HYDRO-PNEUMATIC ENERGY STORAGE SYSTEM

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Outline

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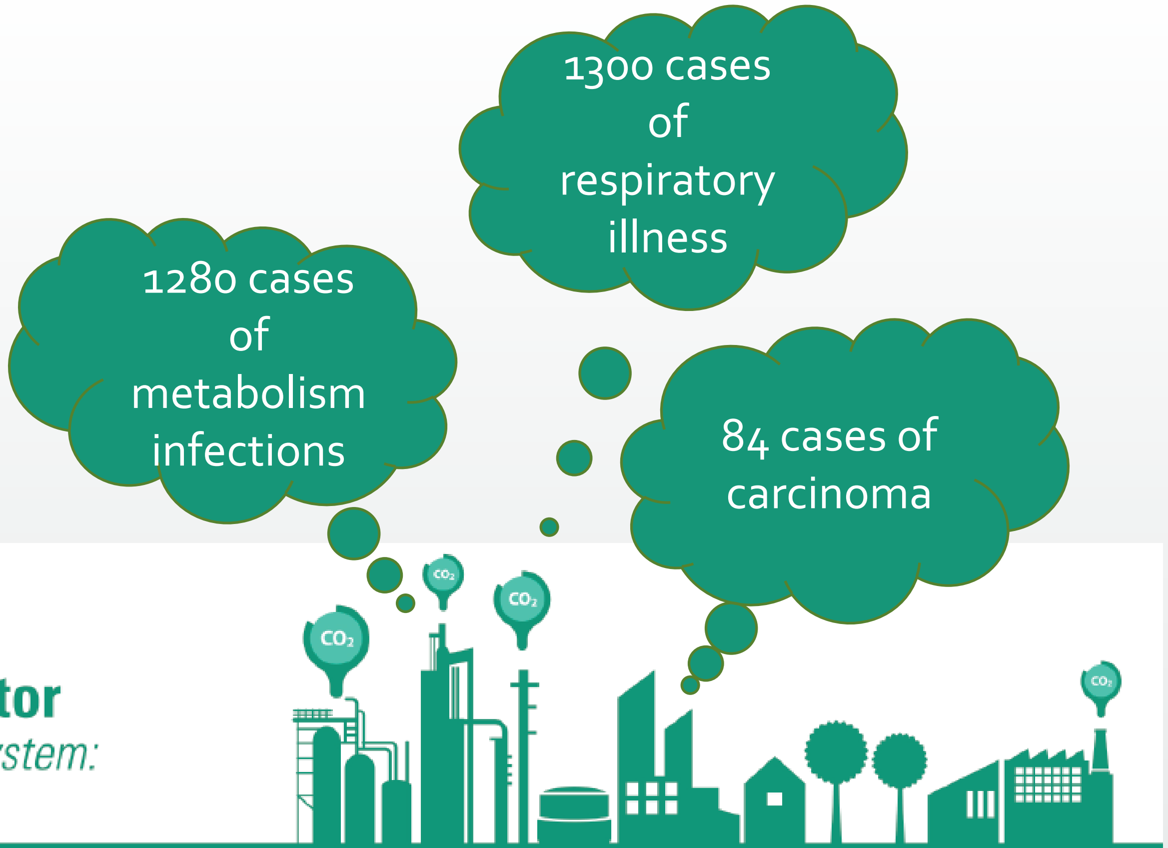
Problem

COUNTRY	ELECTRICITY EMISSION FACTOR (TCO2/MWH)
SYRIA	0.641
MIDDLE EAST	0.690
LEBANON	0.717 (0.650 CALCULATED BY LCEC - 2011)
SAUDI ARABIA	0.757
AUSTRALIA	0.853
LYBIA	0.872
BOTSWANA	2.063

CO2 Emission Factor

for Lebanon's Electricity System:

0.65tCO2/MWh



PLANT	FUEL TYPE	NET ELECTRICITY DELIVERED (MWH)	OM EMISSION FACTOR (TCO2/MWH)
ZOUK	HFO	2,334,885	0.7906
SOUTH (JYEH)	HFO	1,502,664	0.9452
ZAHRANI	DIESEL (CCGT)	3,110,420	0.5567
DAIR AMMAR	DIESEL (CCGT)	2,890,842	0.5572
BAALBECK	DIESEL (CCGT)	200,875	0.8915
TYR	DIESEL (CCGT)	334,902	0.9447
HREICHEH	HFO	284,003	1.0056

Problem

Over 3000 generators in Lebanon

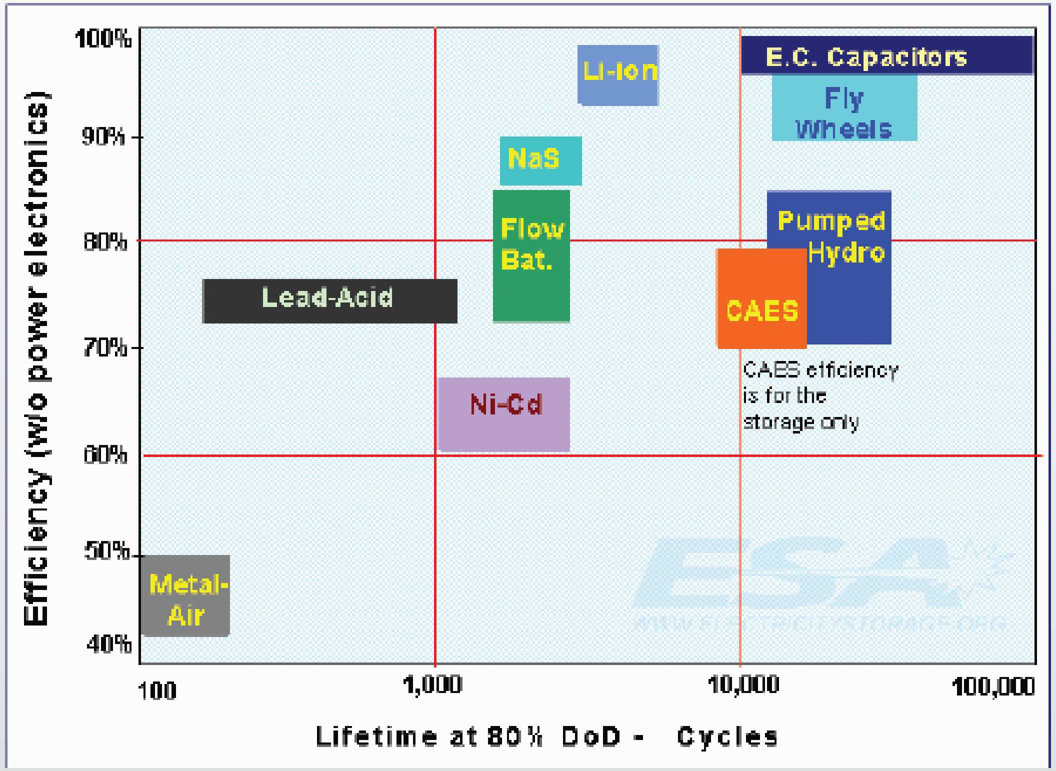
A study by the American University in Beirut in 2013 revealed that the use of diesel generators for up to 3 hours per day in Beirut, raises the rates of daily exposure to cancer by 33%

Existing Storage Systems

Electrochemical batteries are the today's main storage technology used in renewable energies' applications. However, they present important limitations:

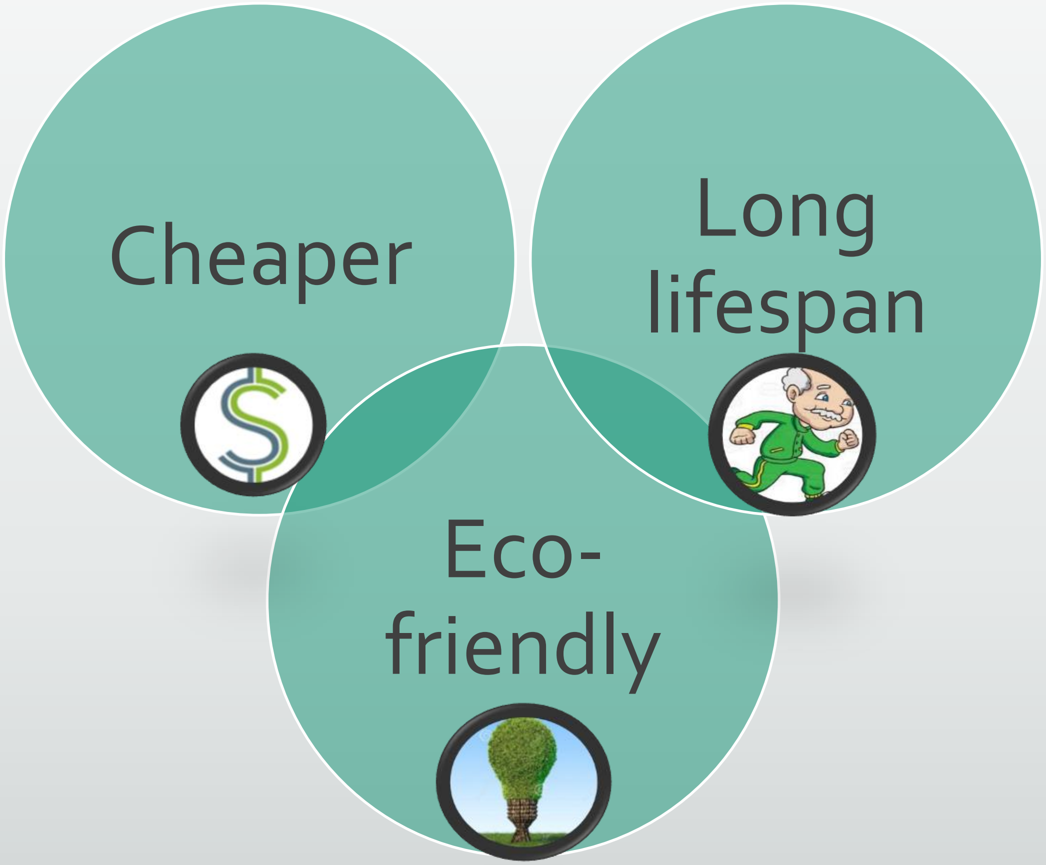
-High Cost
-Limited Duty Cycles
-Difficult and costly recycling
-Problematic waste

Alternative solutions to Electrochemical Batteries are necessary for a sustainable support to renewable sources



Solution

Hydro-pneumatic energy storage system (HYPESS) is:

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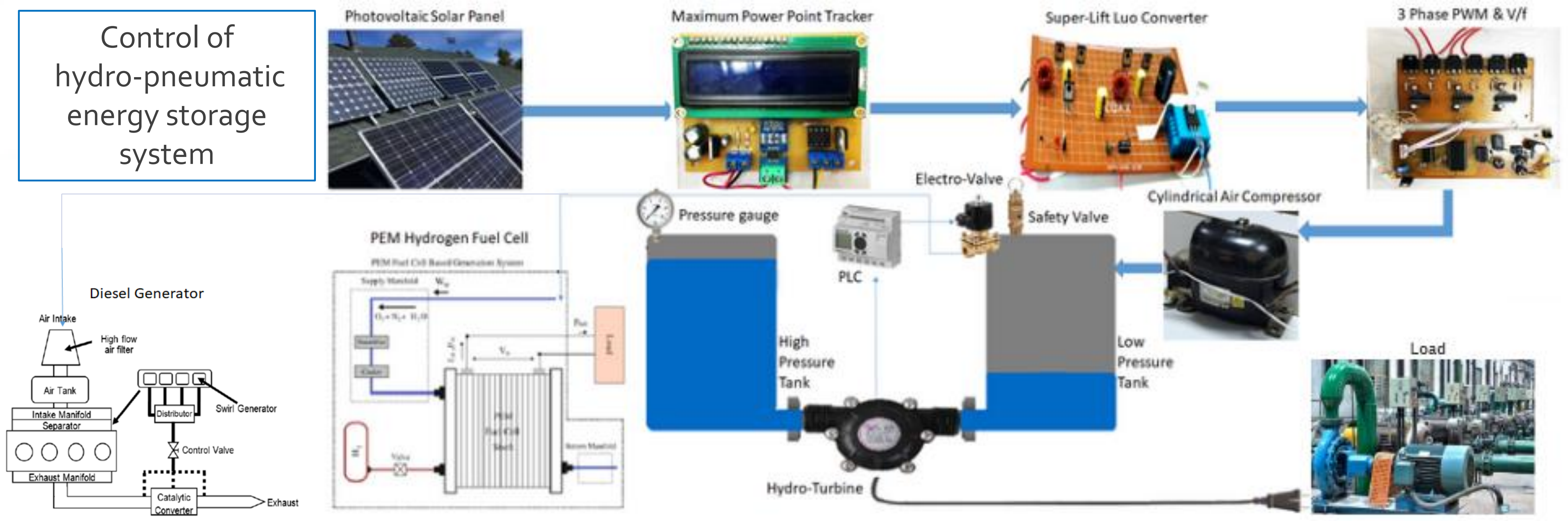
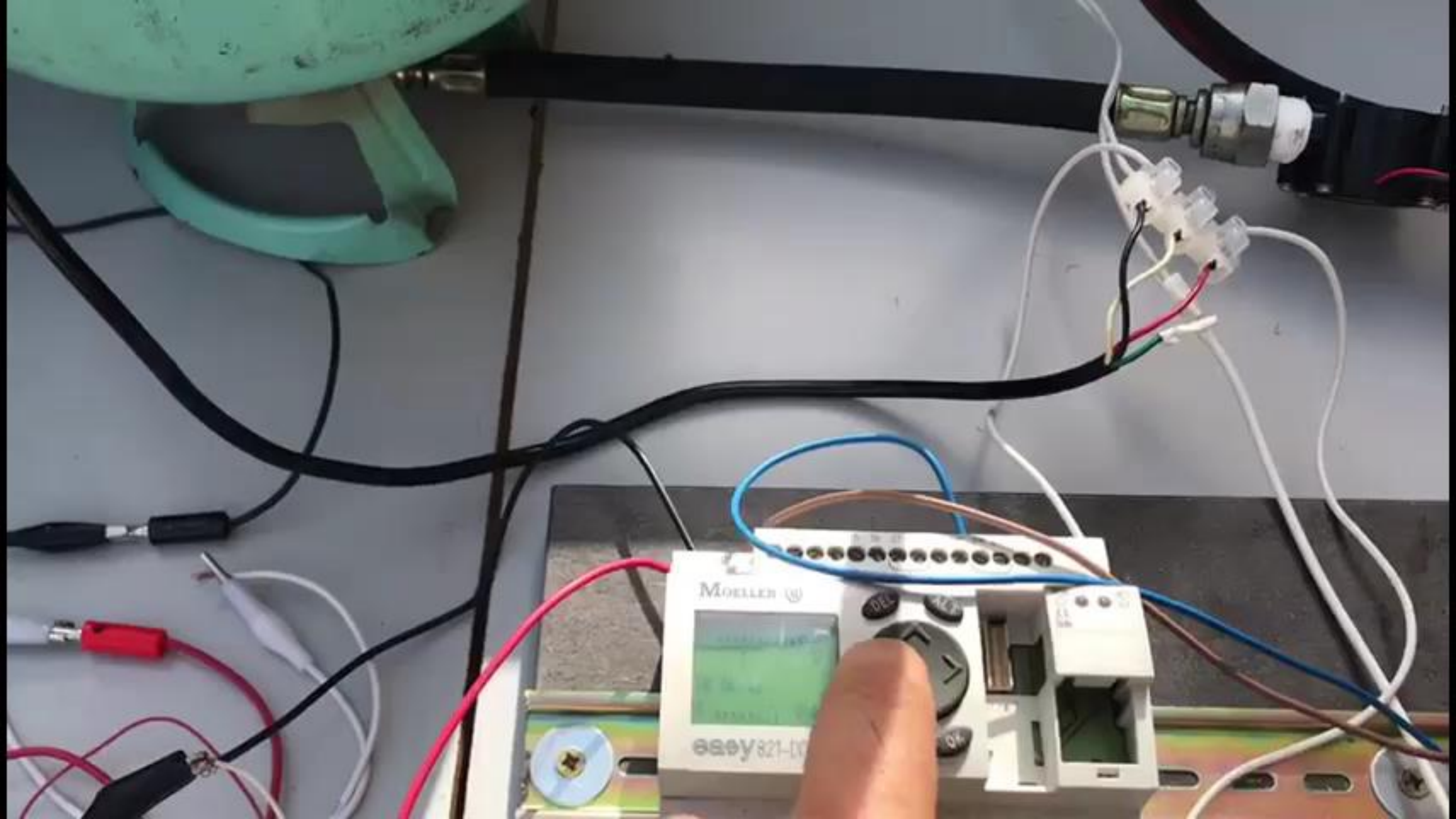
Block Diagram of the Project

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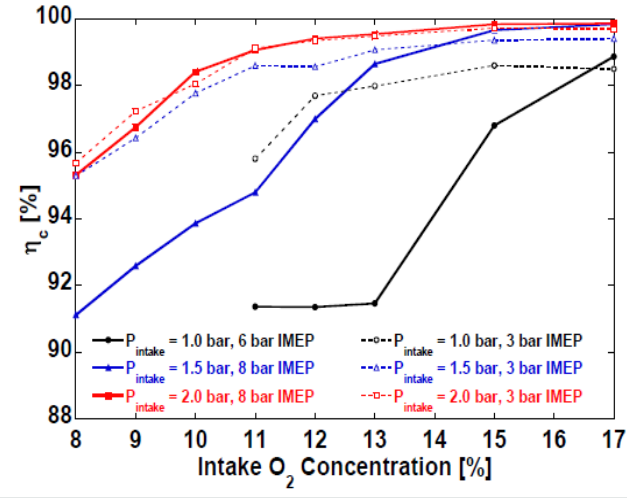
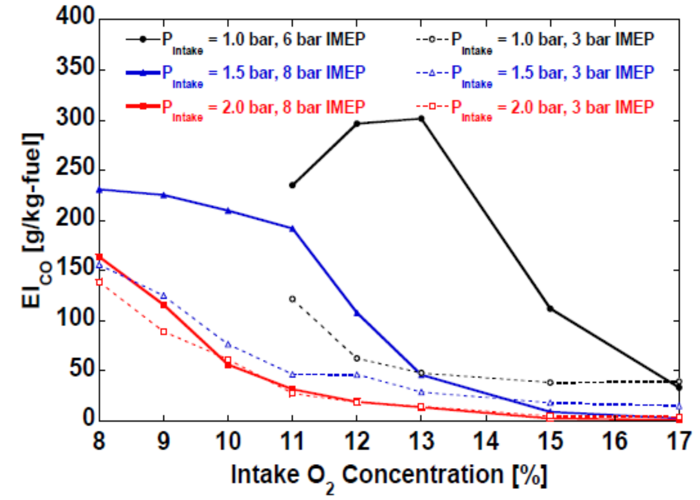
Added value

Optimizing efficiency of diesel generator

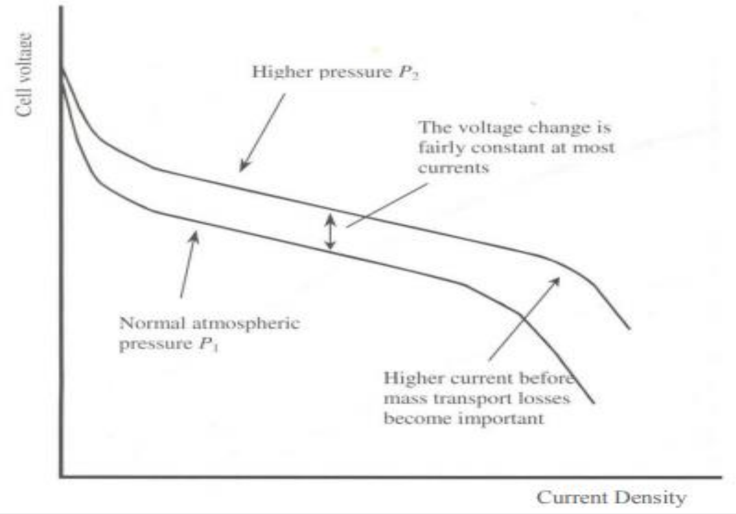


Combustion efficiencies for the O2 concentration sweeps at different intake pressure values



CO emissions indices for the O2 concentration sweeps at different intake pressure values

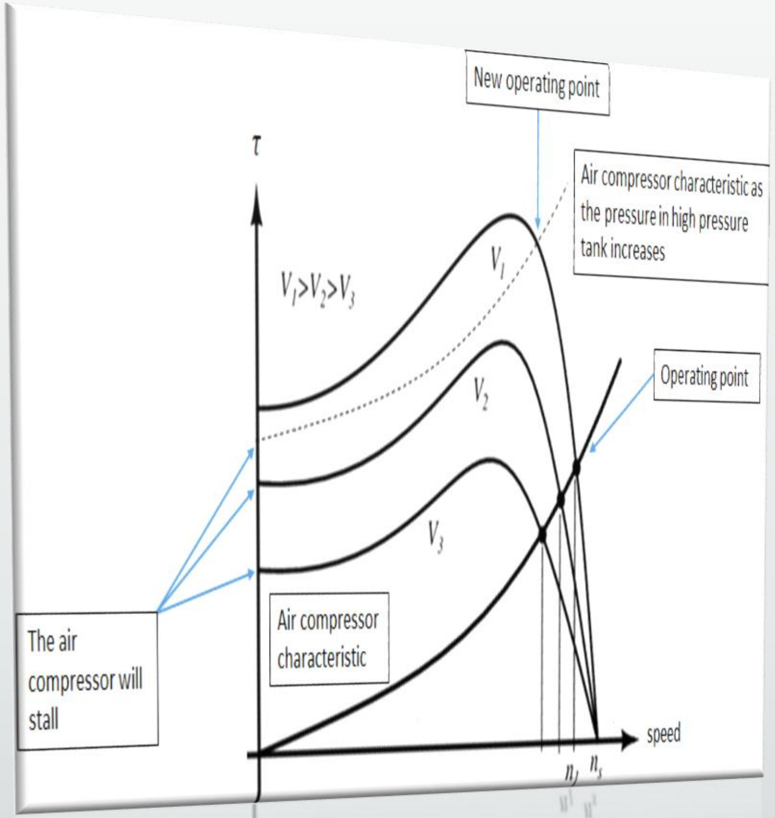
Optimizing efficiency of hydrogen fuel cell

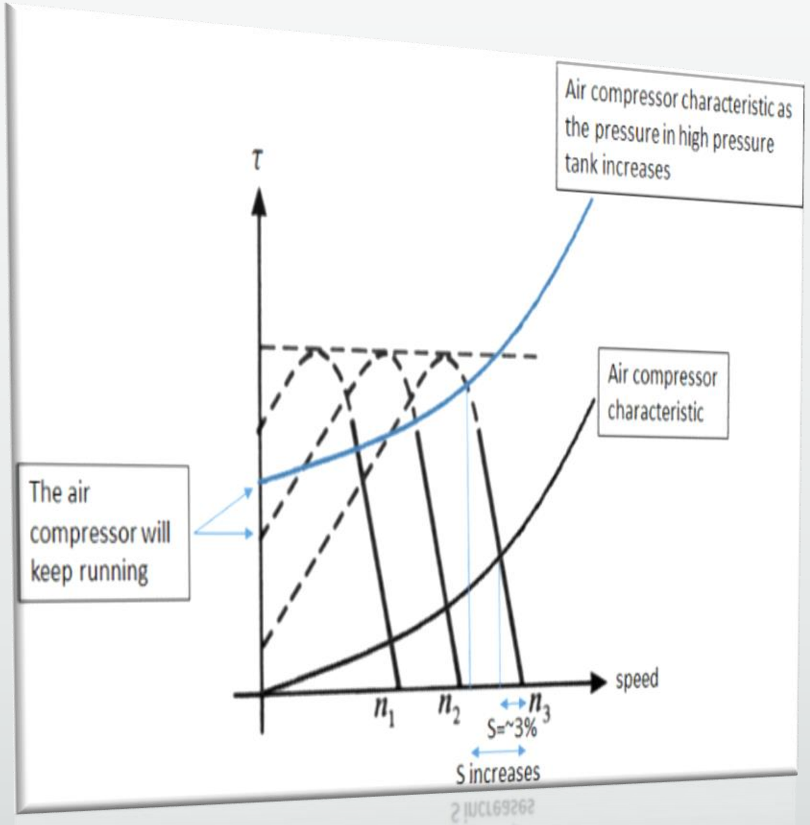


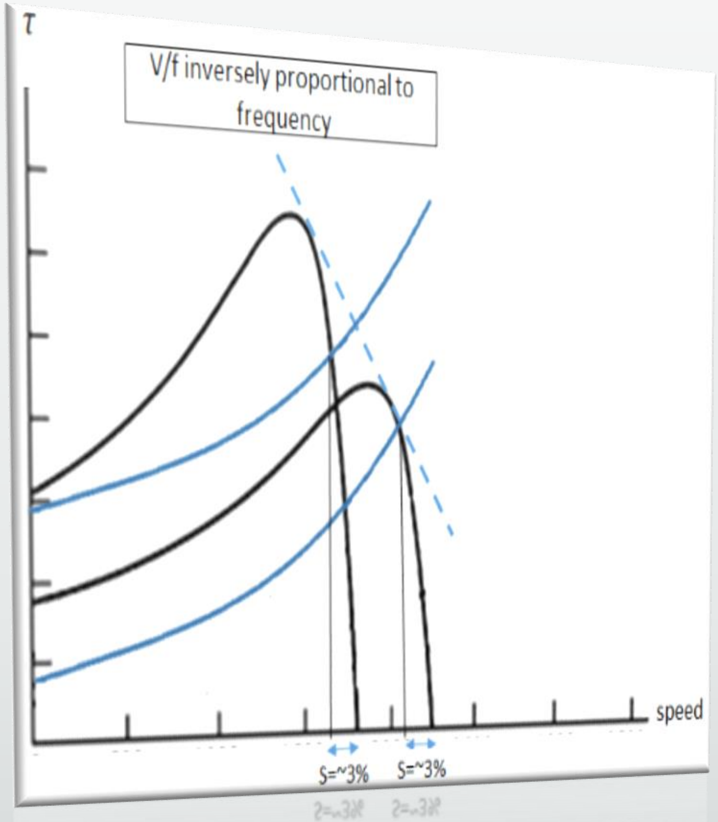
Higher reactant gas pressures in performance improvement for fuel cell

- 67.5 mV increase/cell
- 20% saving in power needed for fuel cell system

Contribution

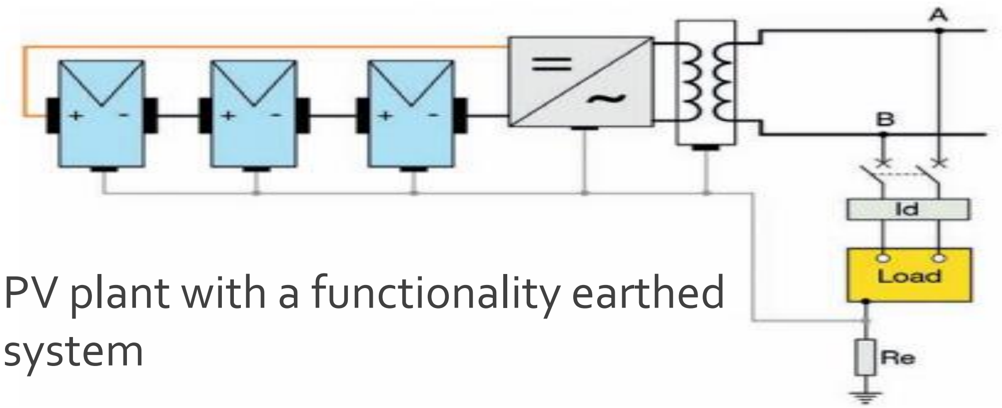




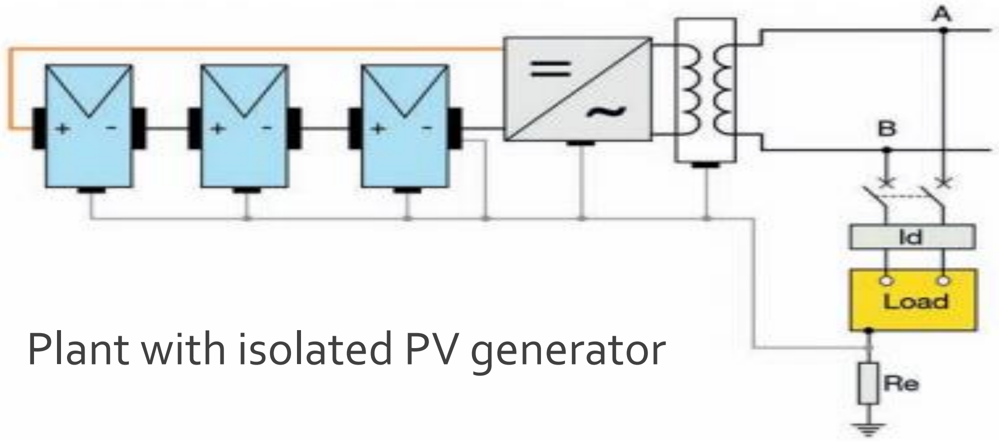


Safety

With Galvanic Isolation



PV plant with a functionality earthed system

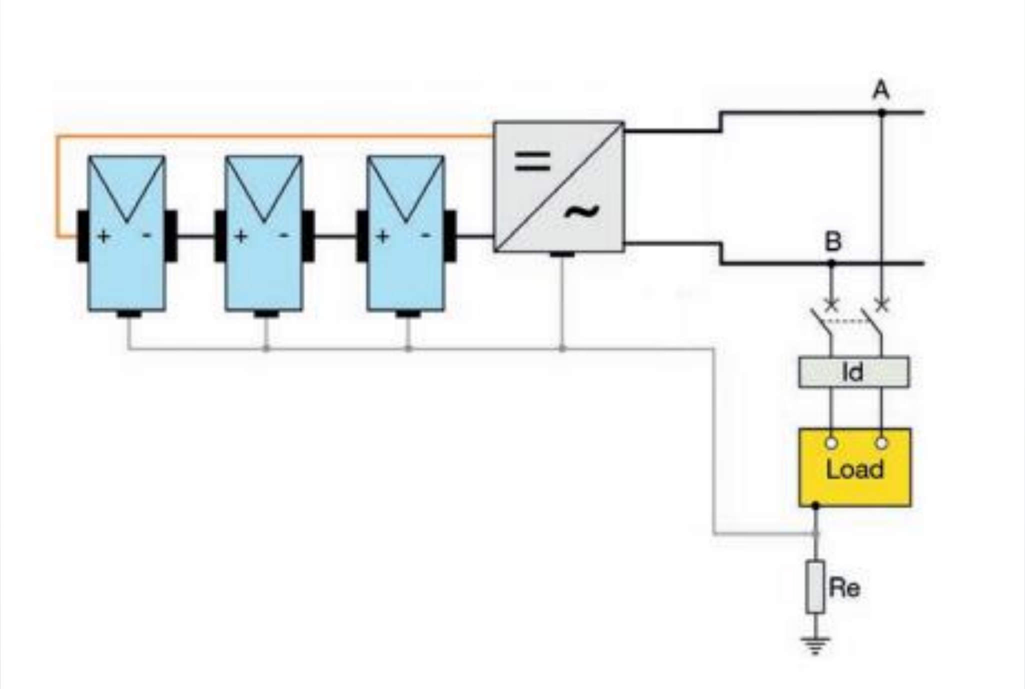


Plant with isolated PV generator

Metallic frame always earthed
In case of isolated earthing an Insulation Monitoring Device detects the first fault and trigger an alarm as the second fault will cause a short circuit.
NEC code mendates the use of Arc Fault Detection to protect from fire and explosion

Safety

Without Galvanic Isolation



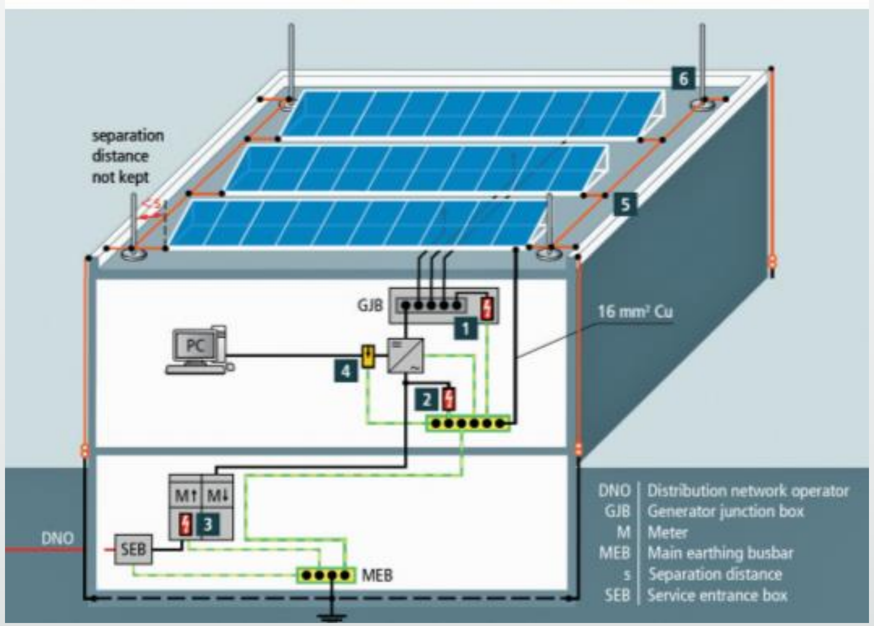
Only metallic frames are earthed and the live parts are Isolated

Residual circuit breaker on AC side must be of type B to detect the DC leakage current.

However some types of solar panels will be subject to corrosion and degradation due to leakage current which requires the functional earthing of the PV which can only be implemented with galvanic isolation

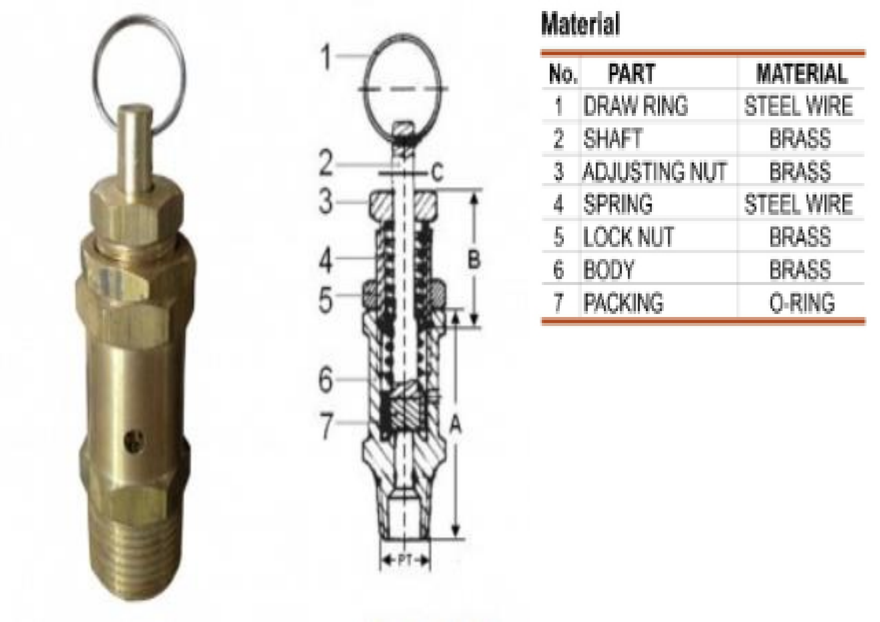
Safety

External Lightning Protection



Air termination rod connected to the mesh or ring earthing via down conductor to inject the lightning into earth. Height and separation distance calculated by the rolling sphere method or angle method

Mechanical Safety



Material

No.	PART	MATERIAL
1	DRAW RING	STEEL WIRE
2	SHAFT	BRASS
3	ADJUSTING NUT	BRASS
4	SPRING	STEEL WIRE
5	LOCK NUT	BRASS
6	BODY	BRASS
7	PACKING	O-RING

Standards

- **IEC 61701-***Salt mist corrosion resistance testing on PV modules.*
- **IEC 61215 / EN 61215 IEC 61215 -** *Aging of PV modules.*
- **IEC 60364-4-41-***Protection against electric shock.*
- **IEC 60364-***Defines standardized earthing systems*.
- **IEC 60364-6**-*The earthing resistance Re of the exposed conductive parts meets the condition.*
- **IEC 60364-7**-*Residual current circuit-breakers on the AC side of the power conversion unit should be of type B.*
- **F.A.C 62-555.330-***Recommended Standards for Water Works .*
- **ISO 3857-1:1977**-*Compressors, pneumatic tools and machines .*
- **ISO 5388:1981**-*Stationary air compressors -- Safety rules and code of practice*

Constraints

Technical constraints:

We were especially challenged by the mechanical part of the project since we didn’t have the necessary background. This was mostly influential when we tried to design the project on Simulink.

Non-Technical constraints:

- Manufacturability: A suitable hydro-turbine for our project would be around 100 W (AC), but no hydro-turbines of this rating are manufactured anywhere.
- Local supply: We couldn’t find exact needed models of the solar panel, hydro-turbine, air compressor, and many integrated circuits and microcontroller, so we were forced to order from abroad which took up from our time and budget.
- Economical constraint: We obviously as students have no or limited income so we had a budget we couldn’t surpass.

Conclusion

This system represents a solution best suited for Lebanon's conditions since there are high rates of pollution emitted by both power generating plants and diesel generators, so on one hand its long lifetime and its long term energy storage make it a cheap, feasible and reliable solution for renewable energy sources used the most in Lebanon (solar and wind) which will encourage their implementation by industrial and commercial projects, touristic institutions or built at a big scale by the government to reduce the reliance on traditional power plants, and on the other hand help achieve complete combustion in diesel generators which will optimize their efficiency reducing their pollution emissions and fuel burned.

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Thank you for listening