Symposium pour l'électronique & le numérique durables

Le 12 décembre 2024, Grenoble

AVEC tech & fest

NANOELEC. Univ. Grenoble Alpes Labex µElec FRANCE 2030 PROGRAMME DE RECHERCHE ÉLECTRONIQUE

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Methodology for measuring the environmental added value of Wide Band Gap power converters (SiC, GaN)

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Supervisor : Charley Lanneluc – CEA-Leti DSYS
Laura Vauche – CEA-Leti DCOS
Jean-Christophe Crebier – G2ELab, CNRS

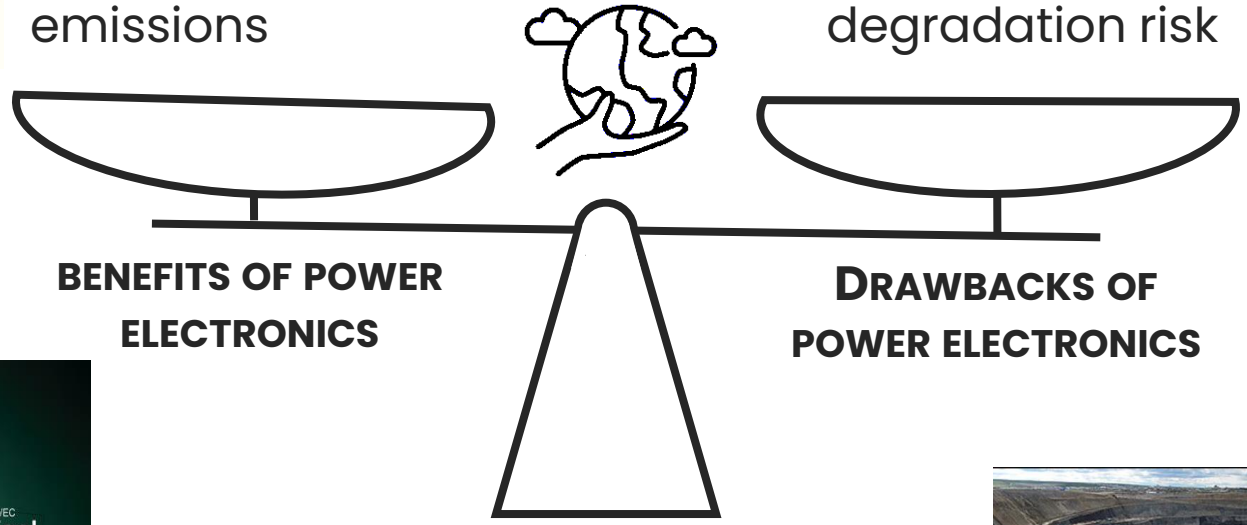
Power Electronics and Sustainability

Supports cleaner energy transition

Reduces carbon emissions

Strains raw material availability

Environmental degradation risk



BENEFITS OF POWER ELECTRONICS

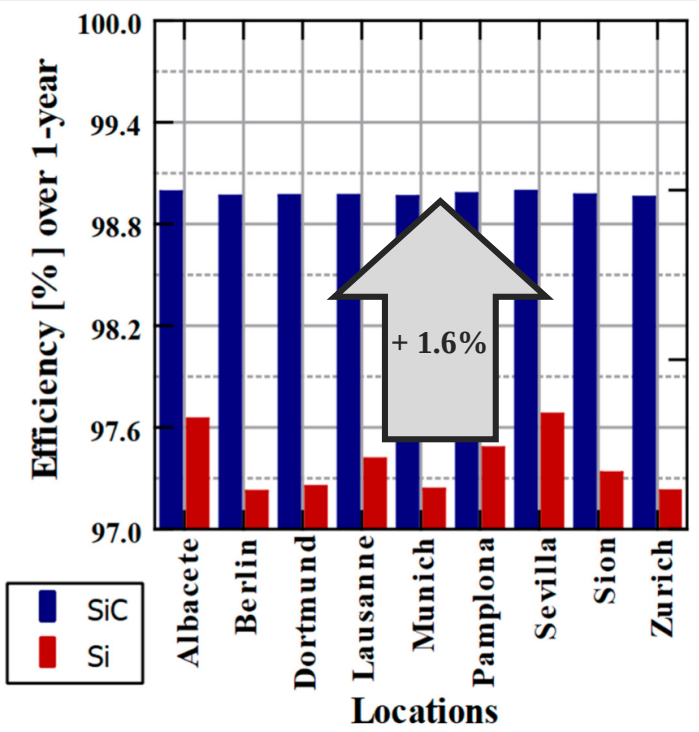
DRAWBACKS OF POWER ELECTRONICS

Adapted from Rahmani, 'Eco-Design Approaches of Power Electronics', ECPE Workshop, 2024

Wide Band Gap (WBG) Technologies in Power Converters

- Environmental benefits at the **using** stage

Operational efficiency of Si and SiC inverter over a year across nine European cities



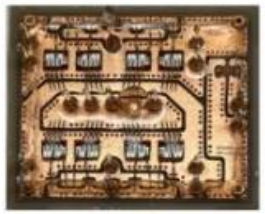
L.B. Spejo, Estimation of Energy-Saving Potential Using Commercial SiC Power Converters. Energies 2024, https://doi.org/10.3390/en17184570

- Environmental benefits at the **manufacturing** stage

Si vs. SiC power module, comparison of Full Material Declaration

Part Number	F4-75R12 KS4_B11	FFMR12W1M 1H_B11
Package	Econo 2B	Easy 1B
Switch	**Si-IGBT**	**SiC MOSFET**
Current Rating (Half Bride)	**150A**	**150A**
Revision	3.0	1.0
Total weight [g]	179,5	22

Si power module



SiC power module (real scale)

F. Musil, "How Life Cycle Analyses are Influencing Power Electronics Converter Design," PCIM Europe 2023, doi: 10.30420/566091368.

Questions

⇨ **How to measure** the **environmental added value** of converters based on wide band gap components?

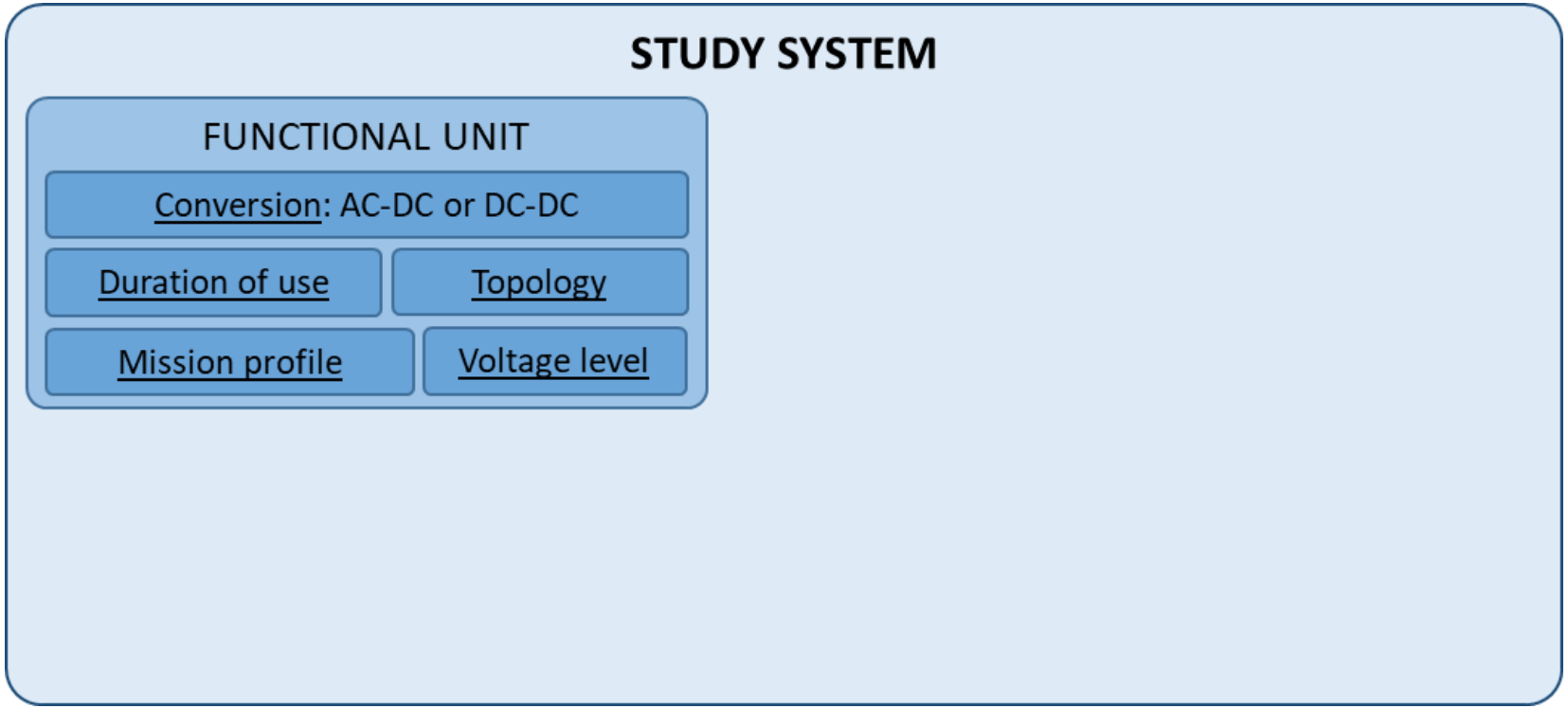
⇨ What conditions should be applied to the **lifestime** of **wide band gap components** to guarantee the benefit of these technologies?

AGENDA

1. System sizing
2. Life Cycle Inventory and prototyping
3. Life Cycle Analysis

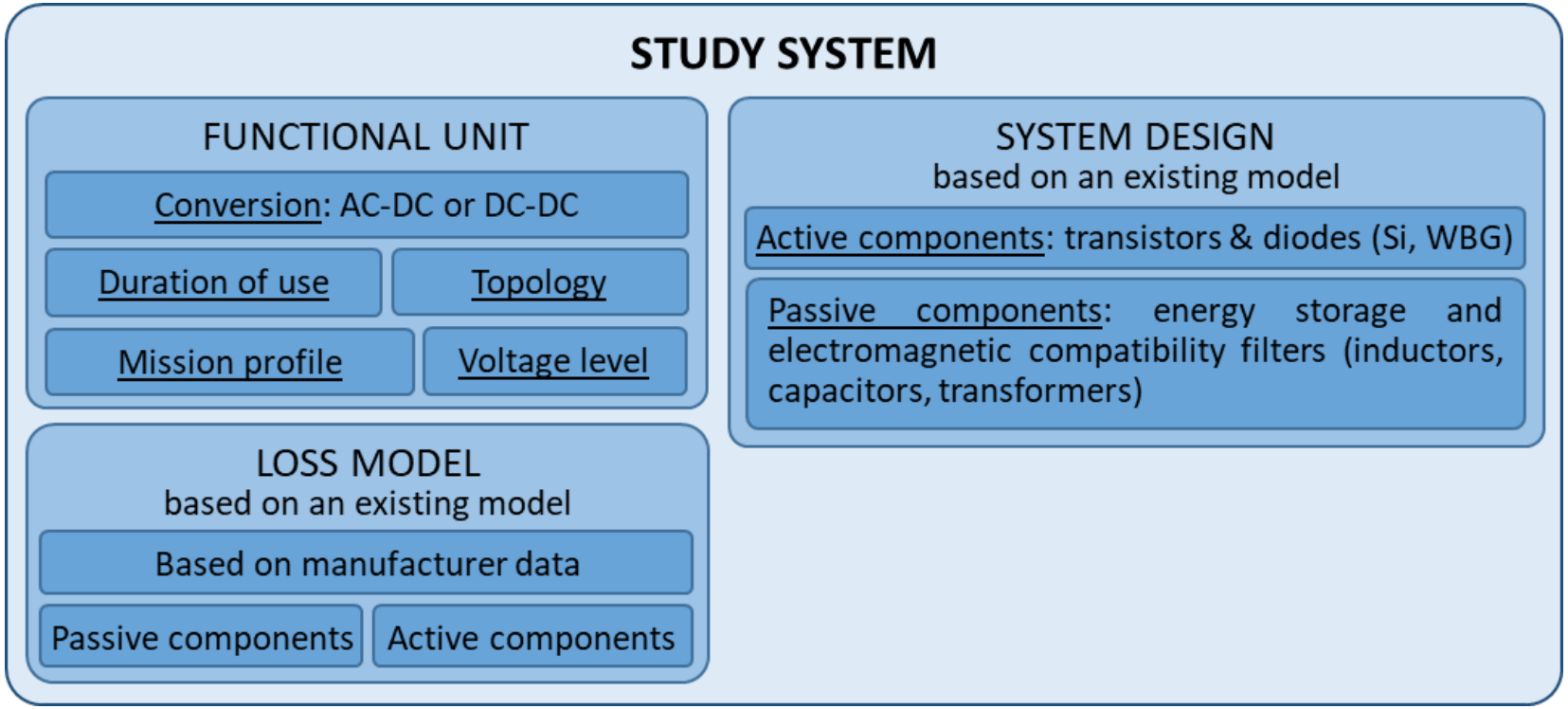
1. System sizing

System sizing

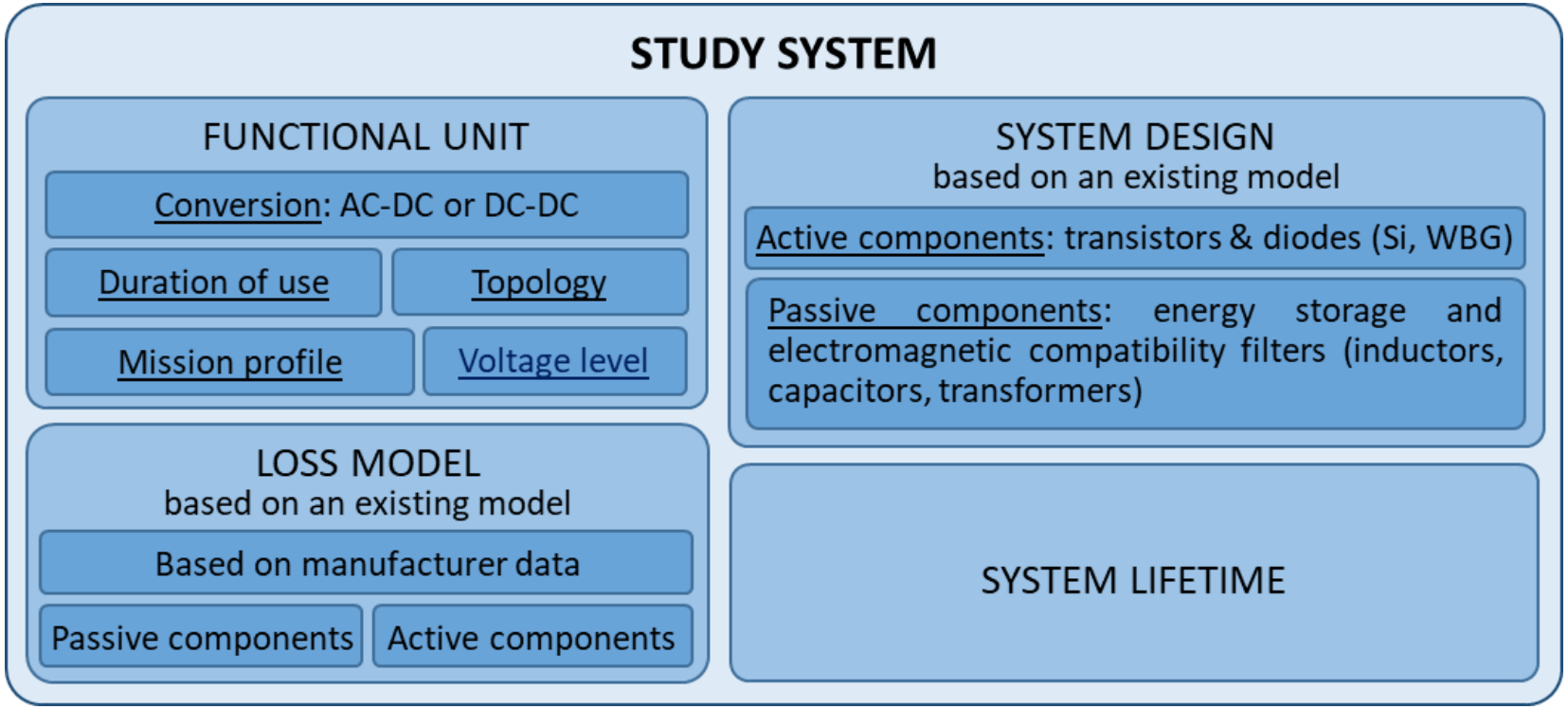


- Functional unit: defines the product's function of use
  basis for measuring and comparing Life Cycle Assessment (LCA) results

System sizing



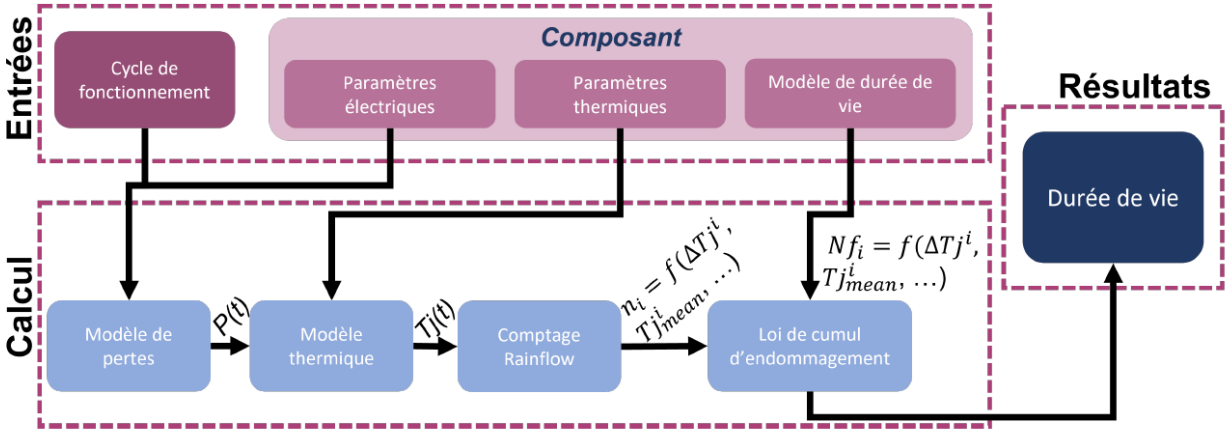
System lifetime



System lifetime

- For Si components:

Method for estimating the lifetime of a power module based on an operating cycle and physical parameters of the component



Briac Baudais. Écoconception en électronique de puissance. Impacts du dimensionnement, de la modularité et de la diagnosticabilité. Electronique. Université Paris-Saclay, 2024.

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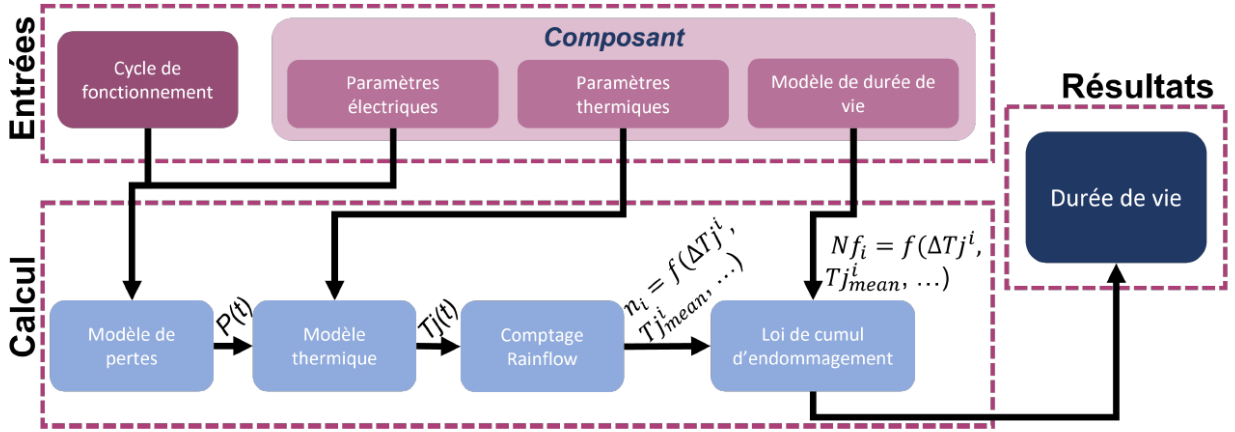

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- An immature model for the lifespan of WBG components:
  - → Lifestime as a variable parameter
  - → Propose a lifespan target based on environmental criteria

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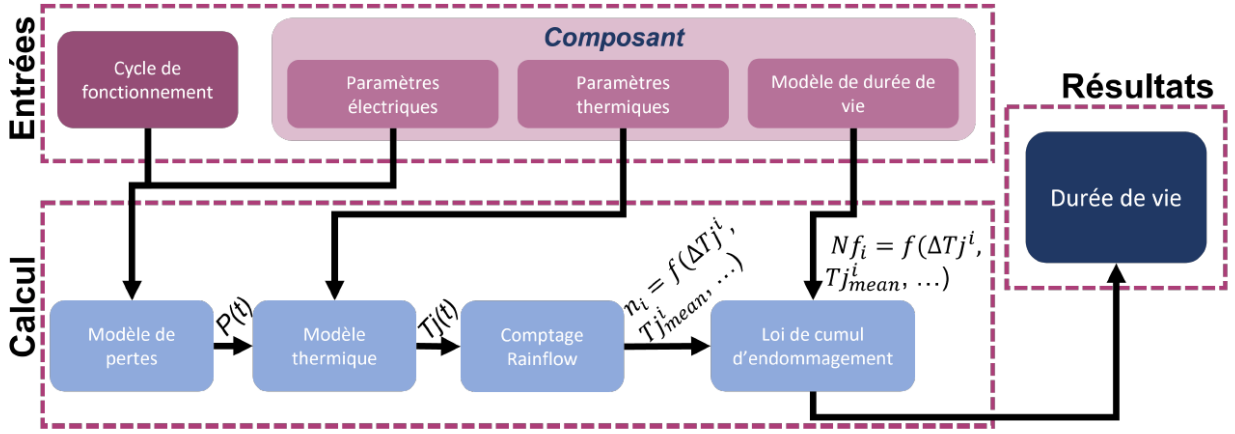

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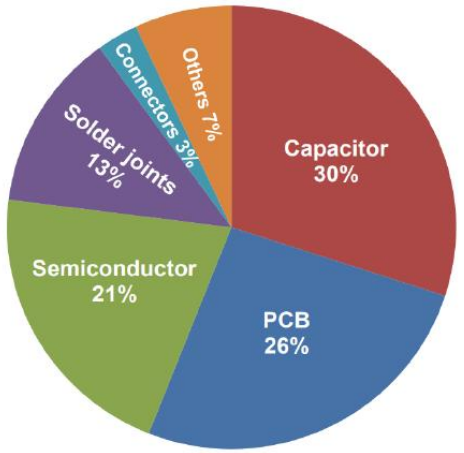
- An immature model for the lifespan of WBG components:
  - → Lifestime as a variable parameter
  - → Propose a lifespan target based on environmental criteria

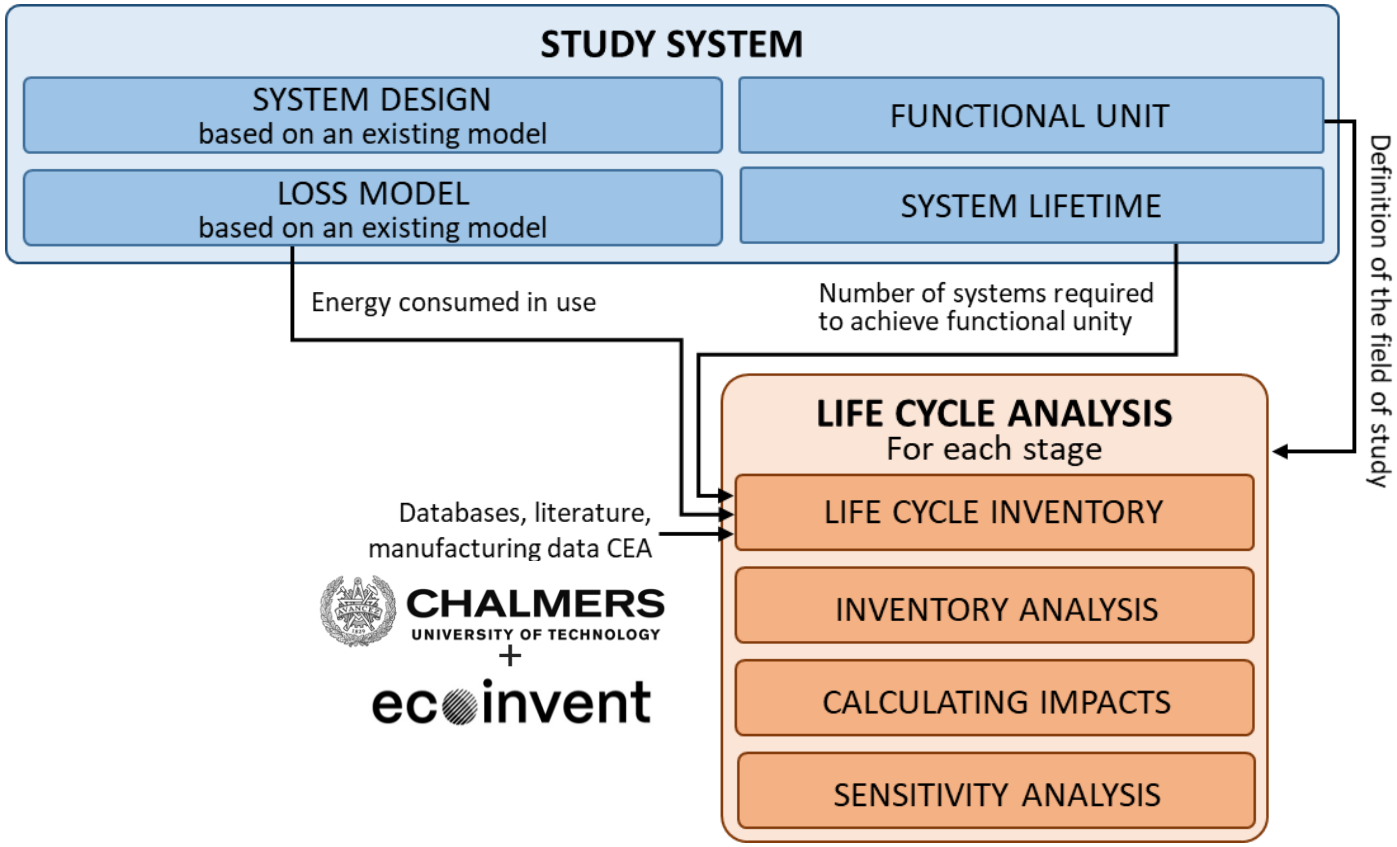
- Extend the model to take account of the lifetime of the DC bus capacity and the PCB

Distribution of failures within power systems



2. Life Cycle Inventory and prototyping

Methodology



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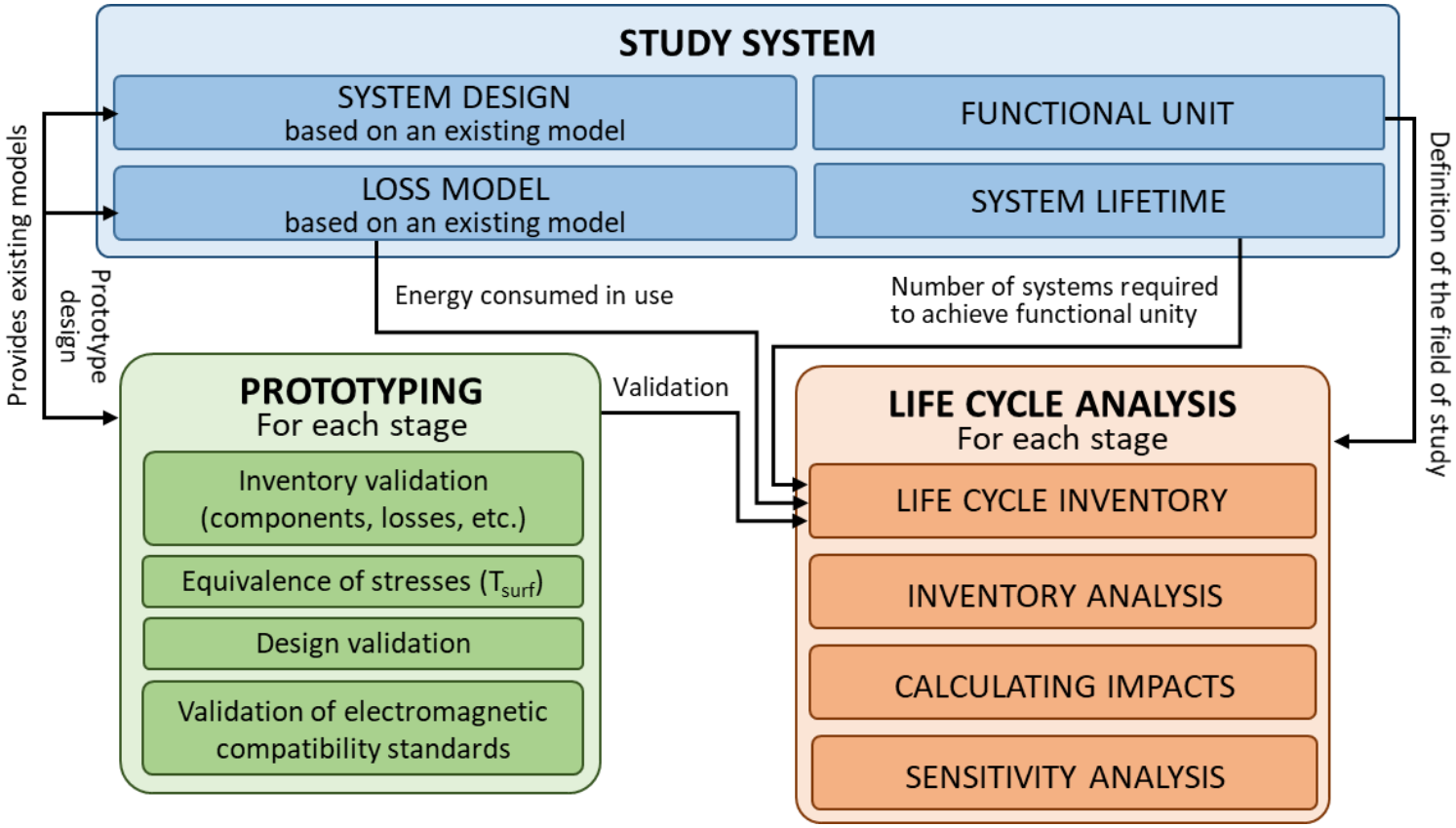

Modular prototyping

- Functional unit: Ensure Uninterrupted Power Supply to a data center with an 800W load for 5 years.
- AC/DC converter PFC totem-pole 230V single-phase/400V DC

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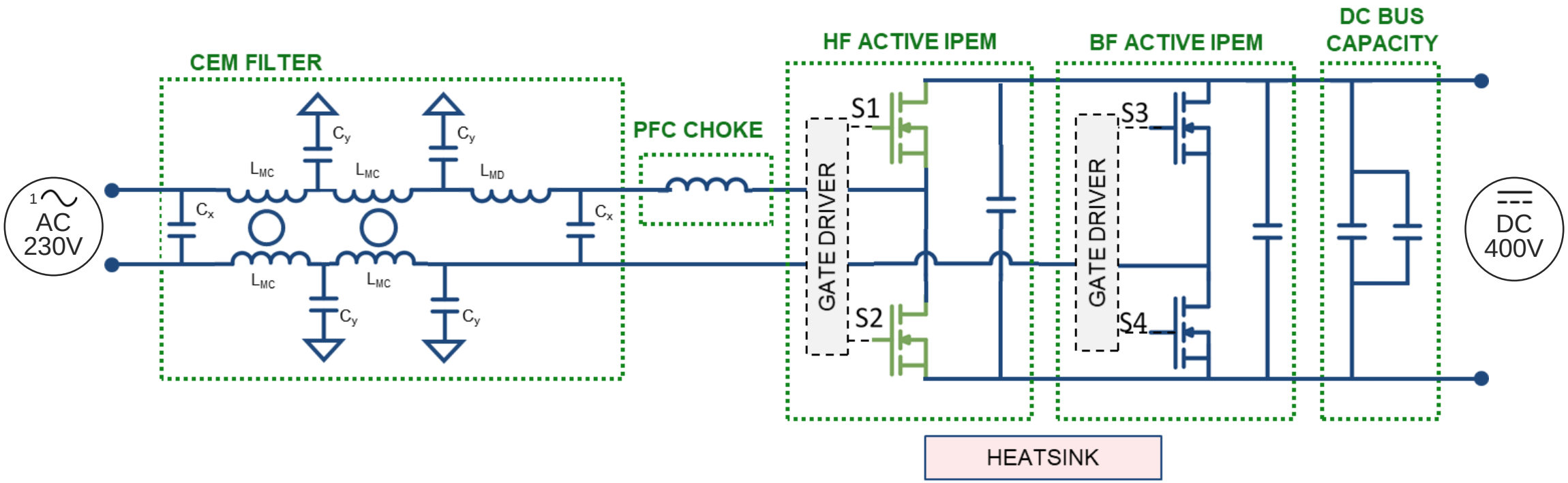

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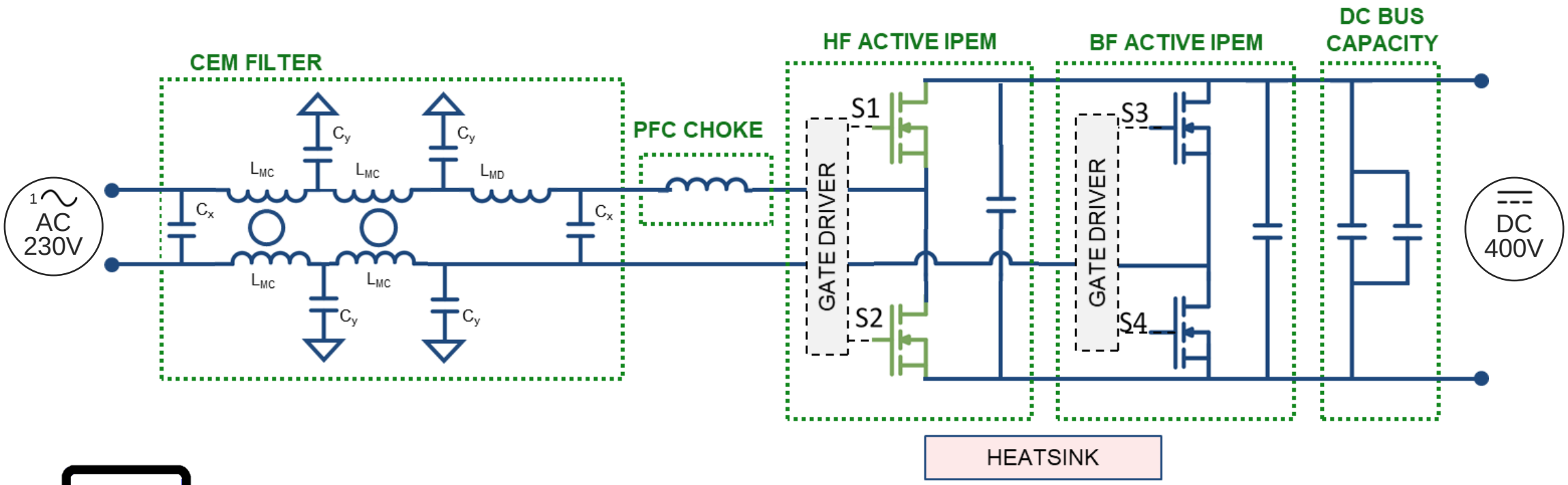
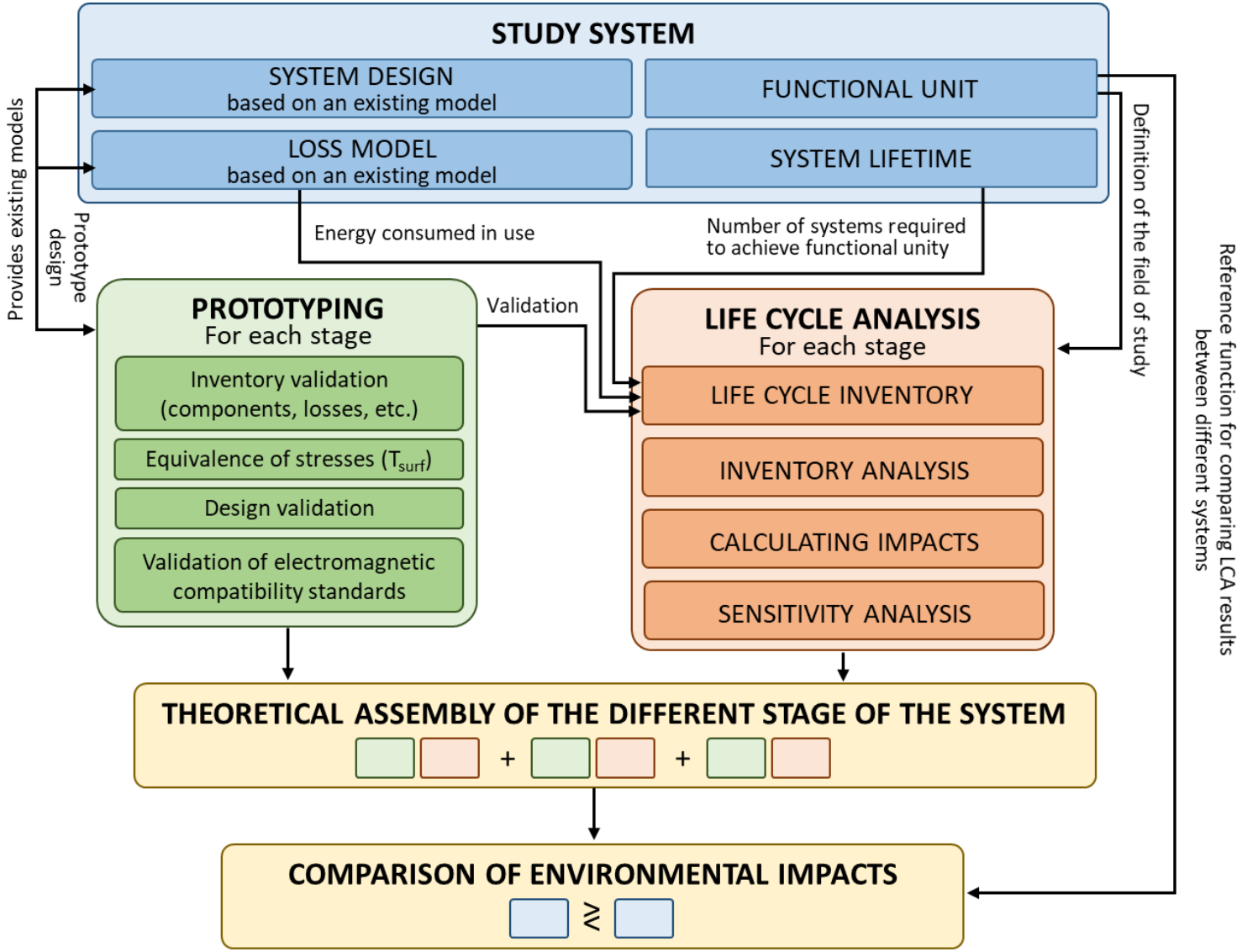


- OBJECTIVES
  - ⇨ Create a customisable database based on experimental measurements
  - ⇨ Create a parameterised LCA tool by functional block for a wide range of cases

3. Life Cycle Analysis

Environmental impact assessment



3. Conclusion and outlook

Conclusion

- The search for energy efficiency does not appear to be sufficient to tackle the problem of **the sustainability of power electronics**.
- **Methodology** to measure the environmental impact of WBG power converters **:**
  1. Sizing power converters
  2. Modular prototyping to feed the Life Cycle Inventory
  3. Life Cycle Assessment
- **Open-source work**: need to cooperate to build complete models and reliable data.
- **Decarbonisation** of energy: **energy efficiency less and less beneficial** for LCA → It is essential to consider other environmental and social criteria
- **From better to good enough**: planetary limits need to be taken into account.

Thank you for your attention

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