

YMER Technology – YMER TMS®: ECS Simulation Conference

Understanding cooling demand and energy management in electric off-highway vehicles for customers and sales engineers

Josef Graubmann, CSO & CTO YMER Group

Agenda

1. YMER and our experience with Thermal Management
2. Challenging requirements in electrical Off-Highway machines
3. Used case of KULI supporting fast answers to some of those challenges
4. And now lets make it fully customer friendly





YMER

Who are we and our experience
with Thermal Management



Our Company

We have an international footprint and are proud of our trustful and long-term customer relationships



Founded 2005,
privately owned



40 Mn. €
turnover
in 2024



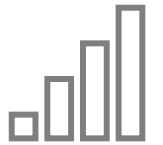
Start of the TMS
business unit
in 2018



Development in
Sweden,
Germany and
USA



Production in
Sweden,
Germany, China
and USA



Over one million
produced
cooling systems,
> 1.500 TMS
delivered in 2024

Best in class cooling systems

Our market know-how and our long-lasting experience enables us to develop best in class cooling systems for our customers

Purley focused on Off-Highway machines



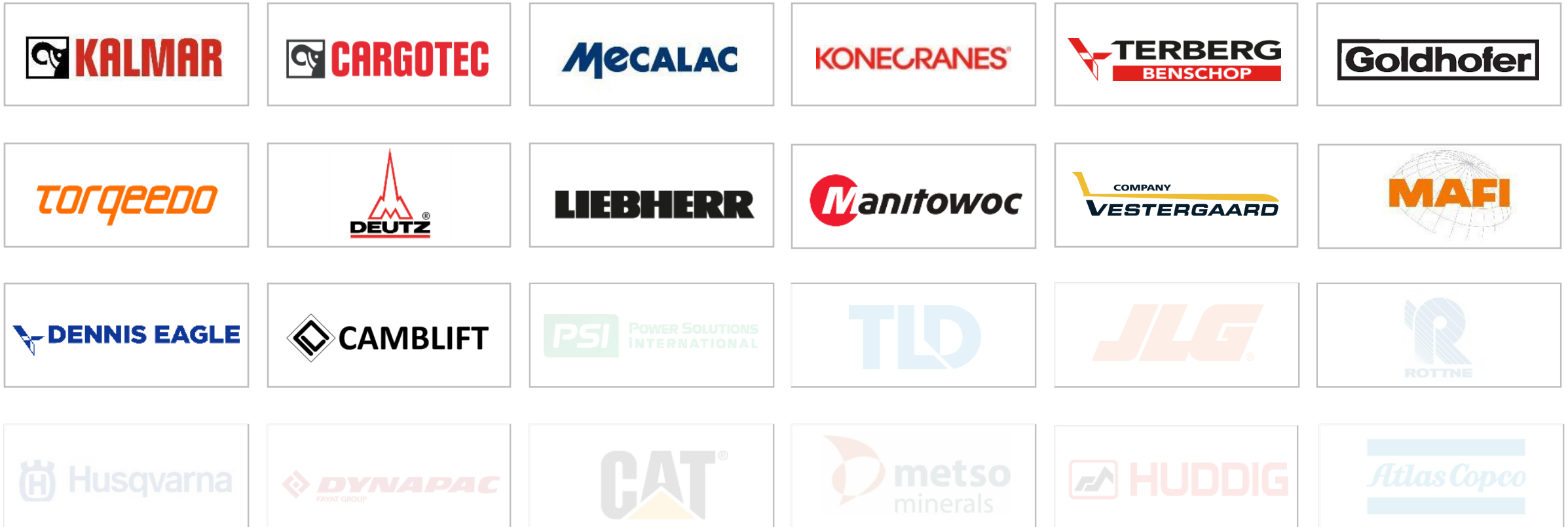
We understand ourself as a system supplier



We work for...



E-machine customers with YMER TMS® in Development or in Series Production



Ymer TMS Applications

Today our YMER TMS® are applied and operating at several different machines and applications.



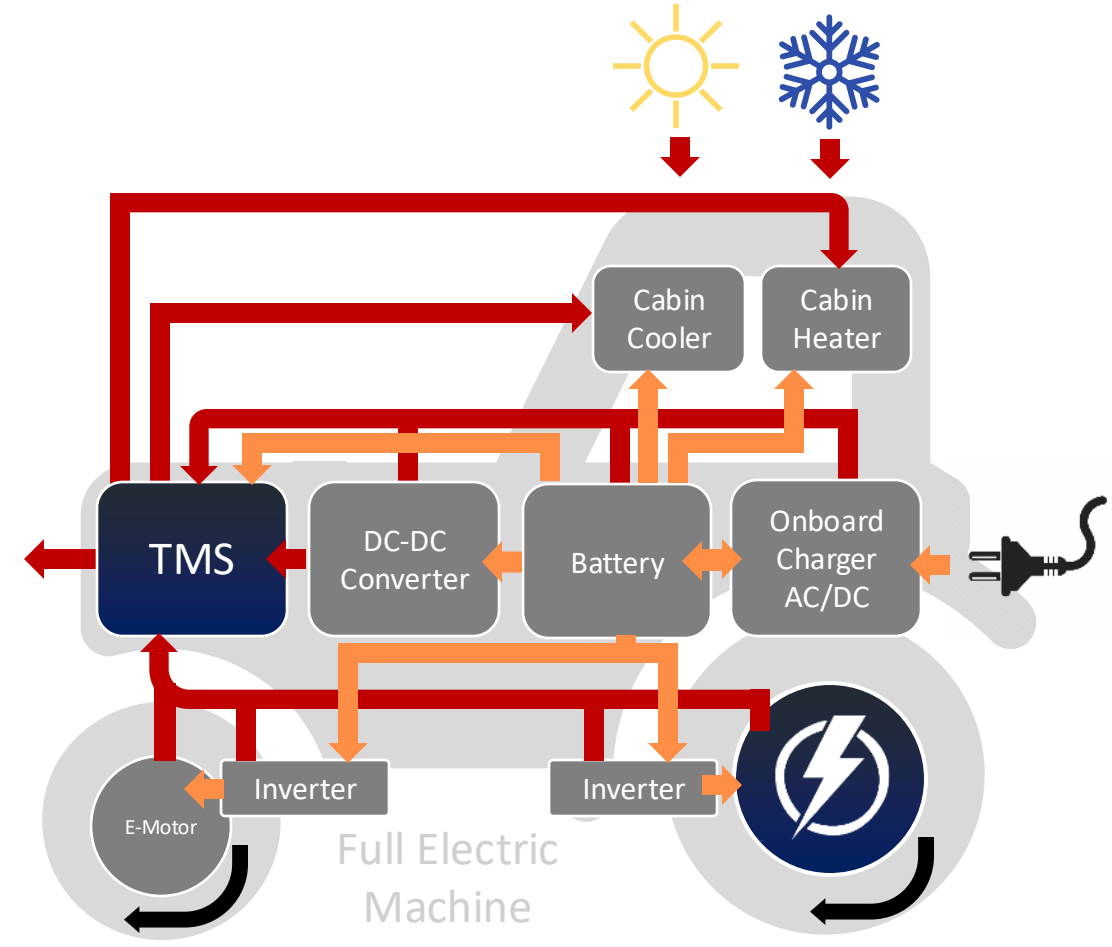
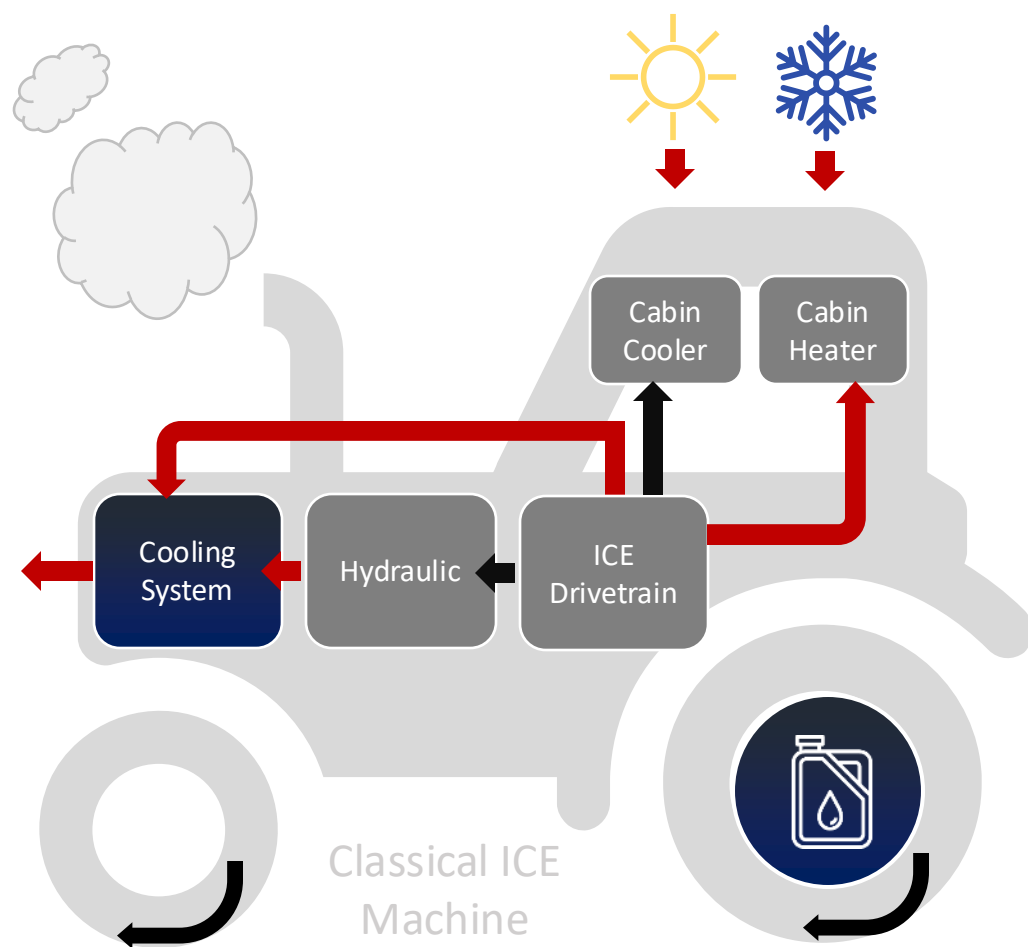


CHALLENGES

Challenges of thermal management
in Off-Highway machines



Challenges within Thermal Management



Thermal Energy

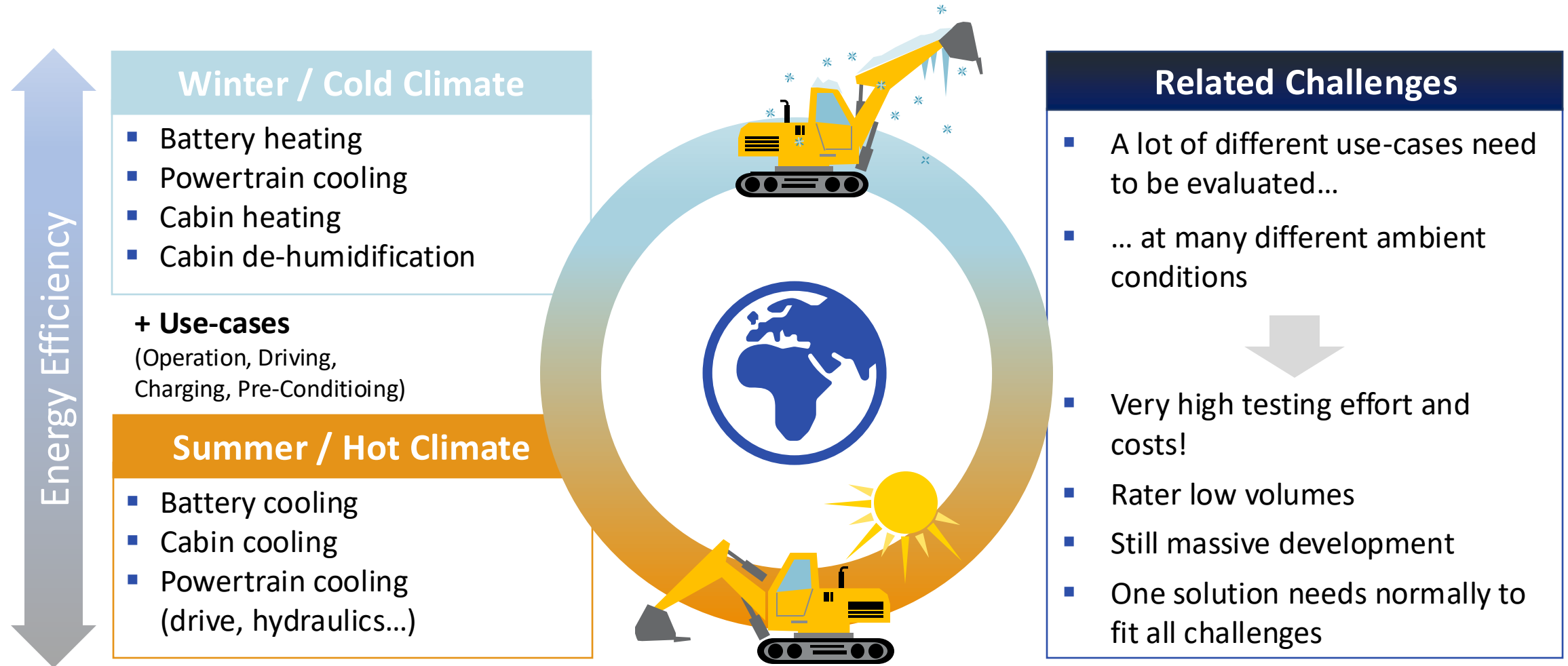


Mechanical Energy



Electrical Energy

Challenges within Thermal Management



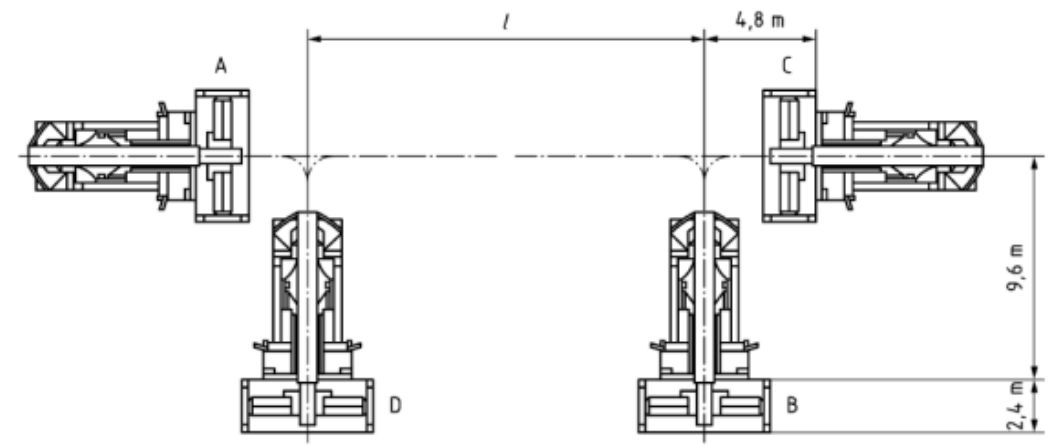
Challenges within Thermal Management

Drivecycle as defined in SS-EN-16796-3



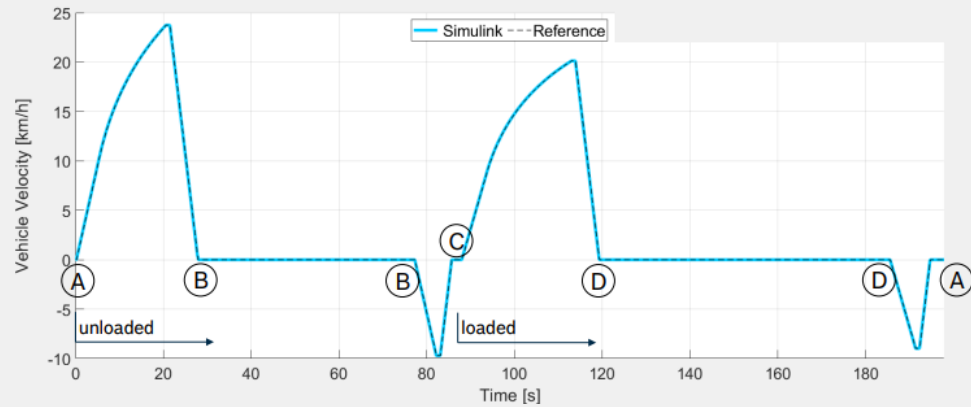
Table 1 — Test specification for container handling lift trucks

	Variable reach container handler / Counterbalance container handler	
	Empty container handler	Loaded container handler
Rated capacity Q	$Q \leq 10 \text{ t}$	$Q > 10 \text{ t}$
Test duration [h]	1	1
No. of cycles [1/h]	30	20
Distance l [m]	100	100
Lift at B and D [m]	4	4

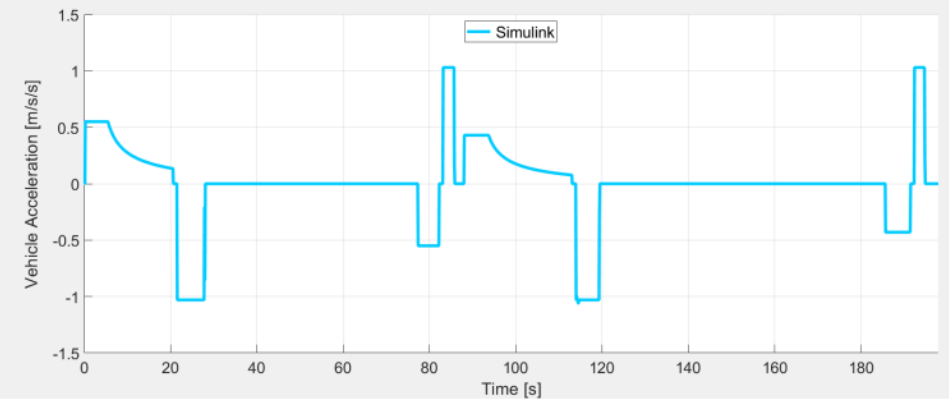


Challenges within Thermal Management

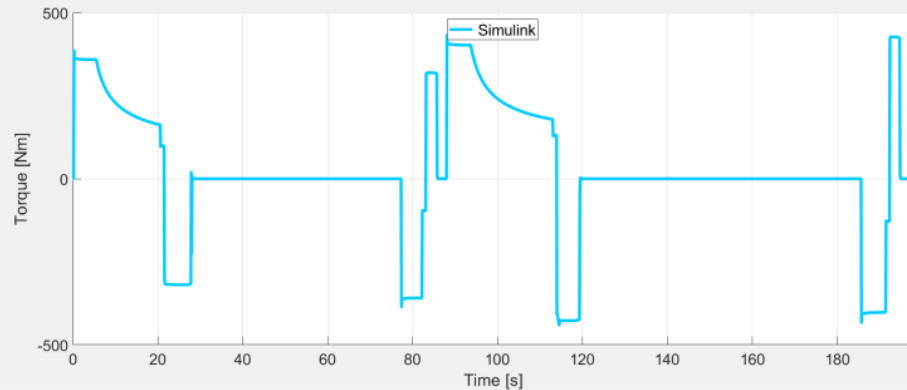
Vehicle Velocity:



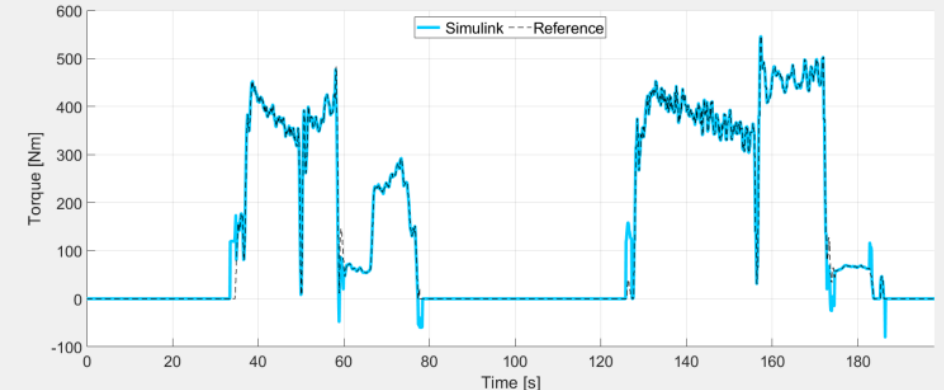
Vehicle Acceleration:



Drive Motor Torque:



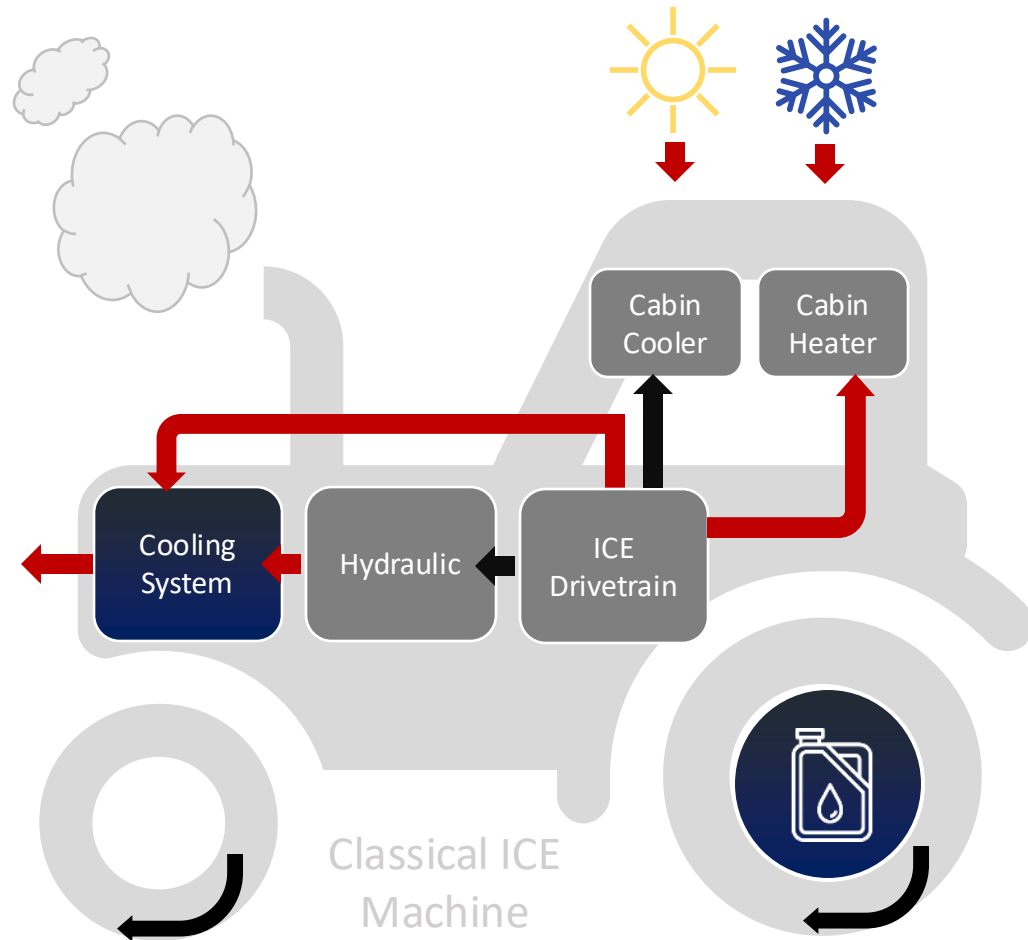
Working Motor Torque:



Challenges within Thermal Management



Challenges within Thermal Management



**I LOVE
DIESEL
FOREVER**



REAL LIFE

Used case of KULI supporting fast answers to some of those challenges



... no its getting big ...

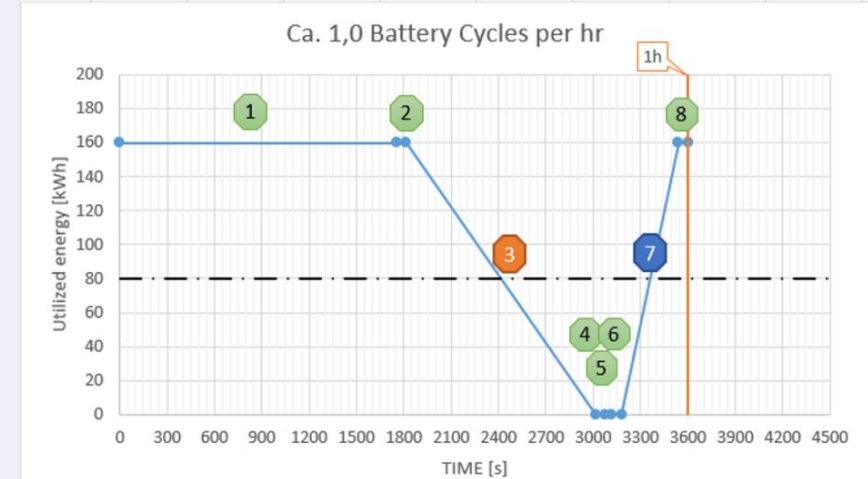


Real Life use of Kul supporting battery cooling

- Application is for a huge off-highway machine:
 - Fully electric drive
 - ICE with ~ 2.000 kW working as genset
 - Around 440 kWh Battery capacity for boosting and regeneration
 - Ambient conditions up to 50 °C (Average 40 °C)
- Battery Info:
 - Total inst. Batteries = 4
 - Capacity / Battery = 108,9 kWh
 - Total Battery Capacity = 435,6 kWh
 - **Heat rejection EOL (all 4 batteries) = 65 kW continuous – 98 kw peak** (Customer Initial Info)

Vehicle use case / Driving cycle:

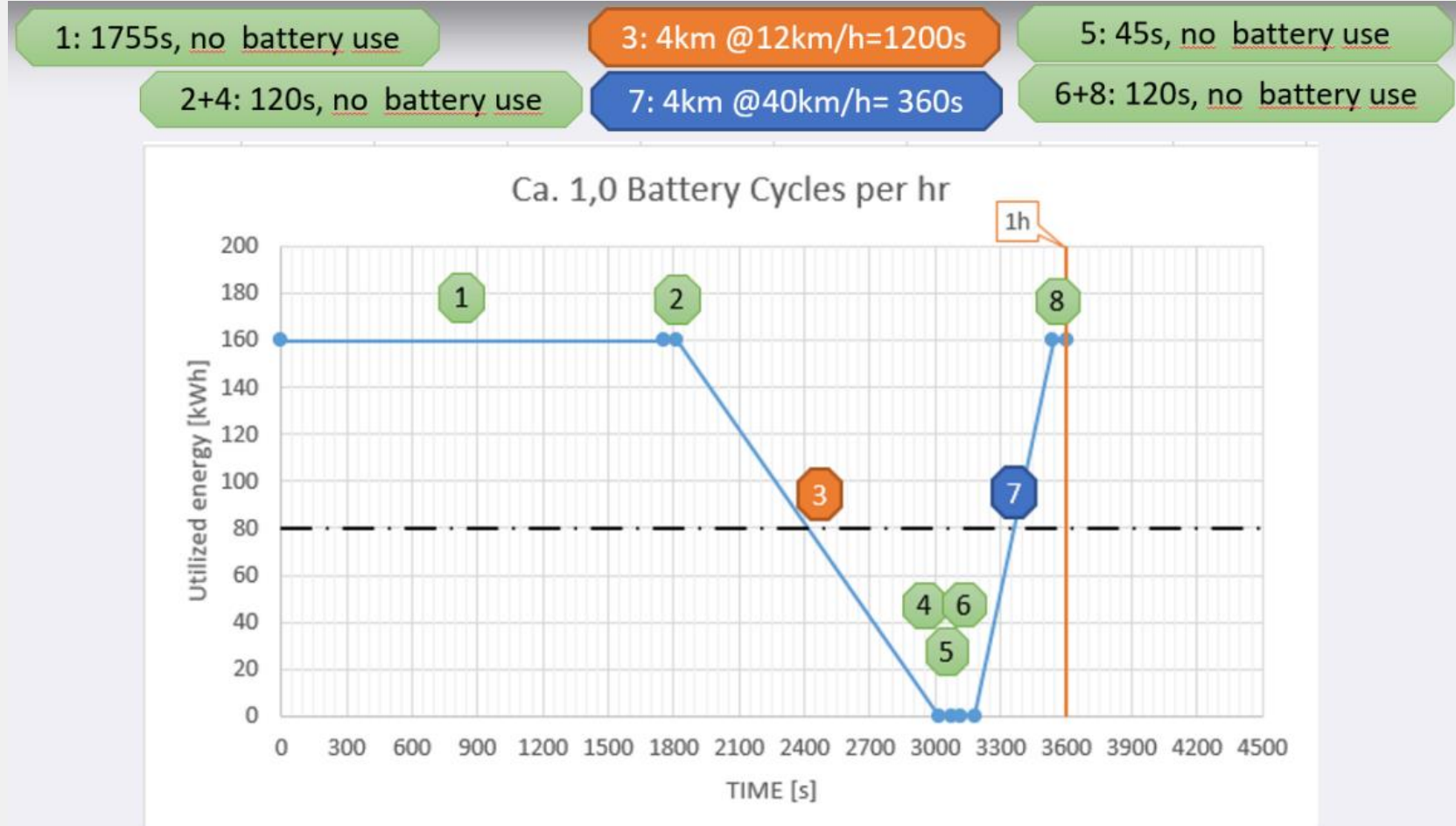
- 1: 1755s, no battery use
- 3: 4km @12km/h=1200s
- 5: 45s, no battery use
- 2+4: 120s, no battery use
- 7: 4km @40km/h= 360s
- 6+8: 120s, no battery use



- YMER initial assumption
 - Cooling performance needed: **around 25 kW**

Real Life use of Kul supporting battery cooling

Vehicle use case / Driving cycle:

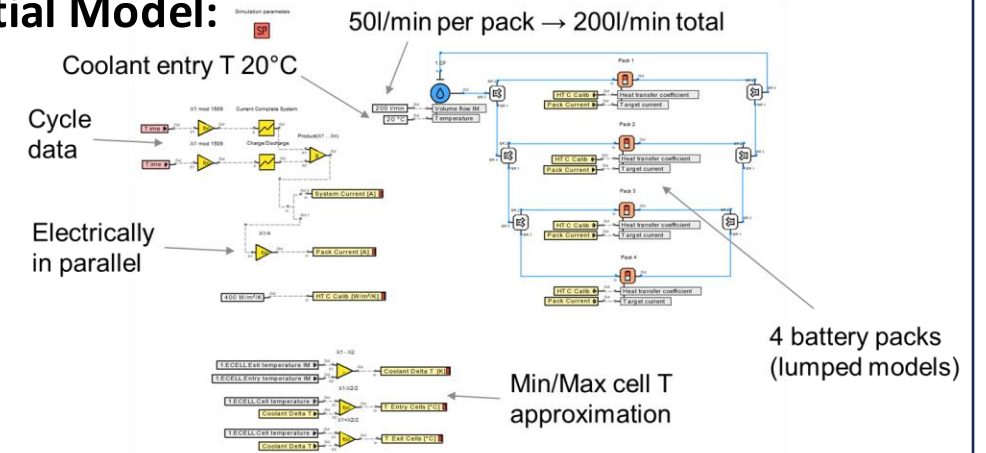


Real Life use of Kul supporting battery cooling

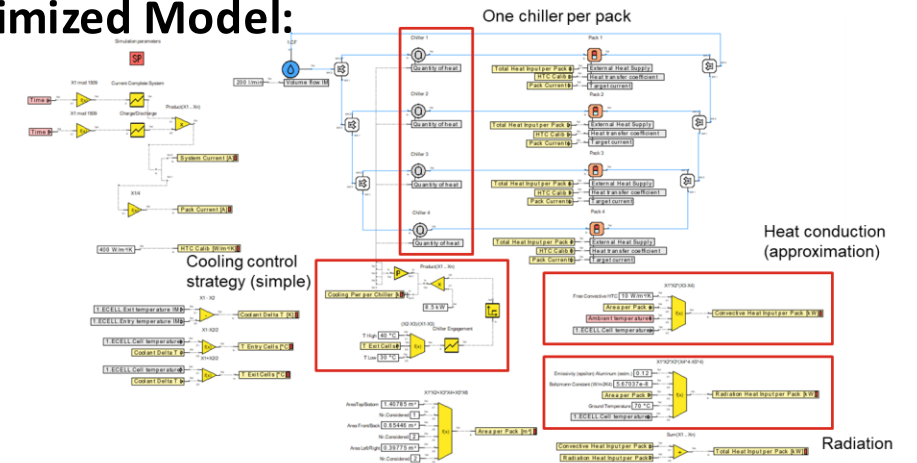
Approach:

1. Simple model to get an initial feeling and see critical influencing factors
 2. Fine-tune model and add simple control strategy
- Main task: confirm stomach feeling of cooling demands
 - Accuracy is not the major key - being in a range of +/- 2 to 4 kW is fully accepted

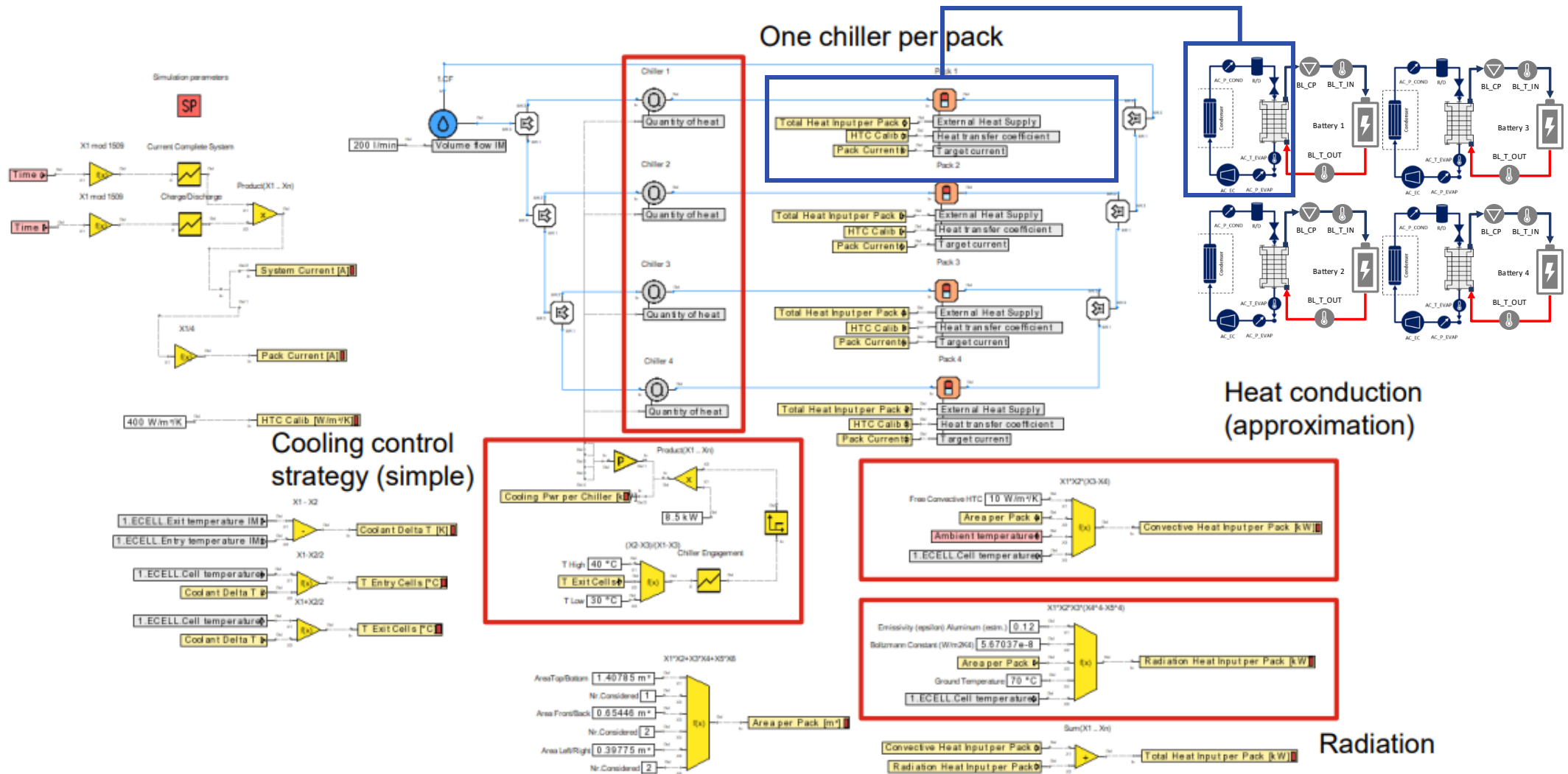
Initial Model:



Optimized Model:



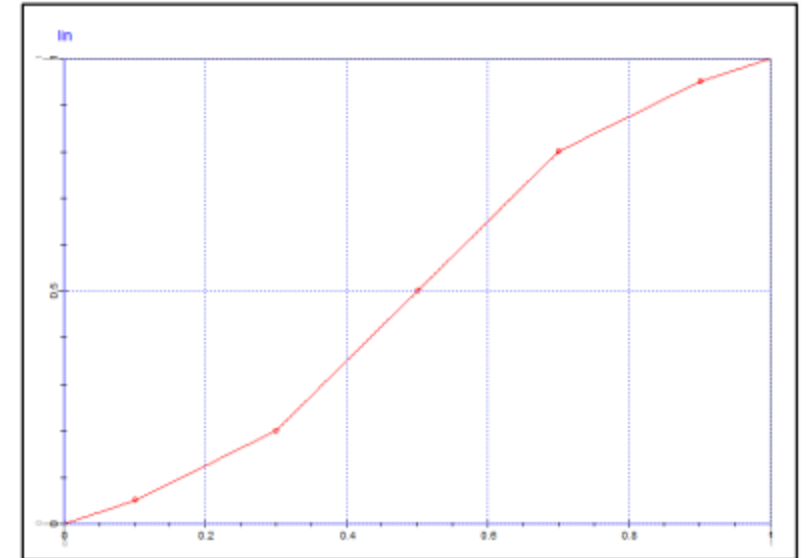
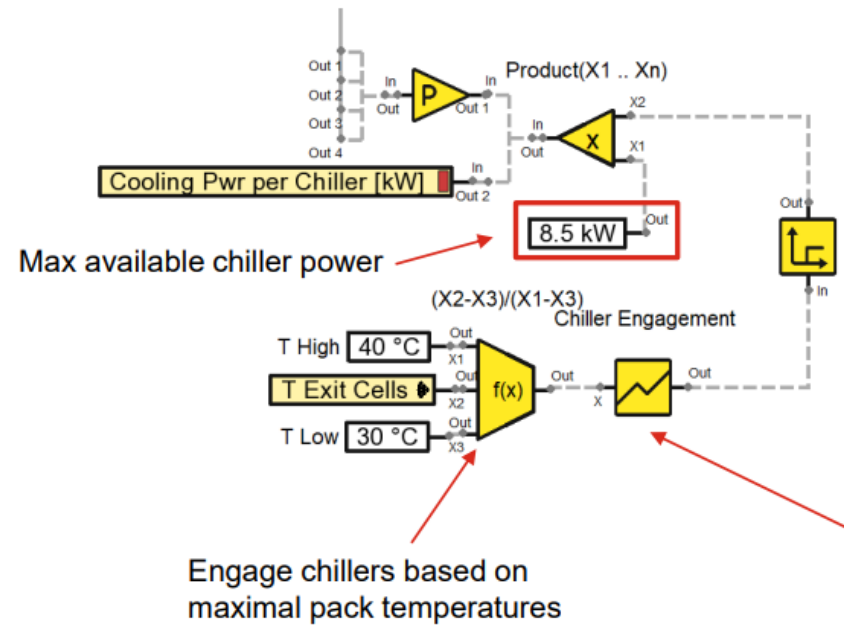
Simulation Model Updates



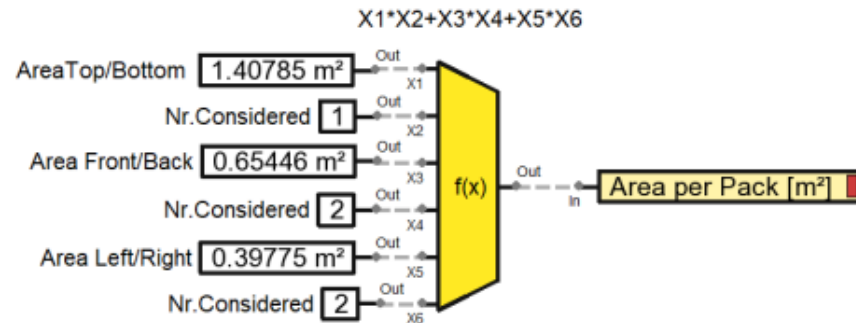
Added a simple control strategy

Added a simple control strategy:

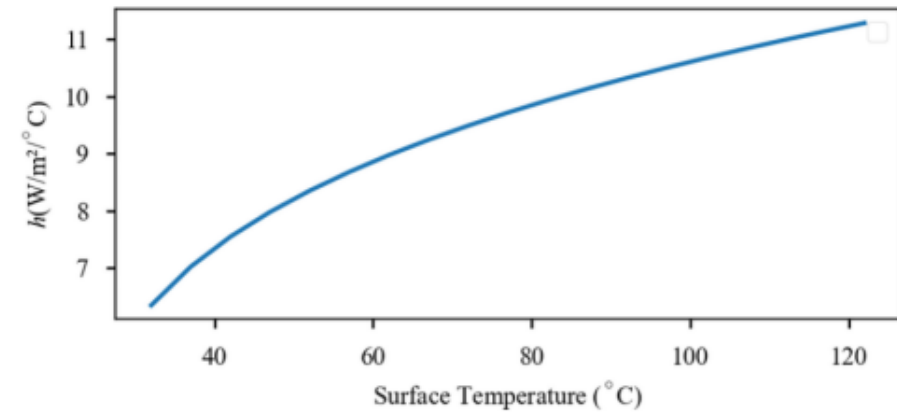
- Full engagement of cooling unit at average cell temp $> 40\text{ }^{\circ}\text{C}$
- Switch off of cooling unit below $30\text{ }^{\circ}\text{C}$ cell temp
- In reality we are using a more sophisticated PID Controller



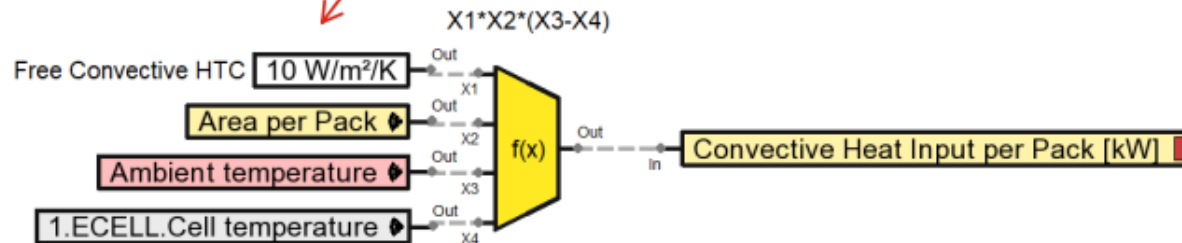
Added and simulated convective Heat Transfer



„active“ area of total pack surface
(here: all sides + top (or bottom))



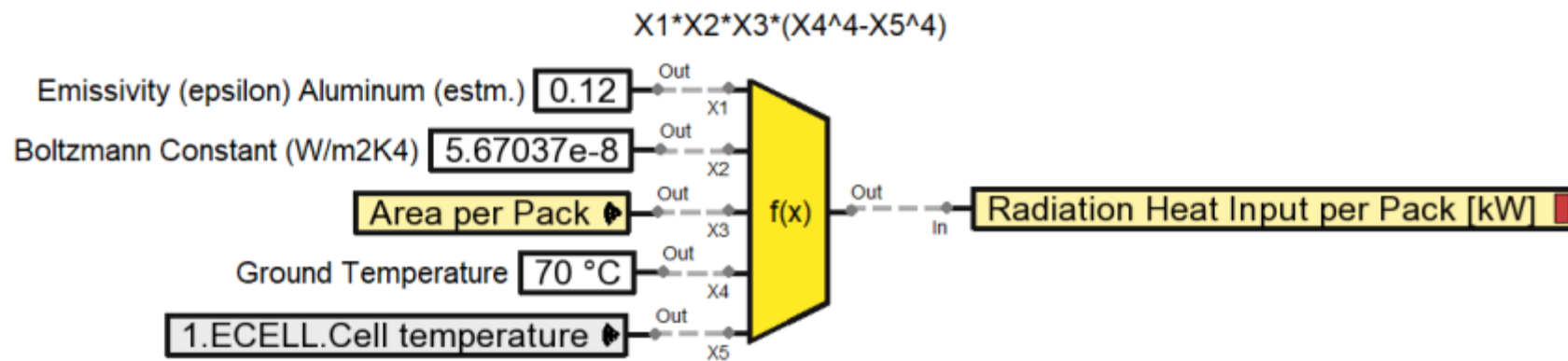
ResearchGate paper for vertical
plate → conservative estimation, will
be rather less



Added and simulated radiation of the battery packs

Added a simple control strategy:

- Uses Boltzmann equation
- Emissivity for aluminum has a wide range (depending on surface treatment) → average value used
- Does NOT refer to ambient temperature, but rather to hot „ground temperature“ over which the vehicle is driving (70°C)





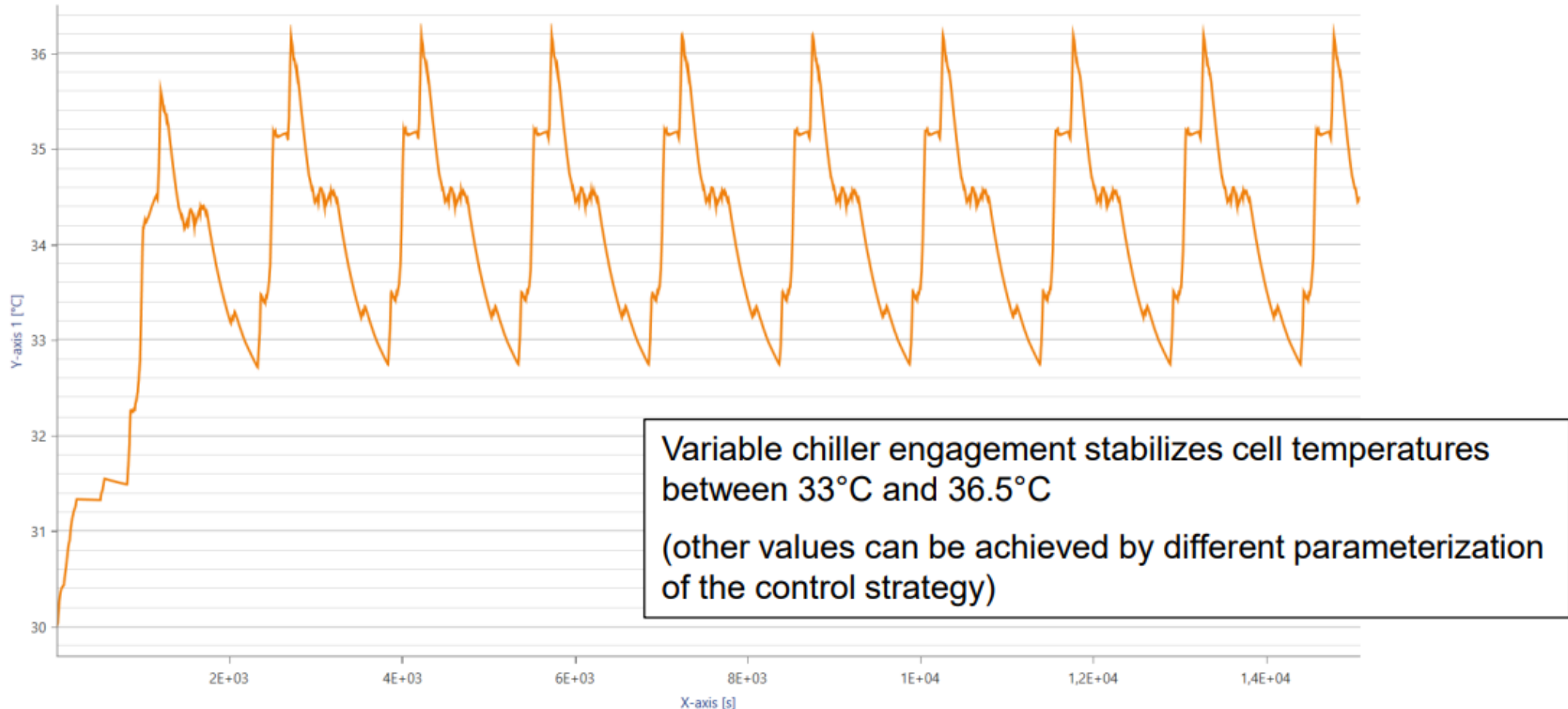
Simulation Results

With 10 driving cycles according
Customer



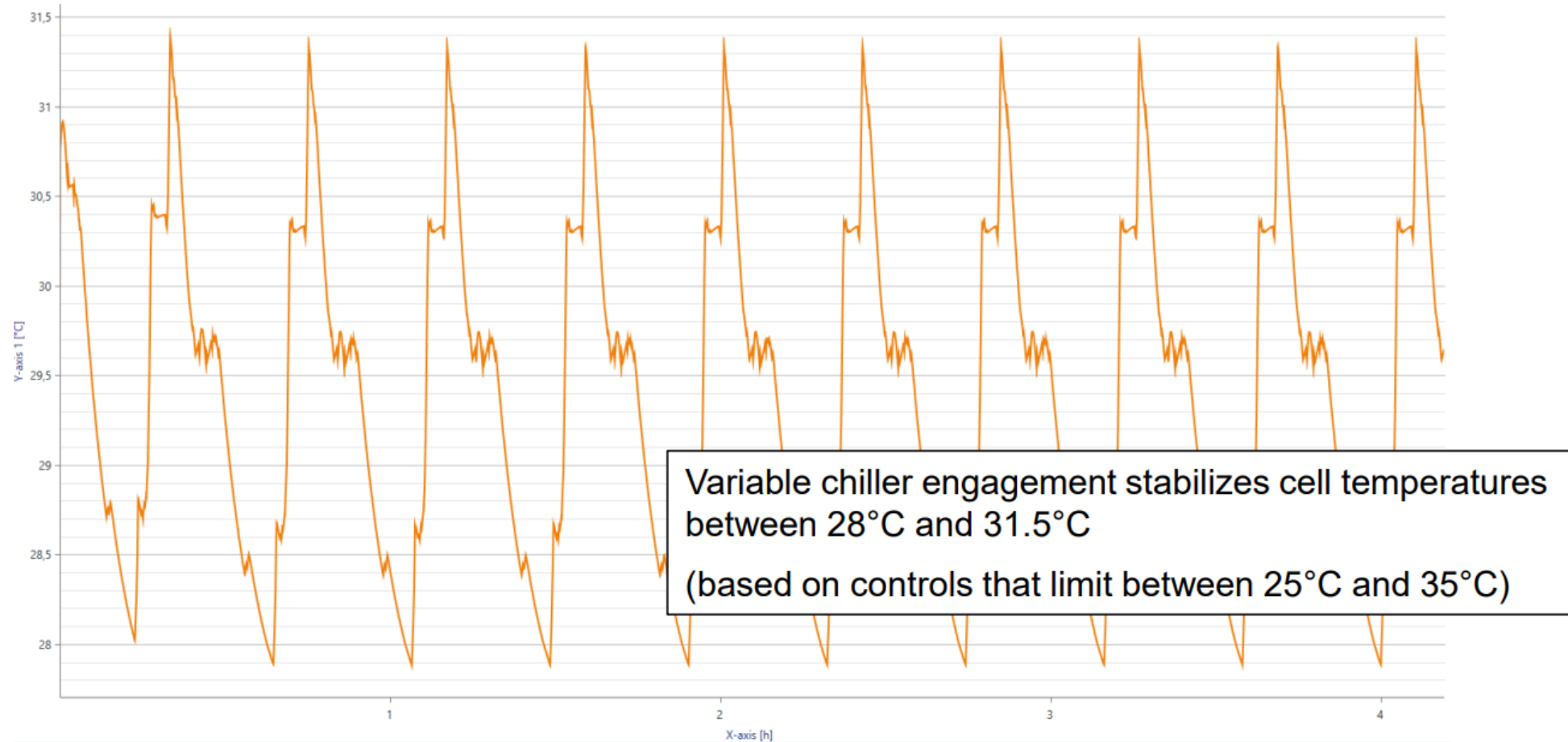
Simulation results (10 Cycles)

Maximum Cell Temperature:



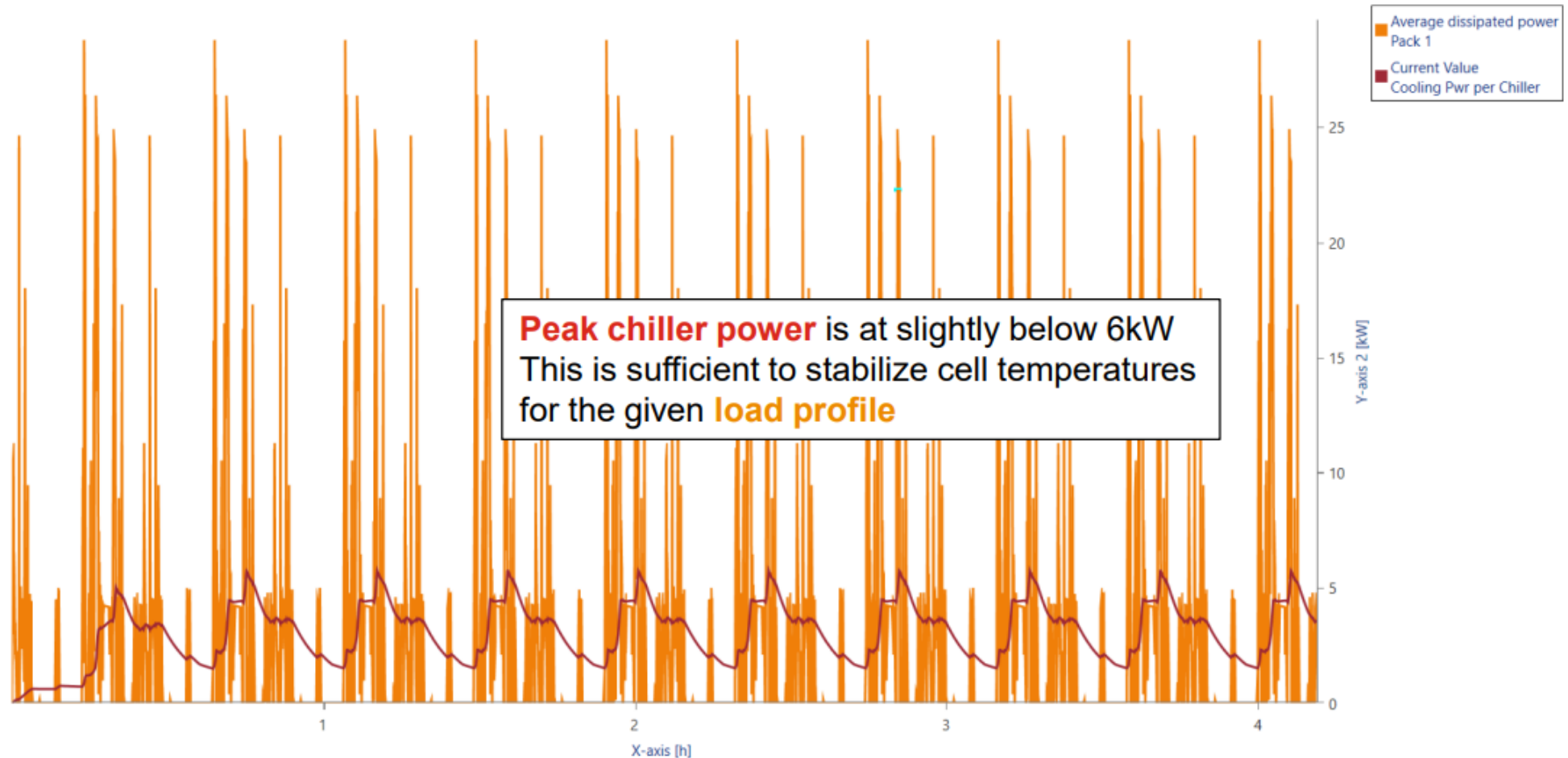
Simulation results (10 Cycles)

Maximum Cell Temperature:



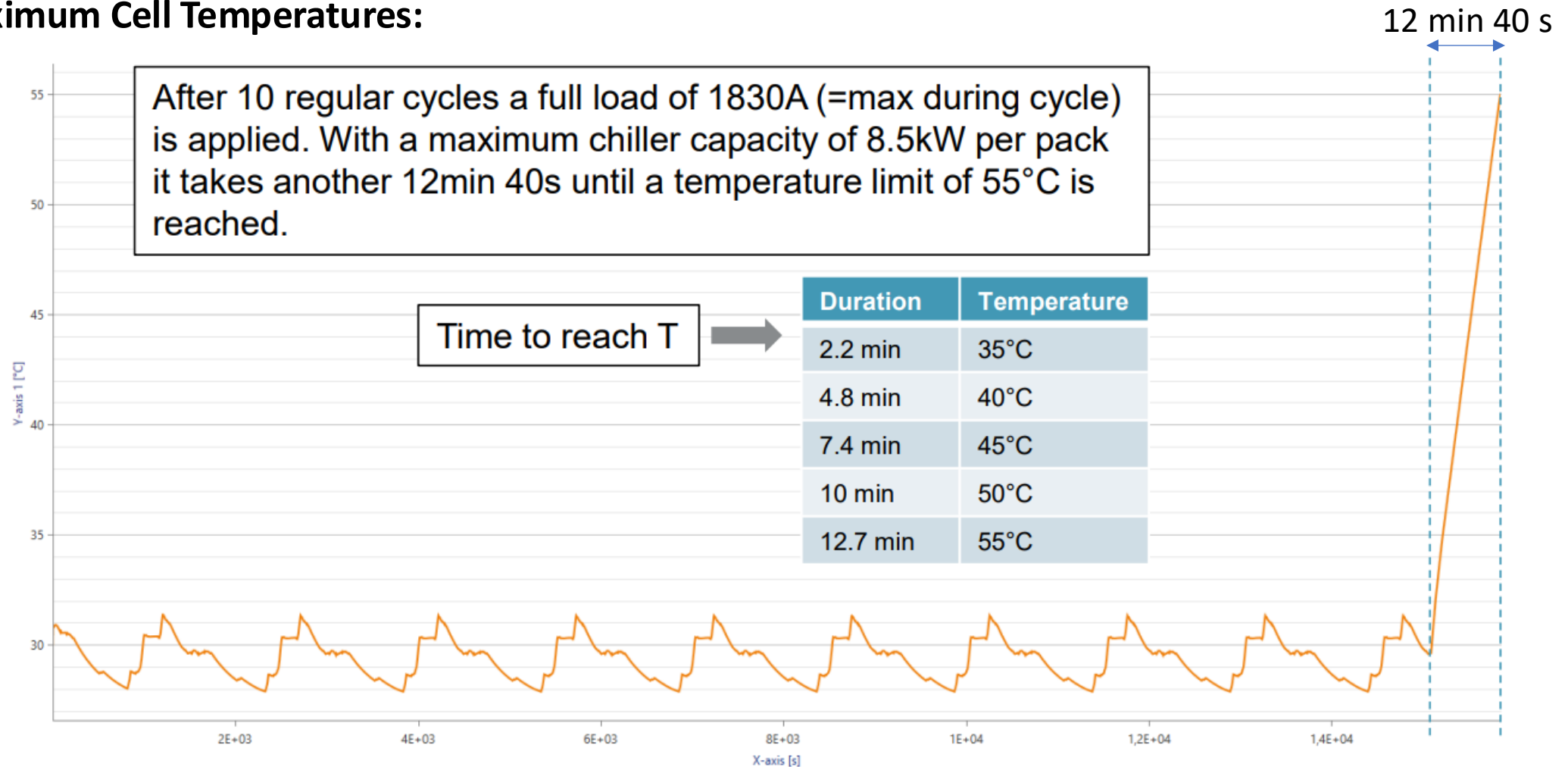
Simulation results (10 Cycles)

Heat Flows:



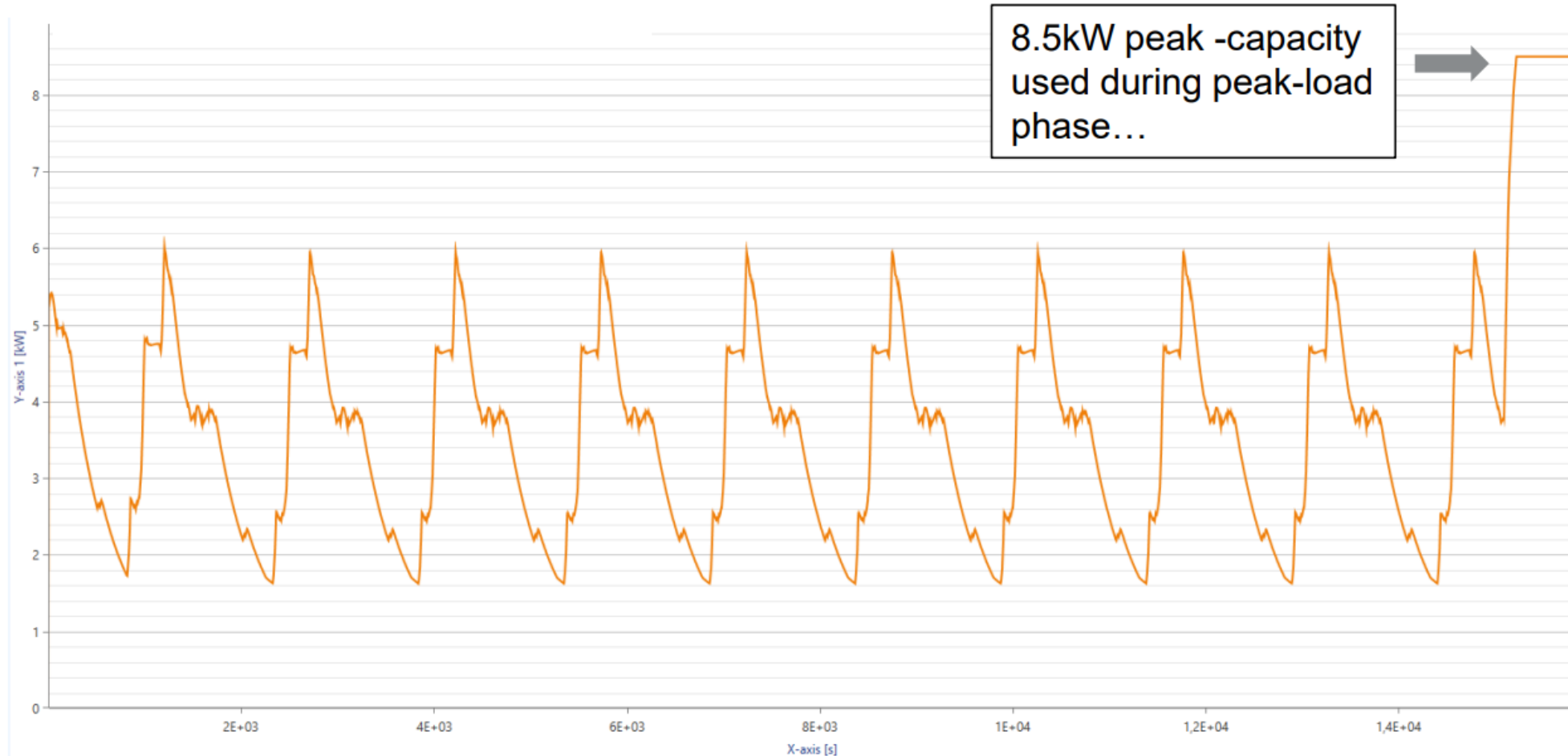
Simulation results (10 Cycles + Full Load)

Maximum Cell Temperatures:



Simulation results (10 Cycles + Full Load)

Chiller Cooling Capacity used:





NEXT STEP

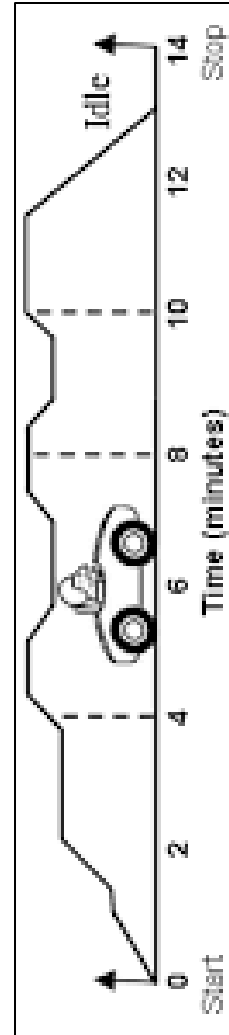
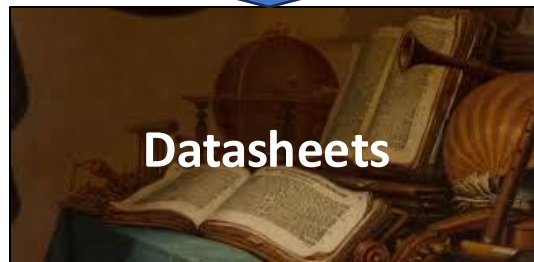
Full machine Calculation Tool
for Sales and Engineering



Customer friendly tool

- Basic idea:
 - Develop a tool which can be used by Sales as well as engineering
- Main task of the tool should be:
 - Enable to transfer customer requirements and especially their machine use into real cooling & heating demands
 - Support the sales in selecting the right system approach for the specific project
 - See before project start and development start if waste heat use make sense
 - Be able to respond to customer questions like battery heat-up and cool-down times
 - Quantify and qualify our today stomach feeling approach and make it more scientific.
- The tool does not need to be absolutely accurate. Its goal is to provide a rough estimate and/or determine a range, e.g., for heating and cooling demand.

What the Simulation should do



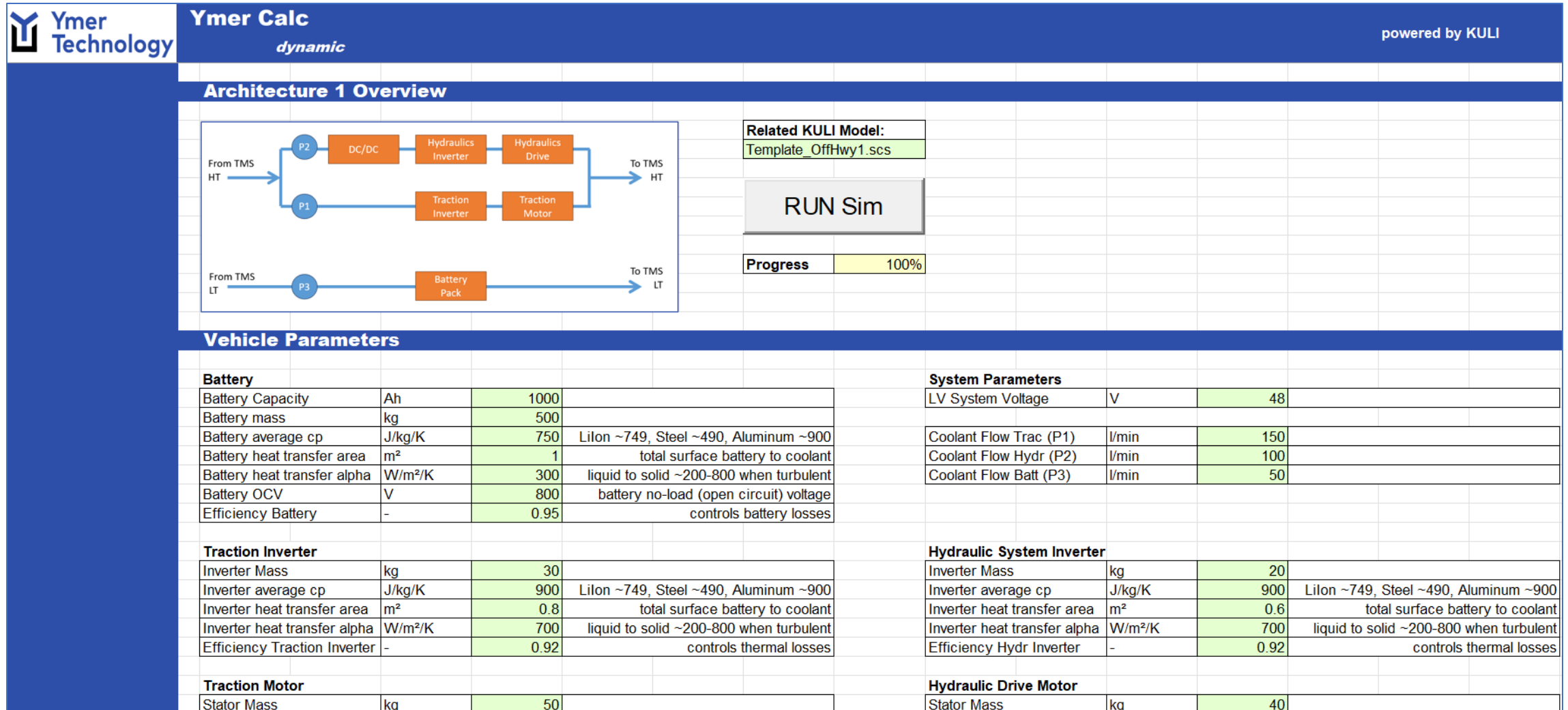
KULI software

- Cooling requirements for the drivetrain
- Cooling and heating demands for the batteries during operation, charging and for heating up and cooling down
- Available waste heat
- Waste heat use

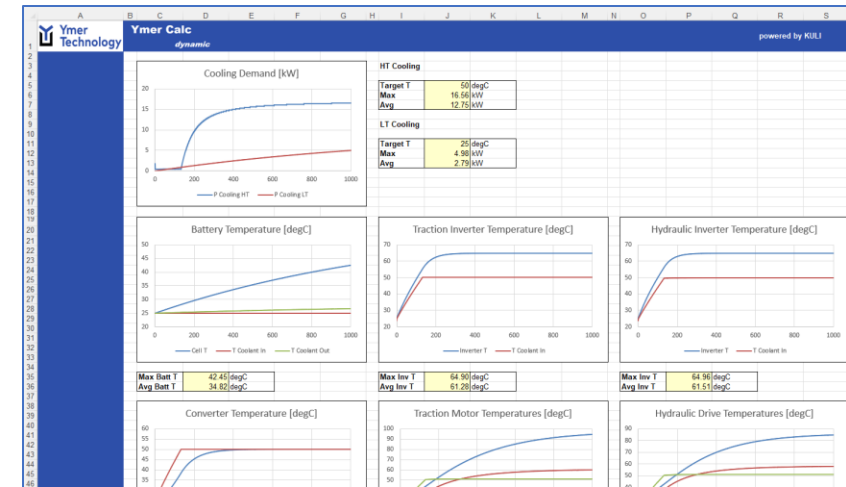
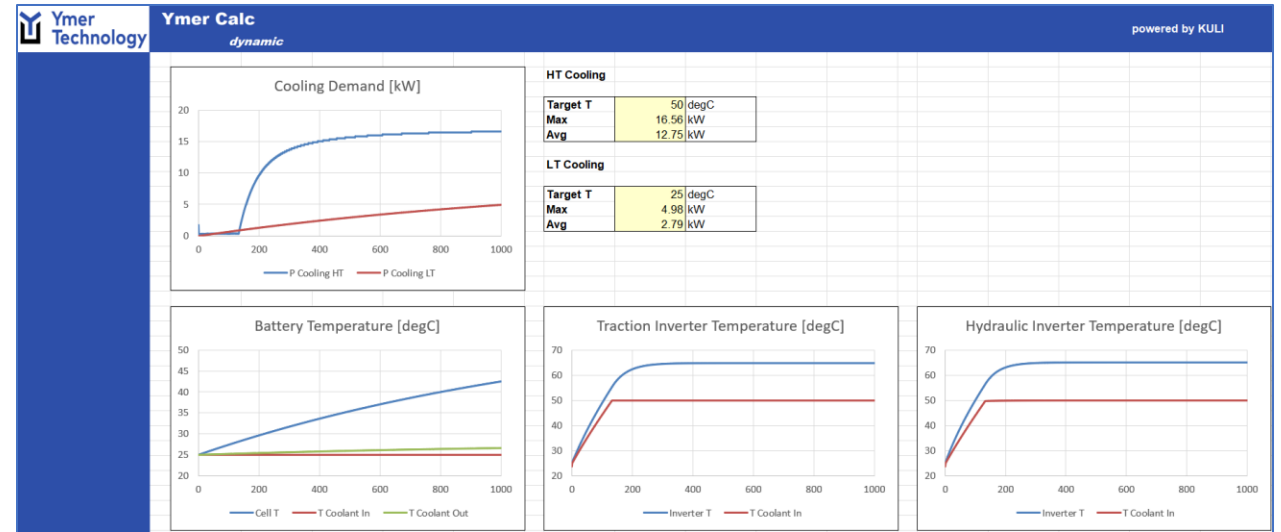
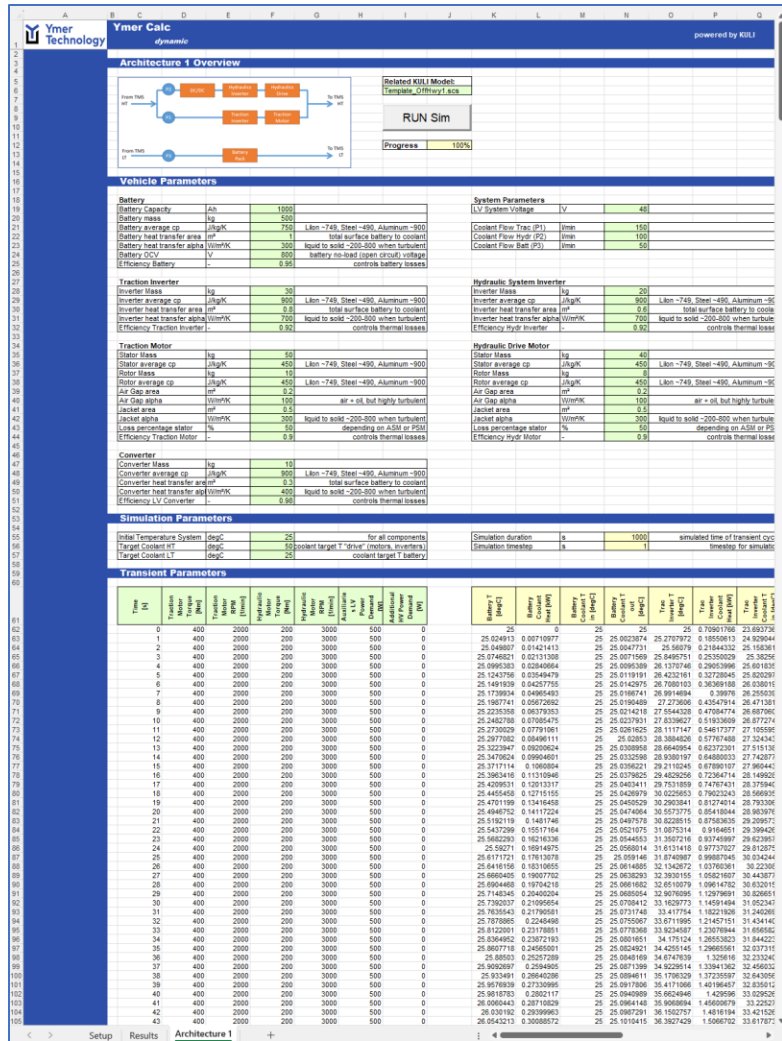
System Layout and Design



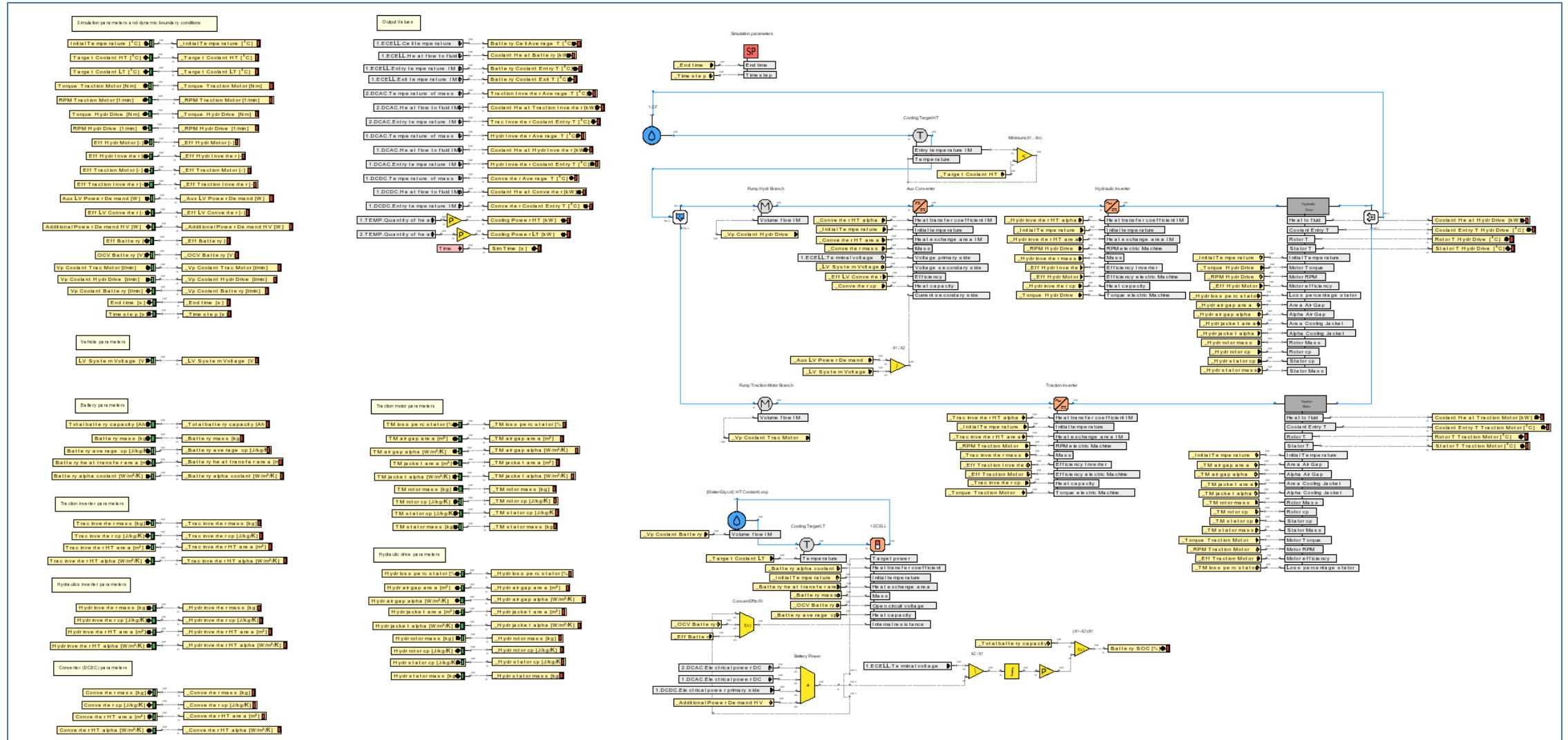
And the initial tries shows: It works!



And the initial tries shows: It works!



And the initial tries shows: It works!





THANKS

And hope to see you soon!

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