



**Politecnico
di Torino**

Evaluation of the technical feasibility of H₂-based solutions for all-electric aircraft


3rd International Hydrogen Aviation Conference

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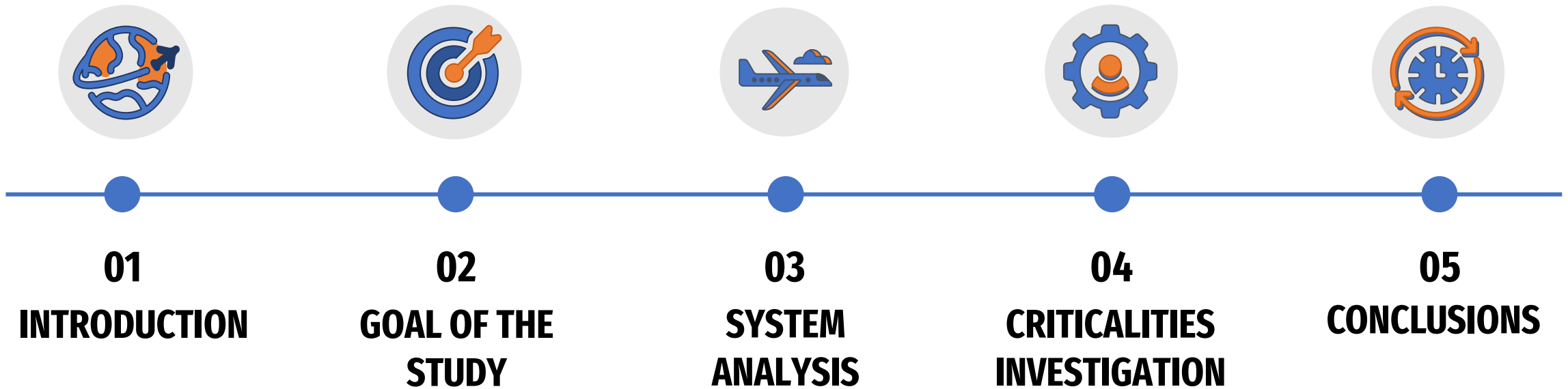
Maria Chiara Massaro
PhD Student



Some of the collaborations with companies
and institutions in the field of H₂-based solutions



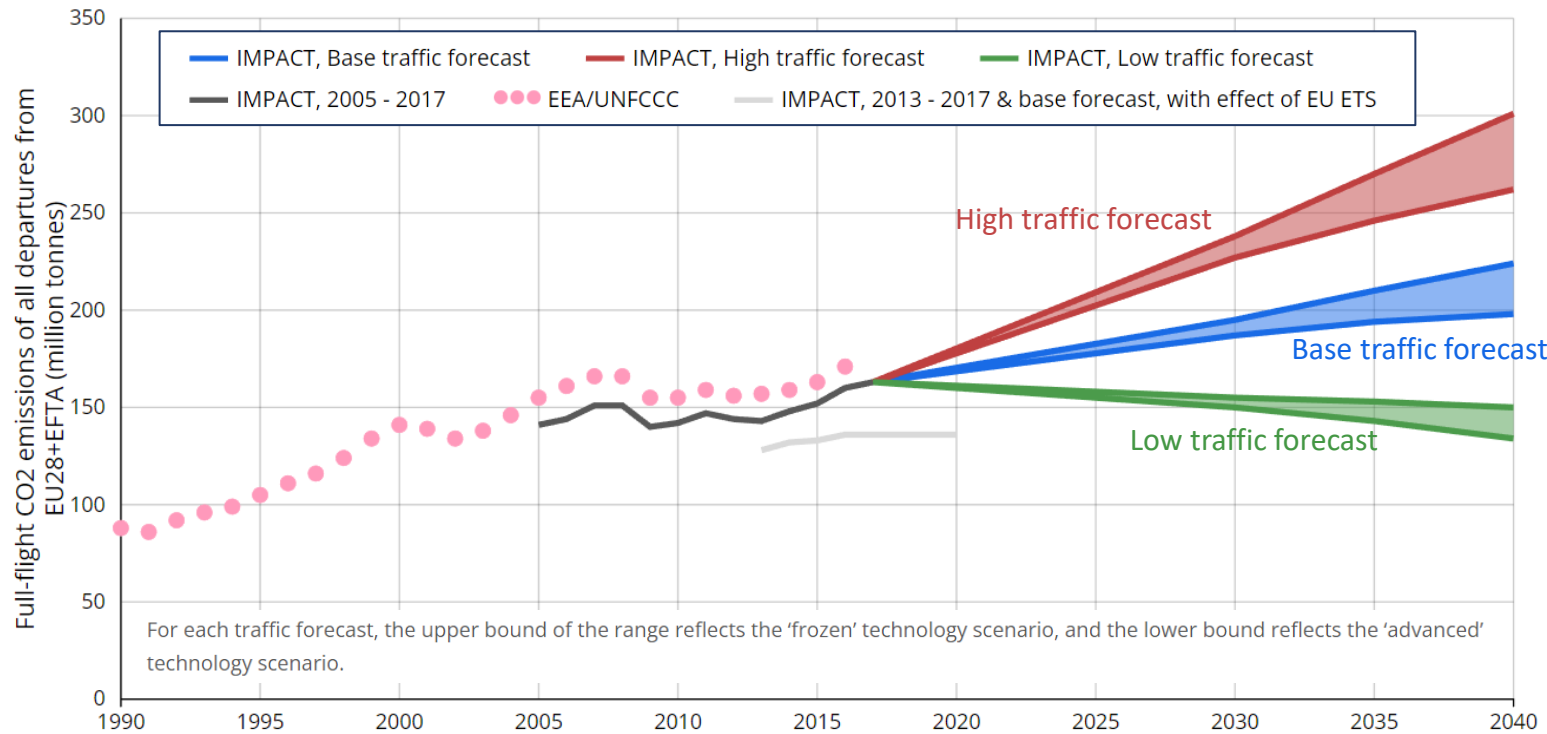
Summary





Introduction

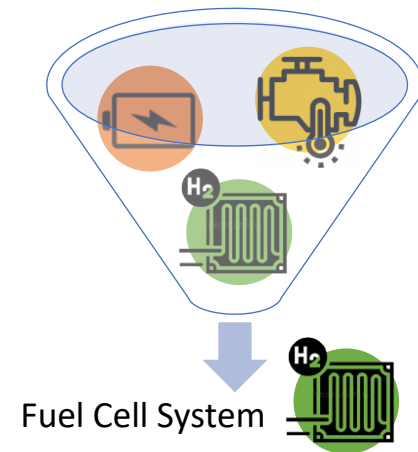
CO₂ emissions are steadily increasing again since 2013



Source: European Union Aviation Safety Agency (EASA)

🎯 **2050: 60% reduction in transport emissions**

📌 Need of **zero-emissions** solution



Goal of the study



120 min flight



Datasheet	
Take-off power	1846 kW
Max cruise power	1590 kW
MTOW	22800 kg
OEW	13450 kg
Fuel load	1800 kg
Max payload	7550 kg
Altitude	25000 ft

Open Source: www.atr-aircraft.com



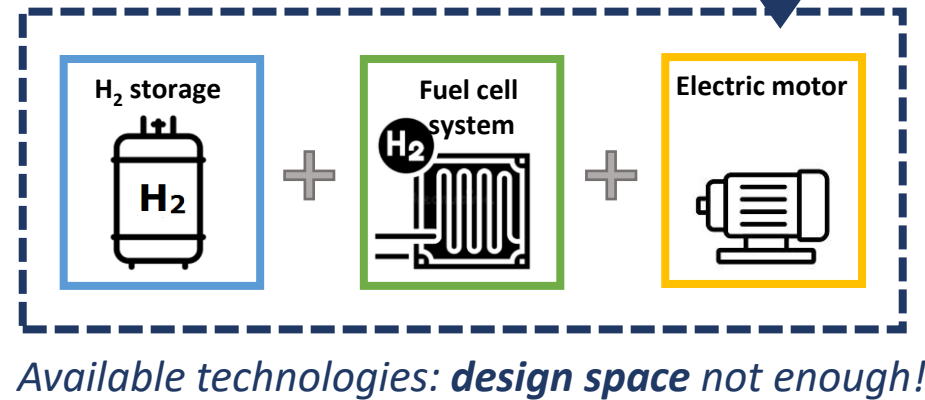
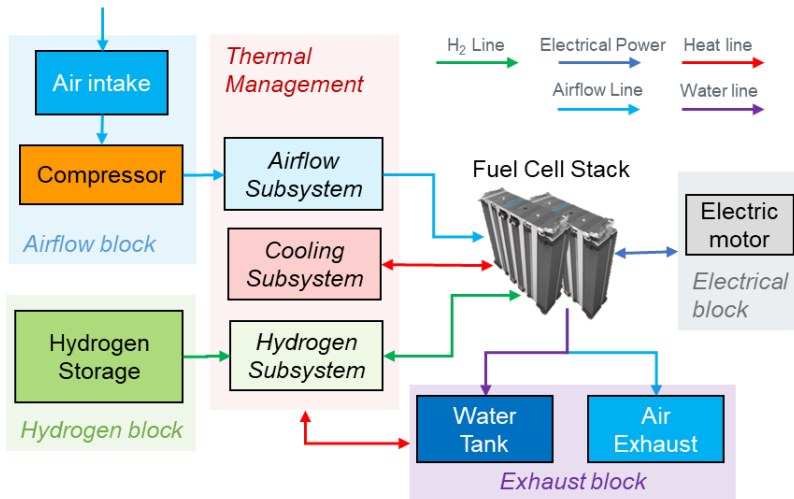
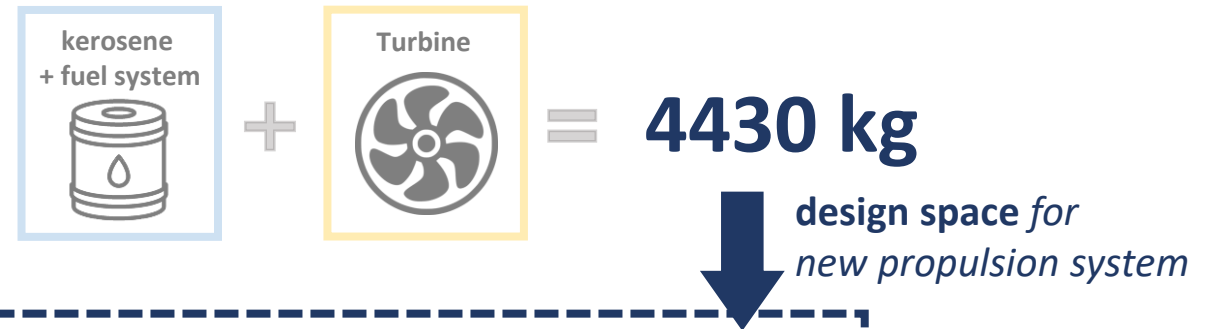
Retrofitting of a regional aircraft

Substitute the thermal engine of a commercial regional aircraft with an **electrical propulsion** based on H₂ fuel cell



System analysis

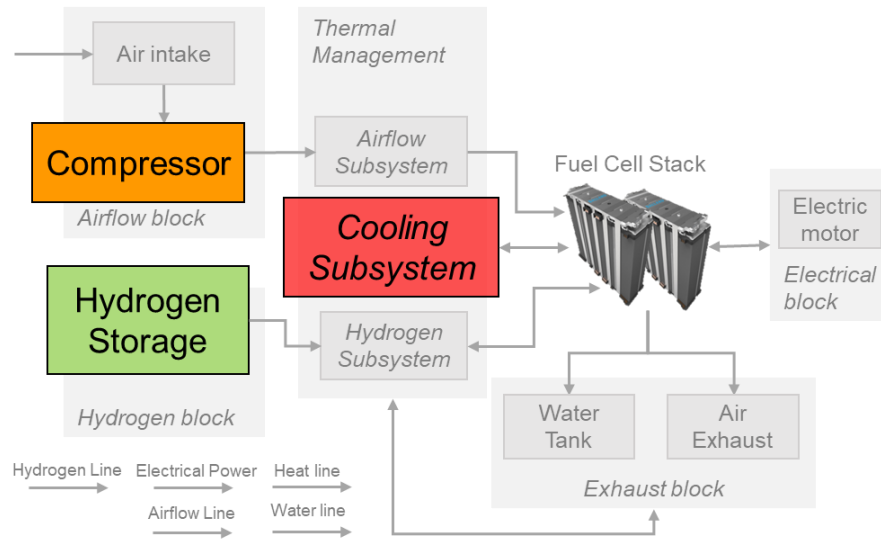
All-electric ATR72-600





System analysis

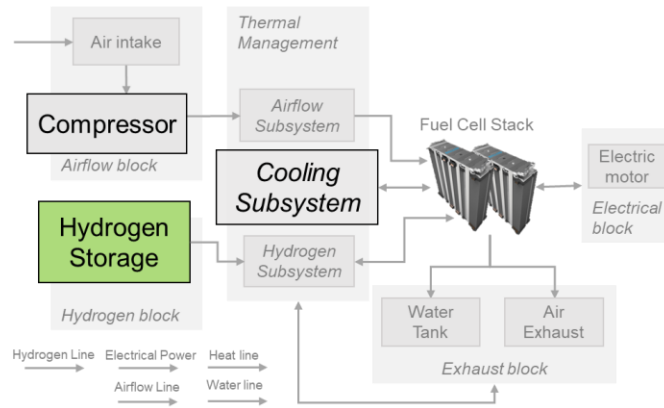
Main responsible for the excess weight:



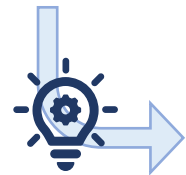
- ❗ **Hydrogen Storage is too heavy**
tank weight is more than **11 times** of H₂ weight
- ❗ **Compressor requires a lot of power**
20% more stacks are needed
- ❗ **High thermal power is produced at low temperature**
cooling system weight is more than **50%** of FC system weight

Criticalities investigation

Actions for technology improvement:



- ! **Hydrogen Storage is too heavy**
 tank weight is more than **11 times** of H₂ weight
- ! **High thermal power is produced at low temperature**
 cooling system weight is more than **50%** of FC system weight
- ! **Compressor requires a lot of power**
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Focus on storage technologies

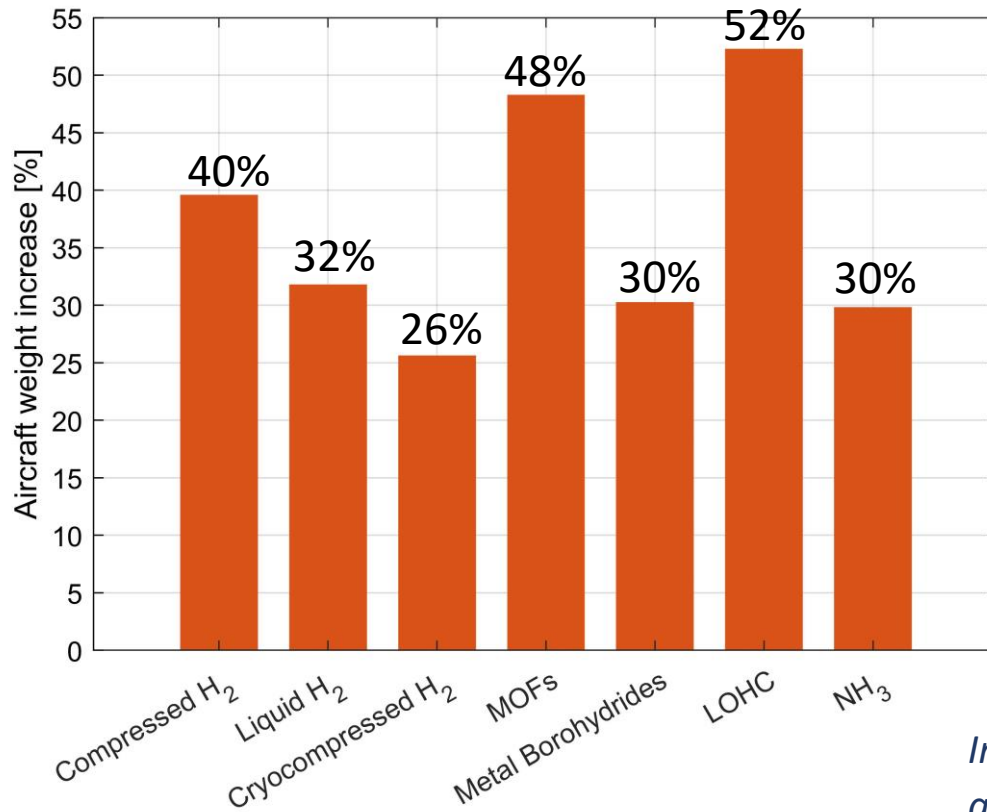
Increase the gravimetric index

H₂ storage technologies

Today State of Art data

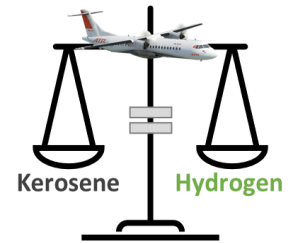


Future perspectives



	FC system specific power kW/kg	Performance target of storage gravimetric index %wt	
Today	0.8 kW/kg	even 100% is not enough!	10% weight increase!
2025	3 kW/kg	21%	

Improvements in both FC technology and storage capability are needed to reach the **target of 0% weight increase!**



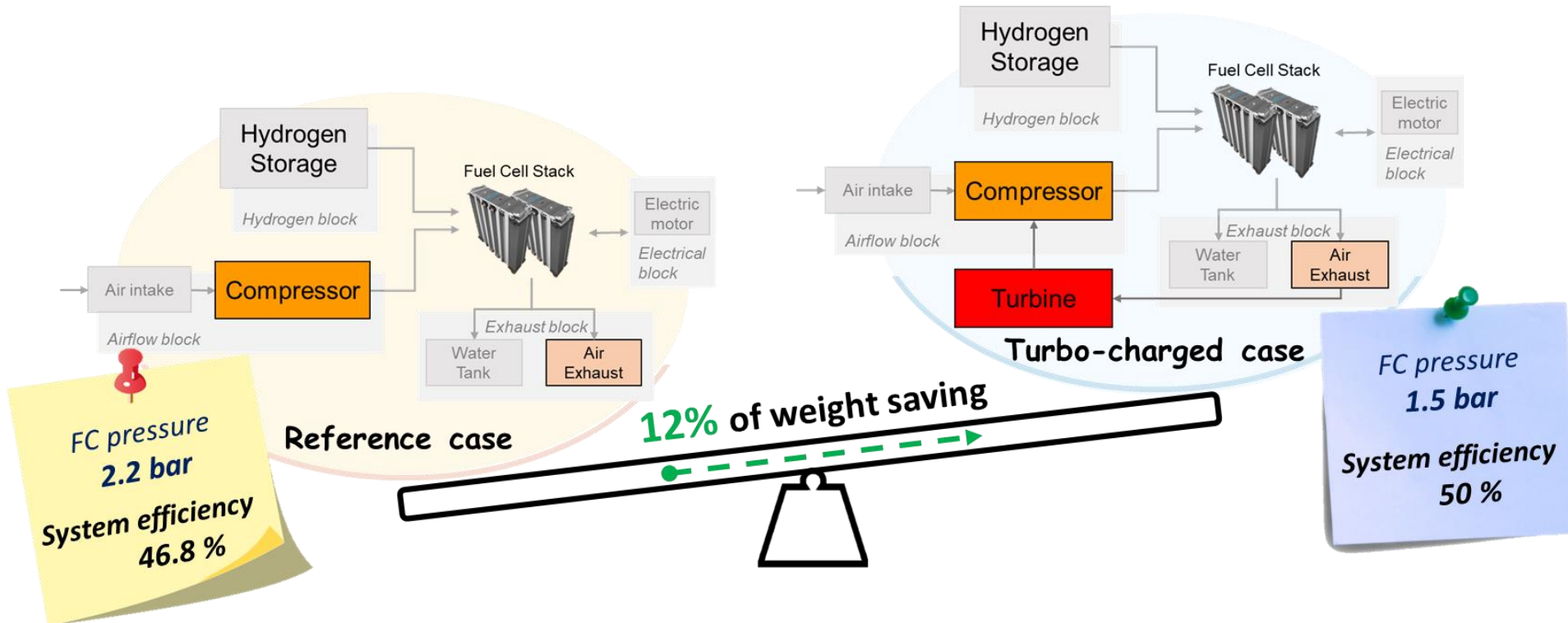
FC optimization: *operative pressure*

→ Raise of FC operative pressure

- Increment of **FC efficiency**
- More power to **compressor**

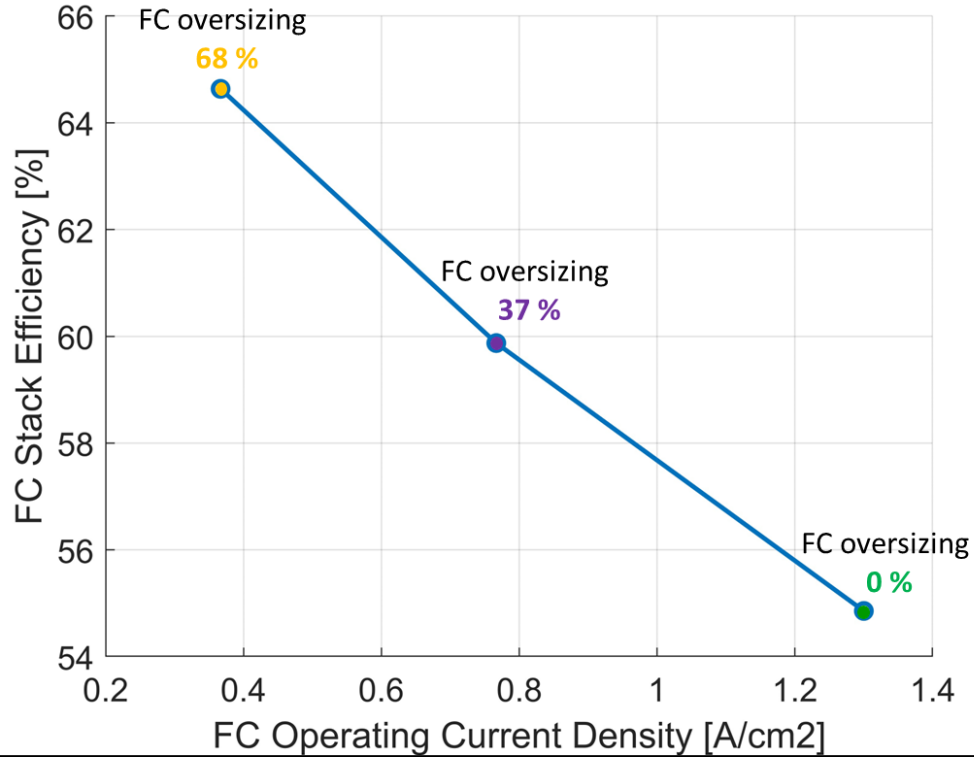
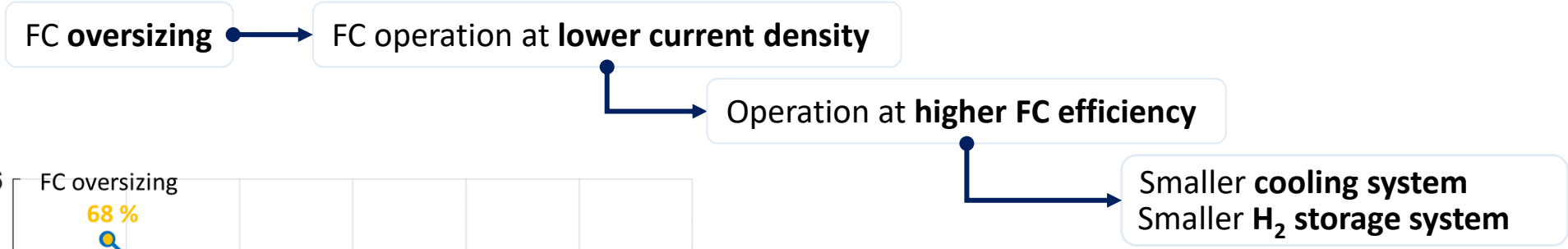
→ Addition of turbine

- Less power to **compressor**
- Increment of FC system **weight**





FC optimization: *working point*

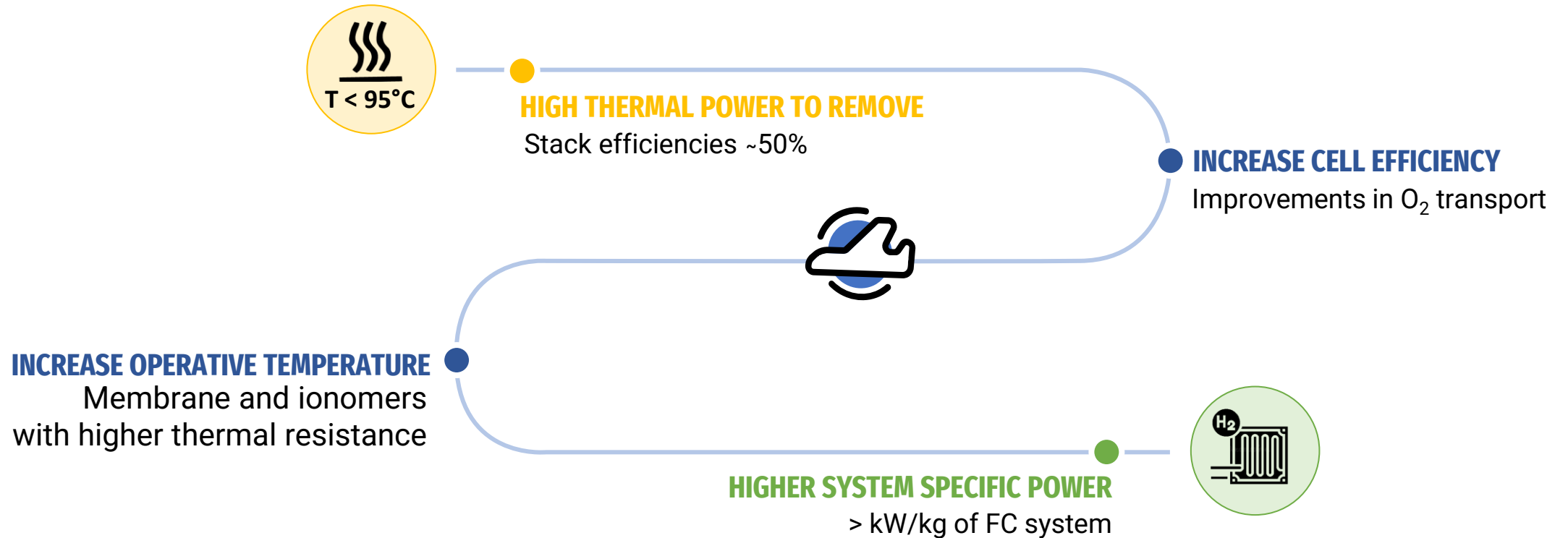


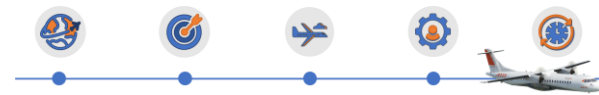
FC oversizing	0%	37%	68%
Released heat	0%	-18%	-30%
FC System + H ₂ storage weight	0%	-7%	-1%

FC optimization: *operative temperature*



Approach for next studies





Conclusions

- 1 → A **preliminary sizing** of fuel cell system for all-electric aircraft was performed
- 2 → The results showed **no current feasibility** because of **not enough design space for FC system**
- 3 → The **major criticalities** of FC system were detected: hydrogen storage, cooling system, compressor
- 4 → The criticalities were investigated separately to find **improvements in the technologies**
- Further studies were proposed to **improve LT-PEMFC**



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Thank you for your kind attention!

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