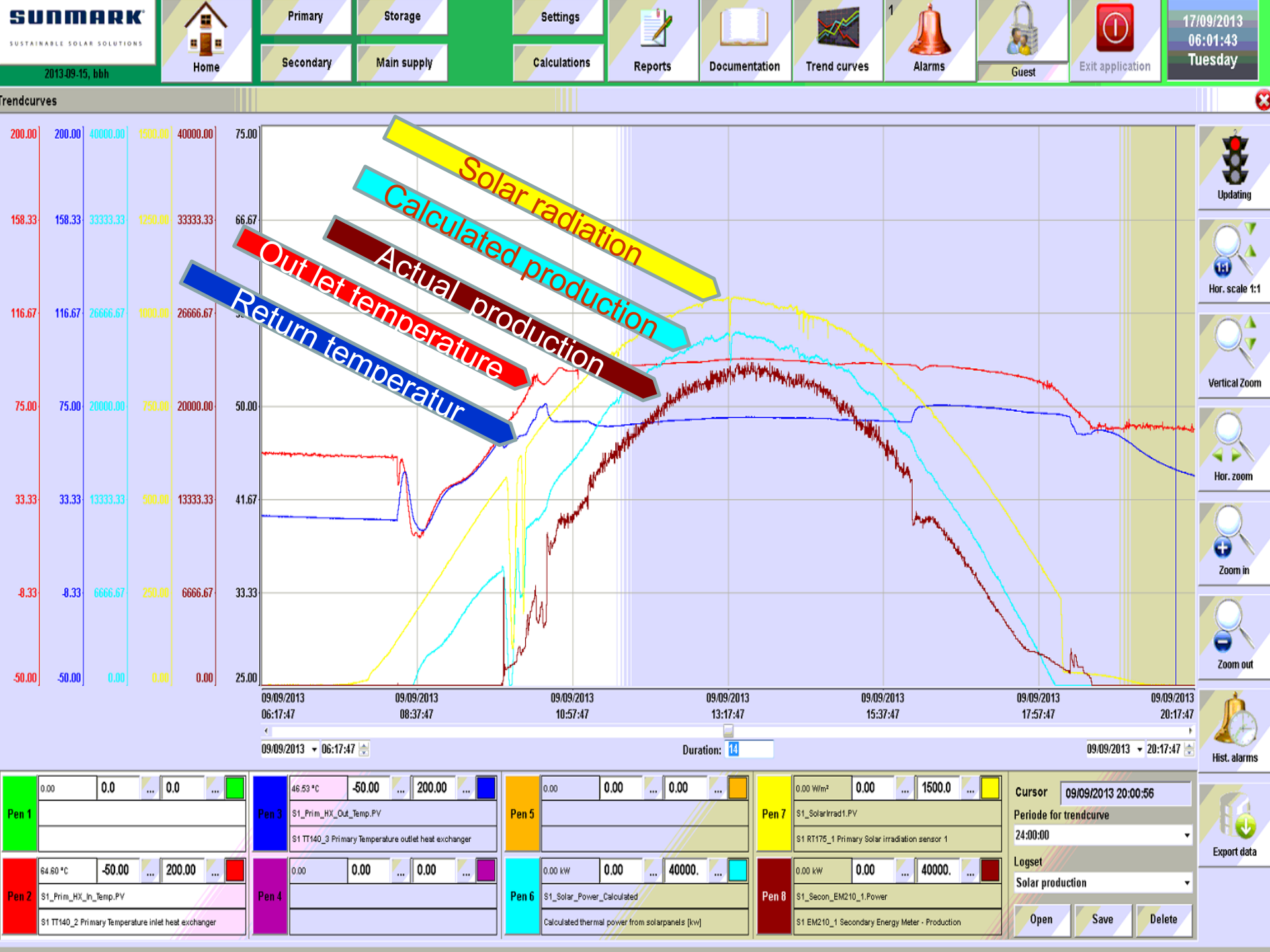
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SUSTAINABLE SOLAR SOLUTIONS
2013-09-15, bbh
Home
Primary
Storage
Secondary
Main supply
Settings
Calculations
Reports
Documentation
Trend curves
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Alarms
Guest
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Solar radiation
Calculated production
Actual production
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Hor. zoom
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Zoom out
Hist. alarms
Export data
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Pen 2
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200.00
S1_Prim_HX_In_Temp.PV
S1 TT140_2 Primary Temperature inlet heat exchanger
Pen 3
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S1_Prim_HX_Out_Temp.PV
S1 TT140_3 Primary Temperature outlet heat exchanger
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0.00
0.00
Pen 6
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0.00
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Delete


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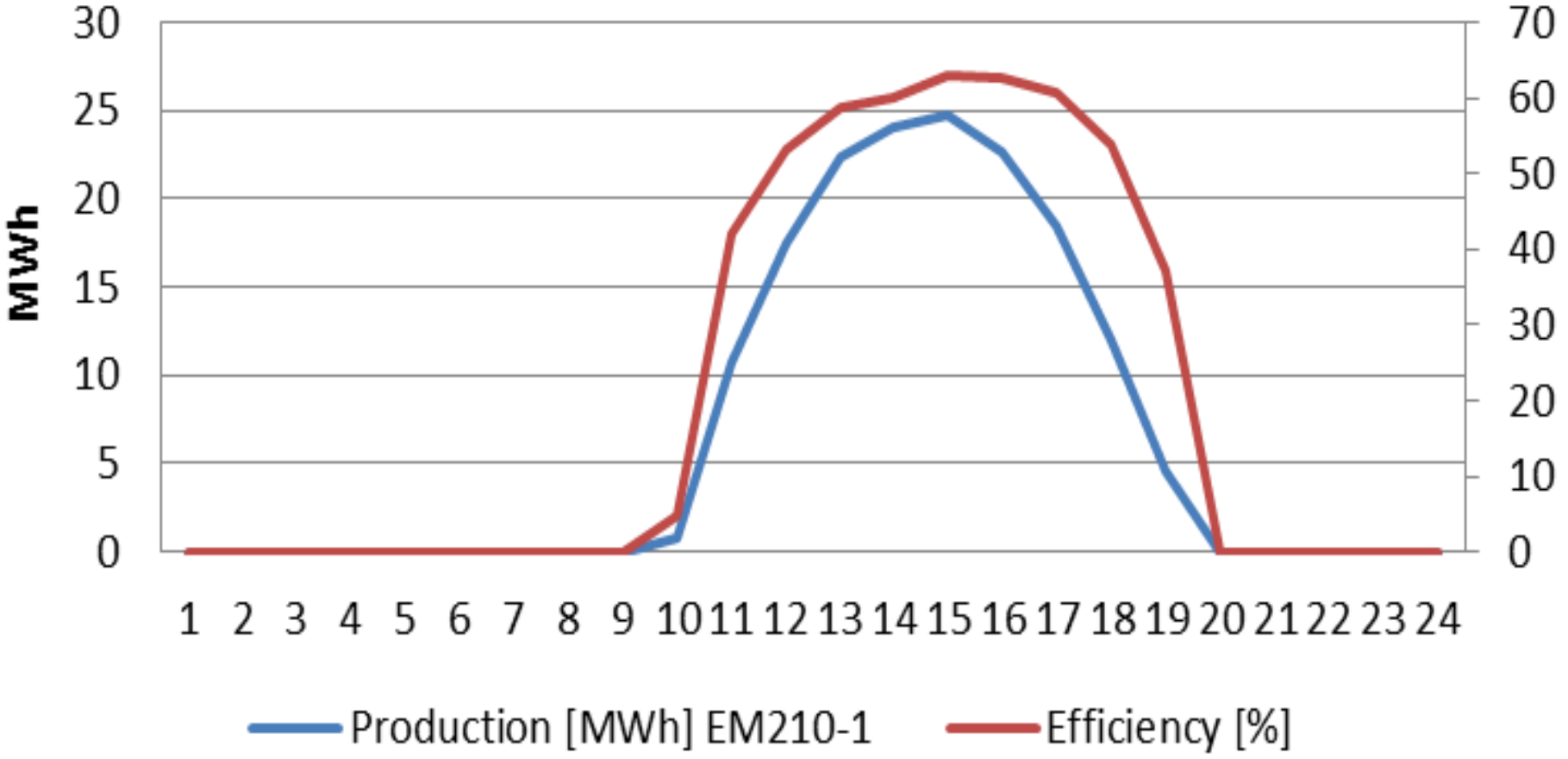
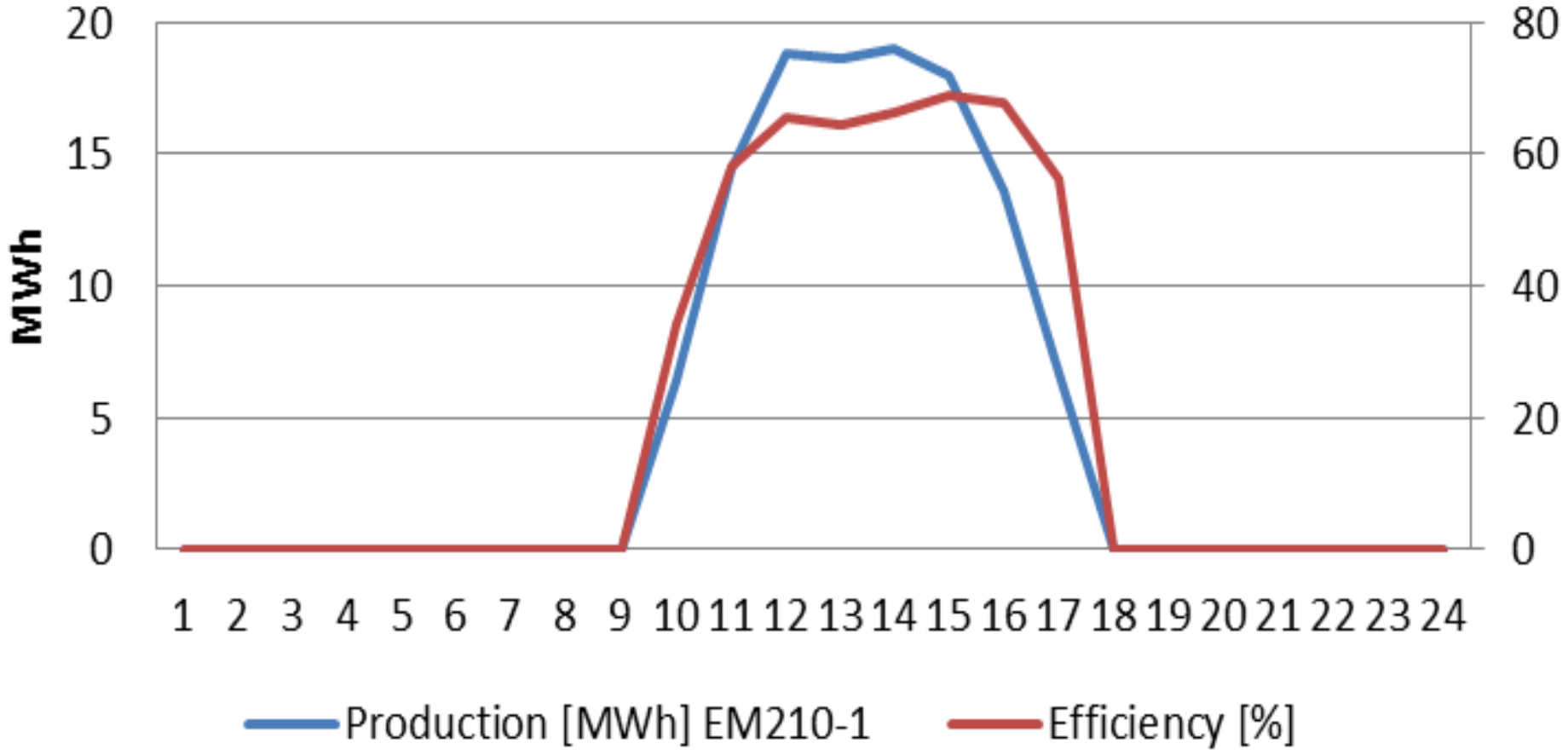
Production & efficiency the 28. of January 2014



Production & efficiency
1. of June 2014



Key lessons

- Stringent working conditions in Mining industry.
  - Safety procedures.
  - Medical tests.

Need of a knowledgeable & experienced team in mining & energy industry.

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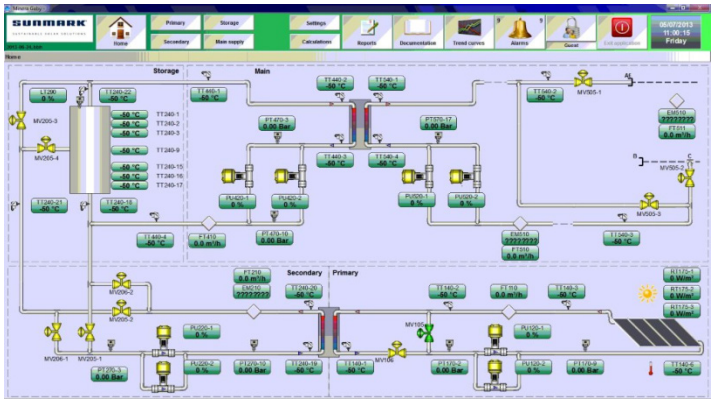
Key lessons

- Not any technology fits well in mining environments.
  - Very harsh weather conditions.
  - Simple and robust technology is needed.

Best technology, detailed planning & control are key to succeed



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Further information

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Thank you for your attention
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