

Thermoelectric Power Generation - The Next Step to Future CO₂ Reductions?!

BMW EfficientDynamics.
Less emissions. More driving pleasure.



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BMW Group



BMW EfficientDynamics

How it began...

1998 - 2002:

How will BMW Group continue to be successful in times of climate change, tougher fuel economy legislation, skyrocketing oil prices and a growing environmental awareness in the broad public?



BMW EfficientDynamics.

Measures to reduce fuel consumption throughout the entire fleet.

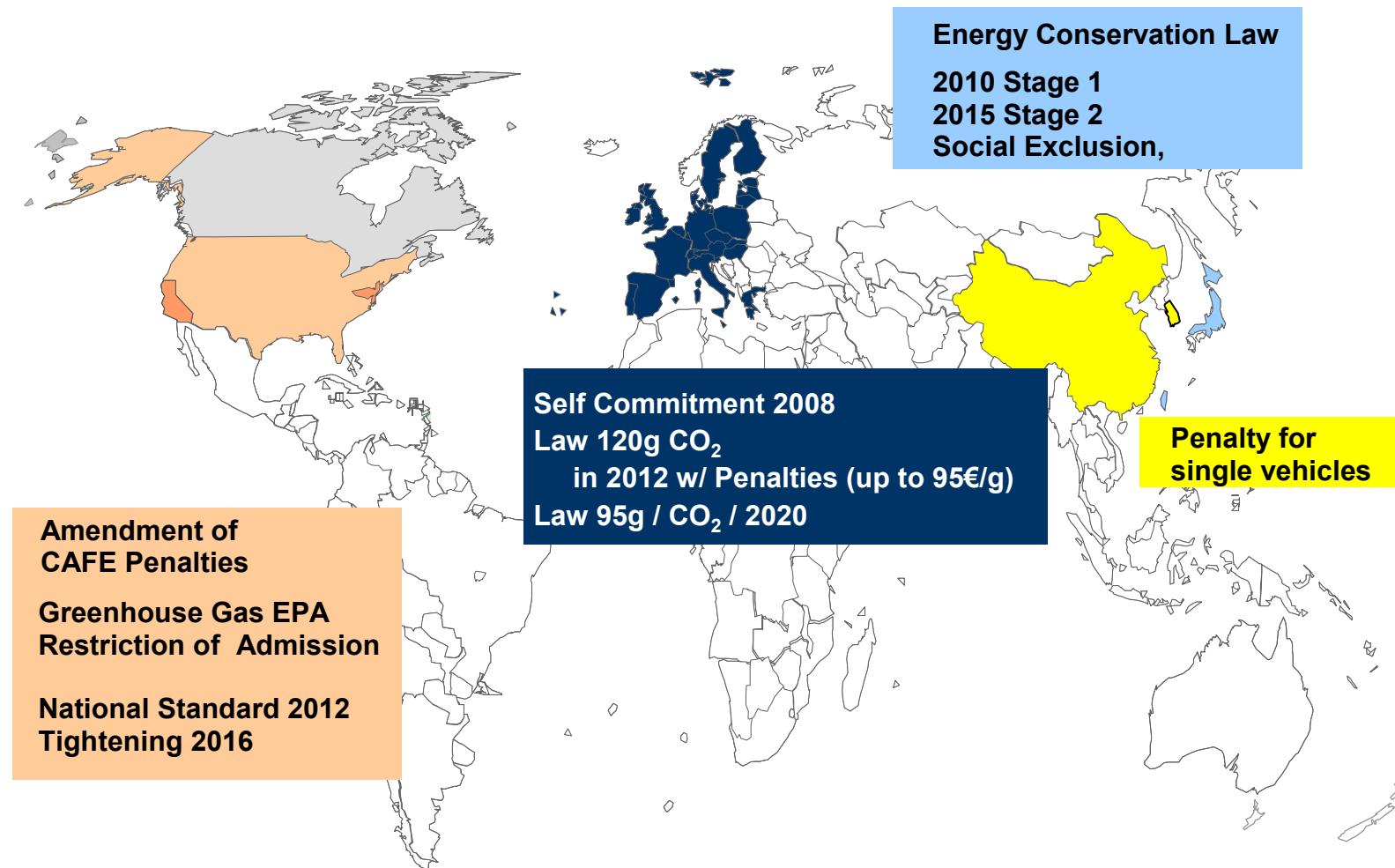
- Over 1.35 million vehicles sold with BMW EfficientDynamics.
- 22 BMW and 7 MINI models with a max. output of 140 g CO₂/km.
- **Reduction of CO₂ emissions from 2005-2008: -25%.**
- CO₂ emissions in vehicle production: -17% in the last four years.

BMW “140 gram“ fleet.



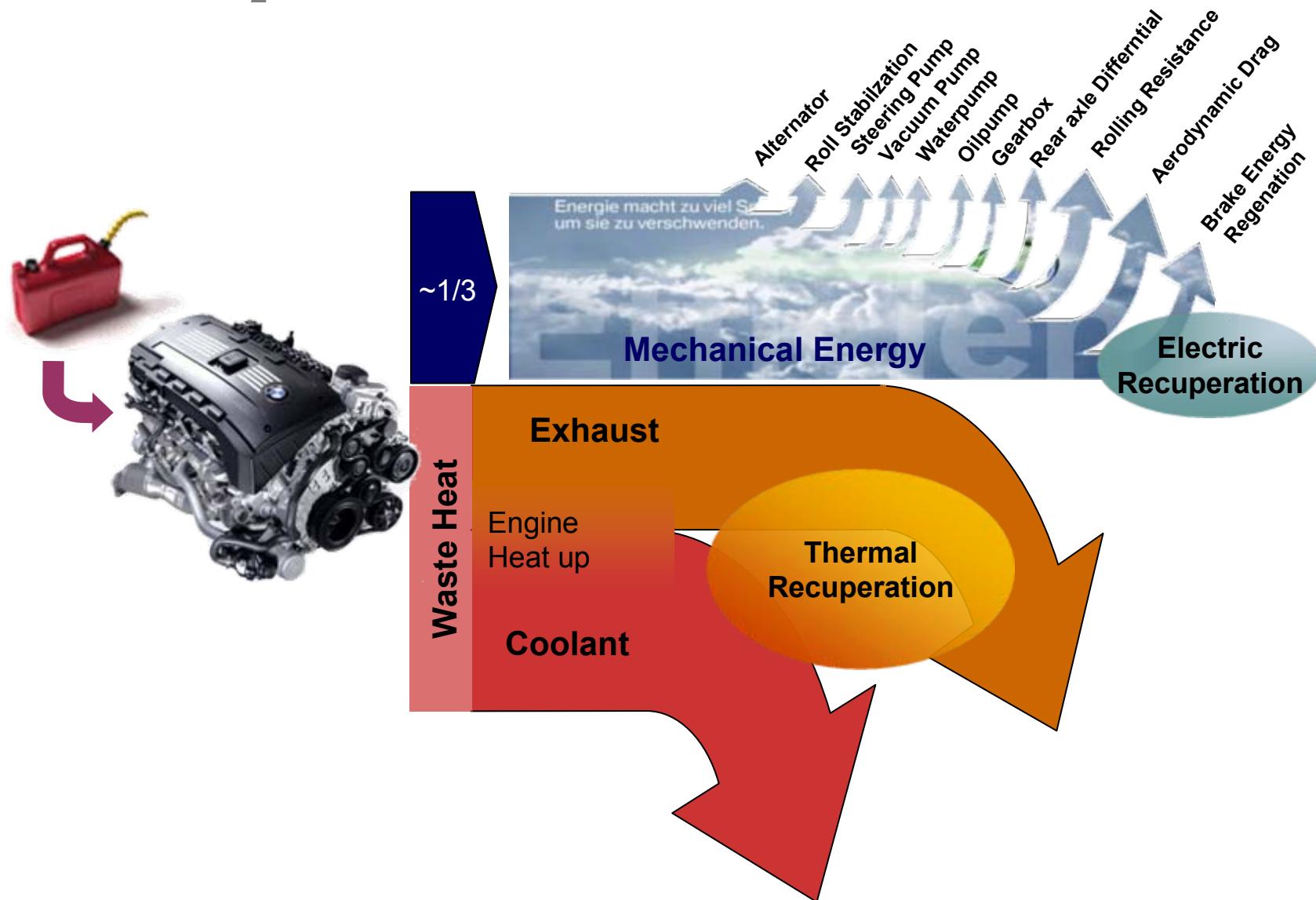
BMW EfficientDynamics.

CO₂-regulations are intensifying worldwide. Guidelines are heterogenous.

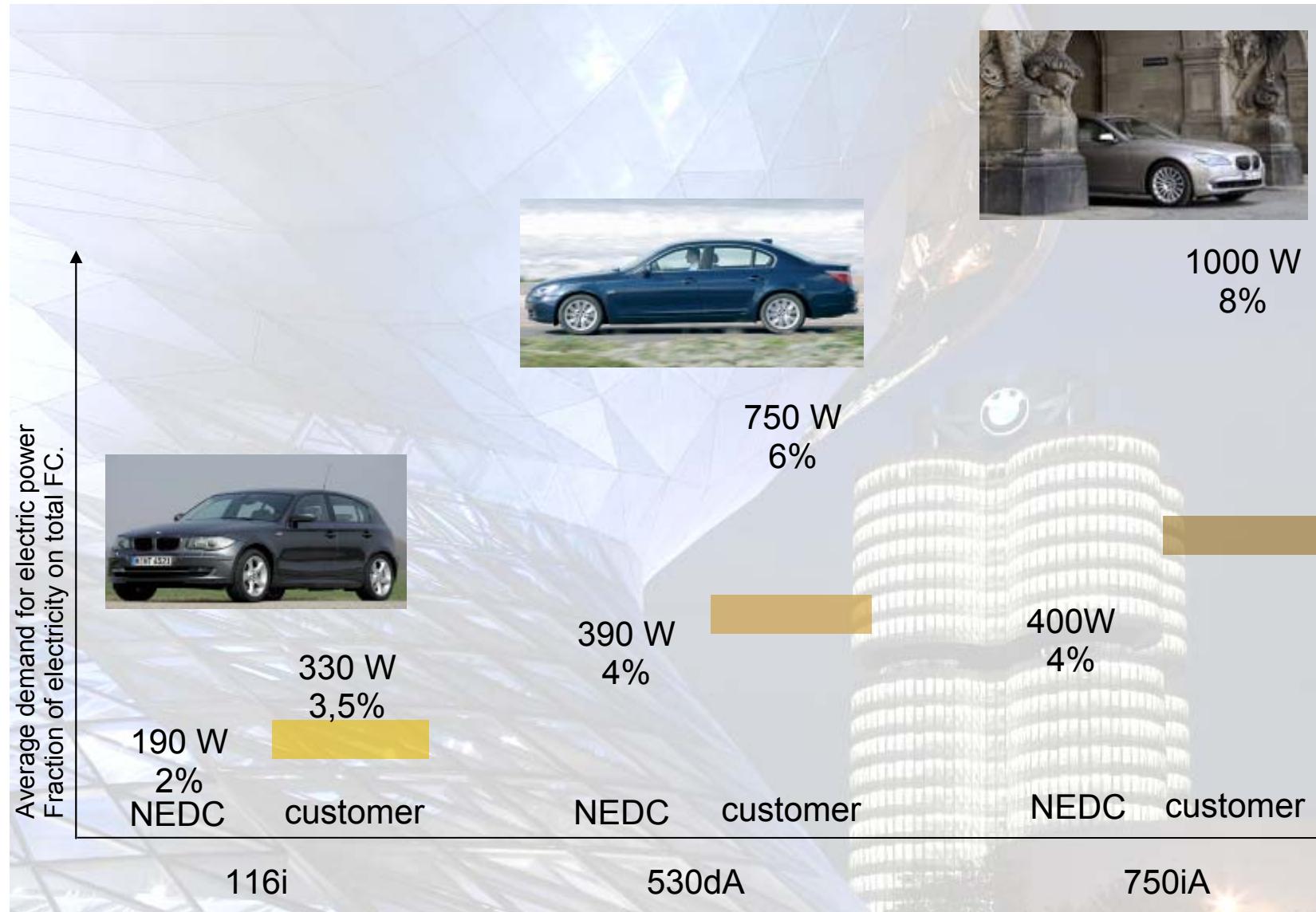


Thermoelectric Power Generation – The Next Step to Future CO₂ Reductions.

Thermal recuperation is a very interesting technology for future CO₂ reduction.



Thermoelectric Power Generation – The Next Step to Future CO₂ Reductions. Onboard electricity is not for free!

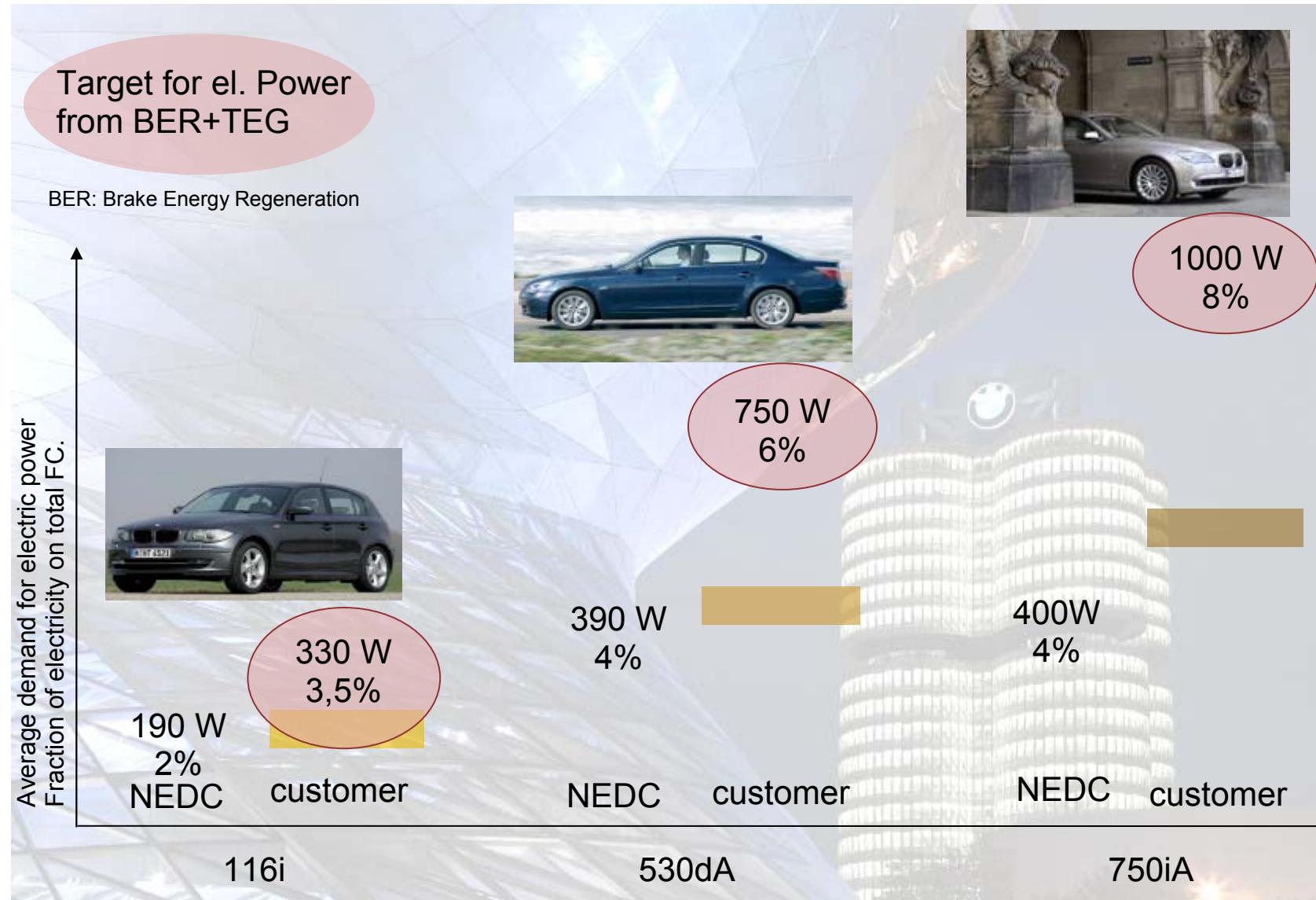


Thermoelectric Power Generation - The Next Step to Future CO₂ Reductions.

There are smarter ways to generate electricity!

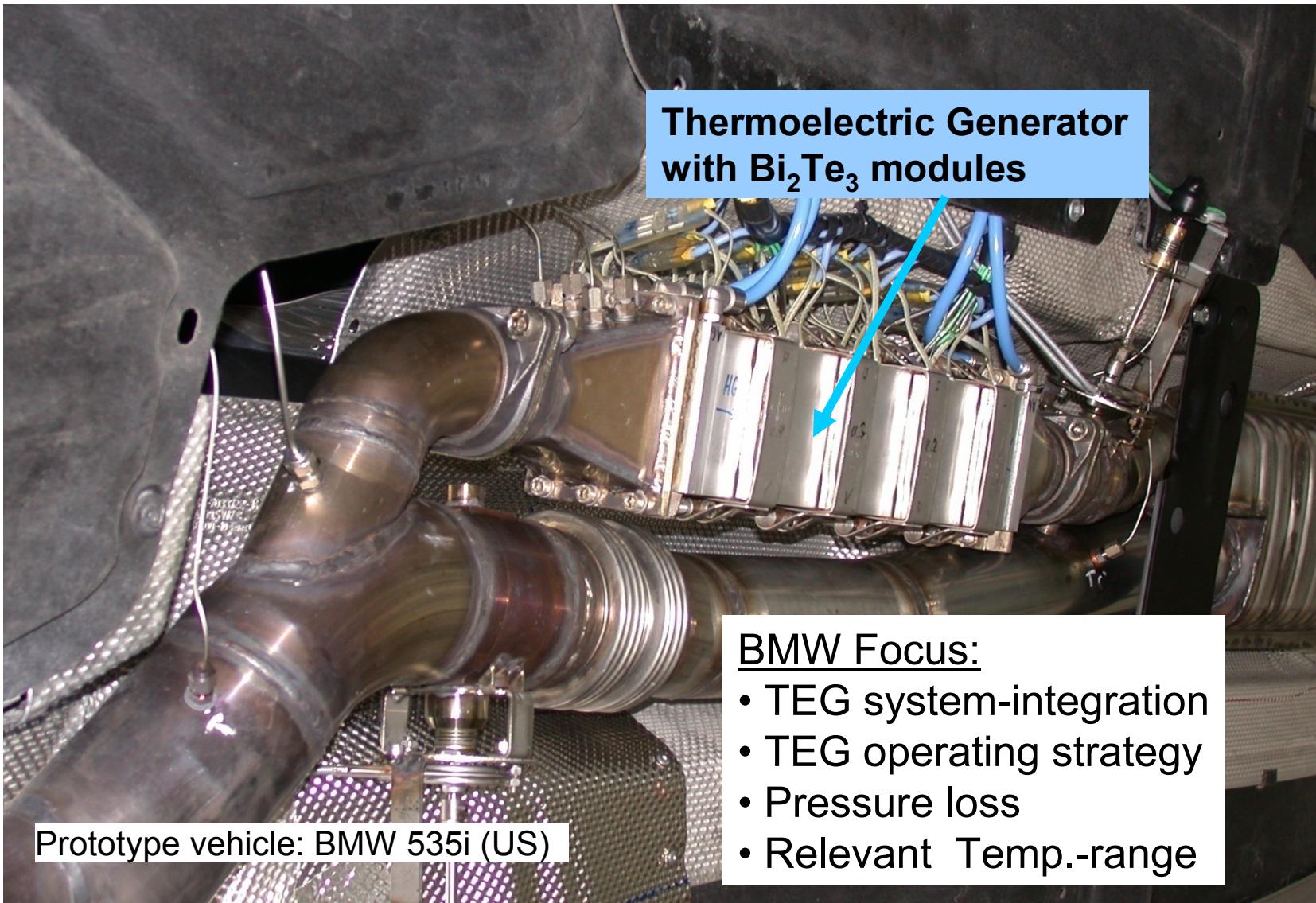


Thermoelectric Power Generation – The Next Step to Future CO₂ Reductions. Onboard electricity is not for free!



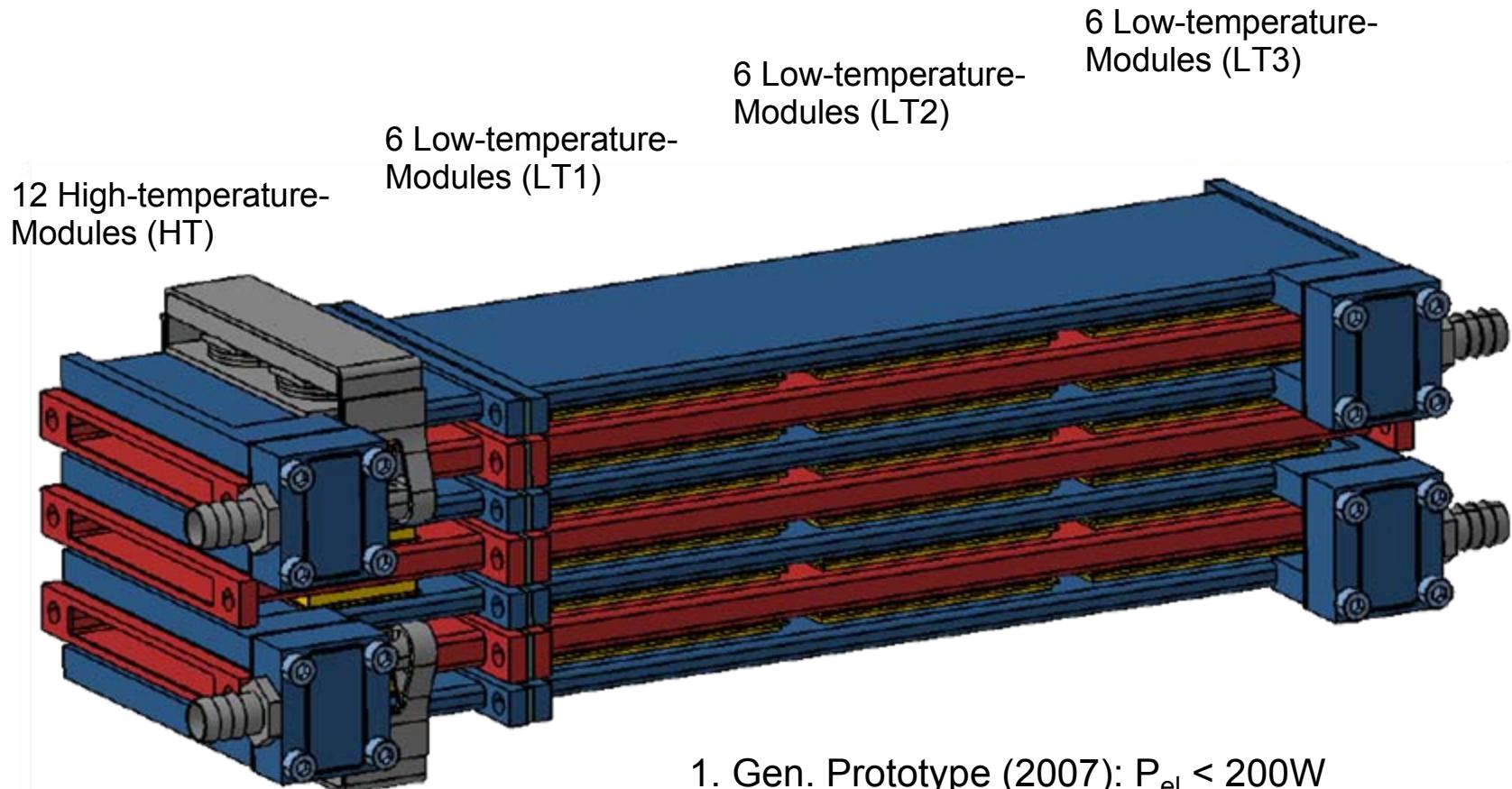
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Thermoelectric Generators can be integrated into vehicles.



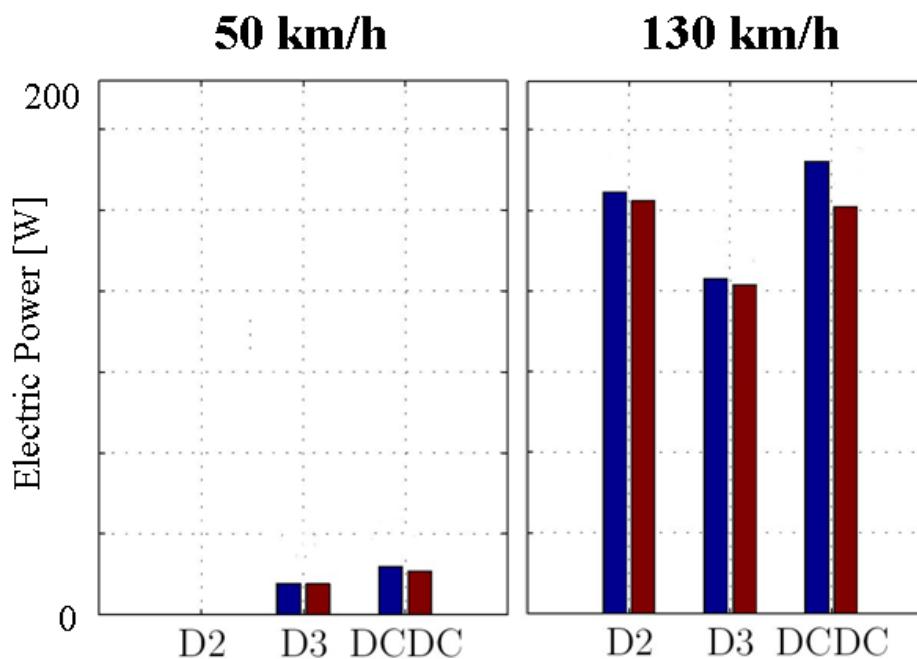
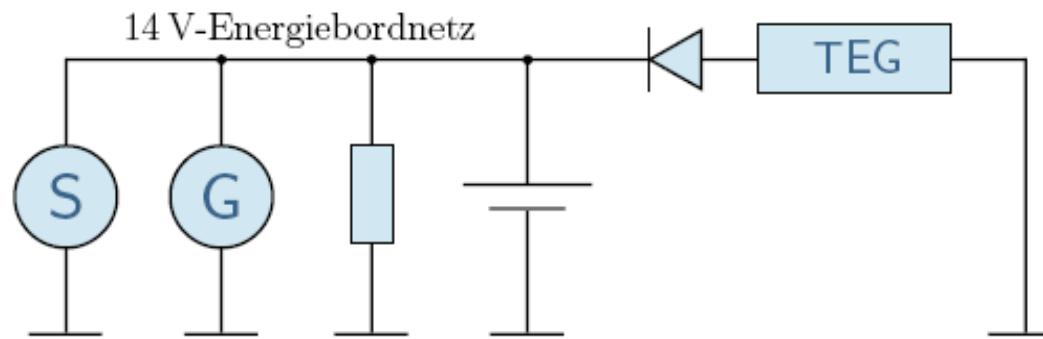
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The 2nd Generation is using high-temperature modules.

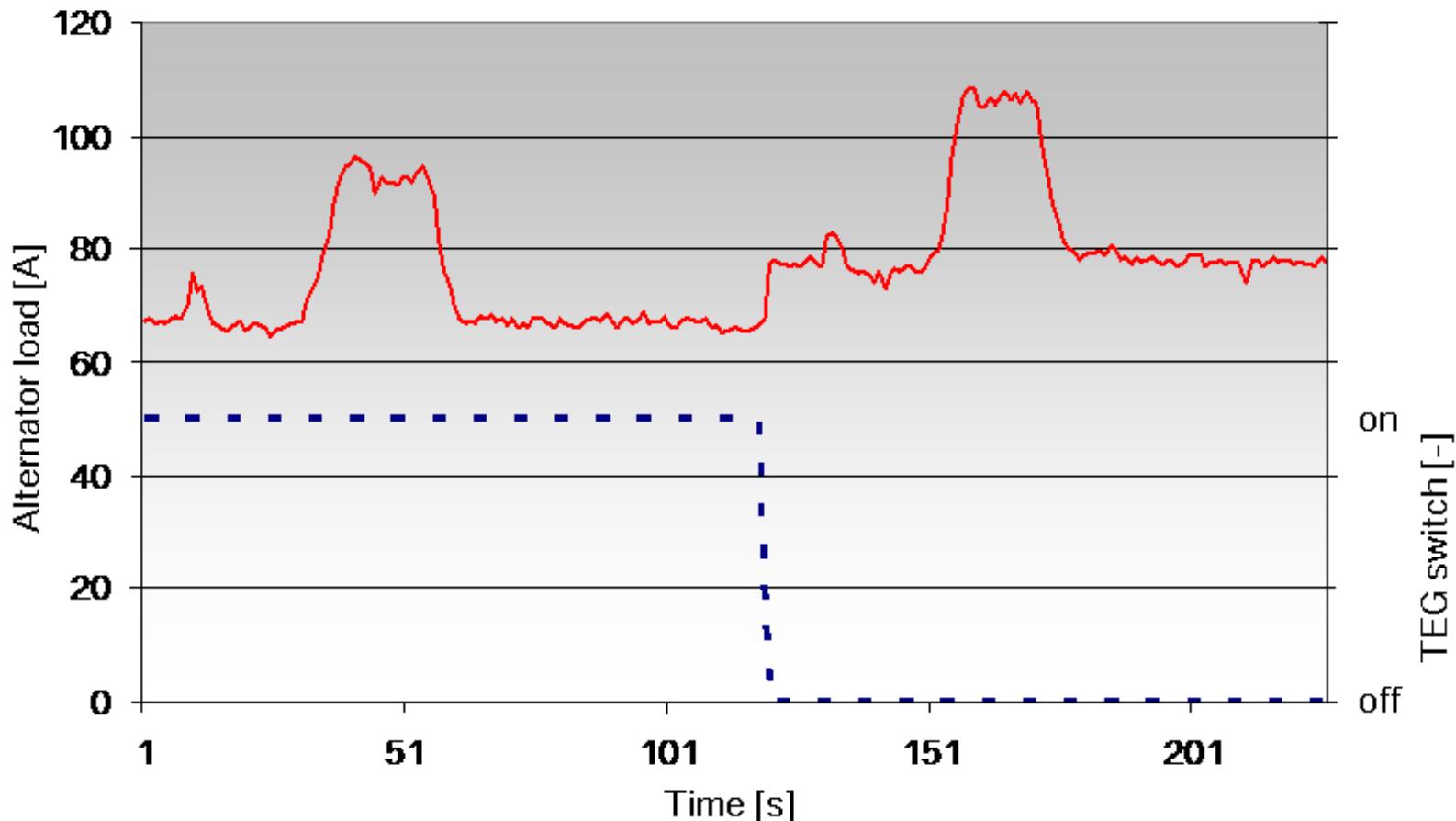


1. Gen. Prototype (2007): $P_{el} < 200W$
2. Gen. Prototype (2009): $P_{el} > 300W$
3. Gen. Prototype (2010): $P_{el} > 500W$
(BSST/DoE funded project)

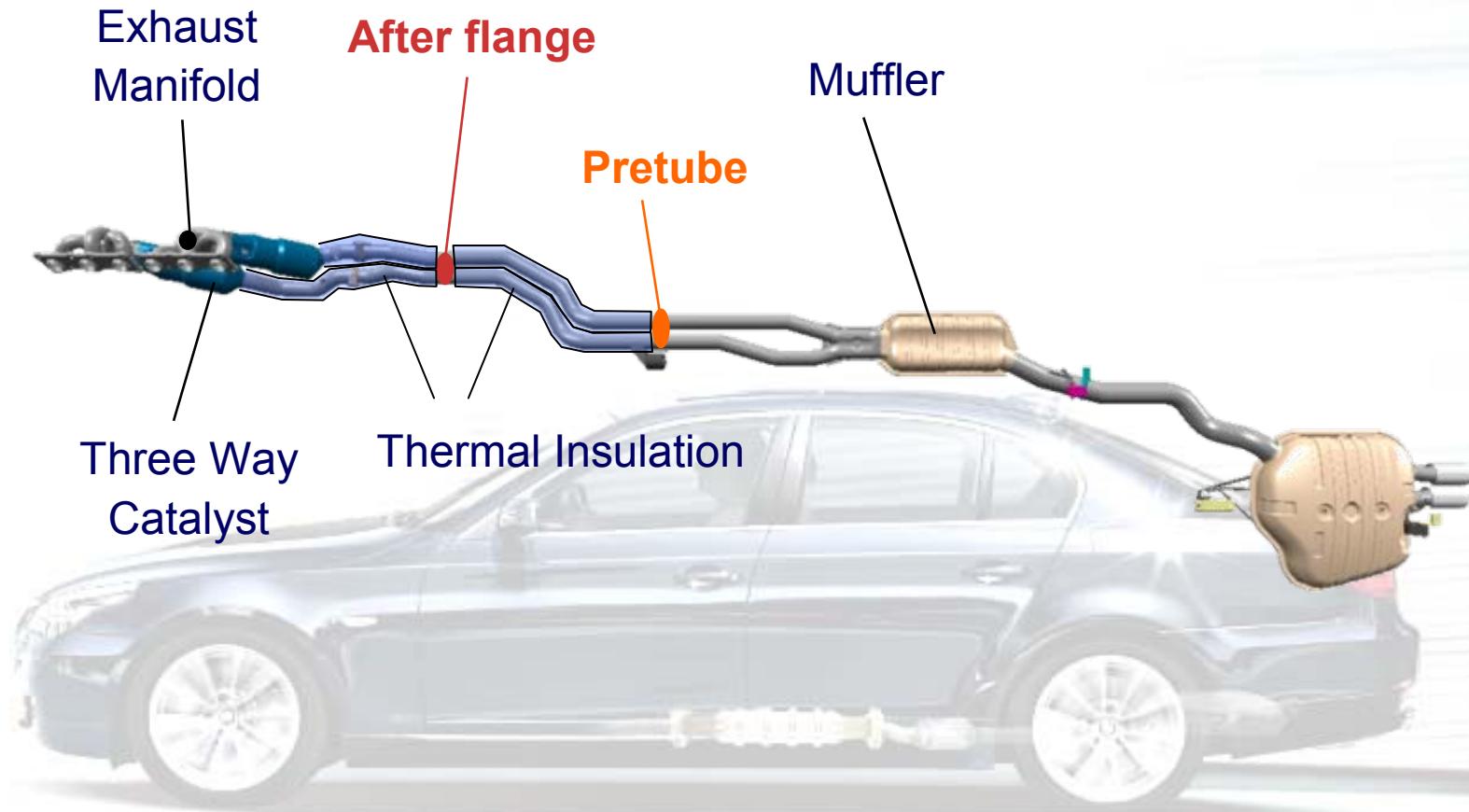
Thermoelectric Power Generation – The Next Step to Future CO₂ Reductions. TEGs can be efficiently integrated into the onboard electric system.



Thermoelectric Power Generation – The Next Step to Future CO₂ Reductions. The TEG directly unloads the alternator.



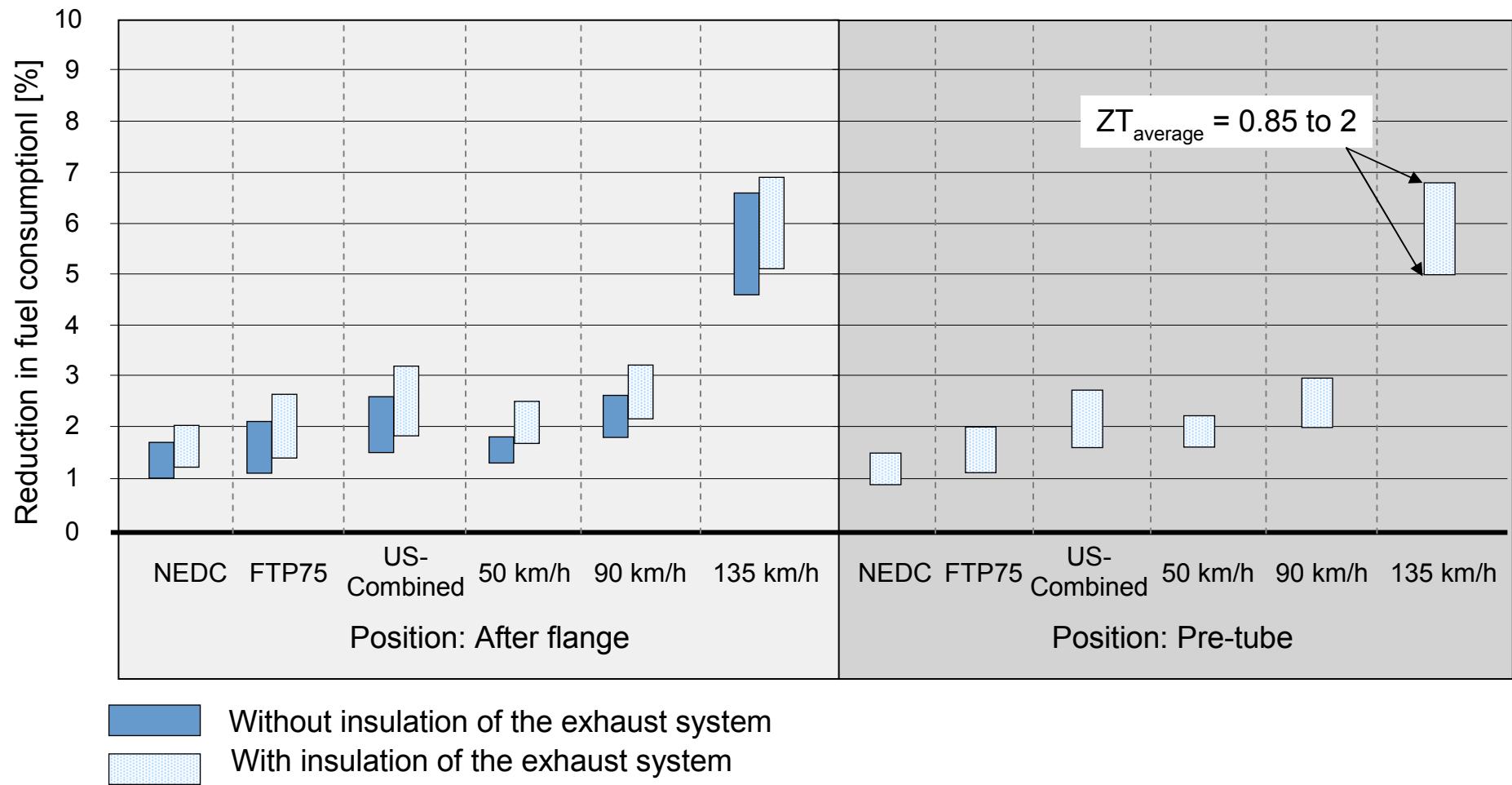
Thermoelectric Power Generation – The Next Step to Future CO₂ Reductions. Possible Locations of a TEG.



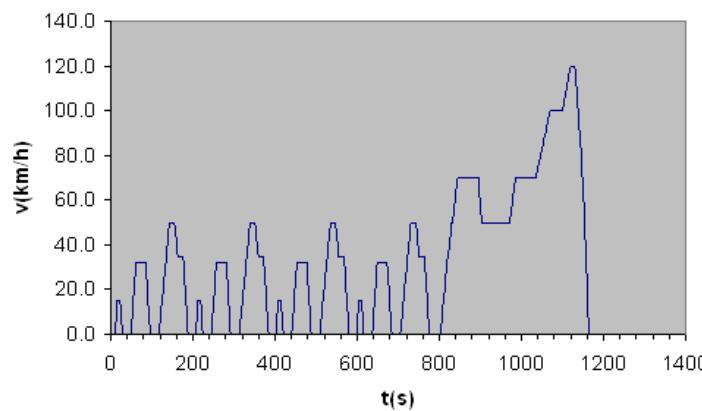
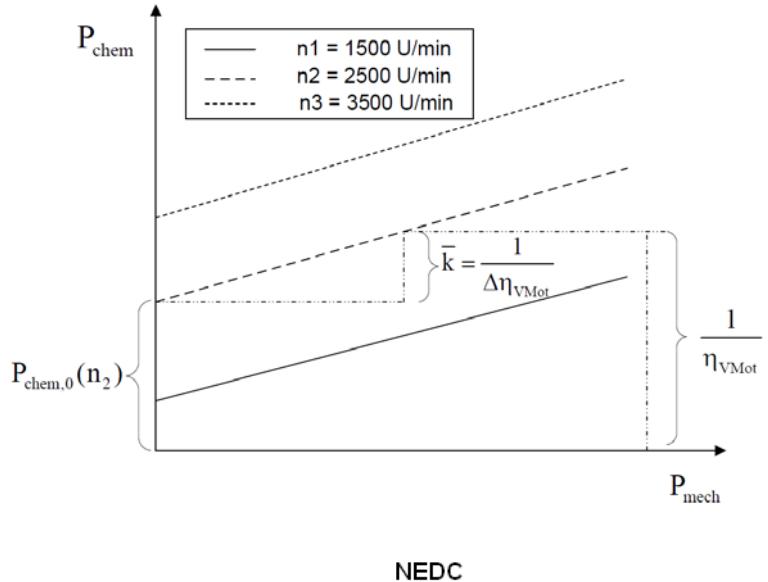
Pretube position possible for TEG integration in existing vehicles (prototype)
After flange position possible for a series application (new developed veh.)

Thermoelectric Power Generation – The Next Step to Future CO₂ Reductions.

The potentials are very attractive, especially for
the customers!



Thermoelectric Power Generation – The Next Step to Future CO₂ Reductions. Electric load corresponds directly to CO₂ Emissions.



NEDC: (European Drive Cycle)

100 W correspond to

$0,13\text{l}/100\text{km} \triangleq 3\text{g CO}_2/100\text{km}$ (gasoline)
 $0,10\text{l}/100\text{km} \triangleq 2,7\text{g CO}_2/100\text{km}$ (diesel)

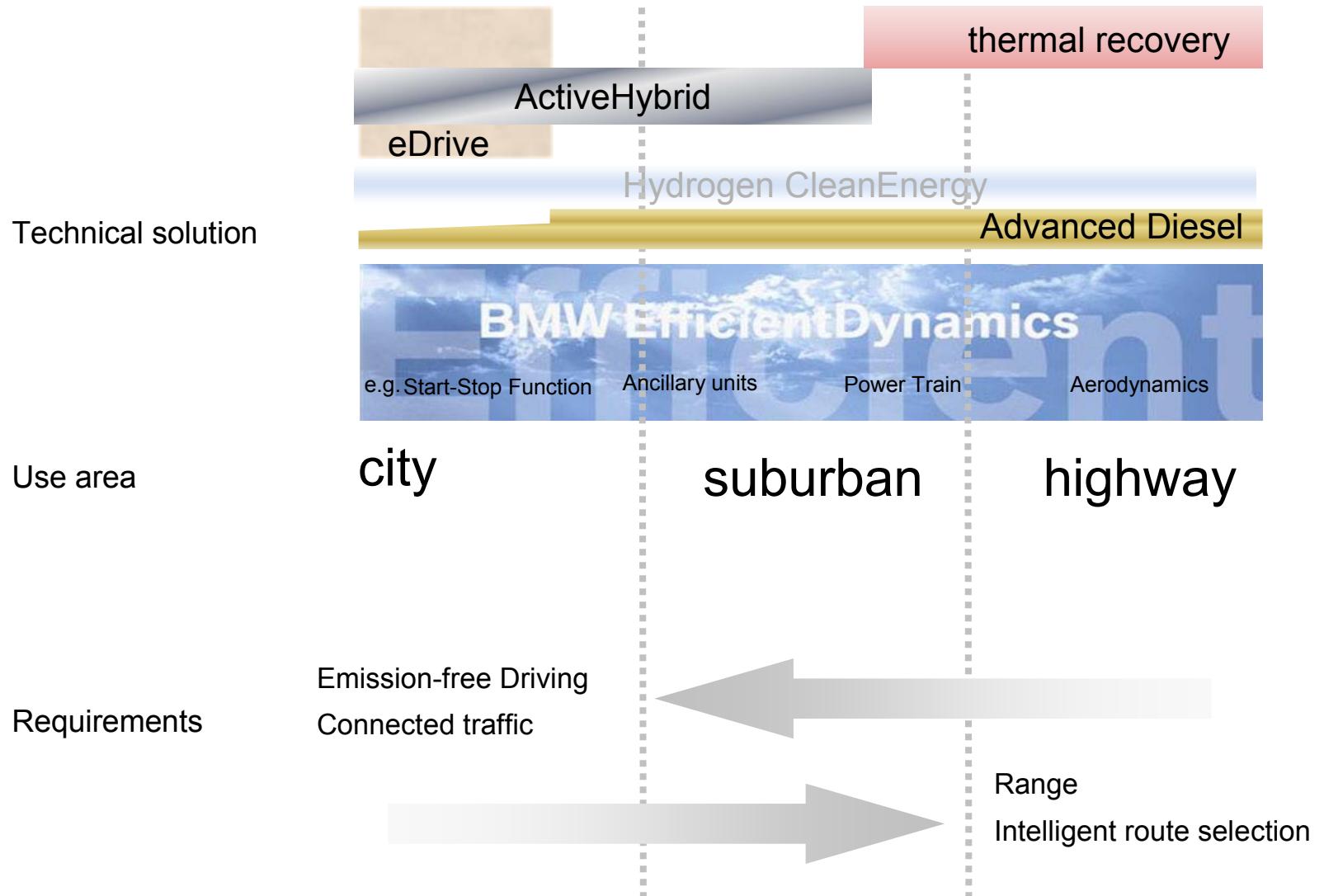
US-Combined Drive Cycle

100 W correspond to

$0,10\text{l}/100\text{km} \triangleq 2,3\text{g CO}_2/100\text{km}$ (gasoline)

Panalities per g CO₂ in the EU: 95€/g

Thermoelectric Power Generation – The Next Step to Future CO₂ Reductions. BMW is developing solutions for different applications.



Thermoelectric Power Generation – The Next Step to Future CO₂ Reductions. Thermoelectric waste heat utilization is a very attractive technology.



BMW CTO Dr. Draeger was awarded with the Eco-Globe 2008 for BMW's Thermoelectric Generator activities.

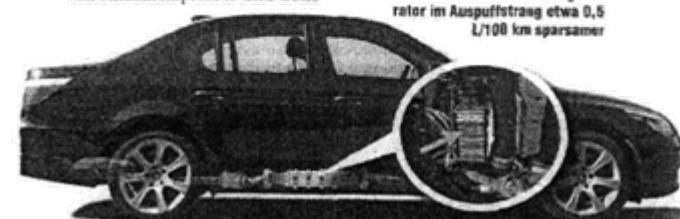


Thanks to DoE for initiating
the development
of this technology!

Unusual Spritstechnik bei BMW Strom auch aus Abwärme

BMW will Autos noch effizienter machen, ohne die dynamischen Qualitäten des Verbrennungsmotors zu beschneiden. So gruppieren die Entwickler spezielle Halbleiter um den Auspuff, um die im Abgas enthaltene Wärmeenergie in Strom zu verwandeln. Im Fünfer-Prototyp fallen bei 120 km/h etwa 600 bis 700 Watt an. Durch die Entlastung der Lichtmaschine lassen sich rund 0,5 L/100 km Kraftstoff sparen. Einsatzbereit soll diese Technik in rund fünf Jahren sein. Auch über die Regelung der Kühlwasserströme Zu- und Abschaltung von Klimakompressor und Geno-

ratoren soll sich künftig der Verbrauch um bis zu zehn Prozent reduzieren lassen. Ein vorausschauendes Auto könnte die Aggregate situationsgerecht einstellen und so die Motorverluste verringern; innerorts ließe sich so die Kühlleistung absenken, um über eine höhere Motortemperatur die Effizienz zu steigern. Voraussetzung für die möglichen Einsparungen sind freilich Radar- und Kamerasensoren sowie ein Navigationssystem, was die Technik sehr teuer machen dürfte.



Der Fünfer ist mit Thermogenerator im Auspuffstrang etwa 0,5 L/100 km sparsamer

Thermoelectric Waste Heat Recovery...

...stands for energy recuperation with sheer driving pleasure!



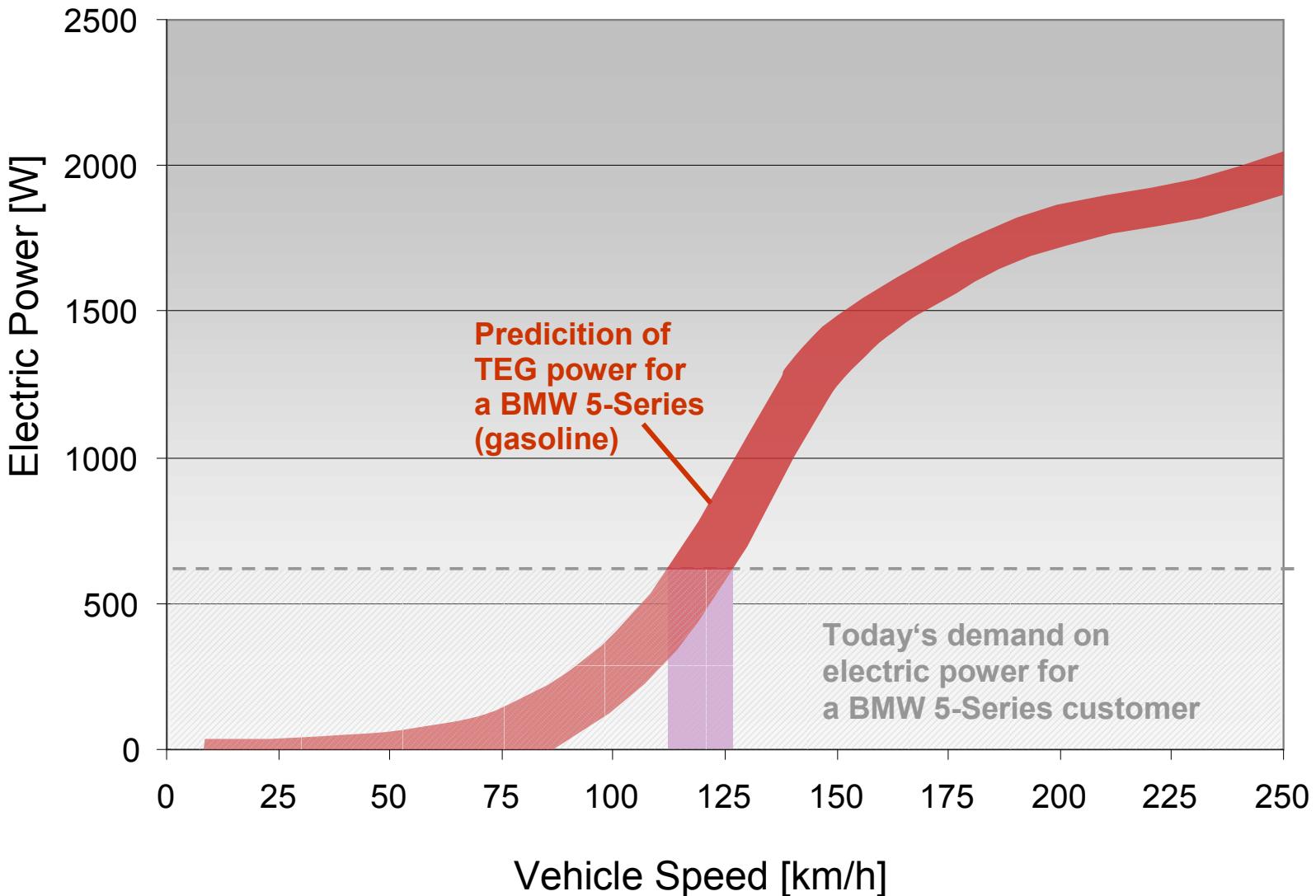
BMW EfficientDynamics.

Individual mobility with further reduced fuel consumption and exhaust emission levels.

BMW EfficientDynamics.
Less emissions. More driving pleasure.



BMW EfficientDynamics™ – BMW's Approach to Reduce CO₂. A TEG can Cover the Averaged Demand on Electricity in Future.



BMW EfficientDynamics.

Innovations in engine technology.

- 9 % fuel consumption



In-line 6-cylinder
petrol engine with
BMW TwinPower Turbo

- 4 % fuel consumption



In-line 6-cylinder
diesel engine with
BMW Variable Twin Turbo

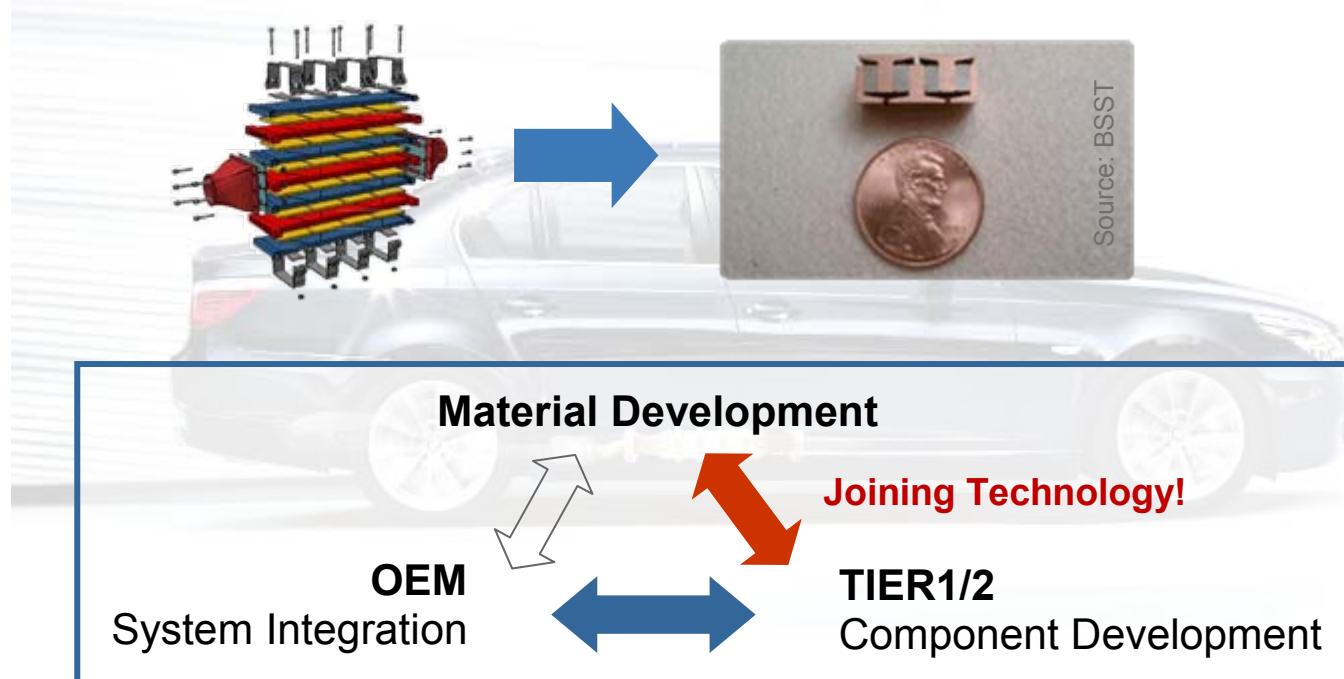
- 6 % fuel consumption



8-speed automatic
transmission

BMW EfficientDynamics™ – BMW's Approach to Reduce CO₂. Thermoelectric Generator (TEG).

- The BMW Group demonstrated with its partners the feasibility of thermoelectric power generation with a BMW 535i prototype vehicle.
FE improvement of ~5% in customer driving is achievable with improved thermoelectric materials.
- TEGs are considered as Eco-innovations in Europe (US?).
- Risks: cost, durability, joining technologies, environmentally friendly materials.



Thermoelectric Power Generation – The Next Step to Future CO₂ Reductions.

A Thermoelectric Generator is an ideal combination to the BMW Brake Energy Regeneration.

