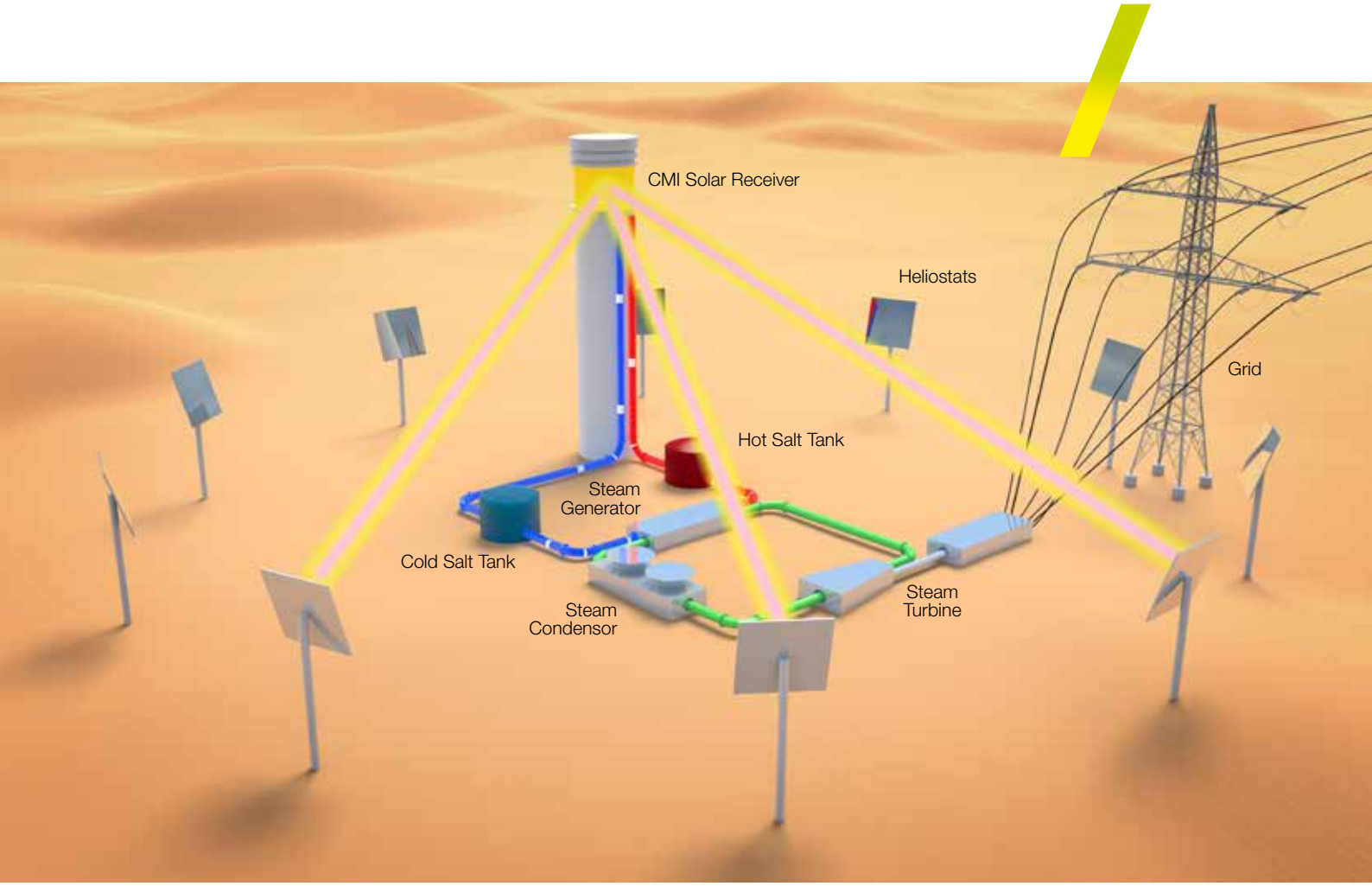
CMI ENERGY

Solar Tower Receivers

The Power
to Change
the World



▲ Central Tower Solar Thermal Electricity

Central Tower Solar Thermal Electricity

On central tower solar thermal power plants, the solar field consists of thousands of mirrors or heliostats located on the ground, each of them being individually computer controlled to concentrate the solar rays towards a receiver located at the top of a tall tower.

The heat flux reaching the receiver easily exceeds 1000 kW/m², which represents more than 1000 times the natural solar flux at the most exposed places on earth!

The receiver consists of tube panels through which a heat transfer fluid is sent to collect the energy already absorbed by the receiver.

Thermal energy is used to generate electricity through a thermo-dynamical process, typically by generating superheated steam to feed a steam turbine that drives a generator as in the classic process of most power plants.

Strengths of Central Towers

- Higher concentration ratios allow higher temperatures, and thus **better efficiencies.**
- The receiver is capable of withstanding high pressures.
  This allows direct production of **high pressure superheated steam** (up to 185 bars) in the receiver.
- A short and mostly vertical piping layout allows fast and easy drainage of the heat transfer fluid and makes the receiver **the safest arrangement for molten salts plants.**
- **No need** for dangerously flammable and polluting thermal oils– used in parabolic trough plants, which limit the generated steam temperature to below 400°C, with a negative impact on the plant efficiency.

The most efficient energy source

This thermodynamic process is specific to Solar Thermal Electricity and is much more efficient than any photovoltaic process. Furthermore, the possibility to economically store thermal energy gives a serious advantage to Solar Thermal power plants compared to most renewable energy sources.

Direct Steam Generation Plants
Economy and High Efficiency

In a direct steam generation thermal solar plant, the solar receiver directly generates steam for the turbine, without resorting to other heat transport fluids. As they do not require separated steam generators, such plants are economical and allow the highest efficiency. However, given the necessarily high pressures involved, steam storage tanks are thick, heavy and expensive.

Direct steam generation is, therefore, not the best adapted technology for a large energy storage. In this case, a molten salts plant will be more efficient.

Molten Salts Plants
Dispatchability and Overnight Power Generation

The best way to insure dispatchability or even overnight electricity production is to store the absorbed solar energy in molten salts, a low-cost, flame-proof and non-polluting fluid.

How does it work?

The solar receiver first converts the absorbed solar energy into thermal energy by heating molten salts, which are stored in a hot molten salts storage tank. Steam can then be produced on demand by pumping the hot molten salts through a steam generator. Cold molten salts are returned to a cold molten salts tank, from which they are sent to the solar receiver to be heated again.

Molten salts freeze if their temperature goes below around 230°C. It is one of the main challenges with molten salts plants. Thanks to their short and vertical piping layout, allowing fast and easy drainage, central towers are the safest solution for a direct heating of molten salts in the receiver.

◂ Central tower thermo-solar plants. Abengoa's PS10 and PS20 plants, Seville, Spain.

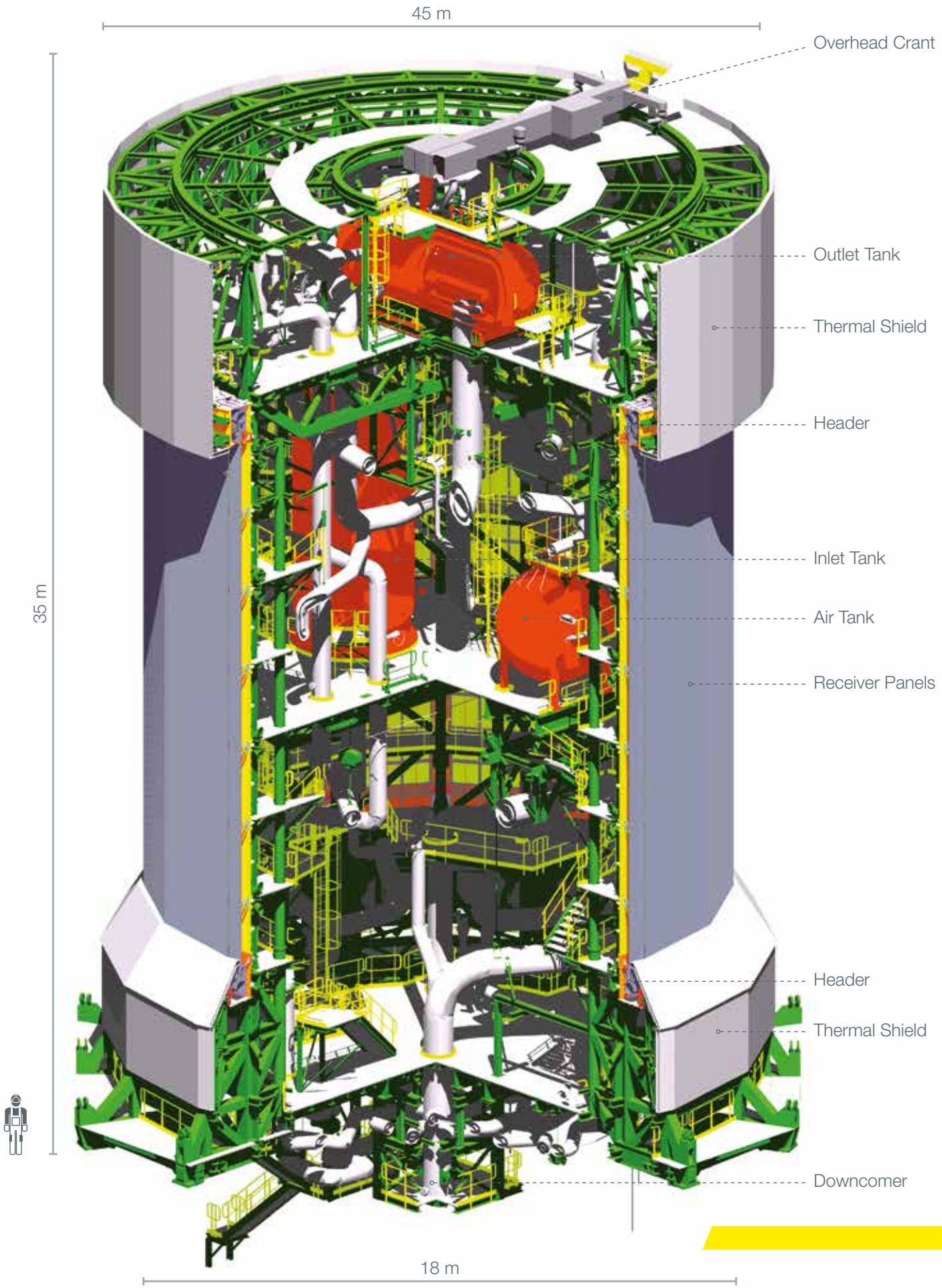
The fabulous strengths of molten salts

Wind and sun energy sources are uncontrolled; they induce a fluctuating electricity production. The network must therefore adapt quickly and efficiently to compensate any power drop. Solar thermal power plants represent one of the best efficient energy sources as they do not generate power fluctuation. They can feed the network anytime instantaneously adapting their production to the demand. That is what is called a « dispachatble » electricity production. Solar Thermal Electricity plants therefore contribute to the stability of the network like any conventional power plant. They also allow the electricity generation 24 hours a day!

CMI's receivers:

Heart of the plant
State-of-the-Art

Electricity Production 24h/day
Energy Storage
Sustainable Energy
Patented Technology


45 m
35 m
18 m
Overhead Crant
Outlet Tank
Thermal Shield
Header
Inlet Tank
Air Tank
Receiver Panels
Header
Thermal Shield
Downcomer

CMI's Receivers, a Jewel of Technology

Located at the top of a 200m tall tower, CMI's receivers collect the concentrated solar energy and transfers it either directly into high pressure steam (Direct Steam Generation) or into hot molten salts. These receivers operate in extreme conditions, which makes them a jewel of boiler engineering and technology.

The main challenges come from the very high energy fluxes involved: above 1000 kW/m^2; several times more than what is reached in conventional fired boilers. This leads to metal temperature locally exceeding 700°C, requiring to use special materials like stainless steels and nickel alloys.

High temperatures induce thermal expansion, stresses, creep, fatigue…

CMI's expertise as a boiler designer allows to control these phenomena and mitigate their effects. Calculations methods had to be refined to verify the lifetime of the equipment, which operates under highly fluctuating conditions.

A major operational risk for the receiver is to have it overheated due to a locally excessive incident flux. This might cause the destruction of a receiver panel in a few seconds. To mitigate that risk, CMI developed a system to closely monitor the metal temperature of every point of the panels from information received from a network of infrared cameras. The system also evaluates in real time the thermal stress at every point of the panels. In case the maximum acceptable stress is locally approached, a signal is sent to request an adjustment of the energy directed toward the receiver. This allows to always operate at the maximum capacity without any risk of damaging the receiver.

◂ CMI's molten salts solar receiver

◂ CMI's solar receiver at Khi Solar One (South Africa) Steam is superheated and directy used in high performance turbines.

▾ Construction of the Atacama I plant (Chile). Molten salts enable large energy storage.

CMI's Achievements

Direct Steam Generation

In 2008, CMI Energy launched its first development upon a request from Abengoa Solar to develop a cavity type solar receiver producing superheated steam (530°C, 130 bars) directly usable by conventional steam turbines.

This CMI receiver absorbs 250 MW of thermal power.

In 2012, CMI was awarded a contract for the design and delivery of a solar receiver for the 50 MWe Khi Solar One CSP plant near Upington (South Africa).

KEY FEATURES:

- 3 cavities arrangement, for maximum efficiency
- Patented superheater design, allowing free tube expansion and minimal thermal stress
- Metal temperature monitoring by infrared cameras
- Patented flux sensors

CMI also designed a receiver that increases the competitiveness of direct steam generation with 3 factors:

- Scale effect: using a 250 MW steam turbine instead of 50 MW
- Improving the steam cycle efficiency by increasing the steam parameters up to 180 barA and 590°C
- Reducing the receiver's area by increasing the acceptable solar flux on the panels thanks to a cylindrical design of the receiver

KEY FEATURES:

- Patented design of superheater panels
- Double drum
- Rifled tubes
- Designed to be erected on the ground and lifted in one piece to the top of the tower

Molten Salts

In 2014, CMI Energy developed a central tower **molten salts receiver** capable of absorbing thermal power of about 750 MWth, to equip molten salts Solar Thermal Electricity plants between 100 and 150 MWe, depending upon the heat storage capacity.

Two CMI solar receivers in total will equip Abengoa Solar's **Atacama I and Atacama II** power plants in Chile. Each of them generates 110 MWe and has an energy storage capability of 17.5 hours.

KEY FEATURES:

- Patented insulated airtight casing
- Designed to be erected on the ground and lifted in one piece to the top of the tower
- Patented IR temperature and stress real-time monitoring system

CMI ENERGY

SOLAR
TOWER
RECEIVERS

CMI Solar, Optimized Solar Thermal Electricity Solutions Backed by 200 Years of Business Success

CMI was founded in 1817 by John Cockerill, an industrial genius who established his business activities in Seraing (Belgium) and sparked off the remarkable economic future of Wallonia. CMI Group has been specializing in steam generation for almost 200 years.

For more than 45 years, CMI Energy has been a leader in the development of Heat Recovery Steam Generators behind gas turbines, mainly for combined cycle applications.

CMI Solar was created in 2011 based upon CMI's long-lasting experience and know-how in steam generation. Since then, CMI Solar has kept alive the tradition of John Cockerill.

CMI Solar develops steam generators for high power concentrated solar power stations and in particular in :

- Generation and management of steam
- Heat exchanges, thermal processes and fluid mechanics
- Management of high temperatures, thermal stresses in material.

V2_03/2016

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