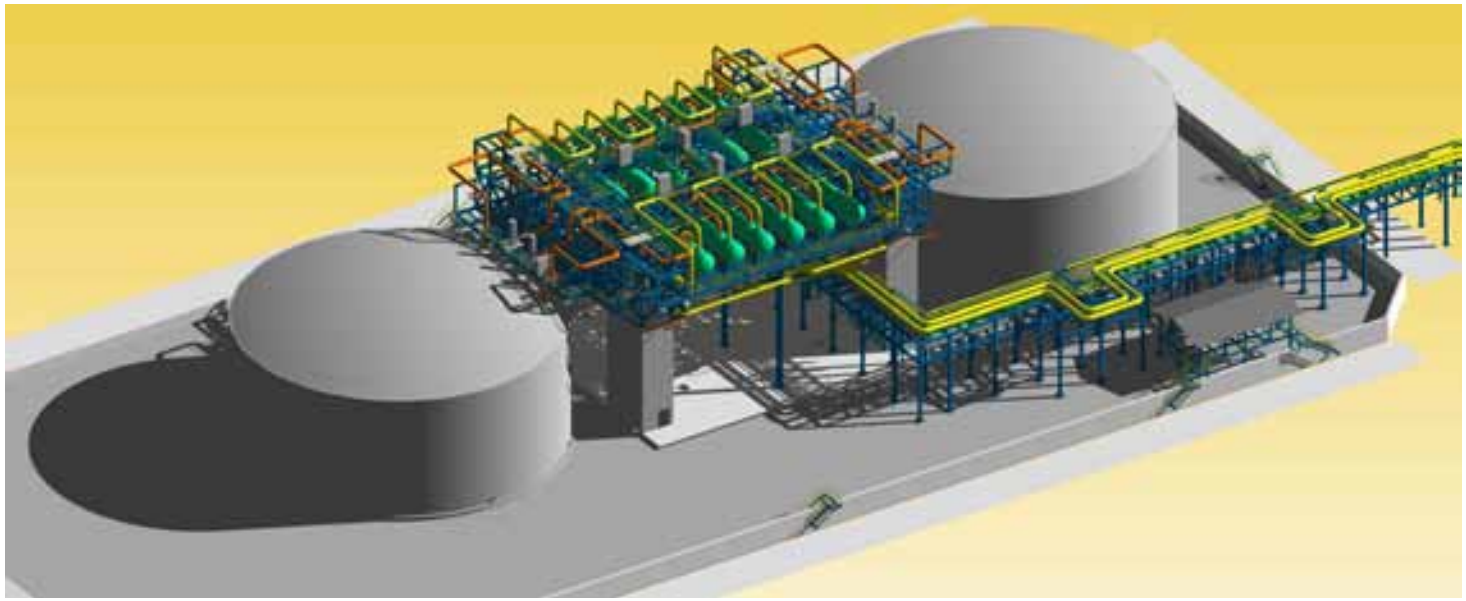
EUROTECNICA

Contractors and Engineers S.p.A.

Thermal Energy Storage Technology



- Eurotecnica is an international process engineering contractor and technology owner, which was established in 1962.
- Eurotecnica is active in the chemicals, petrochemical and refinery fields.
- To date Eurotecnica has successfully carried out more than 130 projects worldwide.
- Eurotecnica is the leading independent Melamine Technology licensor, designer and implementer.
- In a little more than a decade Eurotecnica has licensed 17 Melamine units worldwide for a total capacity of 430,000 t/y, almost 40% of today's world consumption.
- Eurotecnica's portfolio includes a wide range of technologies such as Carbon Black, Polyols, and Thermal Energy Storage for Concentrating Solar Power Plants

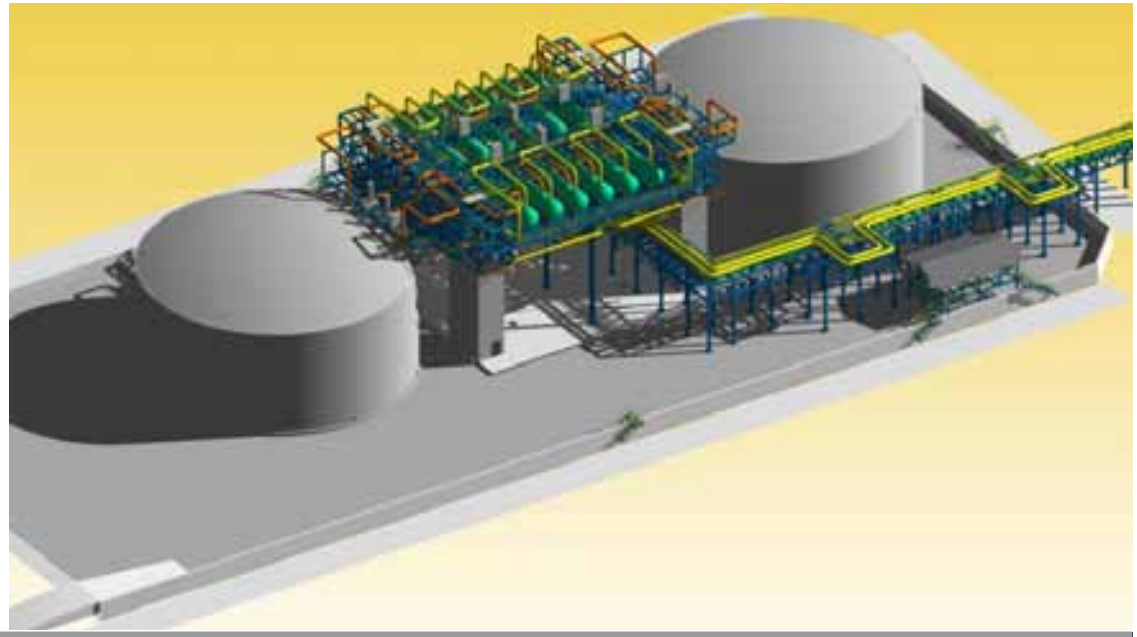
A Concentrating Solar Power plant gathers heat from the sun and utilizes it to produce green electric power. But what to do at night, when there is no sun, and how to match the output of the power station with the demand from the grid?

An Eurotecnica Thermal Energy Storage system can store the heat, in the form of a huge mass of high temperature salts kept in molten state, and release it to produce steam right when electric power is required.

Molten Salts Thermal Energy Storage Systems

Eurotecnica is one of the few companies in the world with technology and references for Molten Salts Thermal Energy Storage Systems for concentrating solar power plant.

The technology is derived from the molten salts expertise gathered by Eurotecnica with the High Pressure Melamine Technology.



BACKGROUND ON MOLTEN SALTS

The Melamine Reactor

100 bar process side

Turn-down range: 20-100%

From 0% to 100% in very short time

Bottling-in shut down

Extremely corrosive environment

Hastelloy material

Focus on thermal and mechanical design of Molten Salts Systems

BACKGROUND ON MOLTEN SALTS

The Eurotecnica added value

Proven Experience on Molten Salts

17 melamine units licensed and built

40% of world capacity

Deep knowledge of standards and best practices in the refinery and petrochemical field

130+ projects performed

many world firsts

Safe and reliable approach to process design

many returning customers,

very long plant operation life

Innovative approach to Thermal Energy Storage

BACKGROUND ON MOLTEN SALTS

Challenges in TES design – an example

So far, Molten Salts have been utilized to transfer heat from a fired heater to a process fluid – TES systems are different

Counterbalancing fouling in a molten salt heating system

New exchanger surfaces

high exchange coefficient

Effect of fouling

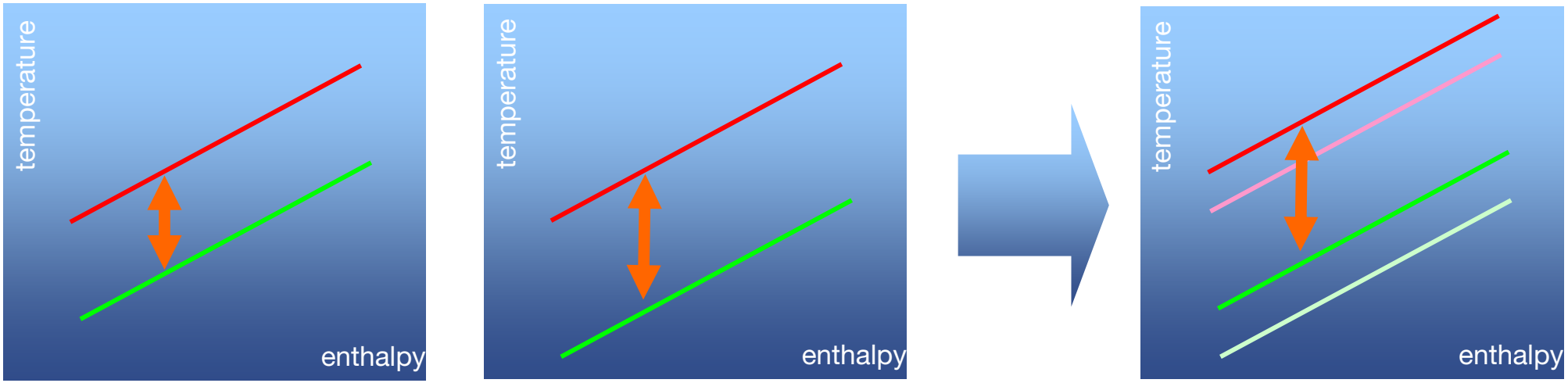
lower exchange coefficient

Higher ΔT to keep duty

Lower process fluid temperature

Action: increase skin temperature in molten salt heater coils

Process fluid temperature is restored



molten salts

process fluid

BACKGROUND ON MOLTEN SALTS

Challenges in TES design – an example

So far, Molten Salts have been utilized to transfer heat from a fired heater to a process fluid – TES systems are different

The same action is not possible in a TES system

New exchanger surfaces

high exchange coefficient

Effect of fouling

lower exchange coefficient

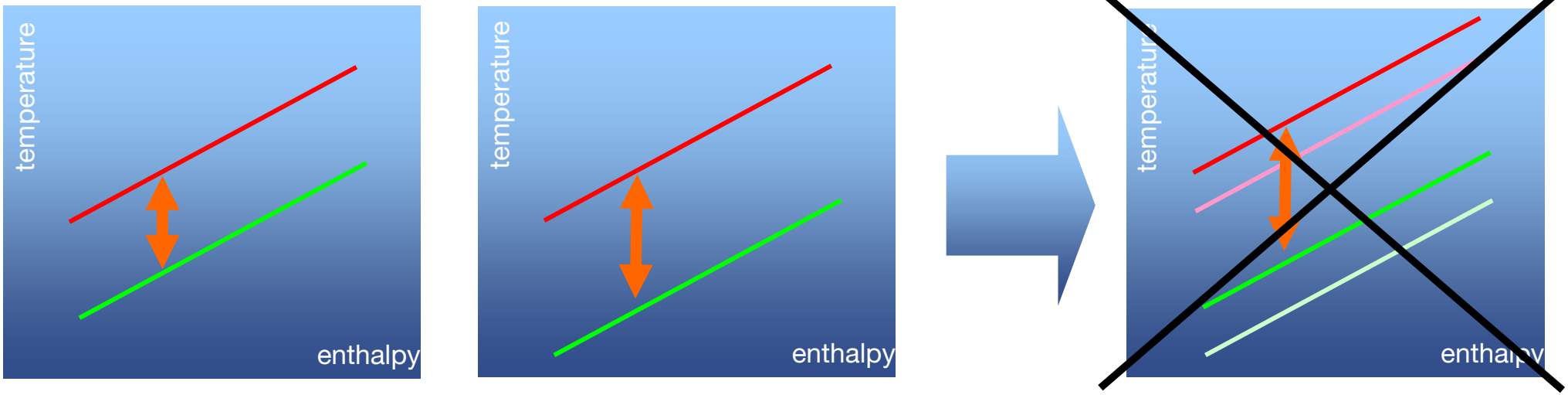
Higher ΔT to keep duty

Lower process fluid temperature

Impossible to increase temperature in MS Tank!!!

The increased ΔT will affect operation

Twice (during charge and during discharge)



molten salts

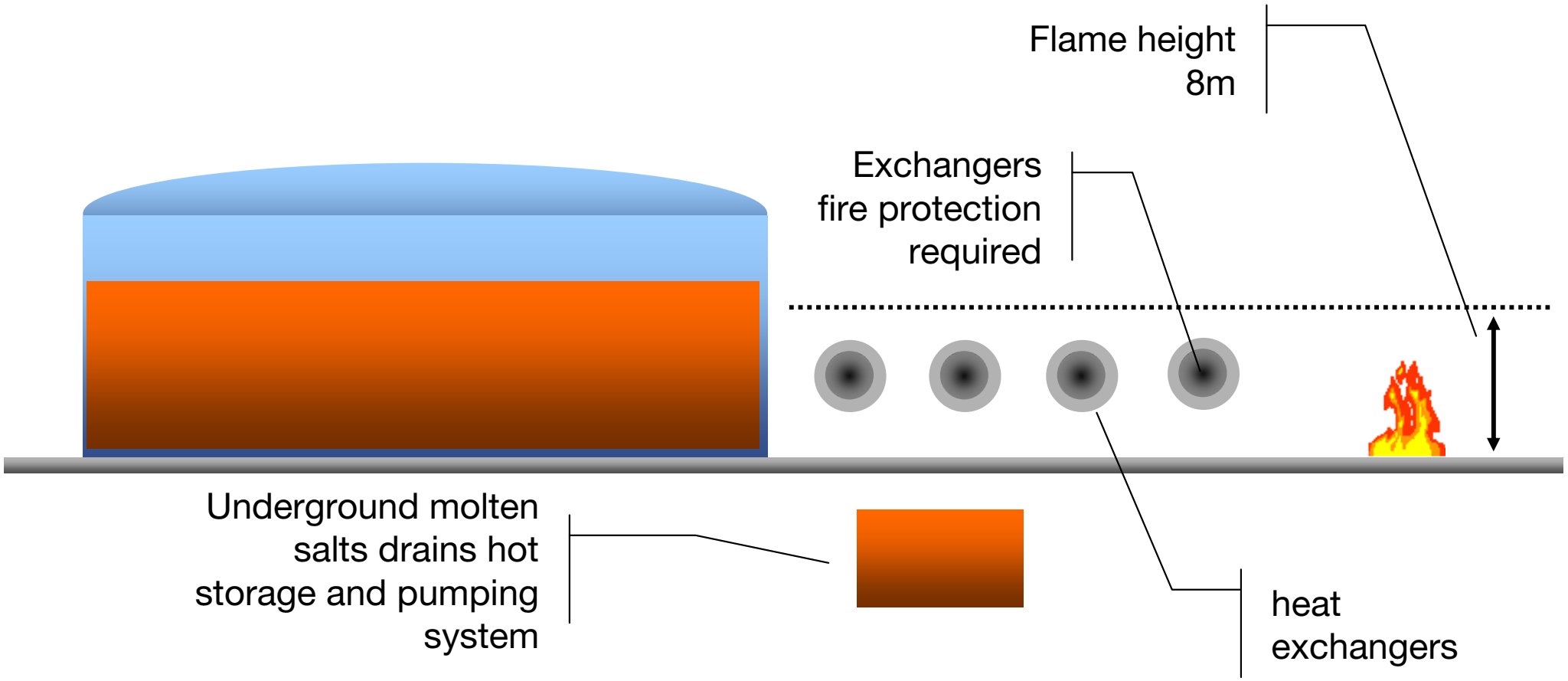
process fluid

SOME DESIGN OPTIONS FOR A TES SYSTEM

Positioning of heat exchangers

Heat exchangers placed near ground level

(ANDASOL 1)

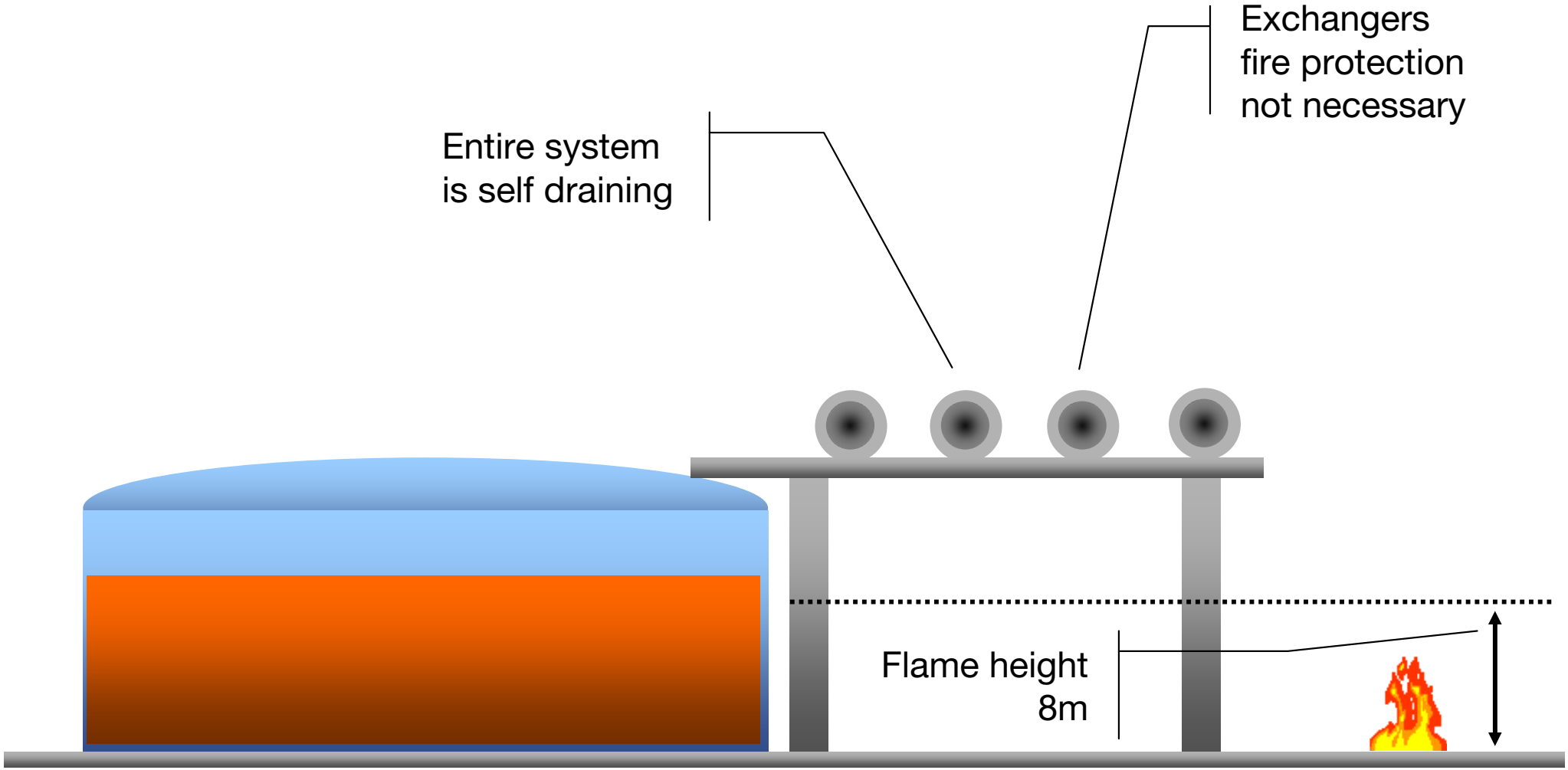


SOME DESIGN OPTIONS FOR A TES SYSTEM

Positioning of heat exchangers

Heat exchangers placed above tanks

(ANDASOL 3)



SOME DESIGN OPTIONS FOR A TES SYSTEM

Typical 3D model study

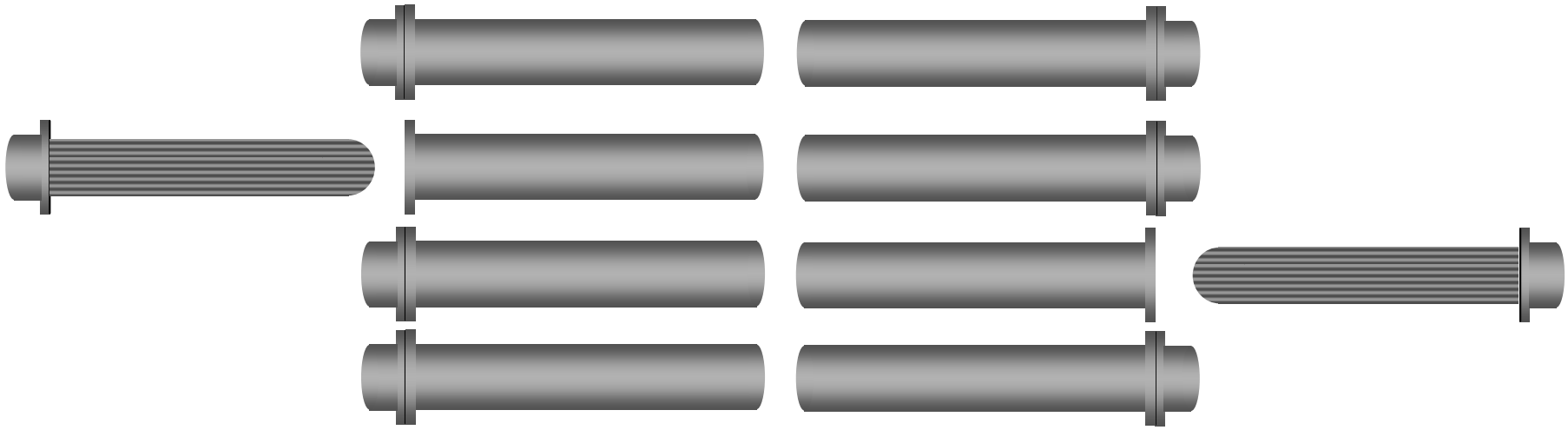
SOME DESIGN OPTIONS FOR A TES SYSTEM

Defining the number of heat exchanger batteries

When decreasing flowrate of molten salts in an heat exchanger, flow quickly approaches laminar conditions, hence the heat exchange coefficient becomes too small for an efficient heat exchange.

Therefore, whenever a wide turndown range is required, it is advisable to split the system into two separate heat exchange batteries, so that one of them can be put off line when required thermal duty is below 50%.

On the other hand, whenever the TES System is so big that it requires multiple TES modules, then the required turndown is attained by simply putting off line one of the modules. This is the case of the Starwood Solar I project.

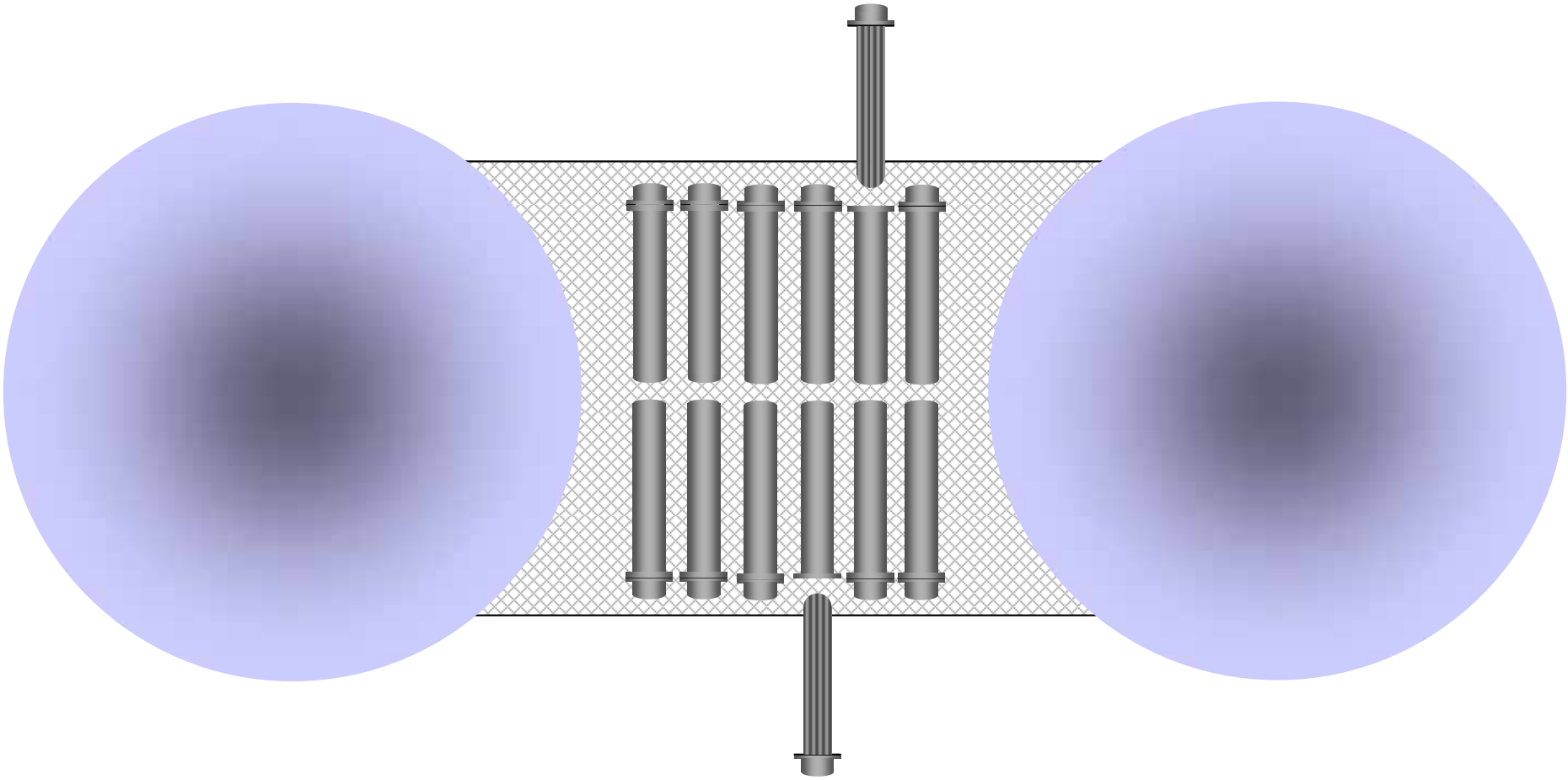


SOME DESIGN OPTIONS FOR A TES SYSTEM

Defining the relative position of heat exchangers and tanks

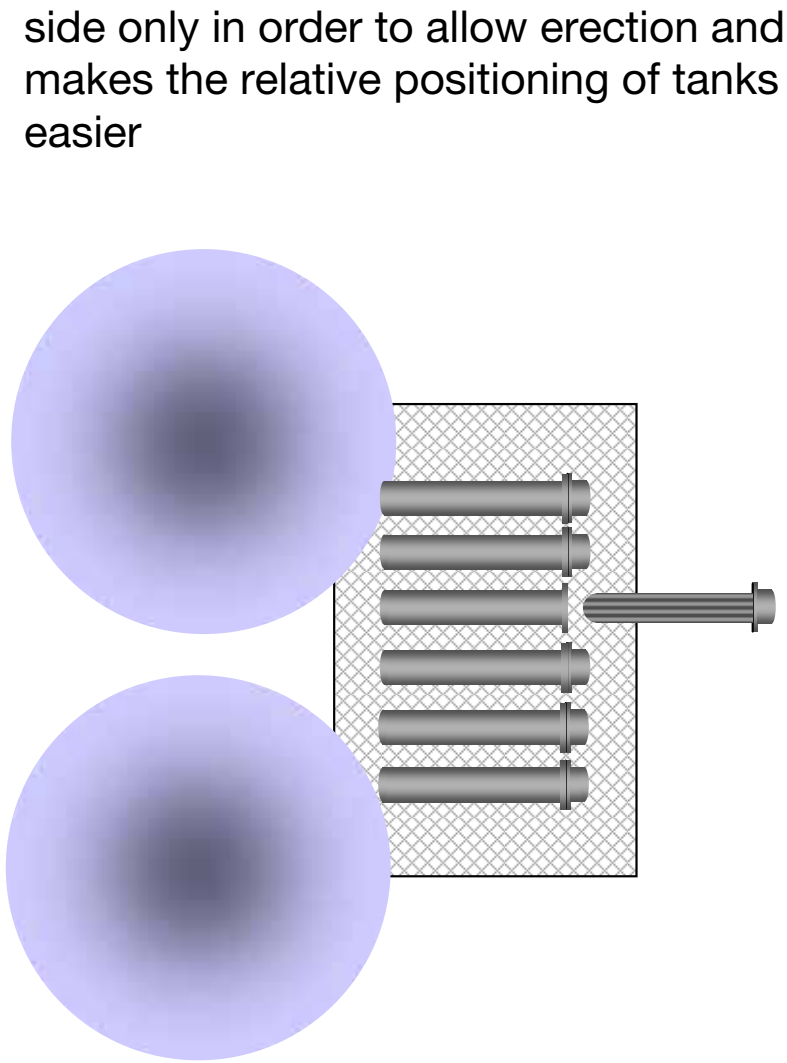
Twin battery TES Systems

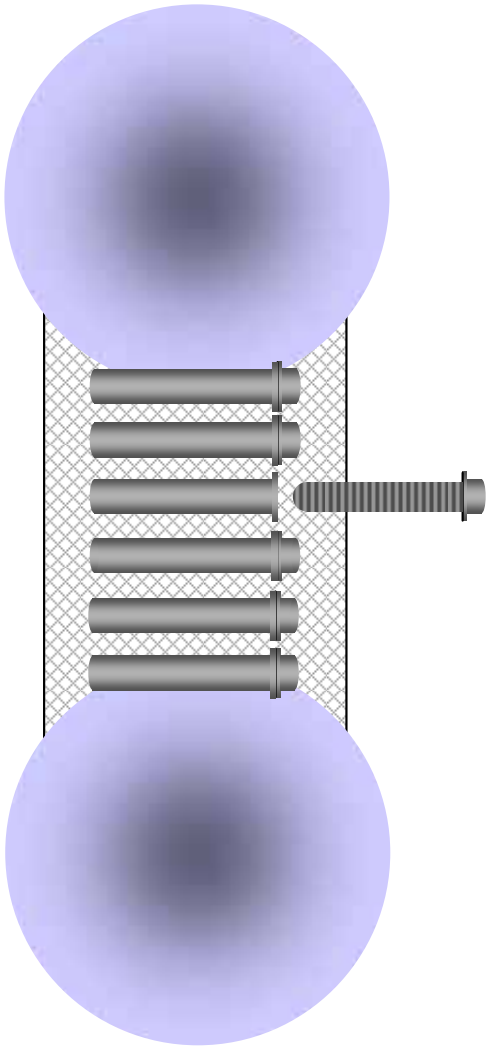
Twin battery TES systems typically require access from two sides in order to allow erection and maintenance. This is a constraint for the relative positioning of tanks and exchangers



Single battery TES Systems

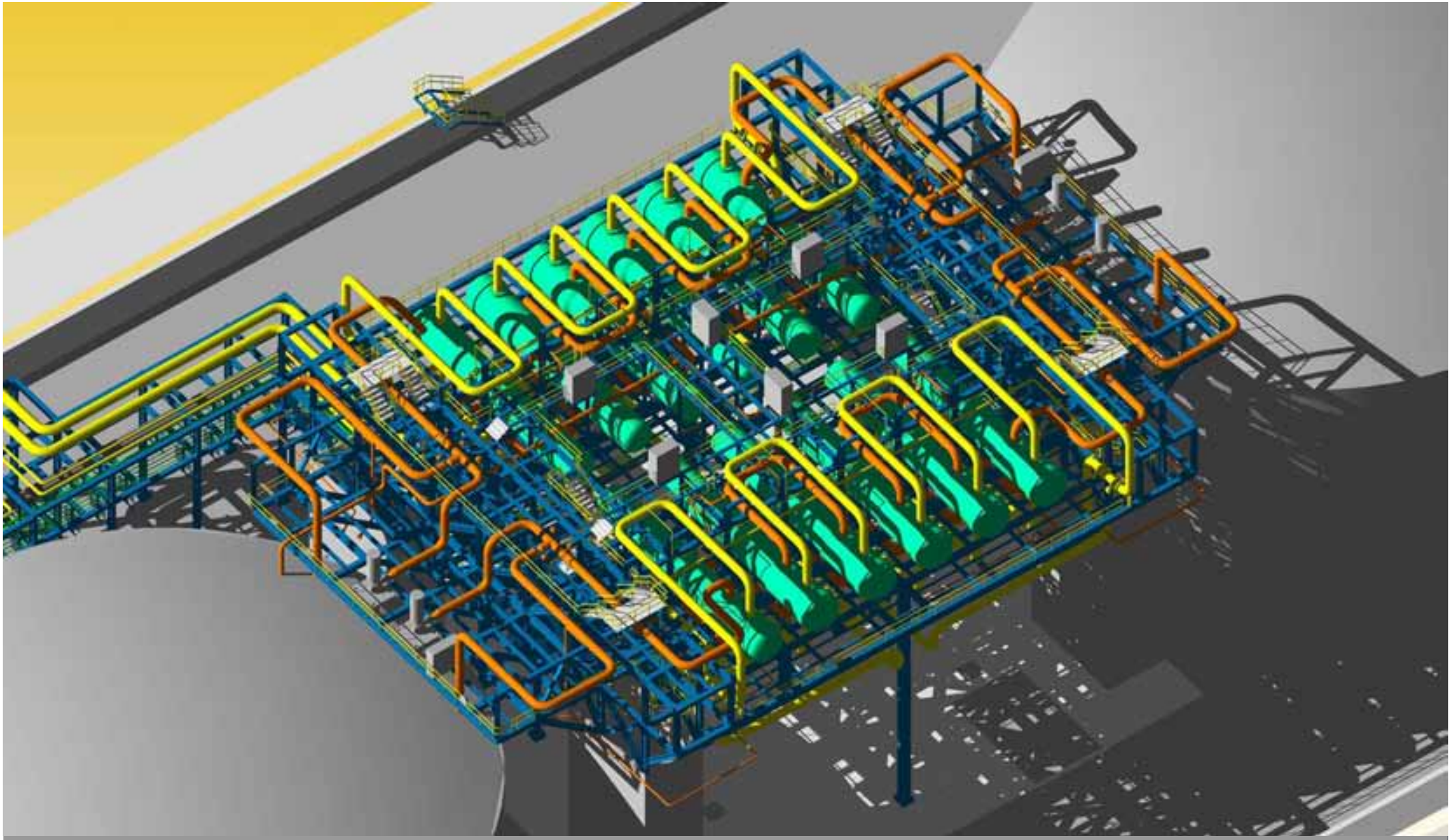
Single battery TES systems typically require access from one side only in order to allow erection and maintenance. This makes the relative positioning of tanks and exchangers much easier





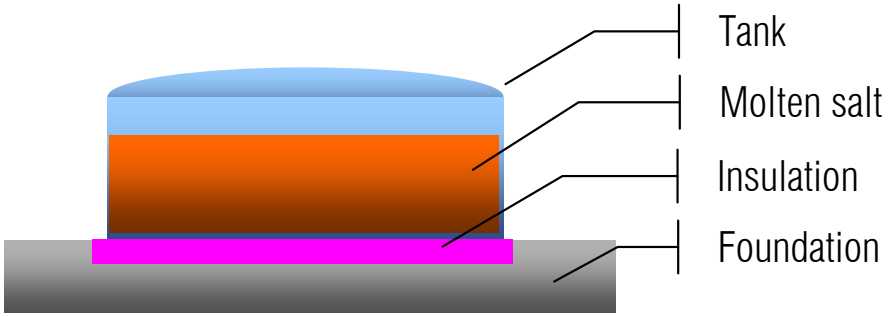
SOME DESIGN OPTIONS FOR A TES SYSTEM

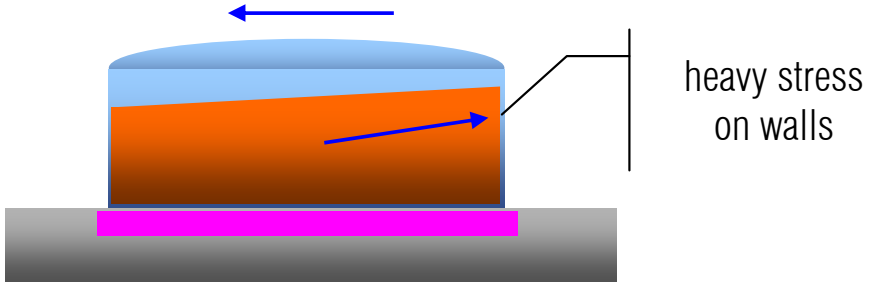
Typical 3D model study – Twin heat exchange battery

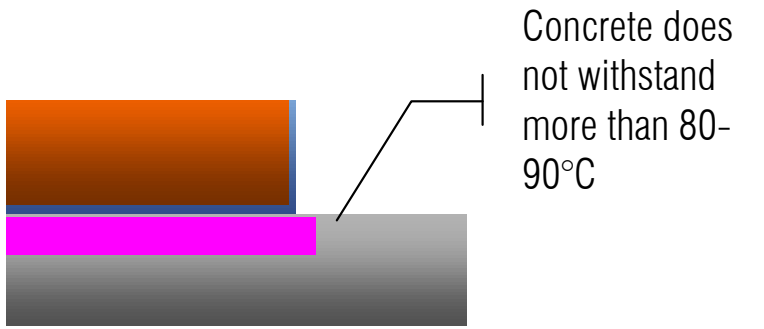


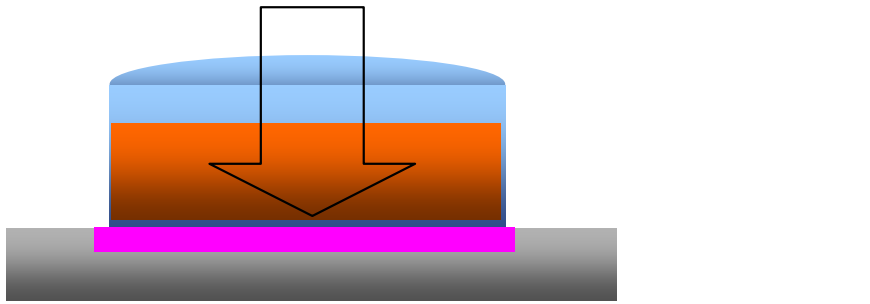
SOME DESIGN OPTIONS FOR A TES SYSTEM

Molten salts tanks foundations









Some issues in tank foundations design

Seismic behaviour

when the tank receives an horizontal acceleration, the mass of molten salts moves in the opposite direction relatively to the tank because of inertia. This creates two counterphase oscillations that put heavy stress on tank walls but that can be relieved by more yielding foundations

Allowable temperature of foundations

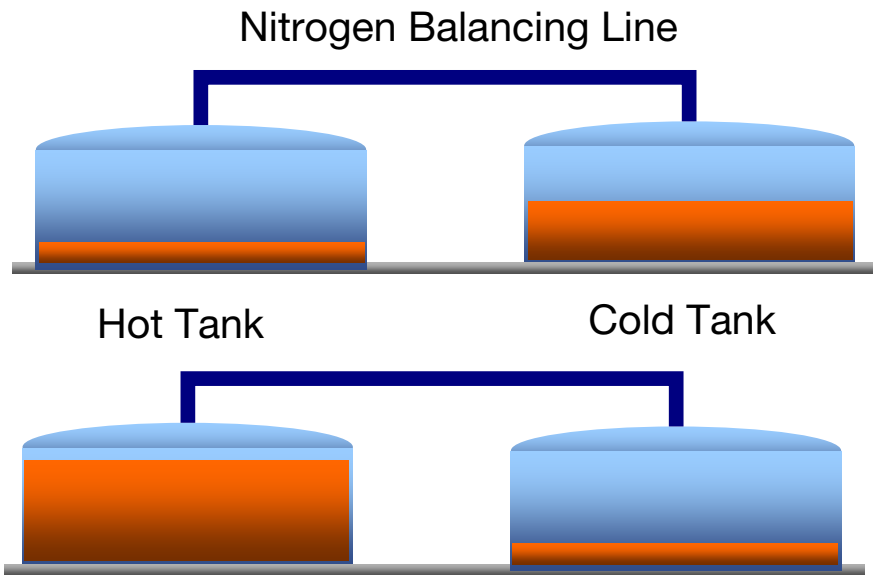
Insulation must ensure that the temperature of the concrete foundation will never exceed 80-90°C under all possible conditions. Obviously, soil thermal conductivity must be factored in.

Long term effect of hot molten salts mass

Weight and charge/discharge cycle of hot molten salts may cause thinning of softer insulation and deformation of the tank bottom, resulting in higher concrete temperature and poorer static and seismic performances.

SOME DESIGN OPTIONS FOR A TES SYSTEM

Nitrogen system



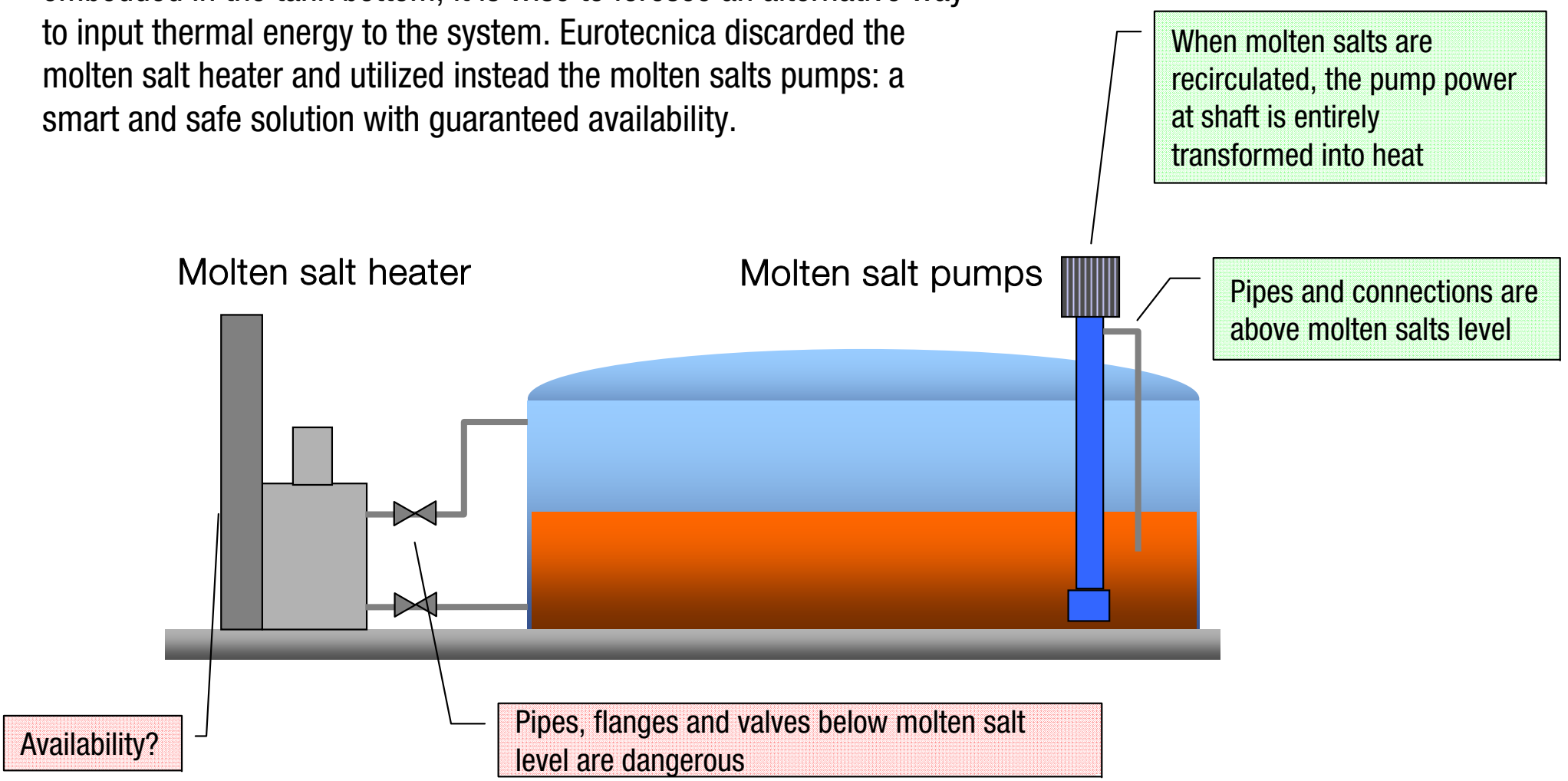
During discharge cycle, the increasing amount of molten salts in the cold tank pushes Nitrogen to the hot tank trhough the Nitrogen Balancing Line. As the temperature in the hot tank is higher, the specific volume of Nitrogen increases and part of the gas has to be purged in order not to put the tanks under pressure.

The amount to be purged can be just released to atmosphere or cleaned from molten salt mists (if any), cooled, compressed and stored in order to progressively recycled to the system while depleting the stored heat.

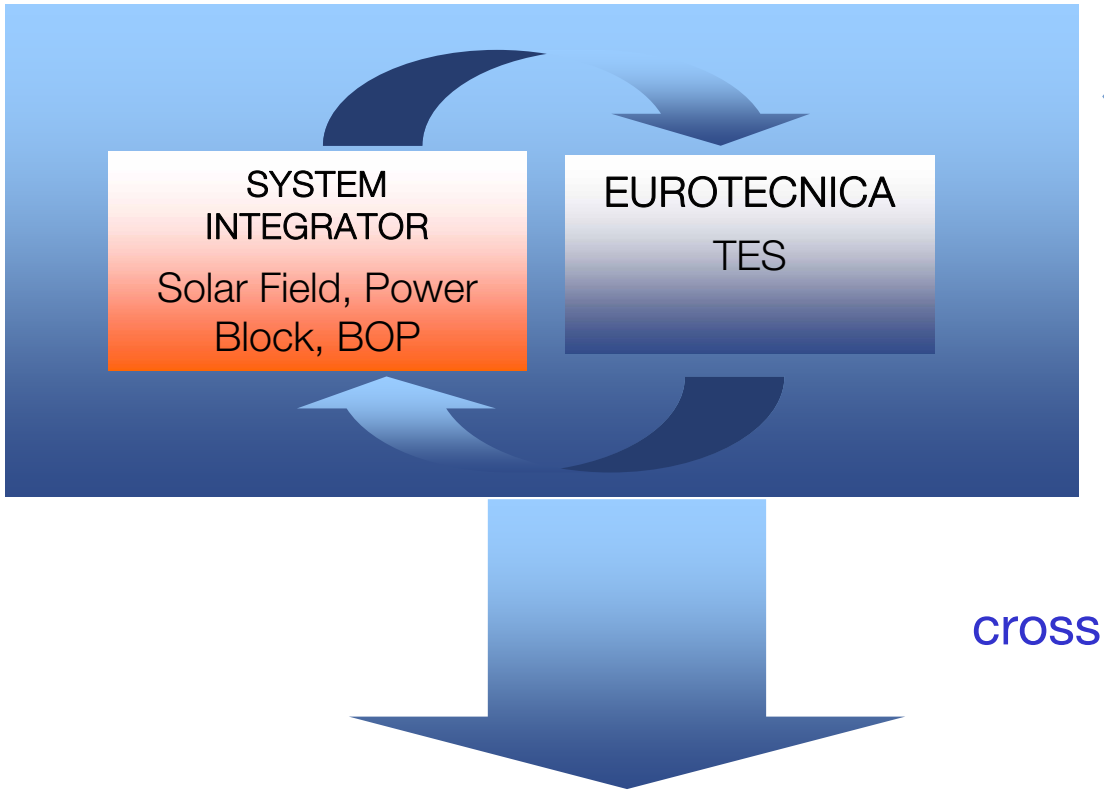
SOME DESIGN OPTIONS FOR A TES SYSTEM

Long term heat backup

In case of very long unavailability of the solar field, a redundant heat backup system has to be foreseen in order to prevent the freezing of the salts inside the tanks. In addition to electric resistances embedded in the tank bottom, it is wise to foresee an alternative way to input thermal energy to the system. Eurotecnica discarded the molten salt heater and utilized instead the molten salts pumps: a smart and safe solution with guaranteed availability.



Integrated design team



Suppliers

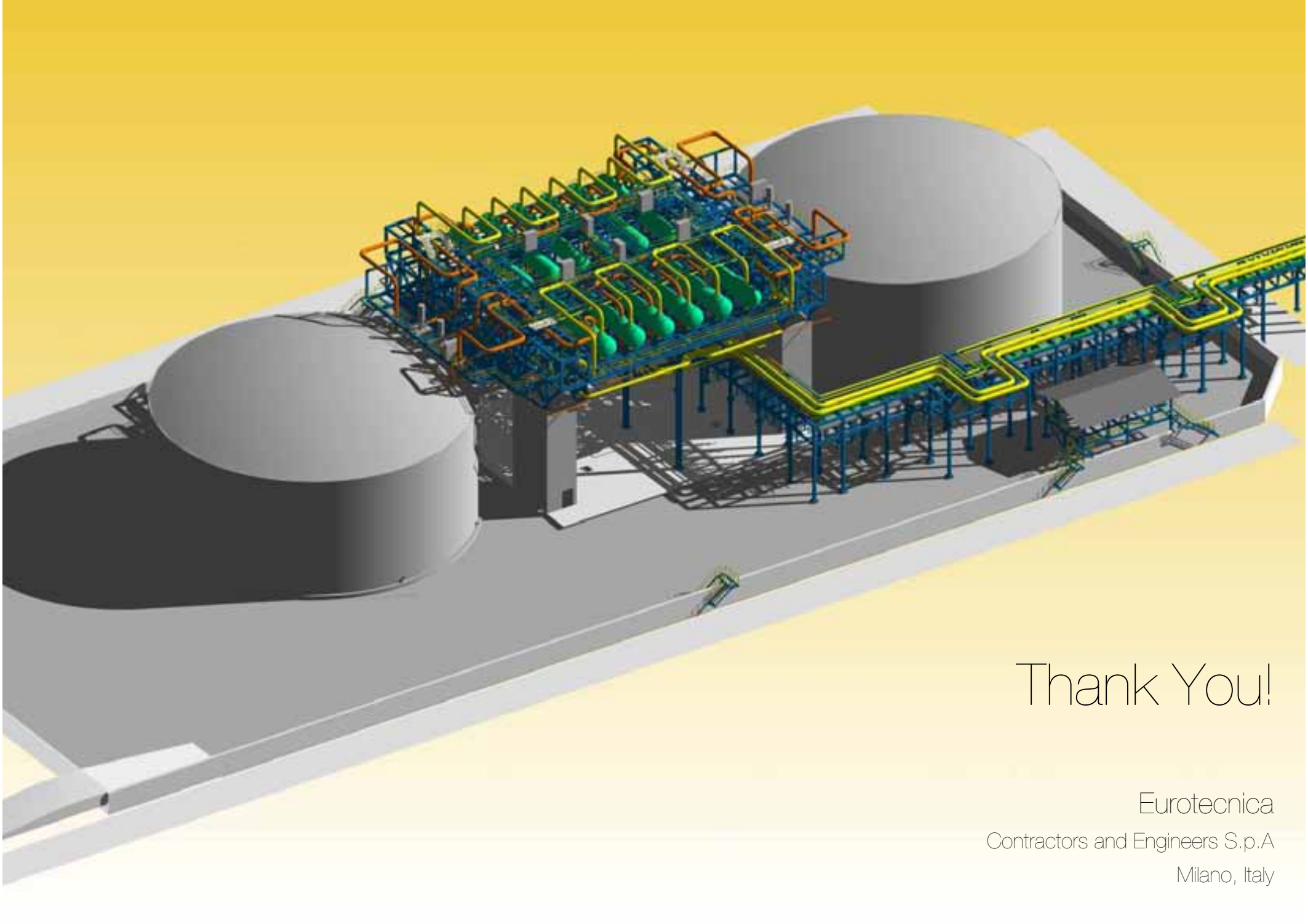
Previous experiences

Carefully thought and cross checked process engineering

Firm budget – Risks minimized

Streamlined project execution

Tighter schedule is possible



Thank You!

Eurotecnica

Contractors and Engineers S.p.A

Milano, Italy