APISAT 2019

2019 ASIA PACIFIC INTERNATIONAL SYMPOSIUM ON AEROSPACE TECHNOLOGY

SURFERS PARADISE MARRIOTT RESORT,
GOLD COAST
4 – 6 DECEMBER 2019

ENGINEERS AUSTRALIA

Electric Systems

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Sensitivity Analysis of General Aviation Aircraft with Parallel Hybrid-Electric Propulsion Systems

Contents

Motivation & Objective

Why hybrid-electric propulsion systems?

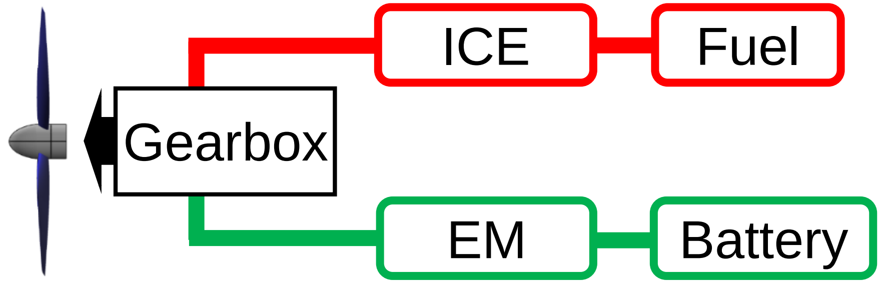
- Combination of benefits offered by electric systems and combustion engines
  - High energy conversion efficiencies
  - High specific motor power
  - Low noise and pollutant emissions
  - High specific energy of fuel

- New degrees of freedom for aircraft design
  - Distributed electric propulsion
  - Solution to the power matching problem

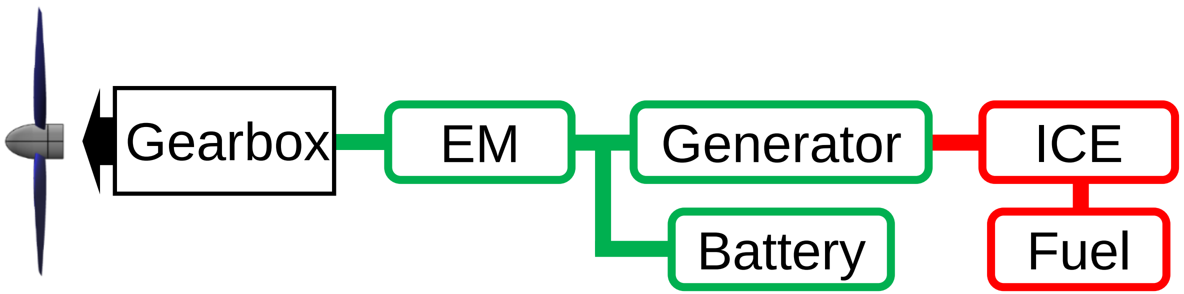
Motivation & Objective

Why parallel hybrid in particular?

- Efficiency benefits in comparison to serial hybrid configurations



Parallel hybrid-electric power train



Serial hybrid-electric power train

Motivation & Objective

Which technological factors drive the future potential of parallel hybrid-electric propulsion systems?

- Evaluation with respect to aircraft design objectives:
  - Maximum take-off mass (MTOM)
  - Primary energy consumption (PEC)

(BP 2019)

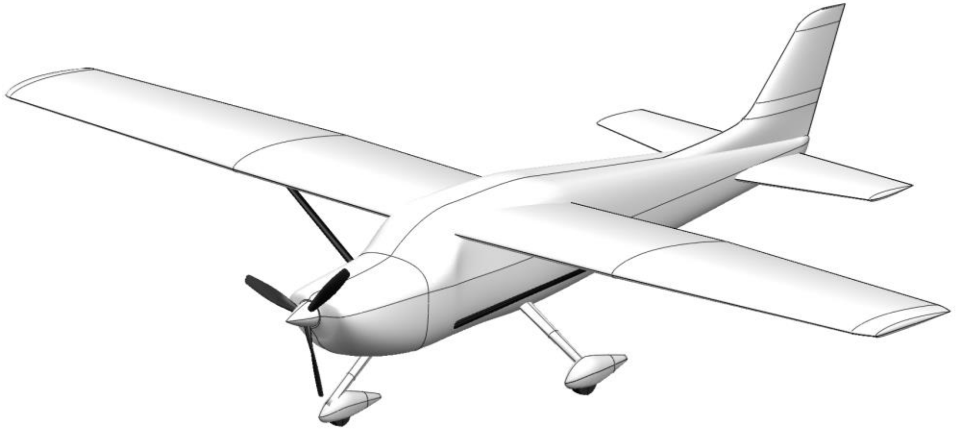
Approach

- Variation of multiple technology parameters with respect to a baseline
  - Battery specific energy
  - Battery specific power
  - E-Motor specific power
  - E-Motor efficiency
  - Battery efficiency

- Baselines for different technology levels and different reference missions

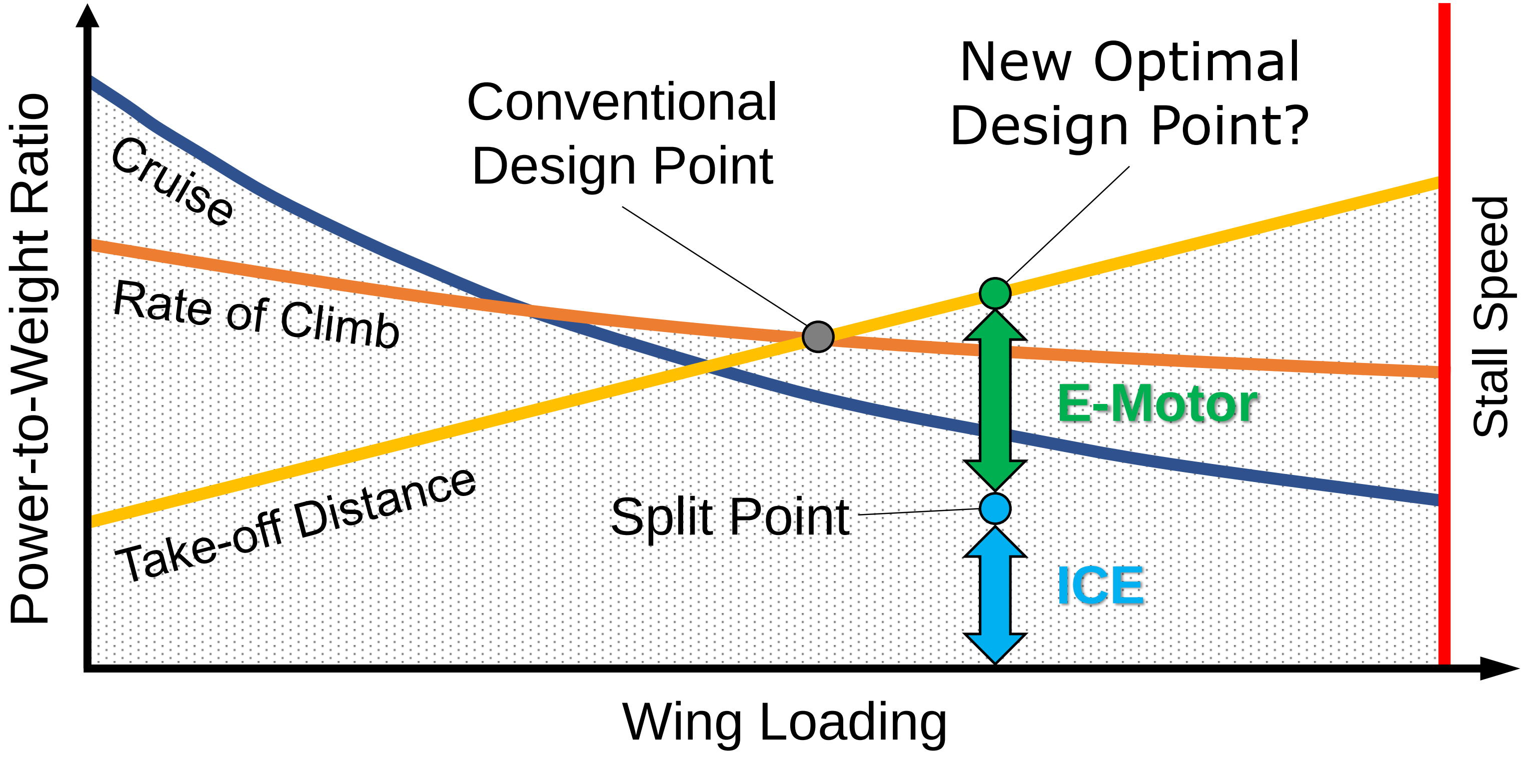
Approach

Mission requirements (~ Cessna 172)	
Design Range [km]	1000 (2000)
Design Payload [kg]	340
Cruise Speed [m/s]	60
Cruise Altitude [m]	2500
Take-off Ground Roll [m]	300
Max. Rate of Climb [m/s]	5



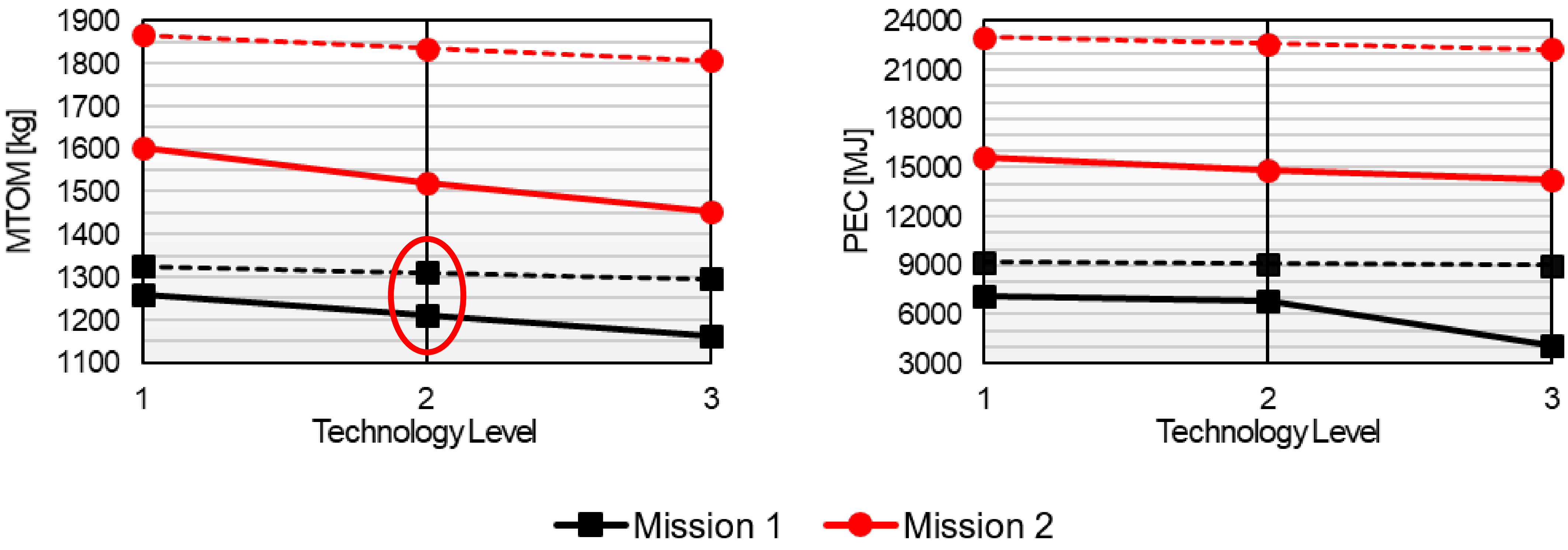
Approach

- Evaluation by conducting initial sizing of each data point



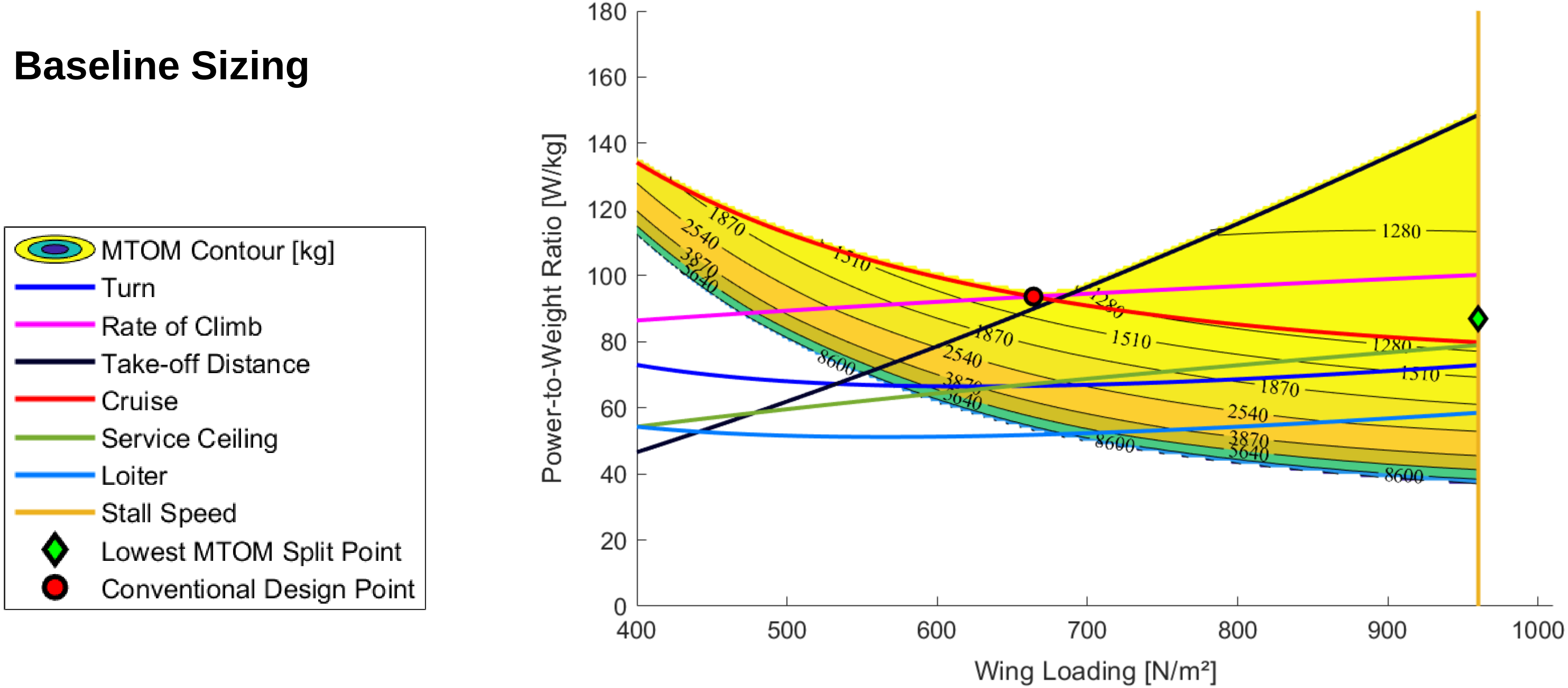
Results

Baseline Sizing



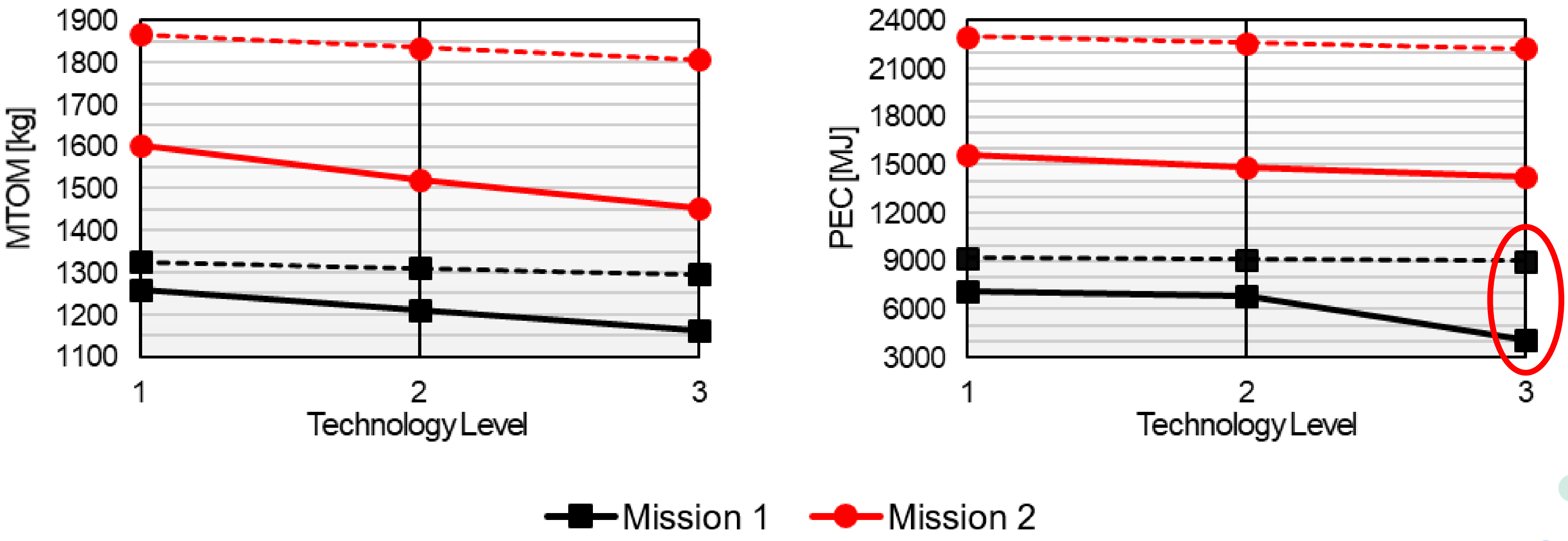
Results

Baseline Sizing



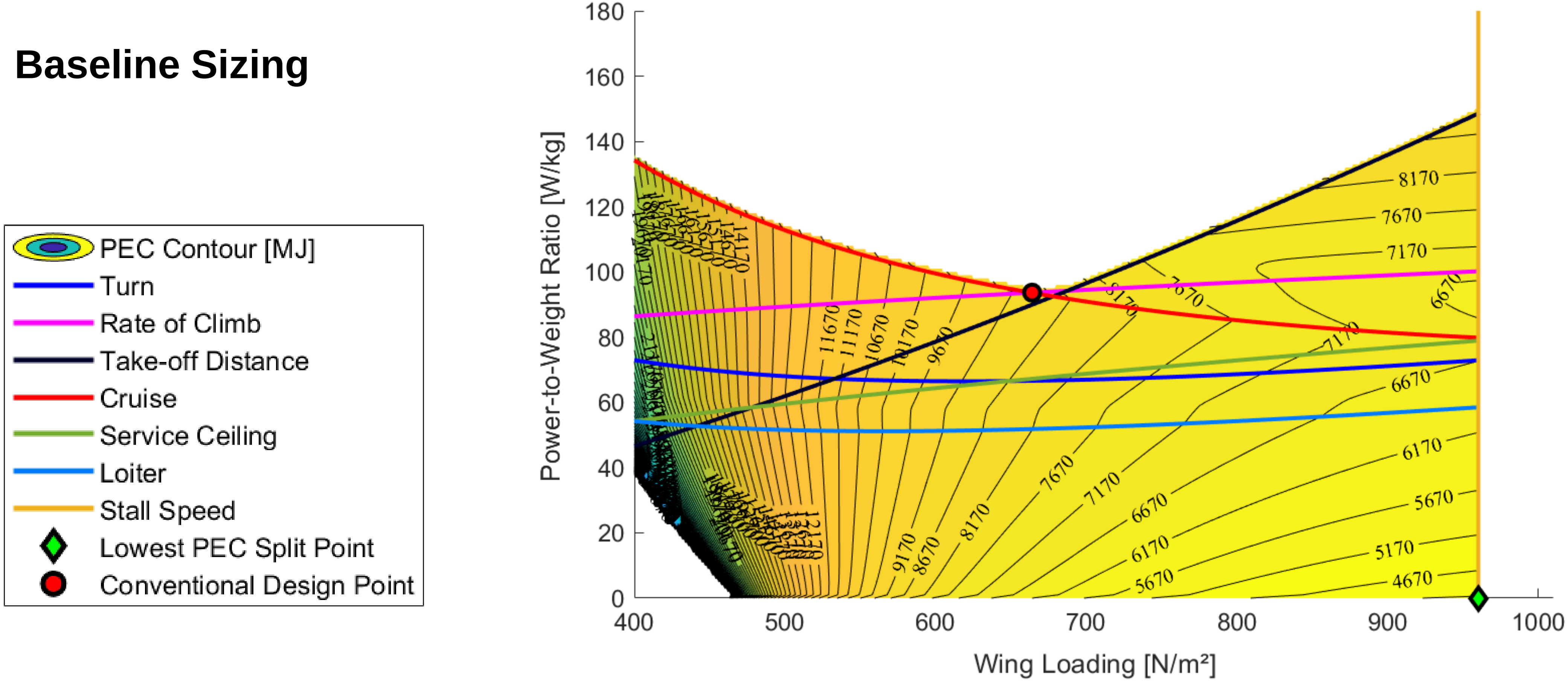
Results

Baseline Sizing



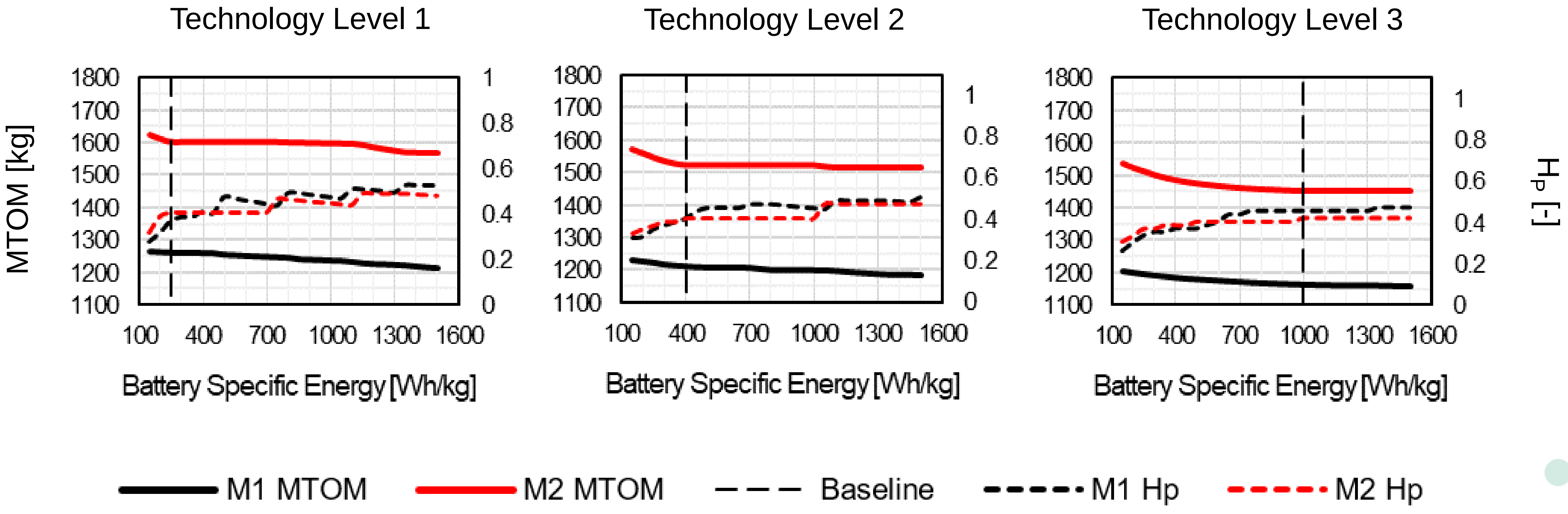
Results

Baseline Sizing



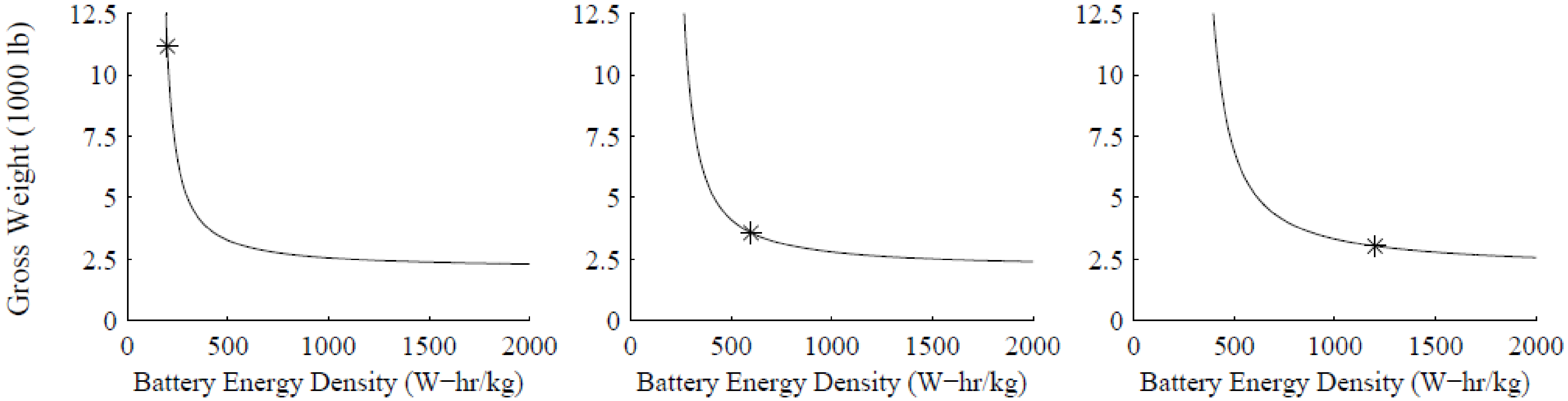
Results

Sensitivity – Battery Specific Energy



Results

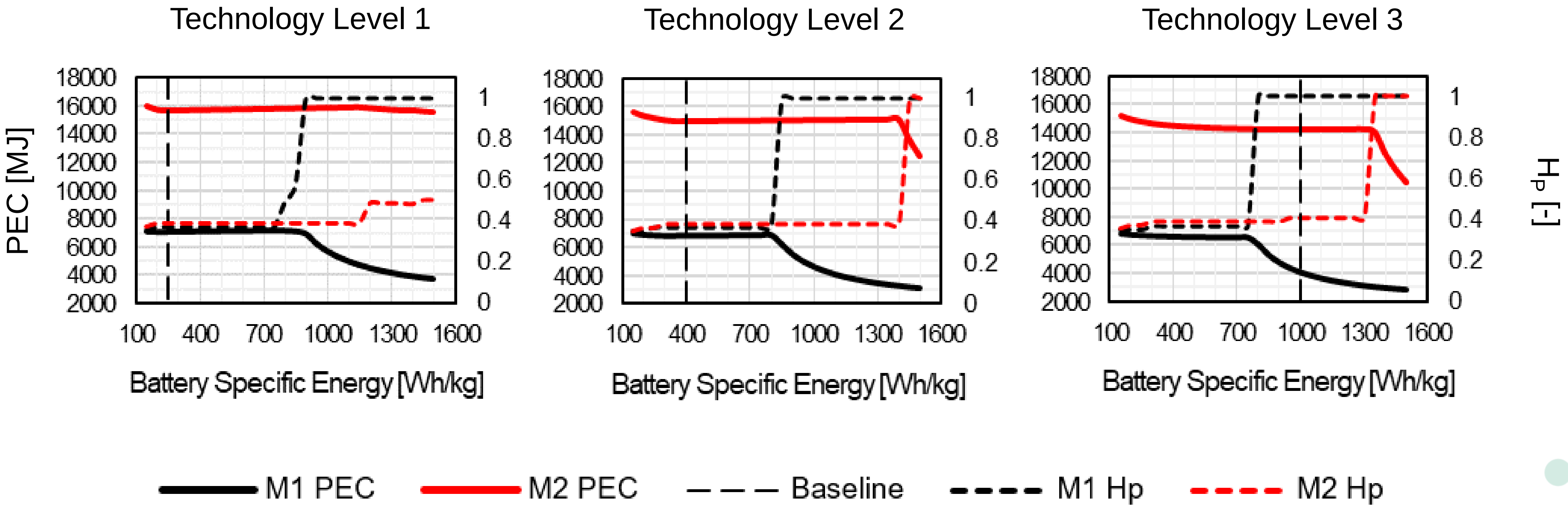
Sensitivity – Battery Specific Energy



(Patterson, German & Moore 2012)

Results

Sensitivity – Battery Specific Energy



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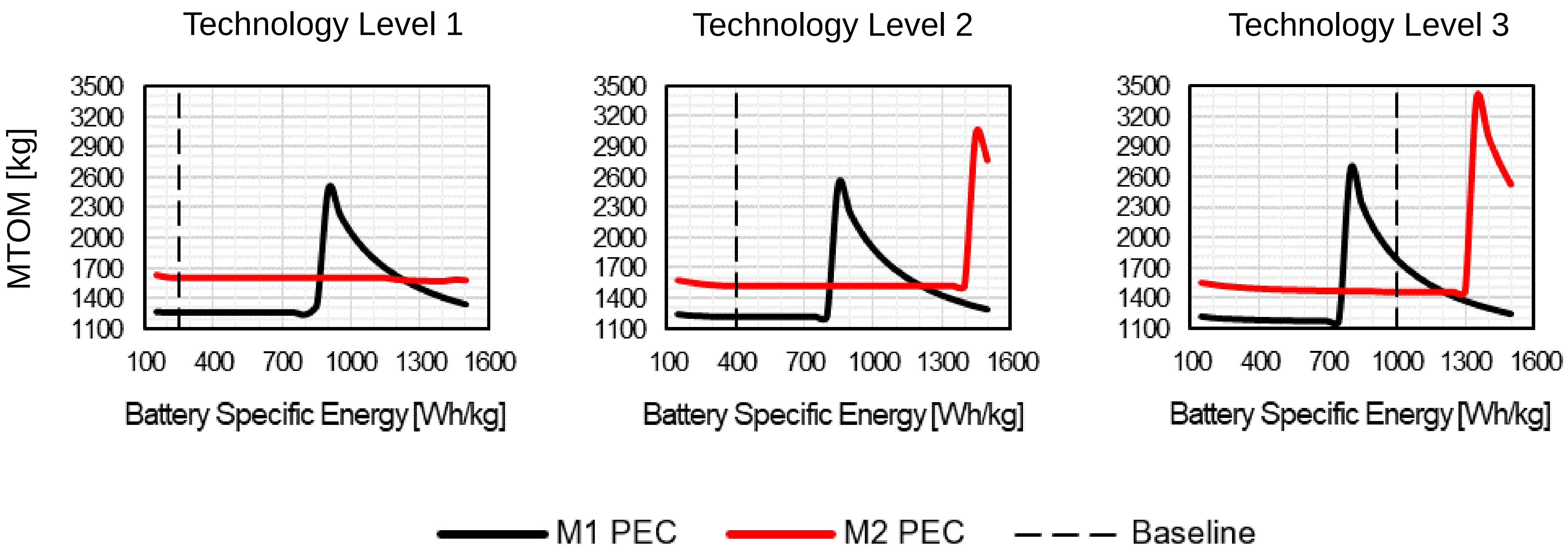

Conclusion

- Battery technology as key factor for enabling parallel hybrid-electric propulsion
  - Specific energy mainly defines degree of hybridization and battery mass
  - Specific energy allows for significant reductions in energy consumption
  - Specific power has high influence only for small parameter values
- Even high values of battery specific energy can further optimize aircraft design objectives
- No extensive improvements by other technology parameters

References

BP 2019, BP plc, viewed 18 November 2019, <www.bp.com>.

Patterson, MD, German, BJ & Moore, MD 2012, 'Performance Analysis and Design of On-Demand Electric Aircraft Concepts', in *12th AIAA Aviation Technology, Integration and Operations (ATIO) Conference and 14th AIAA/ISSMO Multidisciplinary Analysis and Optimization Conference*, Indianapolis, IN.

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