Modelling and simulation of a compressed air storage system coupled to a building and to a photovoltaic generator.

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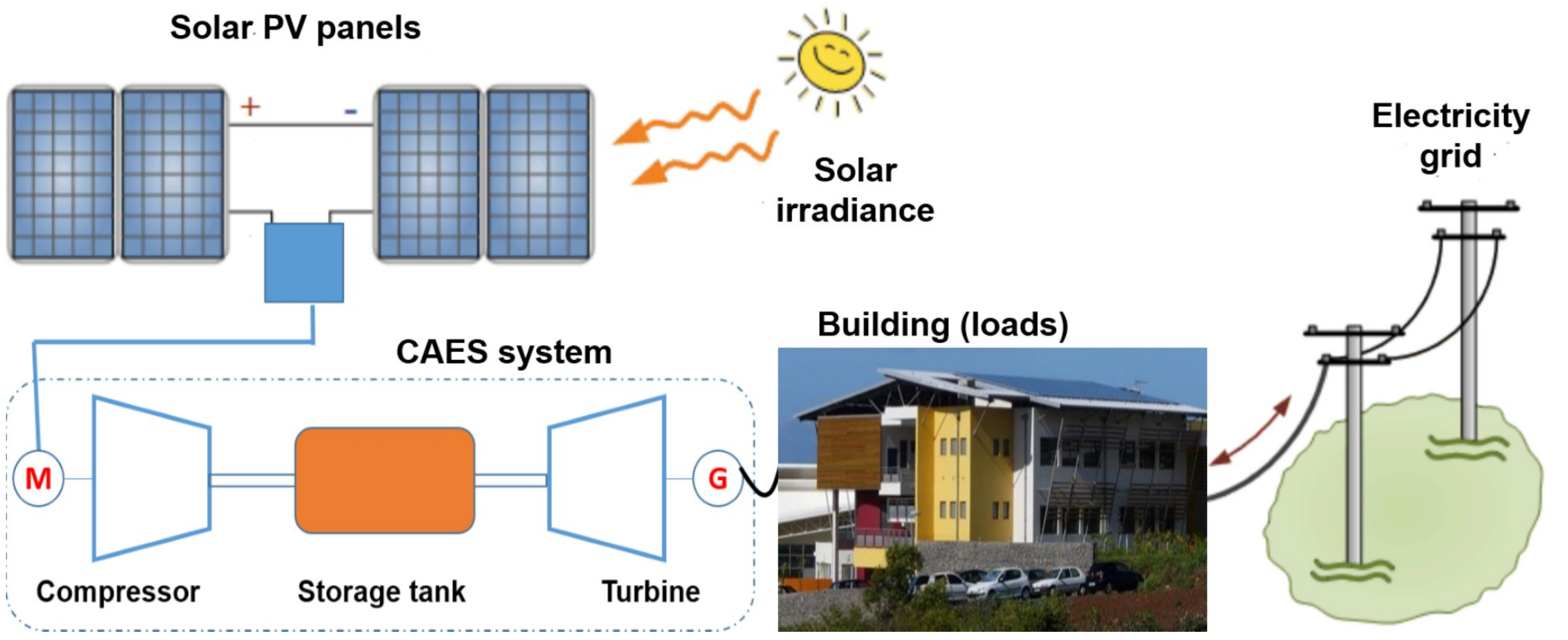
Introduction

By now, the increasing in energy demand, the decrease of fossil resources and the environmental and climate problems caused by these fossil resources are the mains challenges of the researchers. To overcome this issues it is necessary to develop optimized and sustainable energy systems.The Compressed Air Energy Storage (**CAES**) and the development of Net Zero Building (**Net ZEB**) appear as an appropriate solution for island area with a tropical climate and no connected electric grid as Reunion island.The modelisation of a compressed Air Energy Storage system connected photovoltaic generator (PV), a building and the grid will be the main subject of this study.

Objectives

The main goal of this work to model the Compressed Air Energy Storage system supplied by the photovoltaic field and connected to a building (electric charge) which is also connected the Electric grid as shown the figure below.



The excess electricity producted by the PV is used to power the compressor for storing compressed air in a tank. This air will be used to power an air turbine to power the building's loads when demand rises or will be injected to the electric grid,different scenarios will be studied.

Methodology

The work will follow the diagram below:

Review on CAES model ⇨ Analysis and comparison ⇨ Comparison of air state ⇨ Dynamic simulation

State of air:

- **GPI** :Ideal gas with constant thermal capacity;
- **GP** :Ideal gas with variable thermal capacity;
- **GR** :Real gas ;
- **AH** :Humid gas.

Condition of comparison:

Component	Temperature (°C)		Presure (bar)		humidity (%)	
	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet
Compressor	30	-	1	50	50	-
Turbine	50	-	50	1	-	-

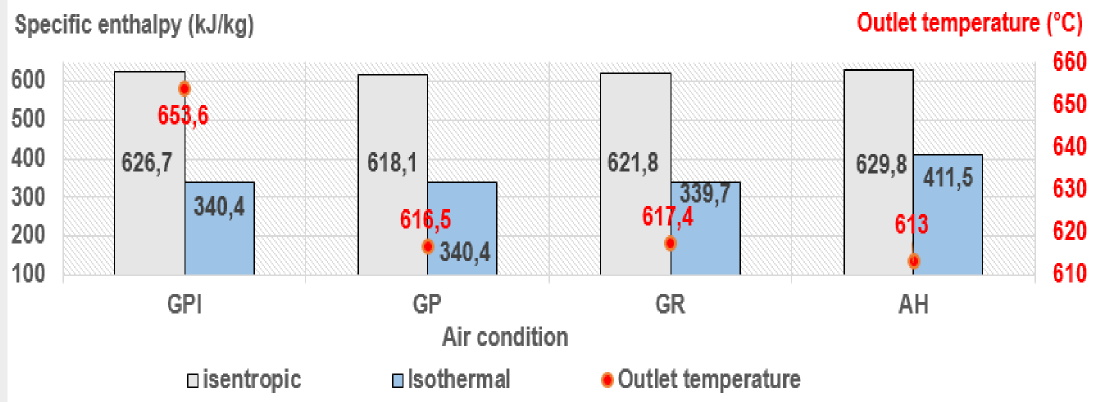
Equation used:

$$w_{comp_s} = h_{out,comp} - h_{in,comp} \quad (1)$$

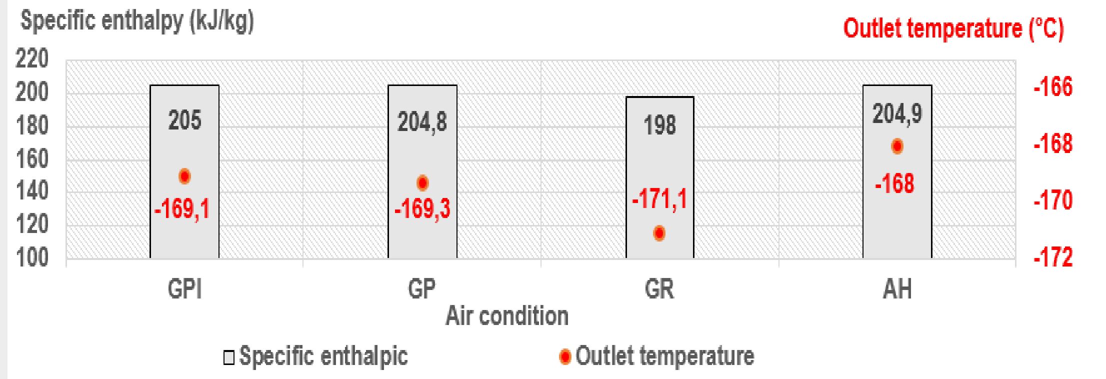
$$w_{comp_i} = T_{in,comp}\left(s_{out,comp} - s_{in,comp}\right) \quad (2)$$

The equation **(1)** is used for Isentropic model and equation **(2)** is used for Isothermal model. The compressor and turbine work is calculated with **EES** software; using the parameters contained in the table.

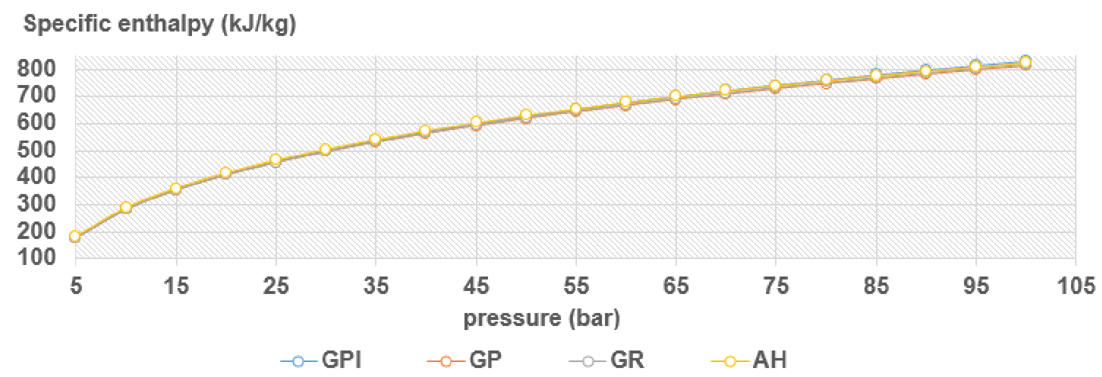
Results

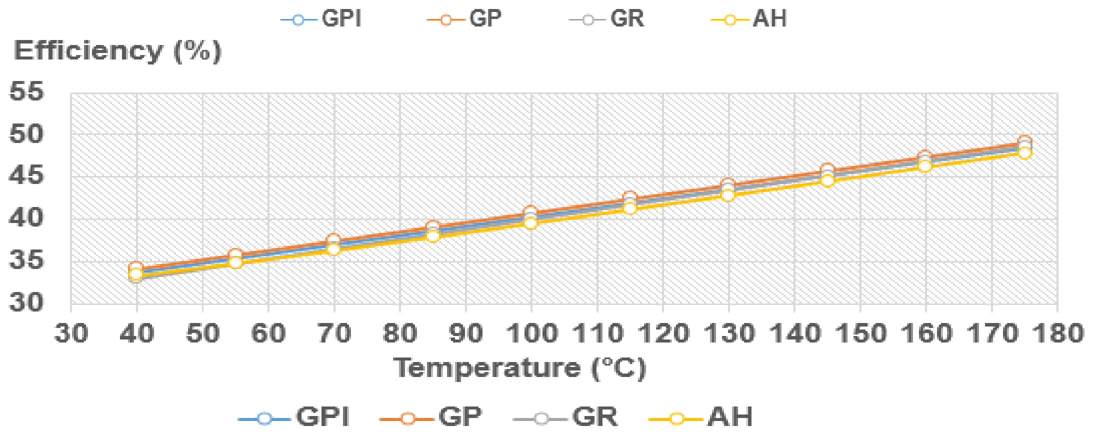


- Enthalpy almost identical for all states of the air;
- Less work for the isothermal case compared to the isentropic case;
- Higher output temperature for the case of ideal gas with constant thermal capacity.



- Negative outlet temperature (about -170 ° C);
- Isobaric heating is necessary to have the positive temperatures.

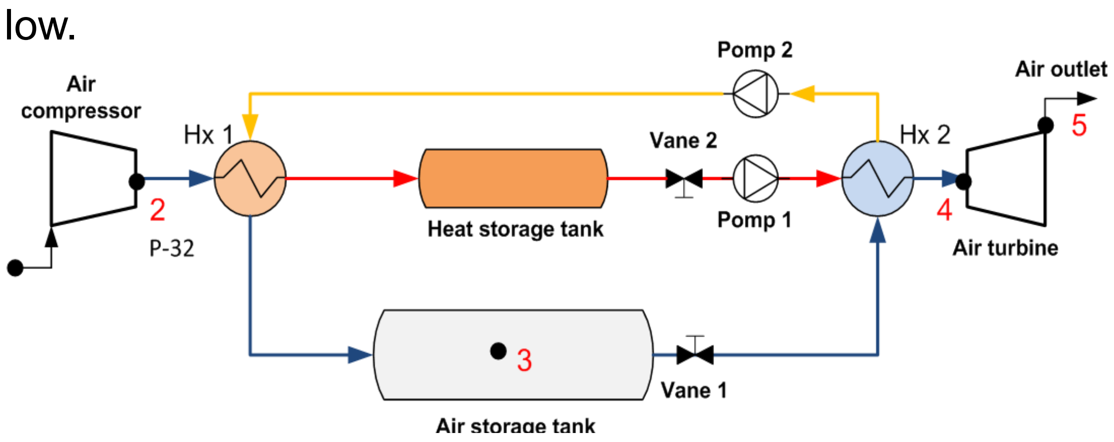




- Increasing evolution of the overall performance of the system depending on the turbine's inlet temperature;
- Warming air at the inlet of the turbine is essential for better performance.

Conclusion and perspective

For the continuation of this study we envisage a dynamic simulation of the overall system as indicates the figure below.



Equation for simulation:

$$\begin{cases} \dfrac{dM_a}{dt} = \dot{m}_{comp} - \dot{m}_{turb} \\ \dfrac{dU_{stor}}{dt} = \dot{m}_{comp}\, h_{comp} - \dot{m}_{turb}\, h_{turb} + \dot{Q}_{stor/ext} \end{cases} \quad (3)$$

The equivalent equation is used to calculate the heat storage system, taking into account the eventual loss in the tank and at the heat exchangers. A dynamic coupling of CAES with a building and a renewable energy generation (photovoltaic) will be studied.