Accelerate, optimize, and secure design of battery thermal management systems thanks to Simcenter Amesim

SIEMENS

Adrien Réveillère

After being a product developer and application engineer already on system simulation, Adrien Reveillere became product manager for Simcenter Amesim in charge of Thermal Management in 2016.

"A good simulation model is the simplest model which answers the question that justified its creation"

- ➔ *Simpler is better*
- ➔ *Assess each step of the way*
- ➔ *Start with a pen and a paper*

Using models to support design:
What is the most important value provided by a numerical model ?

1. You don’t need a prototype so it’s cheaper than test.

2. You don’t need a prototype so you can evaluate it sooner than test.

3. It’s so accura

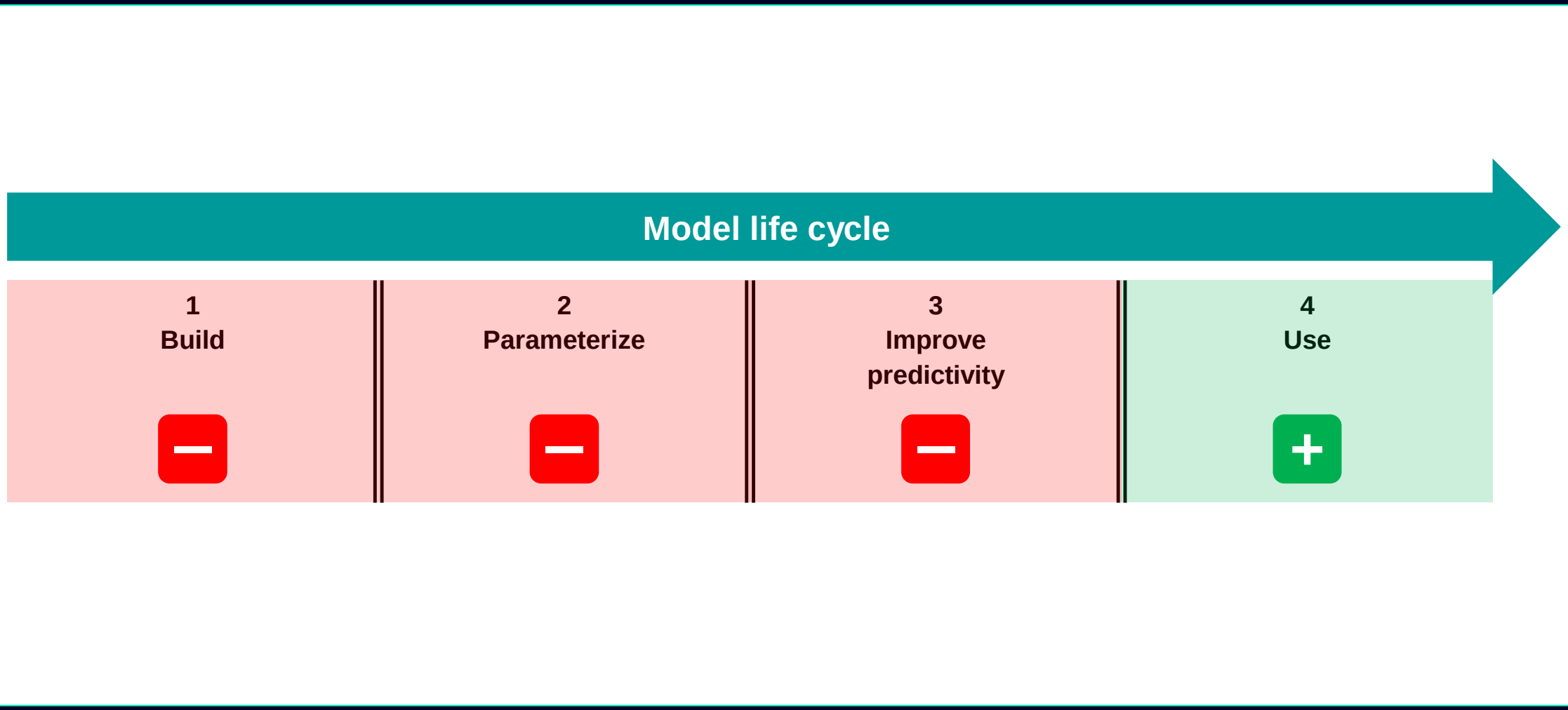
4. It’s virtual so

It provides the necessary answer to the design question that justified its creation.

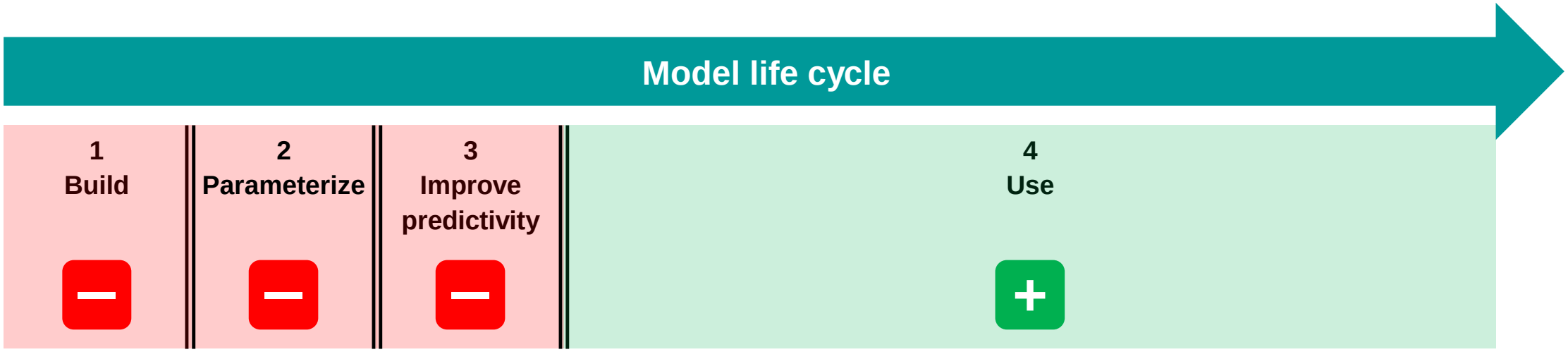
5. You have unlimited number of virtual sensors, so you understand better your system.

6. Something else

Using models to support design : 4 steps for value creation



Using models to support design : 4 steps for value creation



If really at the service of design, simulation departments are focusing on compressing the first steps to maximize ROI

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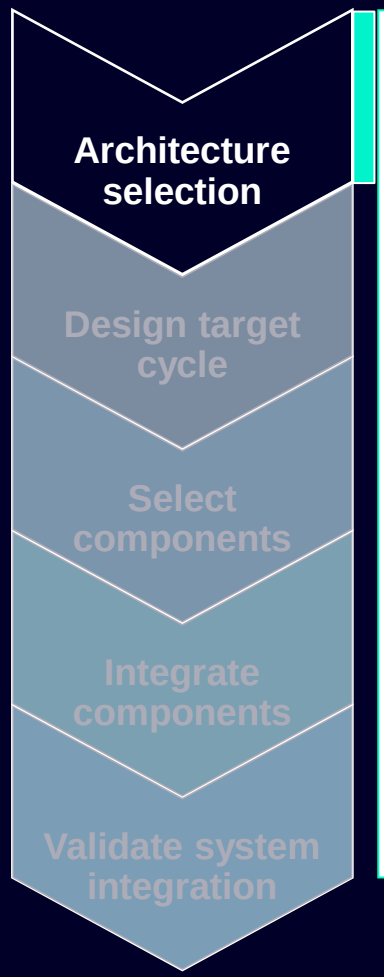
Battery Thermal Management System design: From initial requirement to virtual design validation

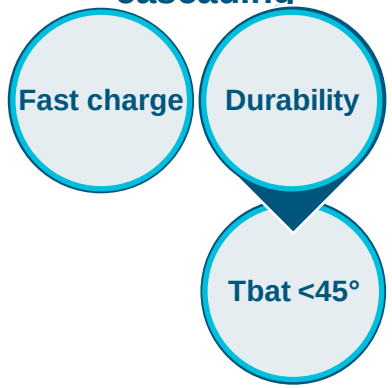


Market Analysis: why customers would buy my product ?

1. **High level of availability of the system**
   → **Need for fast charge**

2. **No loss in availability over time**
   → **Carefully control battery temperature to avoid damages (<45°)**

Requirement cascading



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- **Architecture selection**
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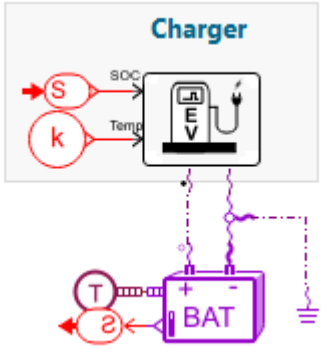
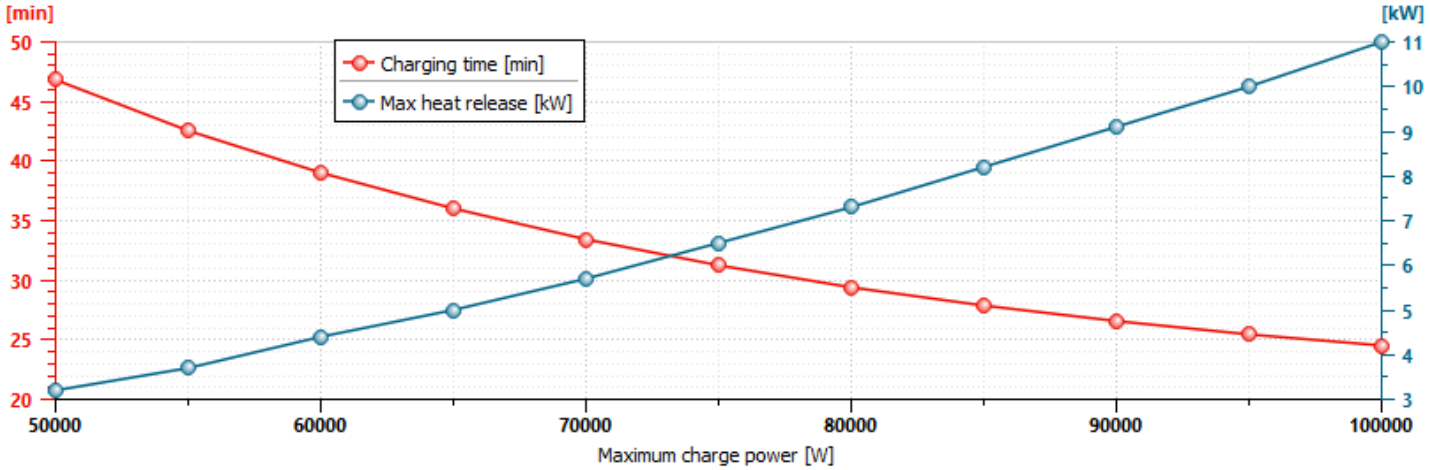
Fast Charge means fast charger:

Yes, but what maximum power?





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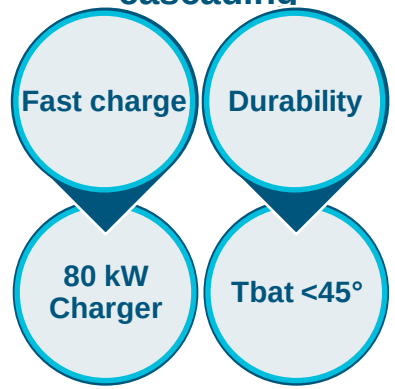

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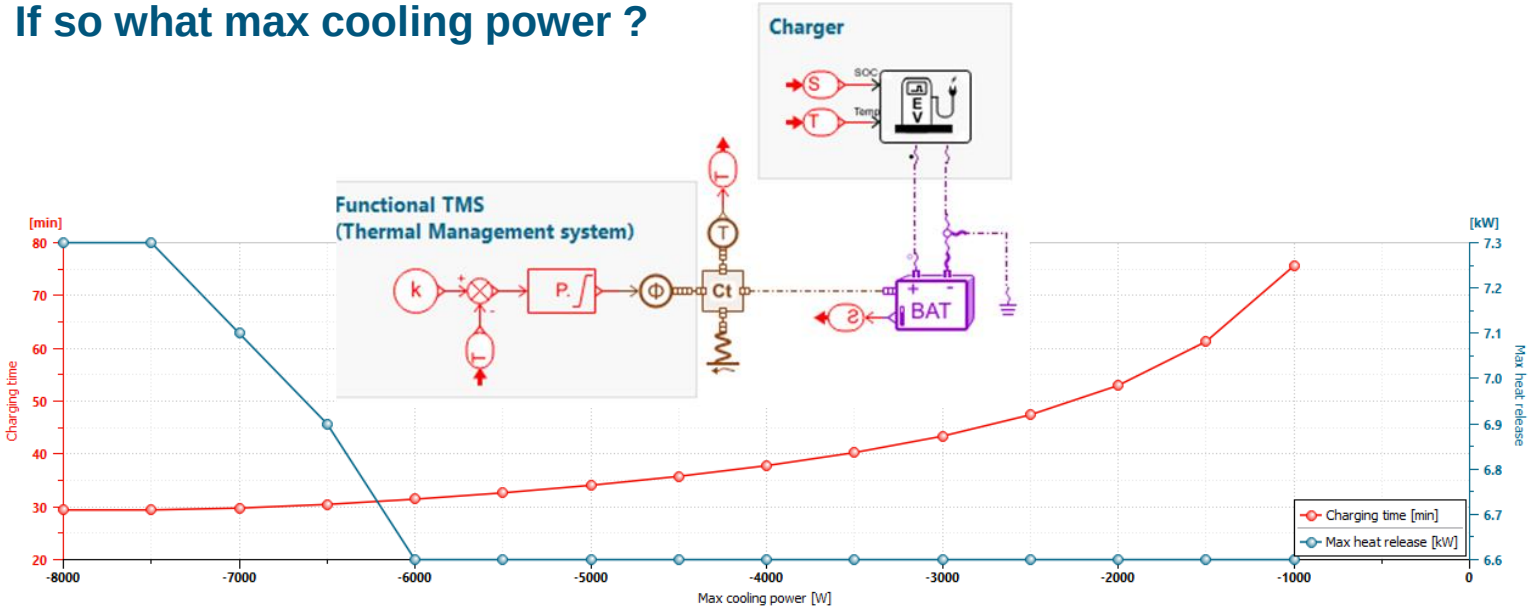
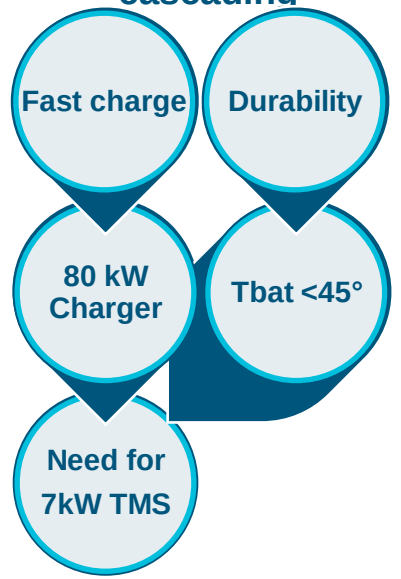
Fast charge requires lot of power, battery safety is guarantee by derating.

But how to reconciliate high power and temperature? Is a TMS required ? If so what max cooling power ?



Requirement cascading



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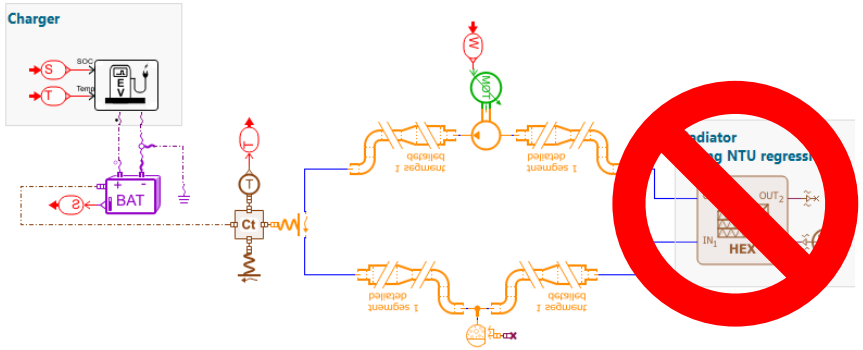
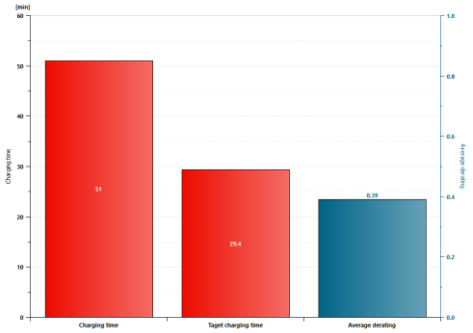
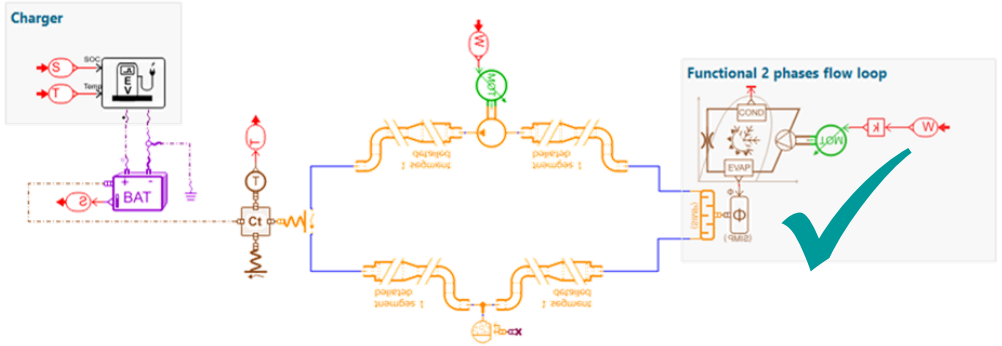
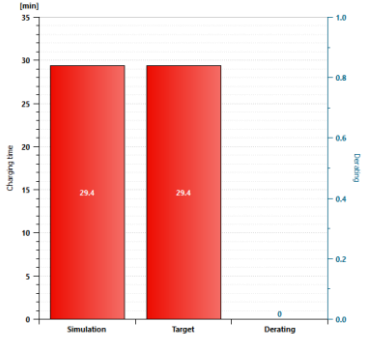
Can a typical radiator based coolant loop make an effective TMS here ?





What about a refrigerant loop? Is 7kW of cooling power enough?





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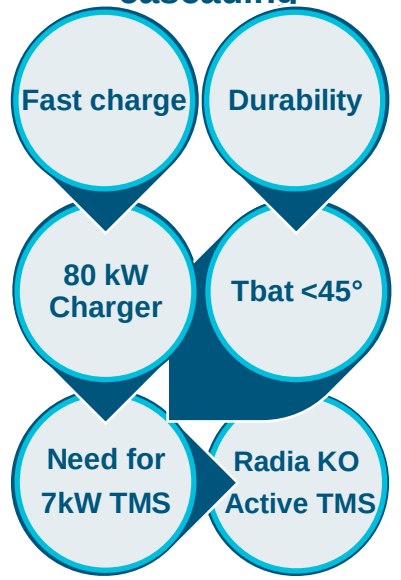

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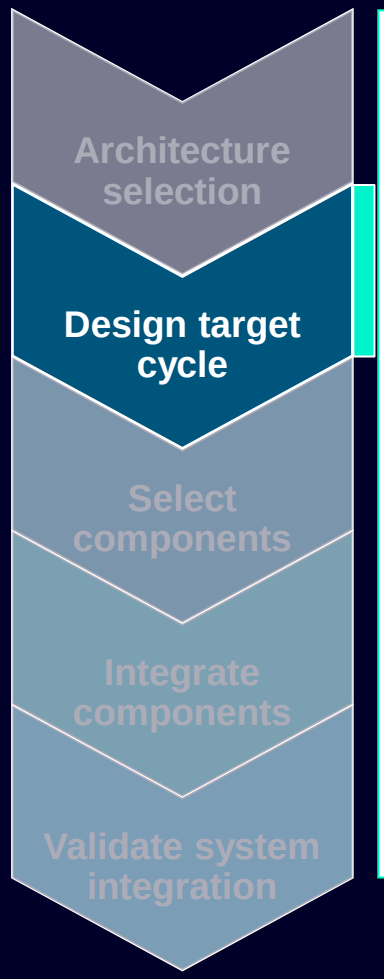
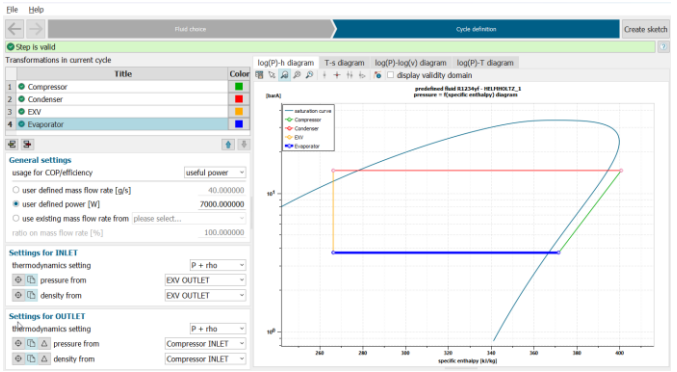


During the previous steps, all the critical values necessary for the design of an optimized thermodynamic cycle have been consolidated:

- **Air speed and temperature are known (2m/s & 35°)**
- **Target cooling power (7 kW)**
- **Coolant flow and temperature are extracted from last model (40 l/min & 20°)**

→ Its now easy to design the cycle using the proper methodology



	Transformation	DeltaP [barA]	DeltaT [degC]	DeltaRho [kg/m**3]	DeltaH [kJ/kg]	dm [g/s]	Power [W]
1	Compressor	10.9235	49.7916	62.8275	29.2063	66.4894	1941.9076
2	Condenser	0.0000	-12.2916	920.9781	-134.4863	66.4894	-8941.9089
3	EXV	-10.9235	-42.4998	-949.9138	-5.6843e-14	66.4894	-3.8702e-12
4	Evaporator	1.6275e-06	4.9998	-33.8919	105.2800	66.4894	7000.0000

COP/efficiency [null] 3.6047

Requirement cascading

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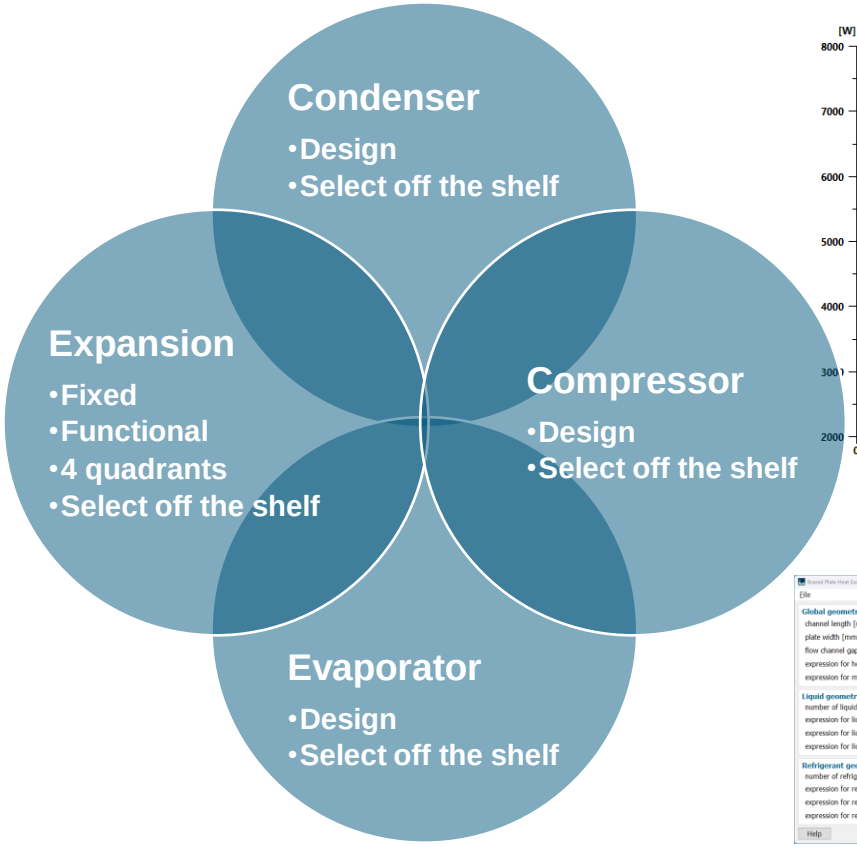

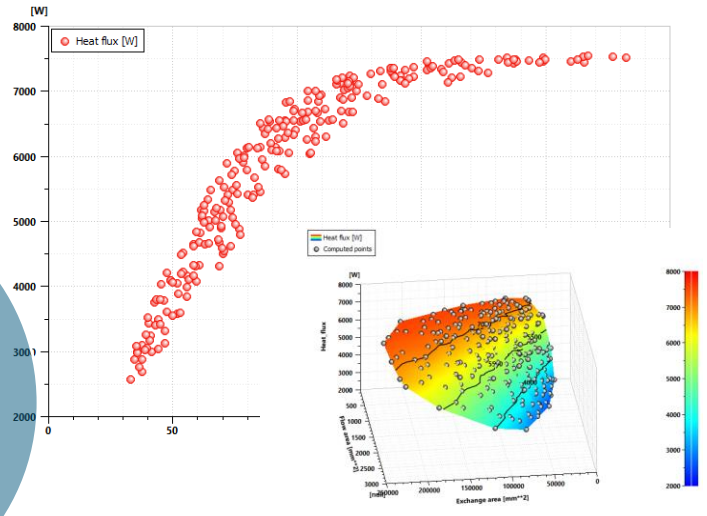

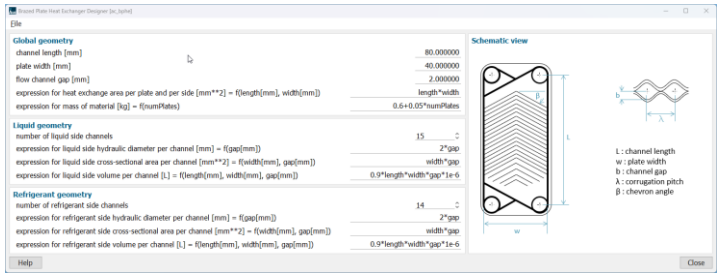

Requirement cascading

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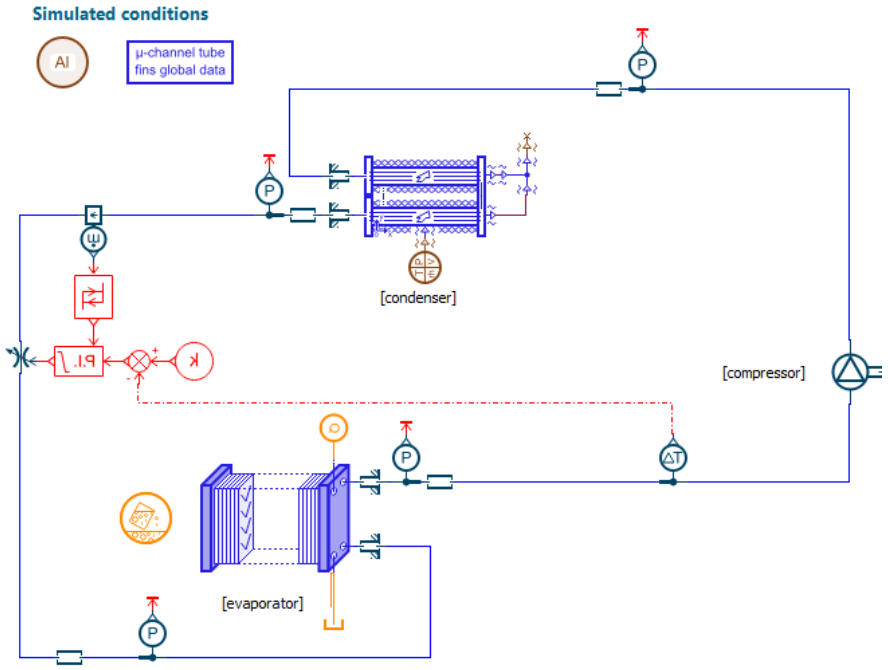
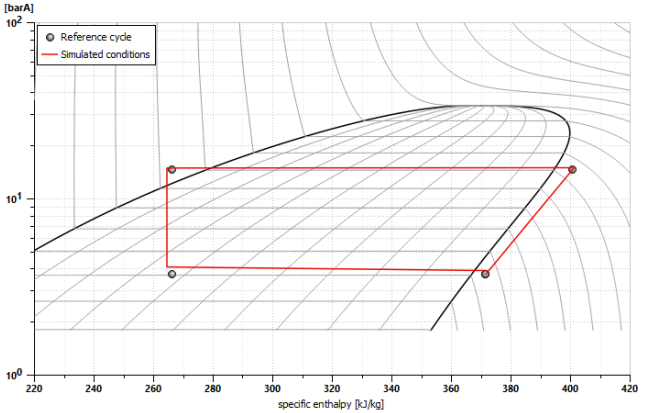
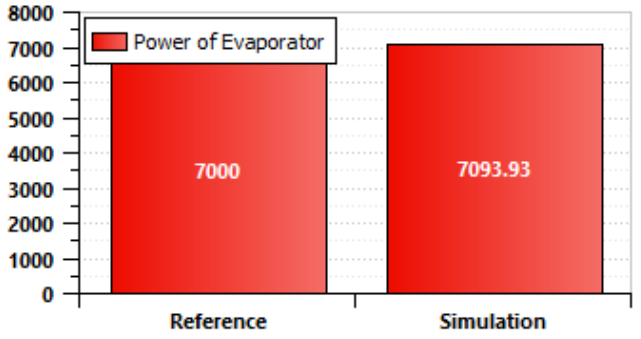
From initial requirement to virtual design validation

- Architecture selection
- Design target cycle
- Select components
- **Integrate components**
- Validate system integration

Validate components integration and estimate refrigerant charge.







Requirement cascading

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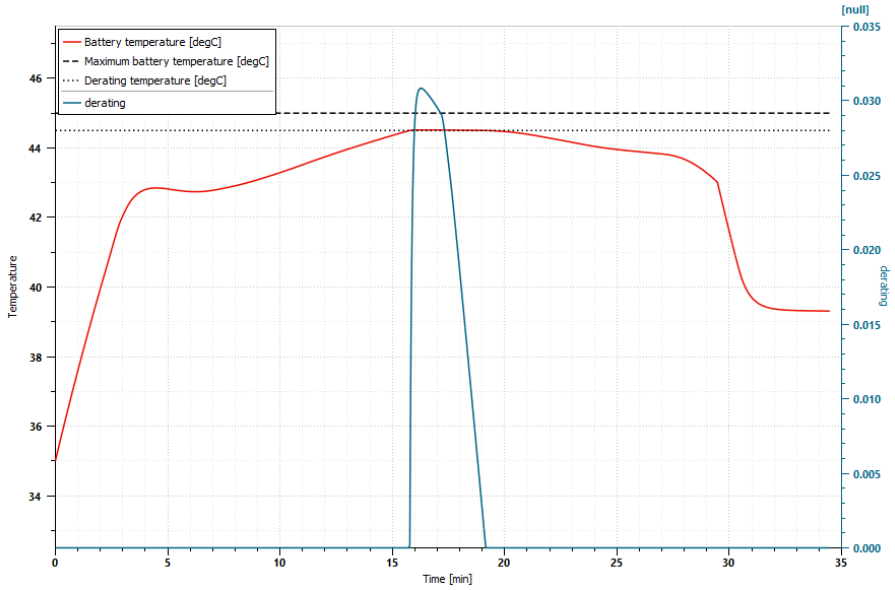
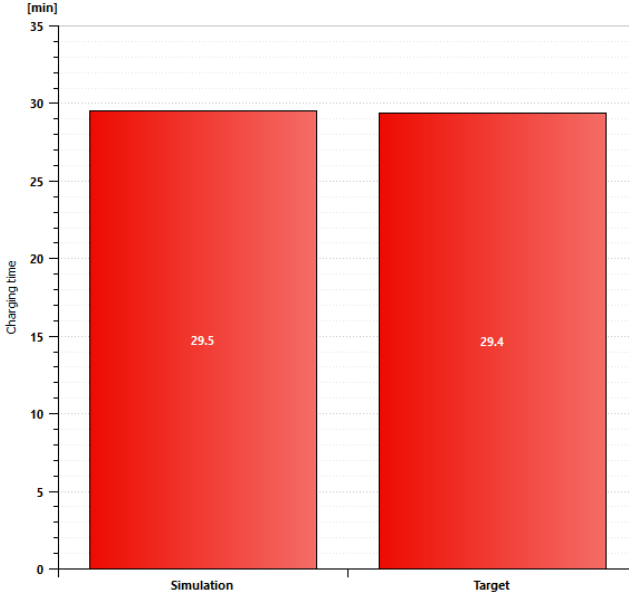
- Integrate components
- **Validate system integration**

Virtually validate your design using the digital twin created in actual operating conditions





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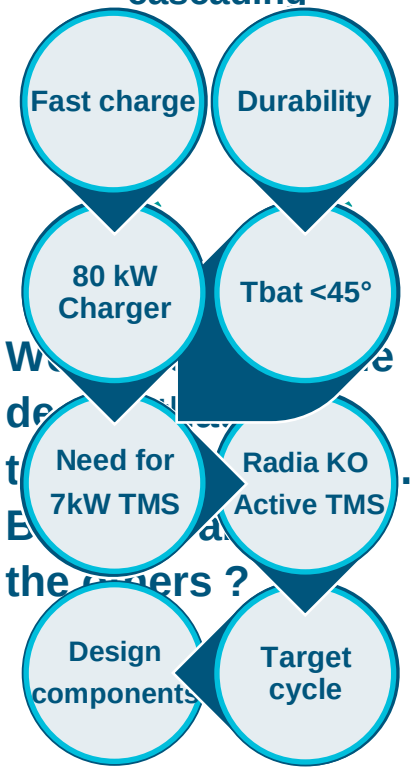

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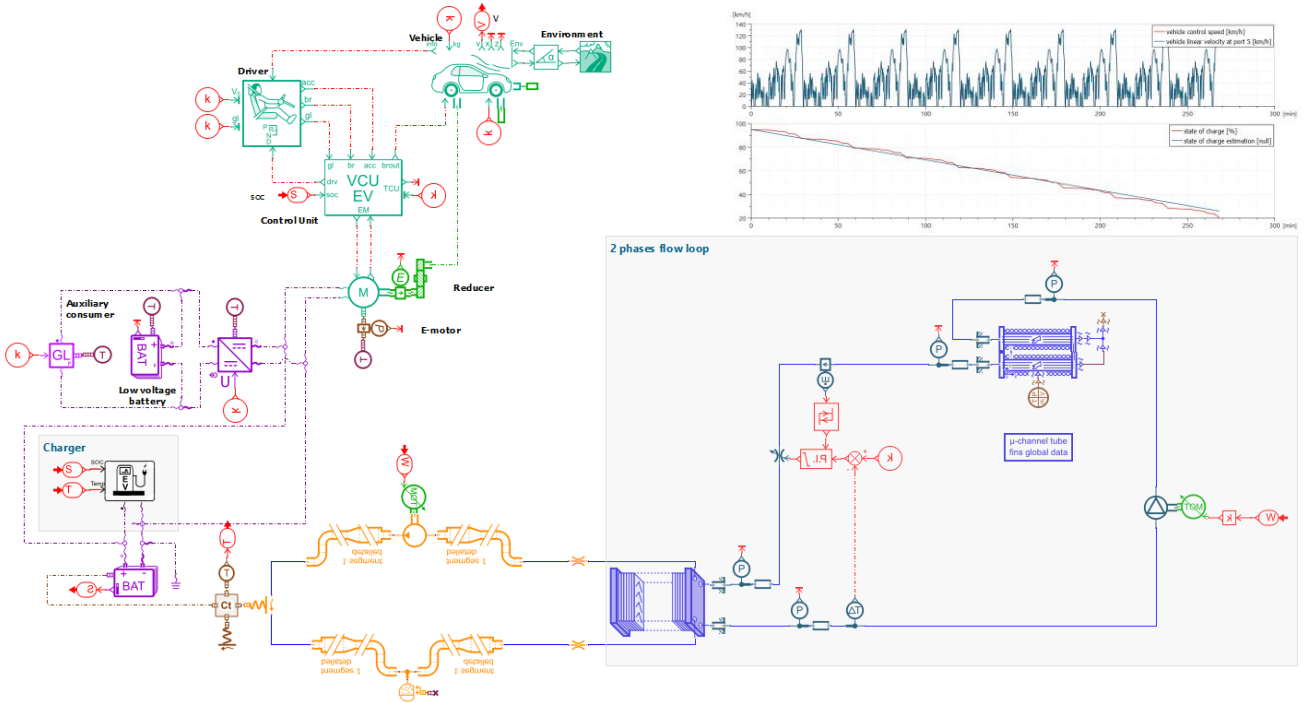
- **Validate system integration**

For fast charge subsystem virtual validation is enough but what about requirement derived from all other operating scenarios?



Requirement cascading

- Fast charge
- Durability
- Maximum Power / Speed
- Climbing mountain
- Cold conditions
- Charging strategy

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Simulation a game changer for design teams?
This is a 30 years old promises …

Simulation can be game changer for disruptive companies, as long as:

- **It is engaged as soon as possible, even if this means strong assumptions**
- **It is evolving with project maturity: required predictivity to select architecture is very different form the one to optimize controls**
- **It is always connected to product requirement**
- **It has a purpose to serve design and do not become an end in itself**

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