The automated DLE optimizer for LM2500(+) & LM6000

AutoTune DLE: optimized engine efficiency within emission limits during part load operation

VBR / Danny Grobbe – Senior Project Engineer / 2023

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Content

About VBR Turbine Partners

An independent competence centre for:

- **LM2500 (+,DLE)**
- **LM6000 (PA – PH)**
- **TM2500 (+)**

One-stop full-service **on-site maintenance experts** for LM gas turbines, control systems, auxiliary systems and enclosures.

Key company characteristics:

- Customer focused
- Responsive
- Flexible

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AutoTune DLE: a joint technology development

AutoTune DLE is a **joint technology development** by VBR Turbine Partners, Thomassen Energy and PSM

AutoTune DLE is based on the patented **AutoTune** technology developed by **PSM** in the USA as a cross-platform solution for **optimizing the combustion** of many Heavy-Duty types of gas turbines:

- 6B
- 7E
- 9E
- 7F
- 9F
- 501F
- GT26

AutoTune is **proven technology**: **over 100 AutoTune systems in operation worldwide** since 2010

What is AutoTune DLE?

The **automated** engine efficiency **optimizer** for **LM2500** & **LM6000** DLE **in part load operation**.

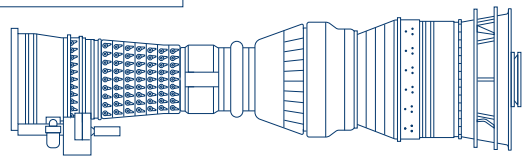
AutoTune DLE is **real-time empirical** combustion-based engine **efficiency optimization**, not model-based (digital twin etc.) engine efficiency optimization.

It consists of **a stand-alone smart solution box** that connects to the control system of a LM gas turbine in order to provide **continuous efficiency optimization** during **part load operation**.

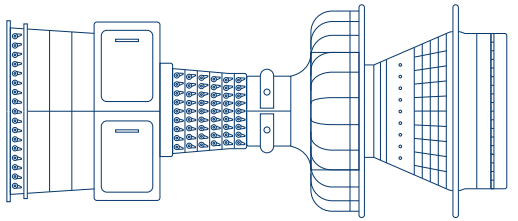
This is an add-on to your existing LM installation that does not interfere with control system settings, day-to-day operation or engine maintenance schedules.

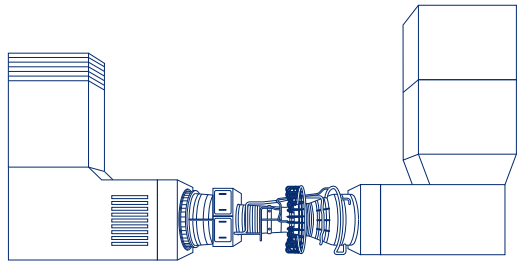
Therefore AutoTune DLE is **instantly applicable** on any LM2500 DLE or LM6000 DLE installation that operates in part load (for at least part of the time).

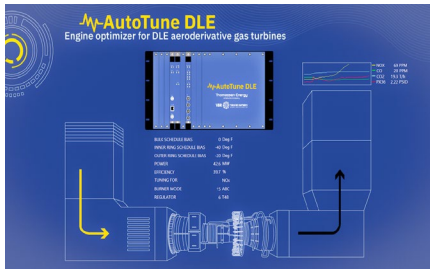
LM2500



LM6000







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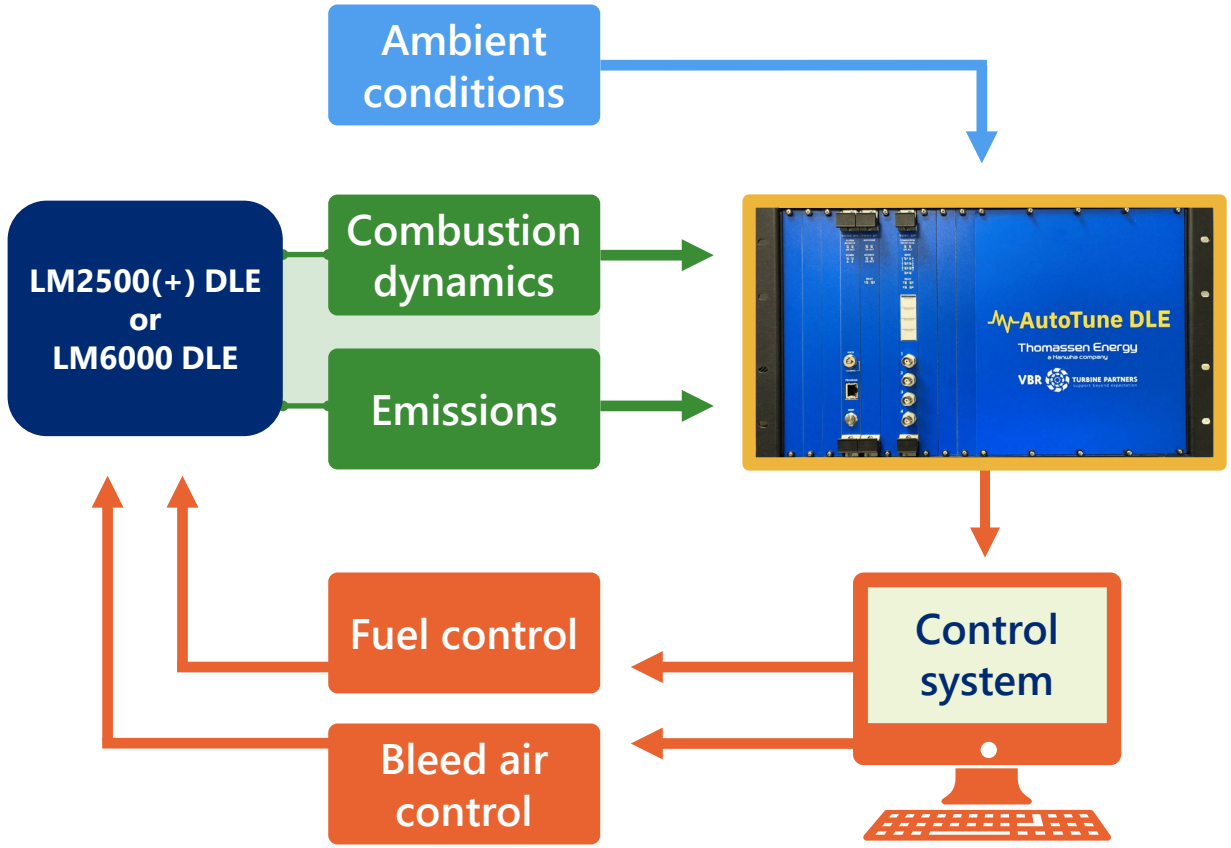
How does AutoTune DLE work?

AutoTune DLE **automatically optimizes gas turbine combustion** during part load operation by continuously and carefully balancing:

- Fuel gas
- Bleed air
- Combustion dynamics
- Emissions

in a closed loop to achieve optimum combustion efficiency all of the time.



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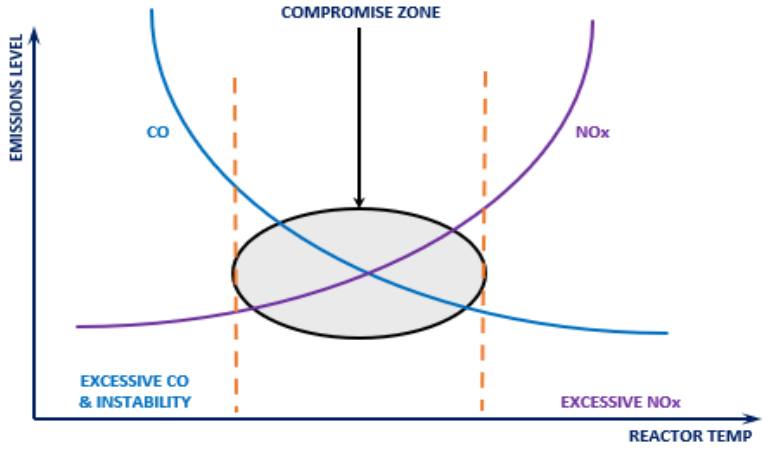
Emissions: the combustion dynamics balance

Increasing temperatures will lead to higher NOx

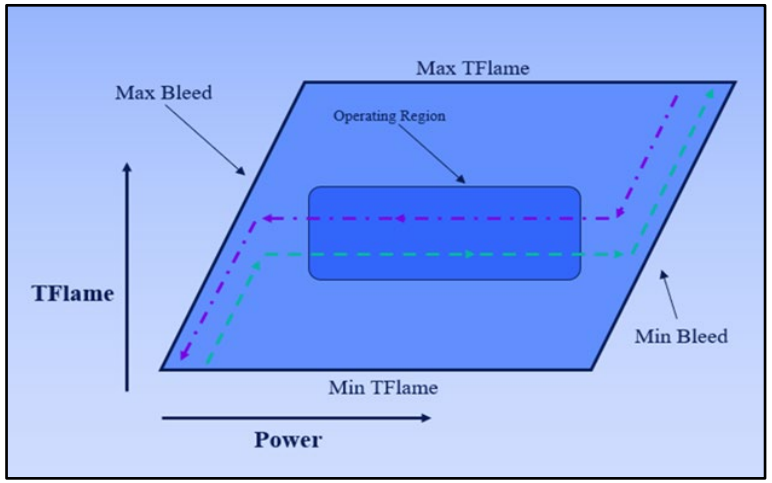
Decreasing temperatures will lead to higher CO

DLE tuning and operating windows

- Combustion and emissions optimizing is only possible within the allowed operating windows.



- Each tuning window is defined by maximum and minimum bulk flame temperature and compressor bleeds.



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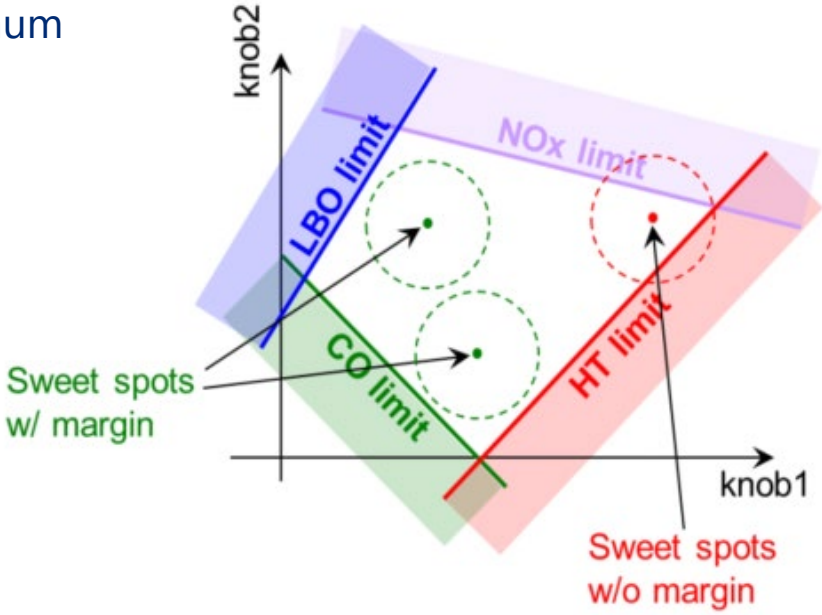
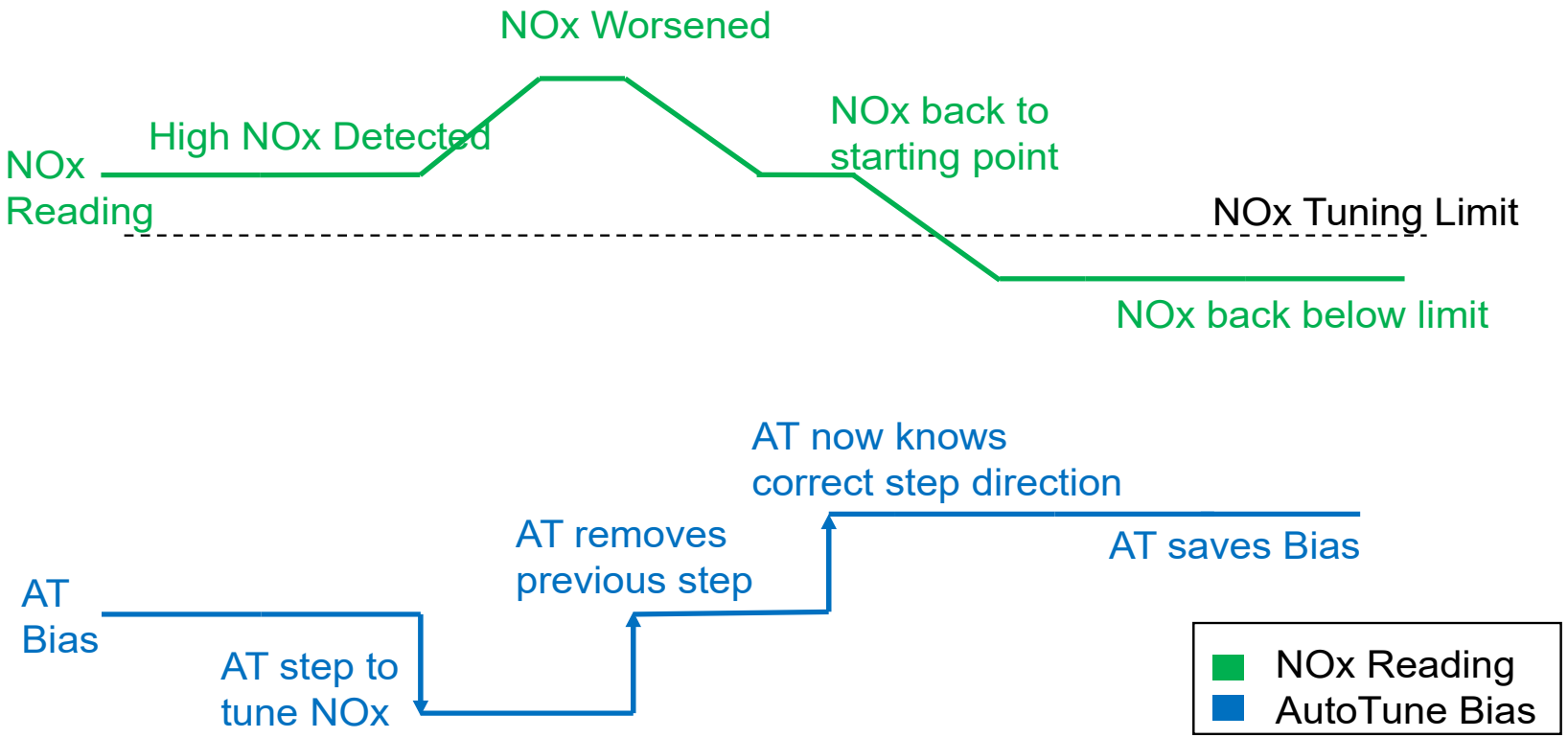
How does AutoTune DLE optimize all emissions?

AutoTune DLE automatically tunes to keep emissions within the legal boundaries.

- AutoTune DLE will continuously process & communicate the appropriate ring flame temperature adjustments to the SpeedTronic or Woodward control system.
- Over time AutoTune DLE will remember and reuse all previously found optimum settings for any combination of inlet conditions and engine load.
- AutoTune DLE applies a machine learning algorithm:
  - This algorithm learns from the specific LM engine on which it is implemented. The operation is continuously and automatically optimized for the individual combustion behavior of each engine.
  - Flame temperature adjustments are stored across all varying ambient conditions and all other parameters for immediate availability when similar conditions are detected in the future.



AutoTune DLE - the machine learning process



AutoTune DLE learns and steps back until NOx is brought back within the legal boundaries again.

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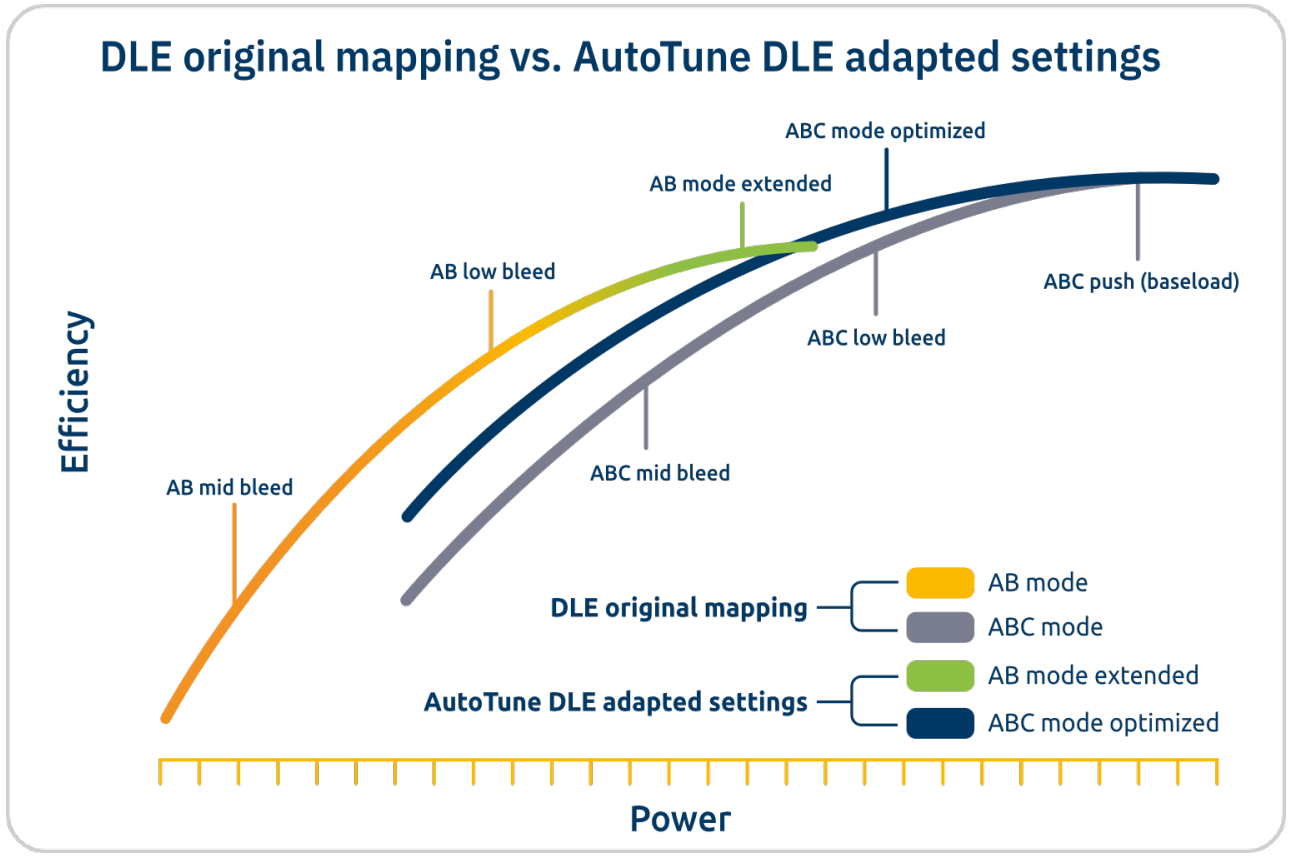
How does AutoTune DLE realize higher efficiency?

- Stretches the AB window when staging up from AB to ABC mode (runs longer with 0% bleed in AB mode).
- In staging down from ABC to AB mode avoids high-bleed operation in ABC.
- In ABC mode reduces compressor bleed as much as possible.



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Customer example of efficiency improvement on a LM2500 DLE

Gas Data

Gas Price	€ 0,95	Nm³/h
Gas Price	€ 95,00	MWh
Caloric Value	20531	BTU
Specific Gravity	0,601	SG
MegaJoule per cubic meter	36,04	MJ/Nm³
MegaWatt per Hour	0,010012	MWh
Gas Price	€ 95,00	MWh

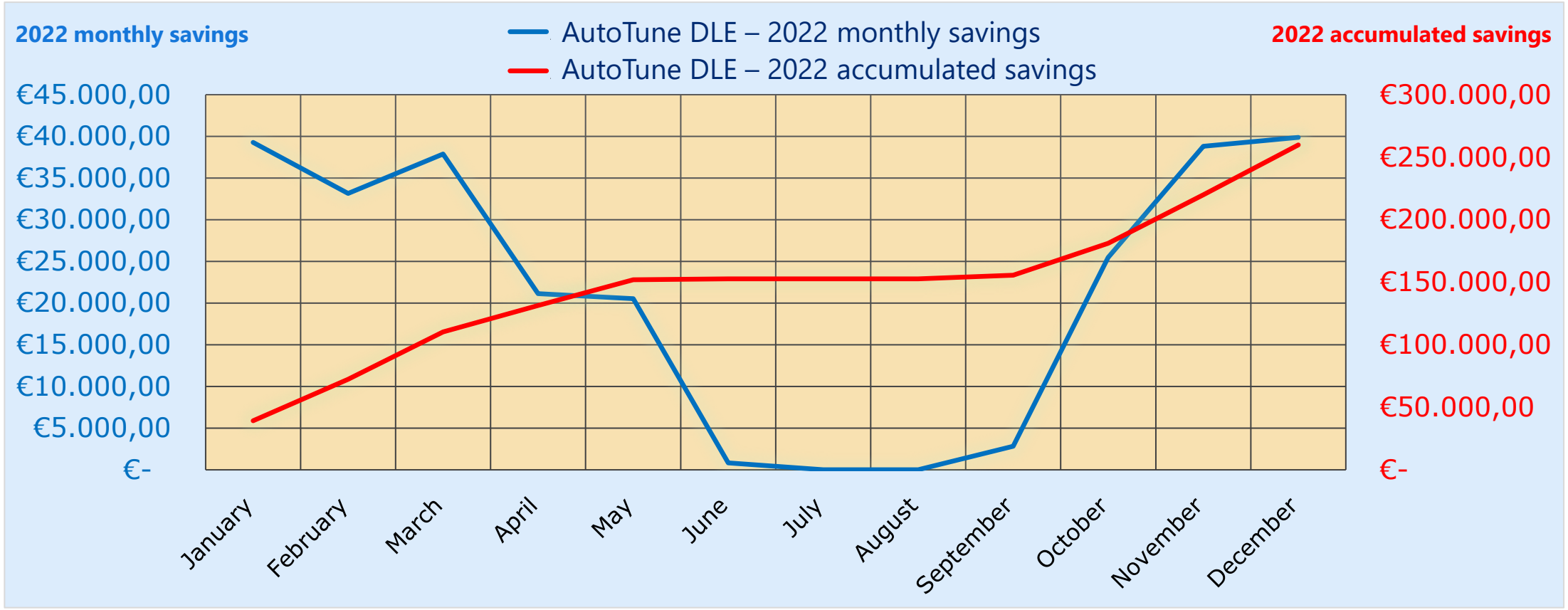
Mapping verified data - LM2500 DLE in burner mode ABC

Ambient	Load	Fuel & Bleed				Fuel				Efficiency
Temp DegC	MW	PPH	Bleed %	Kg/h	Kg/sec	BTU/lb	kJ/kg	Gj/h	Nm³/h	%
10,50	18,44	9404,20	33,52%	4265,67	1,18	20533,17	47760,15	203,73	5792,04	32,58%
10,50	18,43	9223,51	23,89%	4183,71	1,16	20529,82	47752,36	199,78	5679,83	**33,21%**

Efficiency increase LM2500 DLE in burner mode ABC with AutoTune DLE

Temp DegC	MW	PPH	Bleed %	Kg/h	Kg/sec	BTU/lb	kJ/kg	Gj/h	Nm³/h	%
0,00	0,01	180,69	9,63%	81,96	0,02	3,35	7,79	3,95	112,21	**+0,63%**

Customer example of fuel gas savings & CO_2 avoidance savings on a LM2500 DLE



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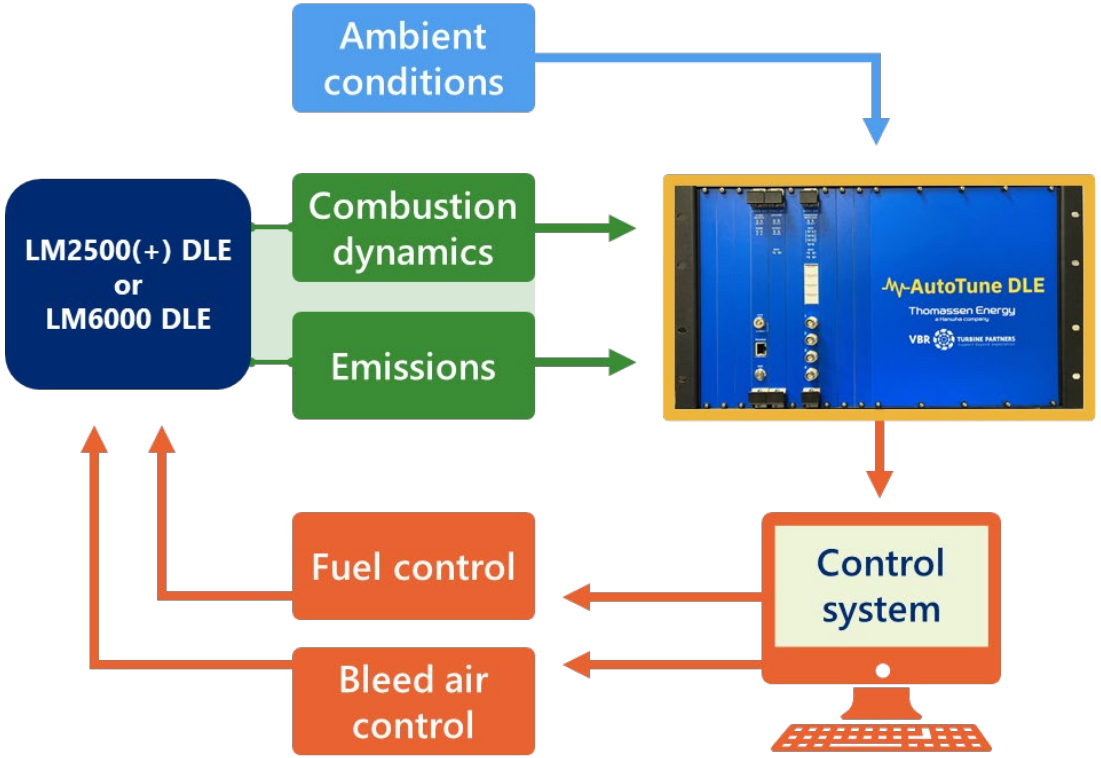
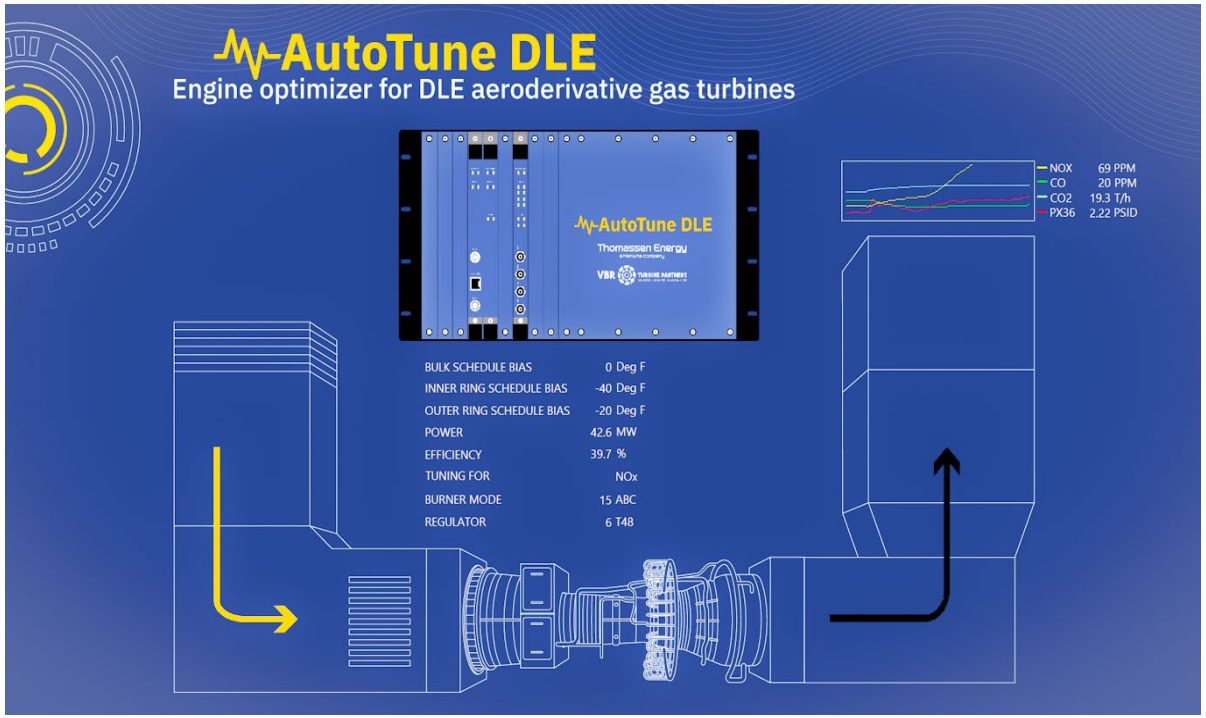
Summary

- AutoTune DLE is **real-time empirical** combustion-based **engine efficiency optimization**, not model-based engine efficiency optimization.
- AutoTune DLE reduces the amount of bleed air in the ABC combustion mode during part load operation.
- Less bleed air results in higher engine efficiency in the ABC combustion mode during part load operation.
- Higher engine efficiency results in **lower fuel consumption and lower CO_2 emissions** in the ABC combustion mode during part load operation.



Deliverables of AutoTune DLE

- At least **0,5% fuel cost savings** at required part-load power output *
- At least **0,5% CO_2 avoidance savings** at required part-load power output *
- Improved **operability** by active engine stabilization / high acoustics protection
- NOx and CO **emissions in full compliance** with legal requirements
- Enhanced **fuel flexibility** (enables mixing in a higher % of renewable fuels)
- Improved **availability** (eliminates production loss of seasonal DLE tuning)



* Your expected fuel cost savings and CO_2 emission savings can be calculated with your own operation data.

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Installation specifications and a requirement for AutoTune DLE

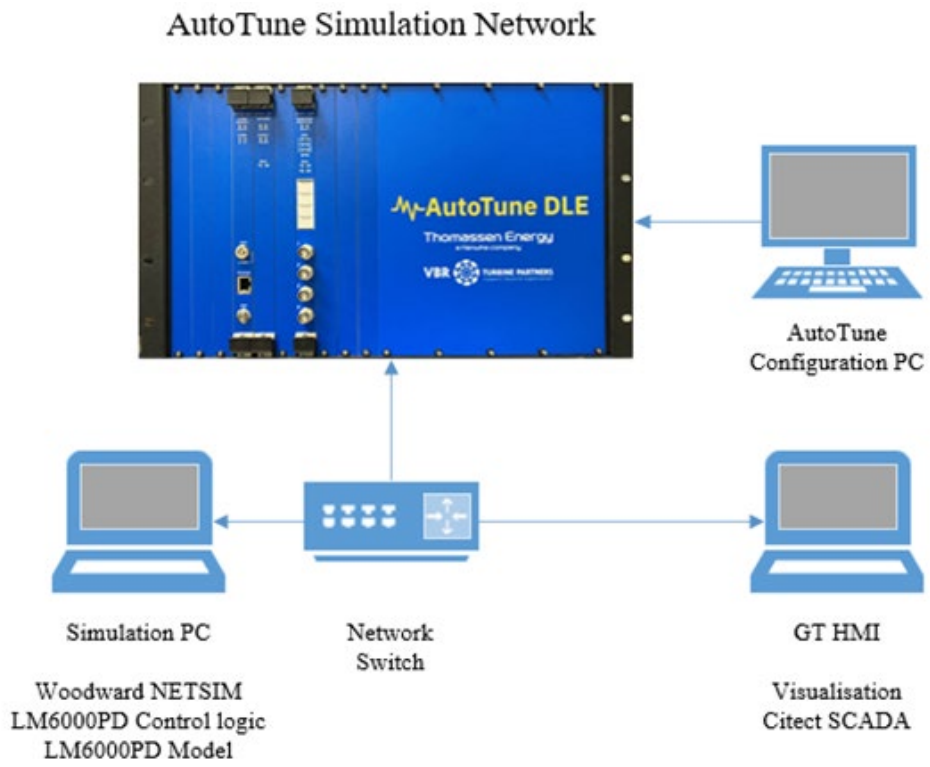
Specifications

- A 19" stand-alone box
  (Containing the 2nd generation AutoTune platform including a combustion dynamics measuring system and digital processing capabilities)
- Hardwired connections with the controls cabinet and the vibration panel
- Modbus connection between the controls cabinet and the AutoTune DLE box
- Back-up / fall back in the controls logic programming

Requirement

- A continuous emission monitoring system (CEMS) to provide real-time emission data to the AutoTune DLE box

AutoTune DLE demonstration setup and customer cost savings calculator



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Learn more about AutoTune DLE?

To learn more about the AutoTune DLE automated efficiency optimizer for LM2500(+) and LM6000 DLE just ask any of our VBR booth staff members ☺

AutoTune DLE contact email address:

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