



Dr. Boris Mazar, March 21st 2012

STATE OF THE ART PROTOTYPE VEHICLE WITH A THERMOELECTRIC GENERATOR.

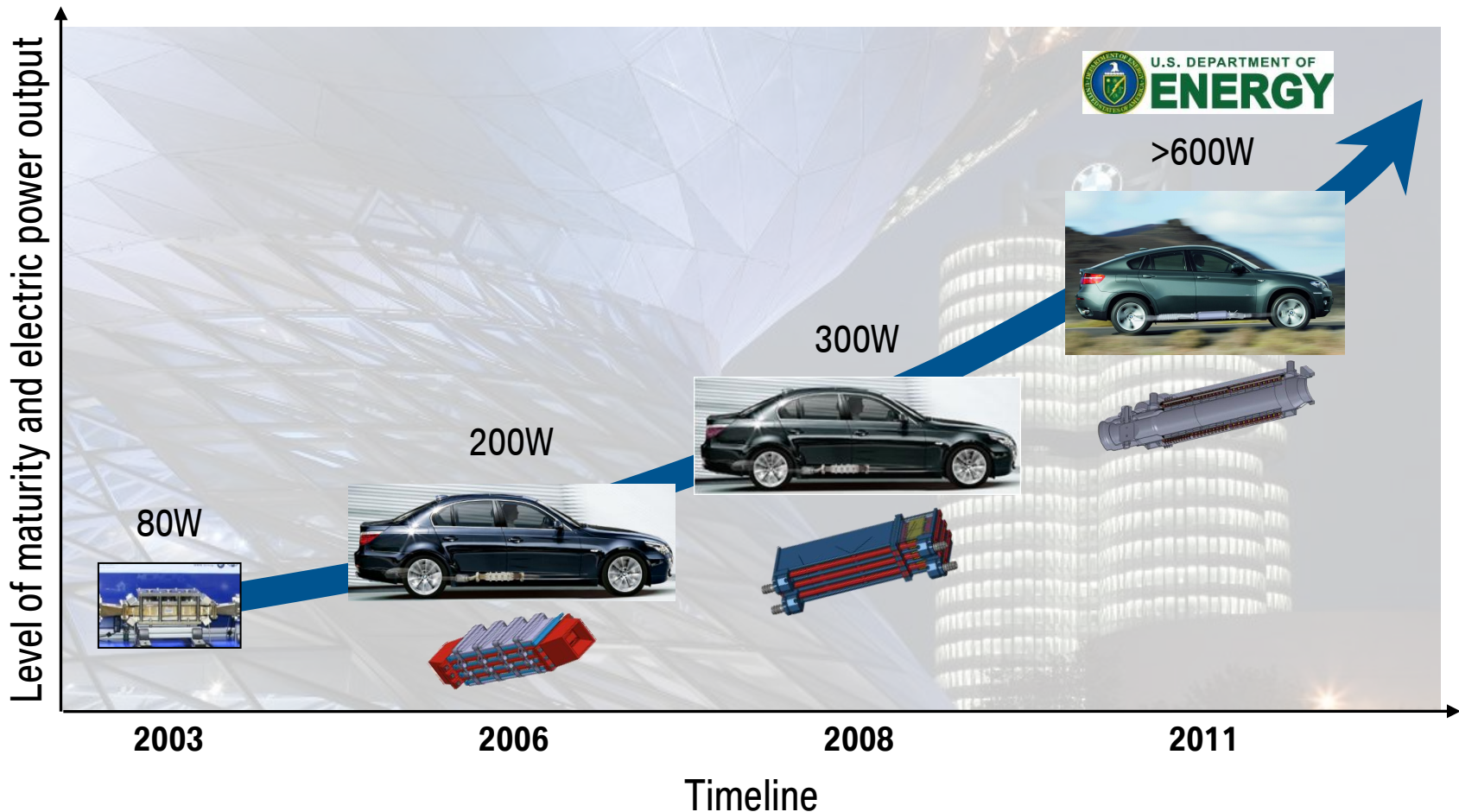
TE APPLICATION WORKSHOP, BALTIMORE.



BMW X6 TEG PROTOTYPE VEHICLE.

THE EVOLUTION OF THE THERMOELECTRIC GENERATOR.

Numerous prototypes have been built, cumulating in the 600W X6 demonstrator.



BMW X6 TEG PROTOTYPE VEHICLE.

THE PROJECT TEAM.

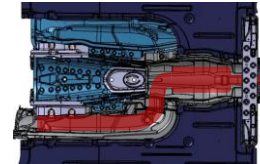
- **Amerigon:** Project leader and component design specialist.



- **ZT Plus:** TE material optimization and production.



- **Faurecia:** System integrator as TIER1 supplier.



- **Ford/BMW:** Vehicle integrators.



- **NREL:** Testing laboratory.

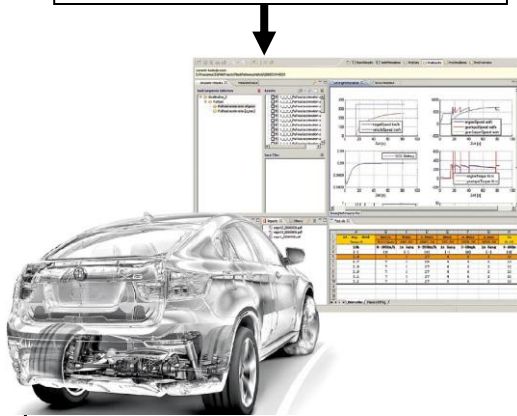


BMW X6 TEG PROTOTYPE VEHICLE.

BMW'S ROLE AND RESPONSIBILITY IN THE PROJECT.

Vehicle simulation

TEG-Model (Amerigon)



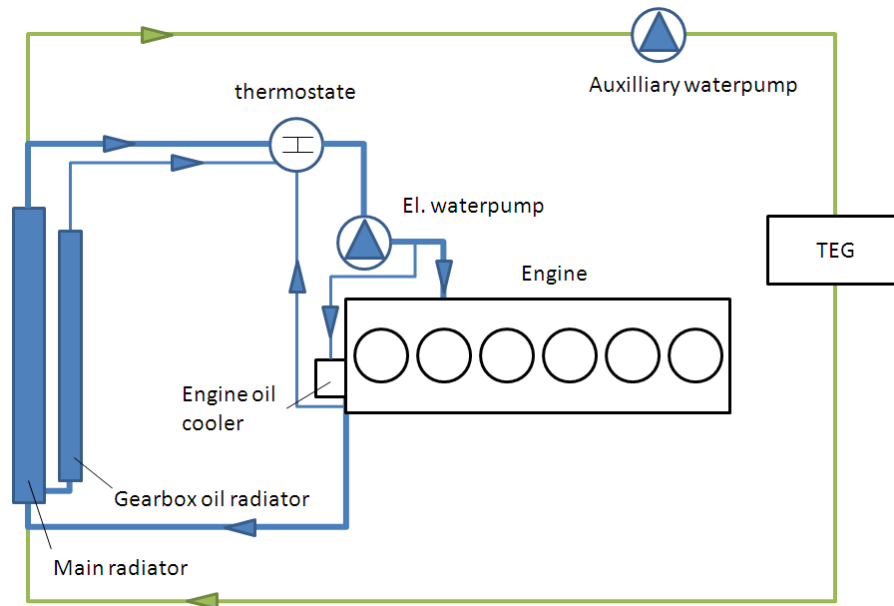
- vehicle parameters
- friction model
- combustion engine
- exhaust line
- cooling system

Vehicle integration



- exhaust line integration
- cooling system integration
- control strategy
- data acquisition
- visualization

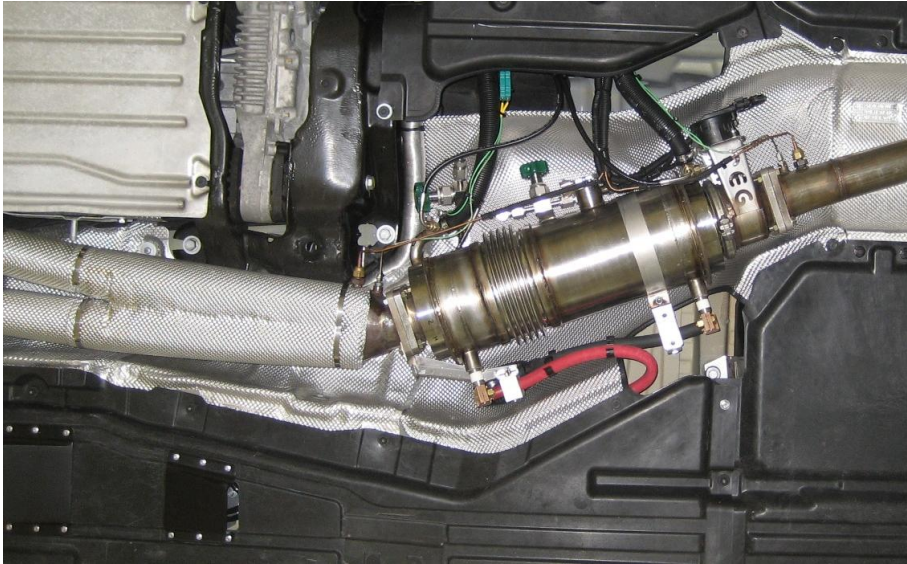
BMW X6 TEG PROTOTYPE VEHICLE. COOLING SYSTEM INTEGRATION.



Constraints and the key success factors:

- At extreme driving conditions the cooling capacity for the ICE must be guaranteed.
- The specific integration concept has a significant impact on the coolant temperature level for the TEG (50-120°C).
- The heat rejected into the coolant can be used for an accelerated warm-up of the power train.

BMW X6 TEG PROTOTYPE VEHICLE. EXHAUST LINE INTEGRATION.



Constraints and the key success factors:

- Under-floor package poses a challenging constraint for the TEG component design.
- Limitation of the exhaust backpressure plays a decisive role in maximizing the FE performance.
- The acoustic and mounting aspects were not considered within this project.

BMW X6 TEG PROTOTYPE VEHICLE. ELECTRIC LOAD.



Constraints and the key success factors:

- Due to the thermal inertia the electric characteristics of the generated power is uncritical to the stability of the power circuit within the vehicle.
- For an efficient integration, the voltage level of the TEG should be close to the value of the vehicle.

BMW X6 TEG PROTOTYPE VEHICLE. INSTRUMENTATION.

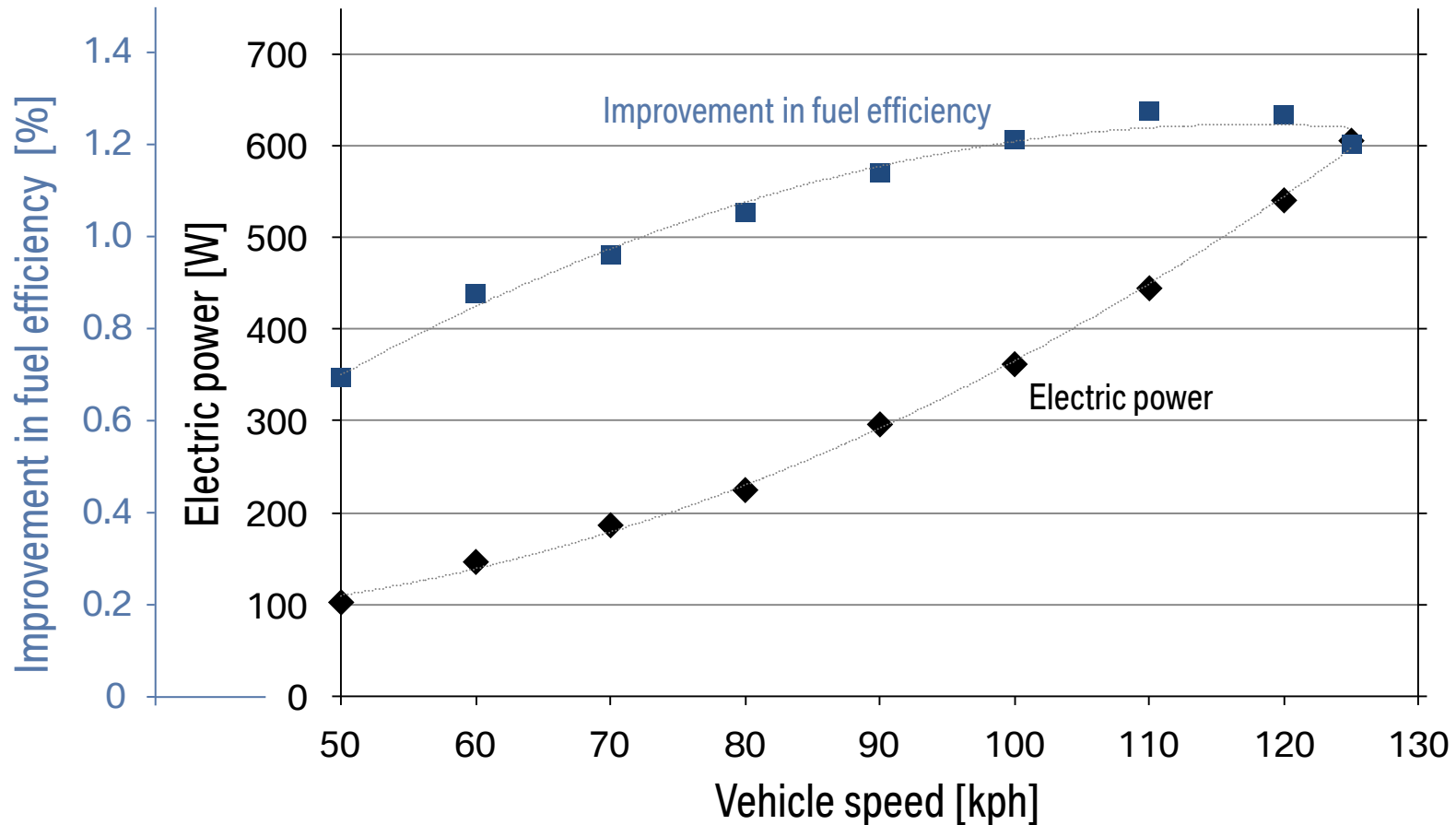


Constraints and the key success factors:

- A comprehensive instrumentation is installed into the vehicle, measuring 48 local temperatures, 6 voltages, 3 currents, 2 pressure drops and 5 volume flow rates.
- Data logger allows to save the data during real driving and dynamometer conditions.

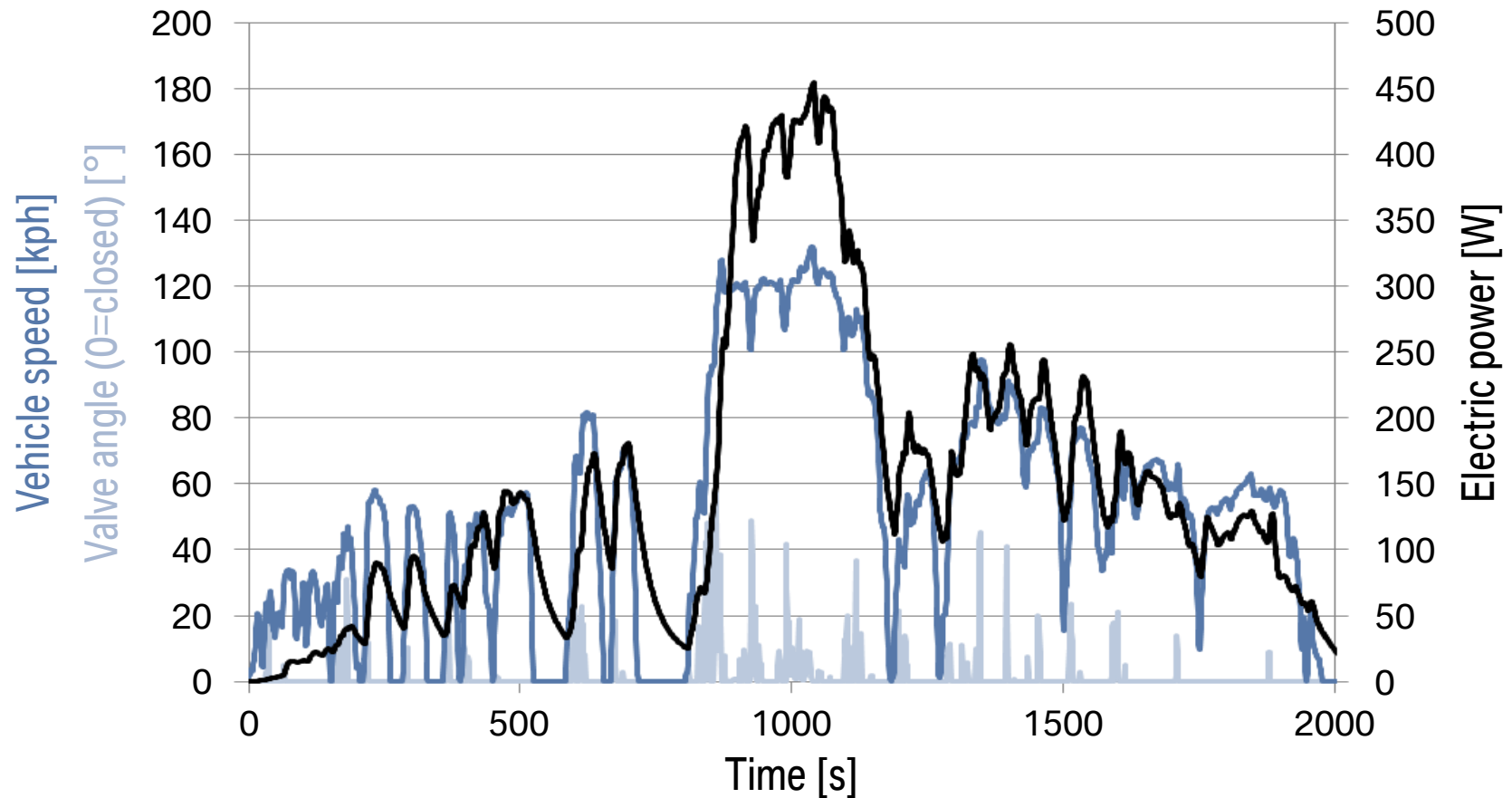
BMW X6 TEG PROTOTYPE VEHICLE.

SYSTEM PERFORMANCE FOR STEADY STATE CONDITIONS.



BMW X6 TEG PROTOTYPE VEHICLE.

SYSTEM PERFORMANCE FOR DYNAMIC DRIVING.



BMW X6 TEG PROTOTYPE VEHICLE. SUMMARY.

- This robust technology is a promising method for waste heat recovery.
- A TEG with unique power levels was successfully built and integrated into a vehicle.
- The established simulation tool and the vehicle integration are the basis for an efficient design process for future TEG components and concepts.

BMW X6 TEG PROTOTYPE VEHICLE. OUTLOOK.

- High technical and commercial risks need to be overcome:
 - Scale-up of material production.
 - Assembly process.
 - System integration (exhaust backpressure, max. cooling power etc.).
 - System durability testing.
- The key for a successful market introduction lies in the reduction of costs:
 - The right choice for the TE material.
 - Lean assembly process.
 - High power levels at medium temperatures.

BMW X6 TEG PROTOTYPE VEHICLE. ACKNOWLEDGMENT.

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Thank you to the team for the constructive and successful cooperation.

