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DEVELOPMENT OF A NEW POWERTRAIN CONCEPT BASED ON THE INTEGRATION OF ELECTRIC GENERATION, ENERGY RECOVERY AND STORAGE

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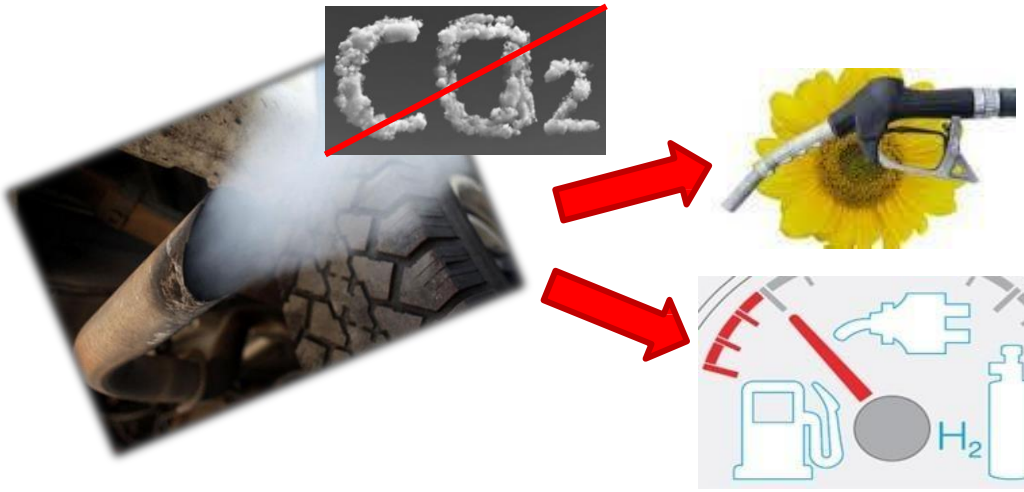
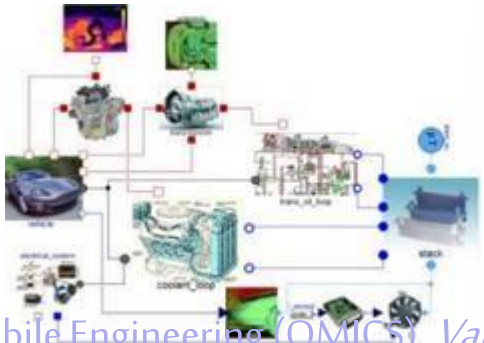
Motivation





To support research and enhance a better future:

SEVENTH FRAMEWORK PROGRAMME

GASTone is one of the project that belongs to the FP7-transport

Organization chart

- **GASTone is a collaborative Project between six partners:**

Concept and Objectives

- **The main goal of the Project is the development of a new powertrain concept based on the integration of:**

Energy recovery and storage

System control strategies

Natural Gas engine

Electric generation

$\eta > 50\ \%$

At vehicle level

Concept and objectives

- **This target will be mainly reached based on the following three streams:**

  (1) The **energy recovery** from the exhaust gases heat with a cascade approach thanks to the adoption of an advanced thermoelectric generator and a turbo-generator.

  (2) The integration of a smart kinetic energy recovery system to substitute the alternator and generate electricity during decelerations **improving the efficiency of the engine**.

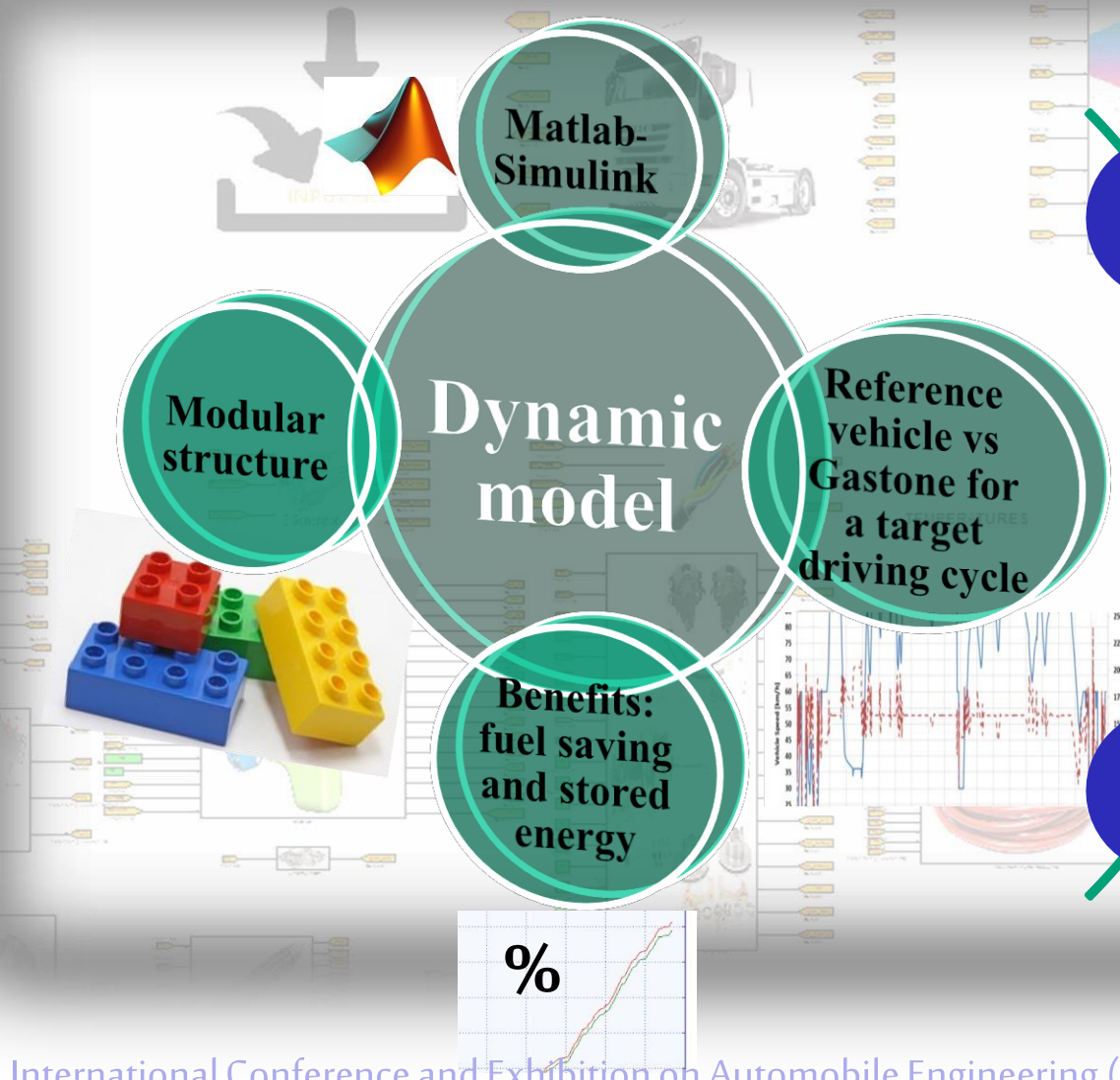
  (3) The **electrification and control of the main auxiliaries** (coolant pump, oil pump, auxiliary e-supercharger and air conditioning compressor) by using the produced electric energy.

- **The system includes sizing and development of an appropriate energy storage system as well as the adoption of electrified auxiliaries.**

- **To optimize and evaluate the integration of the whole system and the control strategy, a dynamic model has been developed.**

- **The project results will be demonstrated at bench level while the benefits of the control strategies will be evaluated at vehicle level thanks to advanced dynamics models.**

Dynamic model



Target of the model:

- Estimate the total fuel consumption over the driving cycle
- Estimate the energy balance of the system: Production vs consumption
- Estimate the temperatures and pressures in each relevant point
- Comparison between the reference vehicle and the Gastone concept

Concept and objectives

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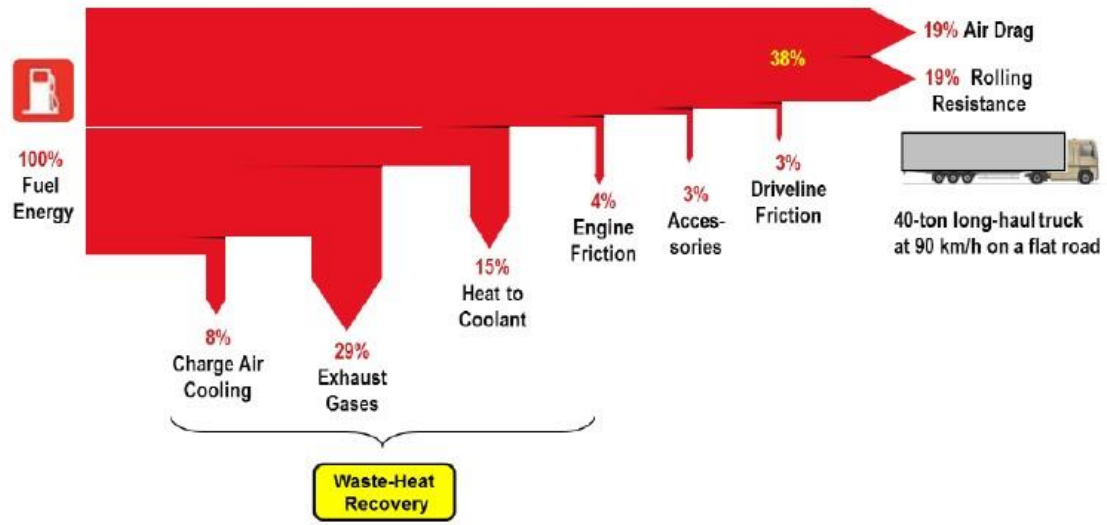
(1) Heat recovery

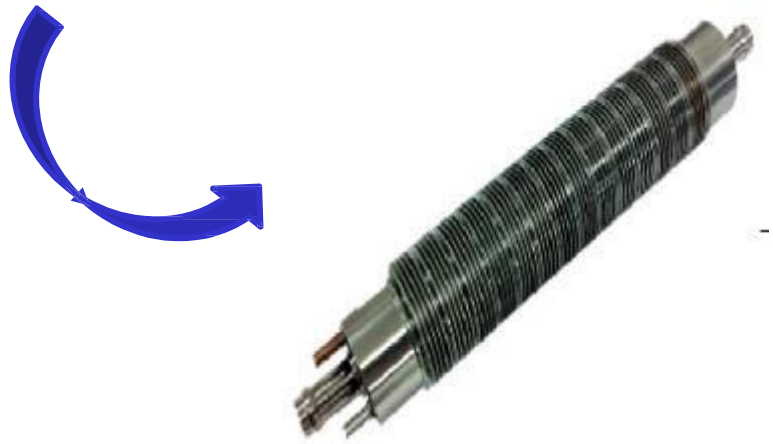


- **Almost 2/3 of the fuel energy of a today long distance truck is dissipated energy available as heat:**
  - 1/3 a high temperature from the exhaust gas system
  - 1/3 dissipated to the coolant system

- **In addition, these vehicles often operate for long periods of time under pretty constant conditions:**
  - Energy recovery systems can be designed to work regularly (beltless driven)
  - The electric energy generated would be used almost immediately

(1) Heat recovery

- **Thermoelectric generator (TEG)**
    - Electric generation from certain materials that can generate electric power from a temperature difference (Seebeck effect) and can provide active cooling or heating when powered by electricity (Peltier effect).
    - Increase of the generation thanks to a bigger temperature differences conditions.
    - Optimum sizing and dimensioning (number of TEGs modules, arrangement, placement).

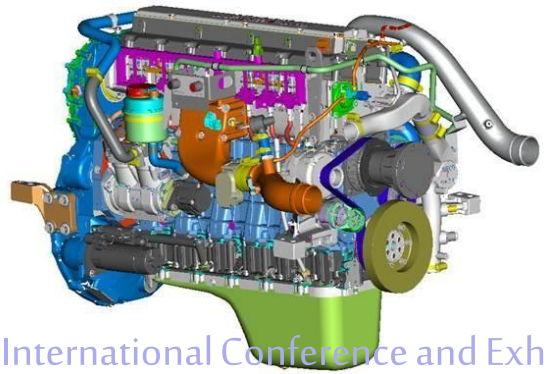


- **Turbogenerator**
    - Considered as mature technology.
    - It will not be investigated in this Project but used.

(2) ICE engine optimization

A relevant engine and powertrain efficiency improvement will be achieved thanks to the combined effect of the following innovations:

- More powerful turbo: higher torque, higher performance, lower pumping losses, down-speeding strategies, eliminate turbocharger lag at low exhaust gas flow levels.
- A liquid cooled charge air cooler
- Substitution of the alternator by a kinetic energy recovery system
- Natural gas engine: higher exhaust gas temperatures and simpler after-treatment system.



(3) Beltless engine concept based on 48V board net architecture

Development of:

- **Additional DC/DC 24V** to ensure the conventional net service.
- Efficient and **Smart solution** to generate and store electric power using a 48V battery.
- Efficient **e-auxiliaries**:
  - ✓ based on 48V level and board net architecture with central integrated control.
  - ✓ e-auxiliaries beltless driven.
  - ✓ Not need to run all of them under full load -> flexibility -> control strategies.

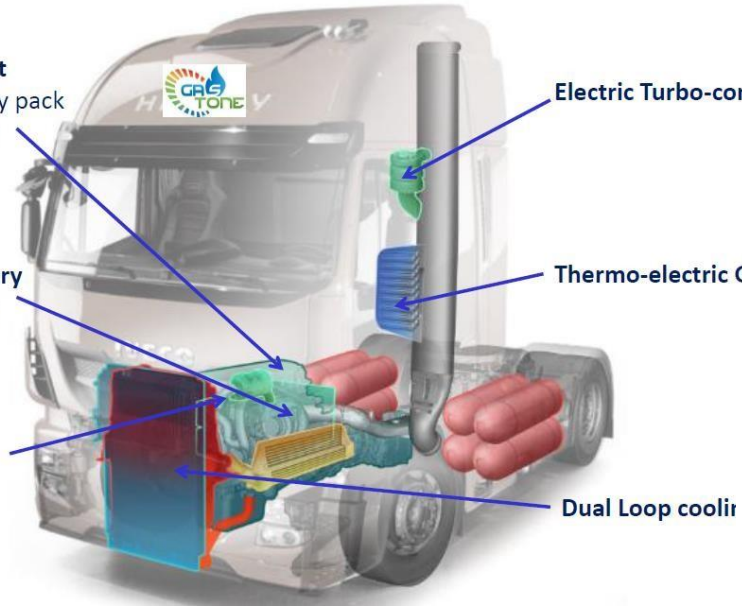
Auxiliary System	Average (kW)	Peak (kW)
Cooler fan	5	30
Water pump	1,5	6
Oil pump	1	2
Brake air compressor	0,5	3
Air conditing compressor	2	10
E- turbo charger	5	10
Starter/Generator	1	50
Steering pump	1	6

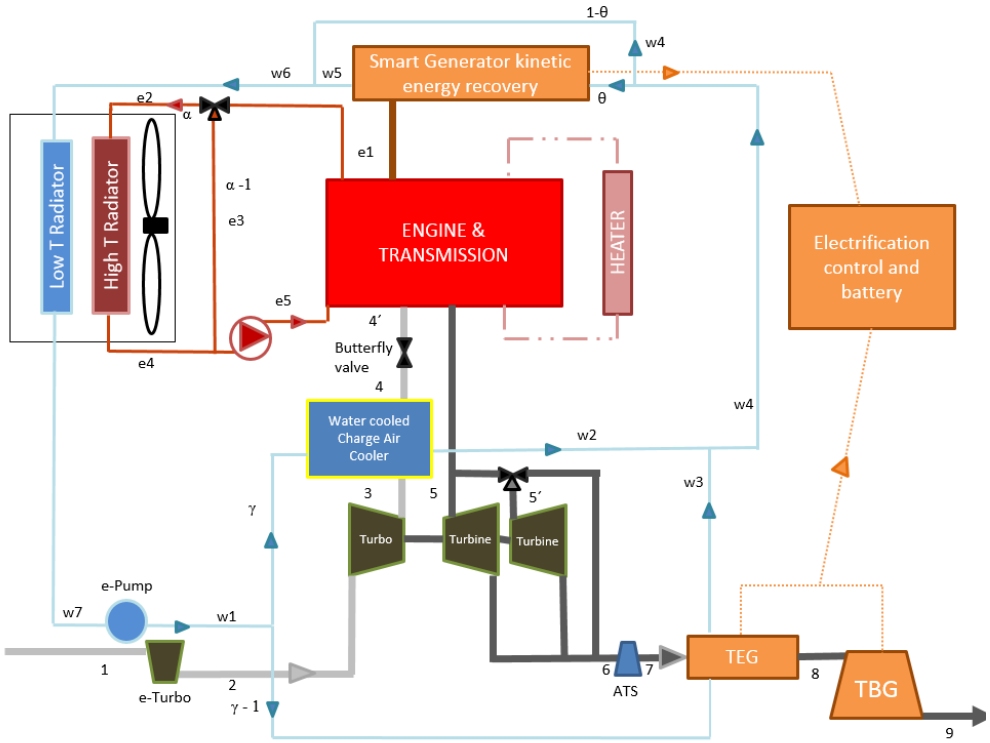
(3) Power pack integration

Dual Voltage boardnet
- new 24V&48V battery pack
- belt driven generator

Kinetic Energy Recovery
- belt driven generator

Electric auxiliaries
- e-water pump
- e-oil pump
- e-turbo





- **Challenge: get the optimum integration of the whole system**

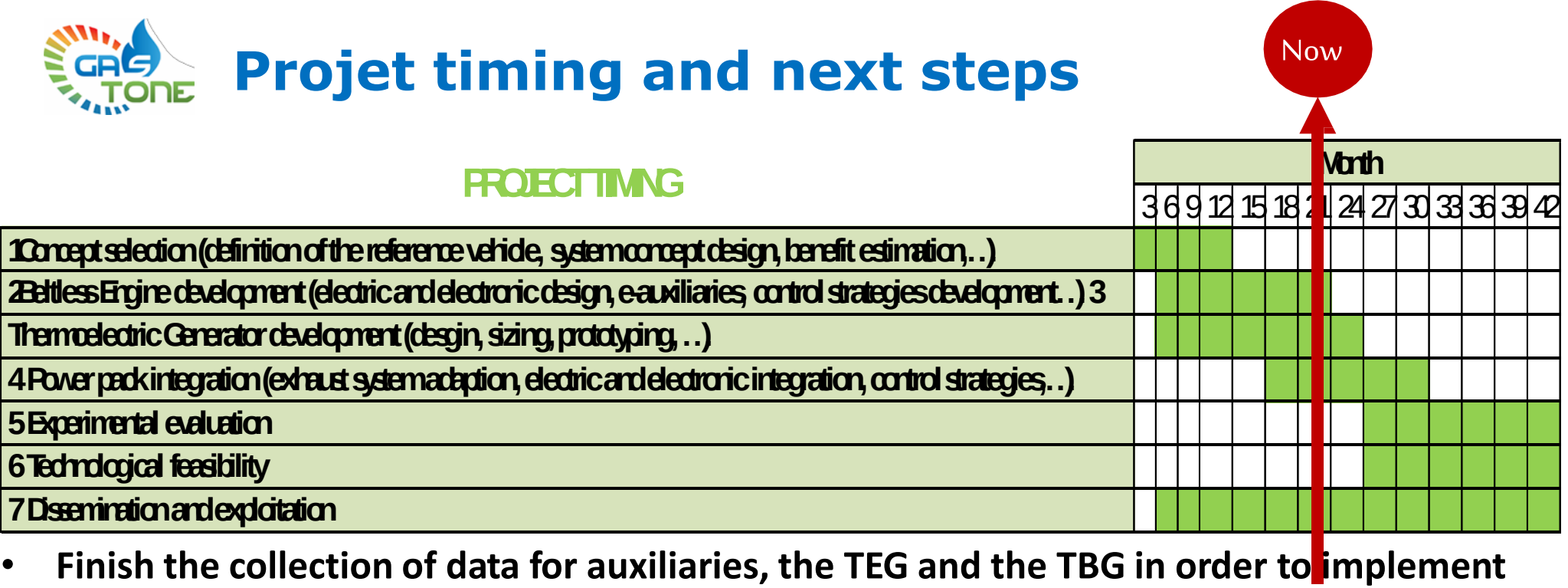
Project expected results

The GASTone Concept expectation is the improvement of the efficiency at vehicle level:

Current efficiency	**38 %**
Natural Gas engine improvement	+4%
Liquid Charge Air Cooler	+1%
e- water pump + e-oil pump	+2%
e- energy management	+1%
Exhaust Heat Recovery (TEG+TBG)	+7%
e- turbocharger	Needs to be evaluated
Expected improved efficiency	**53%**

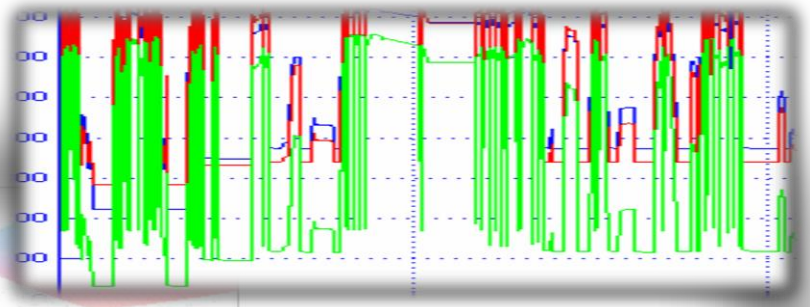
This is the project goal and the final achievement will depend on the design, performance, specification of the components as well as the control strategy and the different economic viable improvements finally made and based on the evaluation in the dynamic system modeled and after presented.

Projet timing and next steps



- Finish the collection of data for auxiliaries, the TEG and the TBG in order to implement them as electric.
- Define and evaluate different control strategies.
- Close the TEG size and design decision to start the prototyping development.
- Integrate and adapt the system based on the optimal control developed.
- Create the system prototype, evaluate it and study its technological feasibility.

Conclusions



- **Currently, we are defining the size and the specifications of the components.**
- **After the collection of the data, the auxiliaries will be electrified and an optimal control strategy will be investigated.**
- **The models of the components are already developed and waiting for validation.**

New powertrain concept based on integration of waste energy recovery, storage and re-use

Thank you very much for your attention!