GASTONE – Development of a new powertrain concept based on the integration of electric generation, energy recovery and storage

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New Powertrain Concept Design

The aim of the GASTONE project is to develop an ***innovative high efficient energy conversion concept for heavy duty engine and trucks***.
The energy efficiency strategy will be based on ***three mainstreams***:

- recovery of the ***kinetic energy*** thanks to a ***belt driven generator;***
- recovery of the ***waste heat*** with an energy cascading approach: ***thermoelectric generator*** and a subsequent ***turbo-generator***
- ***re-use*** of the gained electric energy within an ***advanced board net architecture of e-auxiliaries and e storage***.

Reference Vehicle

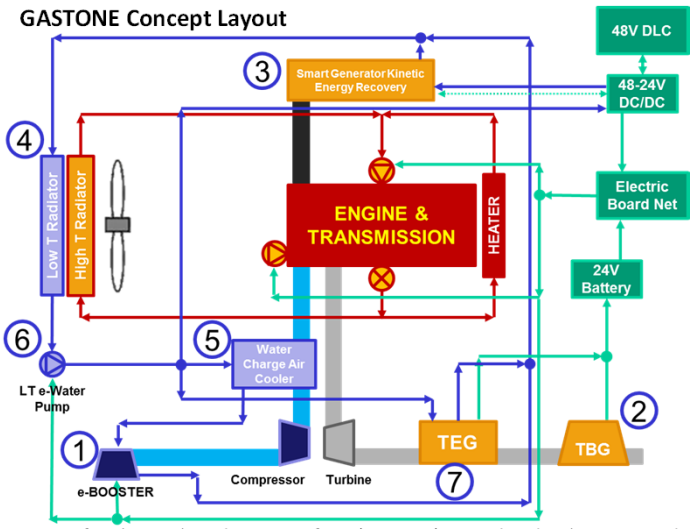
Vehicle:	Tractor 4x2 Artic (UG4T)
Weight:	44 tons
Engine:	Cursor8 L6 CNG Euro VI
Power and Torque:	243kW – 330 HP - 1.300 Nm

GASTONE System Concept and Devices

New devices to be integrated on the prototype engine output of the project:

Electric compressor	→	***1***
Heat recovery turbine (TBG)	→	***2***
Smart generator kinetic energy recovery	→	***3***
Radiator (for low and high temperature coolant loops)	→	***4***
Water charge air cooler (WCAC)	→	***5***
Electric pump	→	***6***
Thermoelectric Generator (TEG)	→	***7***

GASTONE Concept Layout



A specific electric board net interface (in green) is under development and includes:

DC/DC converter 48/24Volts
Additional 48Volts battery package*

* implemented in order to store the electrical power output surplus

Cost per Function Tool and Imputation Cost Criteria

The cost per function tool is the output of the cost quantification approach used:

- ***Comparing*** the Baseline system with the GASTONE system ***highlighting the contribution of each component*** in order to achieve the ***most relevant functions/performances***;
- ***Estimate the investments*** required to achieve a target and ***plan the future development*** of the vehicle taking into account also the ***economic impact*** related to the ***introduction of a specific technology in a series production***;
- Baseline and GASTONE systems' costs have been ***weighted**** referring to the results of a specific performance.

* defined as the increase of the performance (***GASTONE results***) compared to the normal production (***NP results***) system.

$$weight = \frac{GASTONE_{results}}{NP_{results}}$$

		COST [%]		Weighted COST	
		Baseline	GASTONE	GASTONE	GASTONE
		NP Cost	Estimation (referred to NP = 100%)	Weight [-]	Δ Cost [%]
Performance	Electrical Performance	100	591	3,5	69
	Mechanical Performances	100	394	2,0	97
	Fuel Economy	100	325	1,4	132
	Other Performances	100	171	0,7	20

Simulation Tool and Preliminary Results

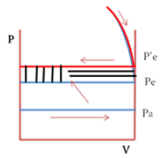
All the sub-systems have been integrated in a global Simulink model; there will be two basic objectives:

- ***Sizing*** of the different components of the circuit and definition of the most proper configuration;
- ***Comparison of the fuel consumption*** of the GASTONE vehicle versus the reference one.

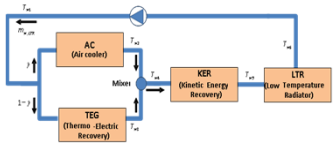
Engine modelled on bench data

Engine speed	Torque [Nm] @Load%					
rpm	100%	70%	55%	36%	15%	0%
2100	954	928	700	449	149	0
1999	1157	992	713	454	146	0
1799	1291	1003	734	466	166	0
1599	1307	1016	738	453	175	0
1400	1308	1025	768	481	206	0
1200	1267	1004	727	477	214	0
1100	1077	1031	751	490	221	0
1000	846	848	779	496	211	0
800	697	698	700	510	228	0
598	599	600	599	516	270	0

Engine speed	Power [kW] @Load%					
rpm	100%	70%	55%	36%	15%	0%
2100	210	204	154	99	33	0
1999	242	208	149	95	31	0
1799	243	189	138	88	31	0
1599	219	170	124	76	29	0
1400	192	150	113	70	30	0
1200	159	126	91	60	27	0
1100	124	119	86	56	25	0
1000	89	89	82	52	22	0
800	58	58	59	43	19	0
598	38	38	38	32	17	0



TEG and TBG back pressure increase after TWC



Low temperature loop implemented

Estimation of accessories' energy request

Accessories	Electric energy [%kWh]
Water pump	2
Oil pump	16
Brake air compressor	2
e-turbo	7
Starter	2
Steering pump	16
AC compressor	33
Other Accessories	23
Total	100

BASELINE ENERGY REQUEST

Energy balance at the design point (85km/h)

Device	Electric energy [%kWh]
TEG – Thermo Electric Generator	13
KER – Kinetic Energy Recovery	0
TBG – Turbo Generator	7
Electric Energy Balance	20

ENERGY REQUEST REDUCTION

Device	Electric energy [%kWh]
TEG – Thermo Electric Generator	10
KER – Kinetic Energy Recovery	41
TBG – Turbo Generator	21
Electric Energy Balance	72

Energy balance over ACEA long haul driving cycle

The system is able to provide an high amount of electric energy enough to cover an high percentage of the ***baseline request***; this means a ***performance improvement from the fuel economy point of view***. The brand new GASTONE engine is going to be ***tested on a dedicated bench*** and the ***model validated by the end of 2016***.

ORGANISERS: Ministry of Infrastructure and Construction; European Commission; Instytut Badawczy Dróg i Mostów Road and Bridge Research Institute; CEDR Conférence Européenne des Directeurs des Routes Conference of European Directors of Roads; ERTRAC European Road Transport Research Advisory Council; ERRAC The European Rail Research Advisory Council; WATERBORNE; alice Alliance for Logistics Innovation through Collaboration in Europe
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