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CENTRO DE TECNOLOGIA DA MOBILIDADE

Engineering School – The biggest Engineering Centre of Latin America
Mechanical Engineering Department

Prof. Dr. José Guilherme Coelho Baêta

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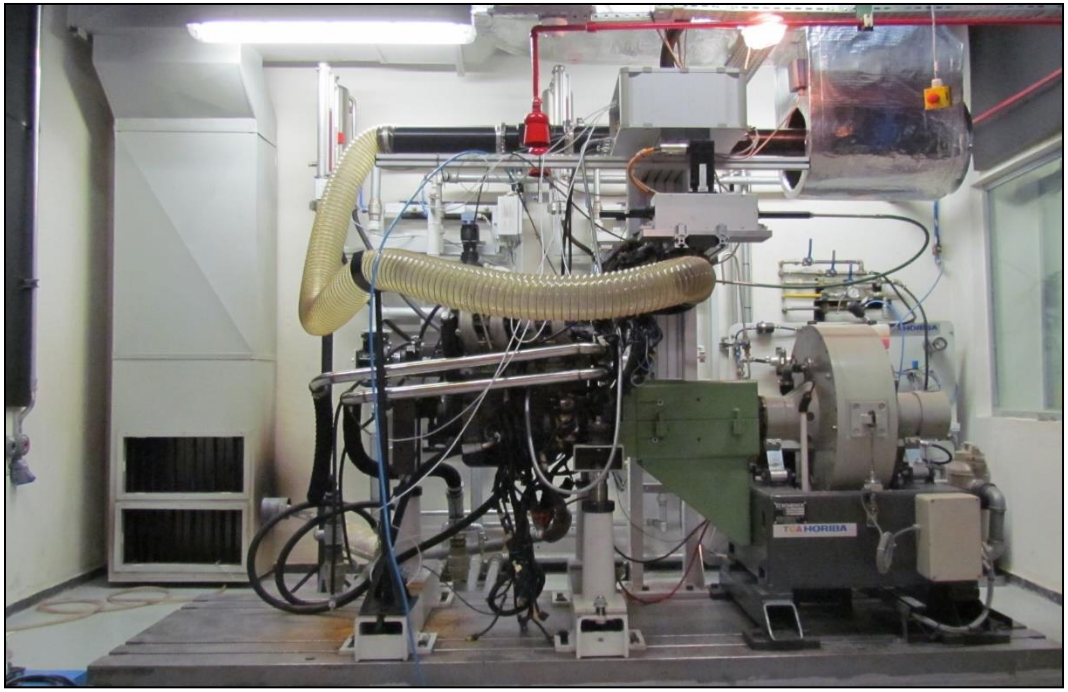
PRESENTATION TOPICS

1. **CTM Labs. Infrastructure**
2. **Developed and current projects in CTM**
3. **Why Ethanol?**
4. **Twin-Stage Turbocharger Downsized Ethanol DISI Engine Project**
5. **Full Spark Authority in Highly Boosted Ethanol DISI Engine Project**
6. **Conclusion**

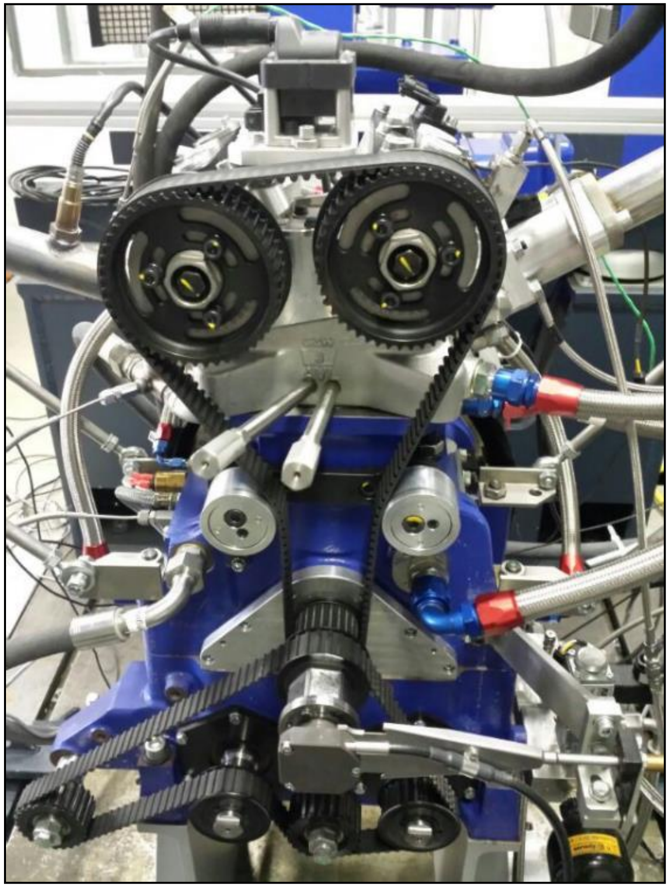
1. CTM Labs. Infrastructure

- **Engine R&D Lab**

Bench Dynamometers W230, W430, D210



SCRE



Engine Control Systems

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1. CTM Labs. Infrastructure

- **Vehicle R&D Lab**

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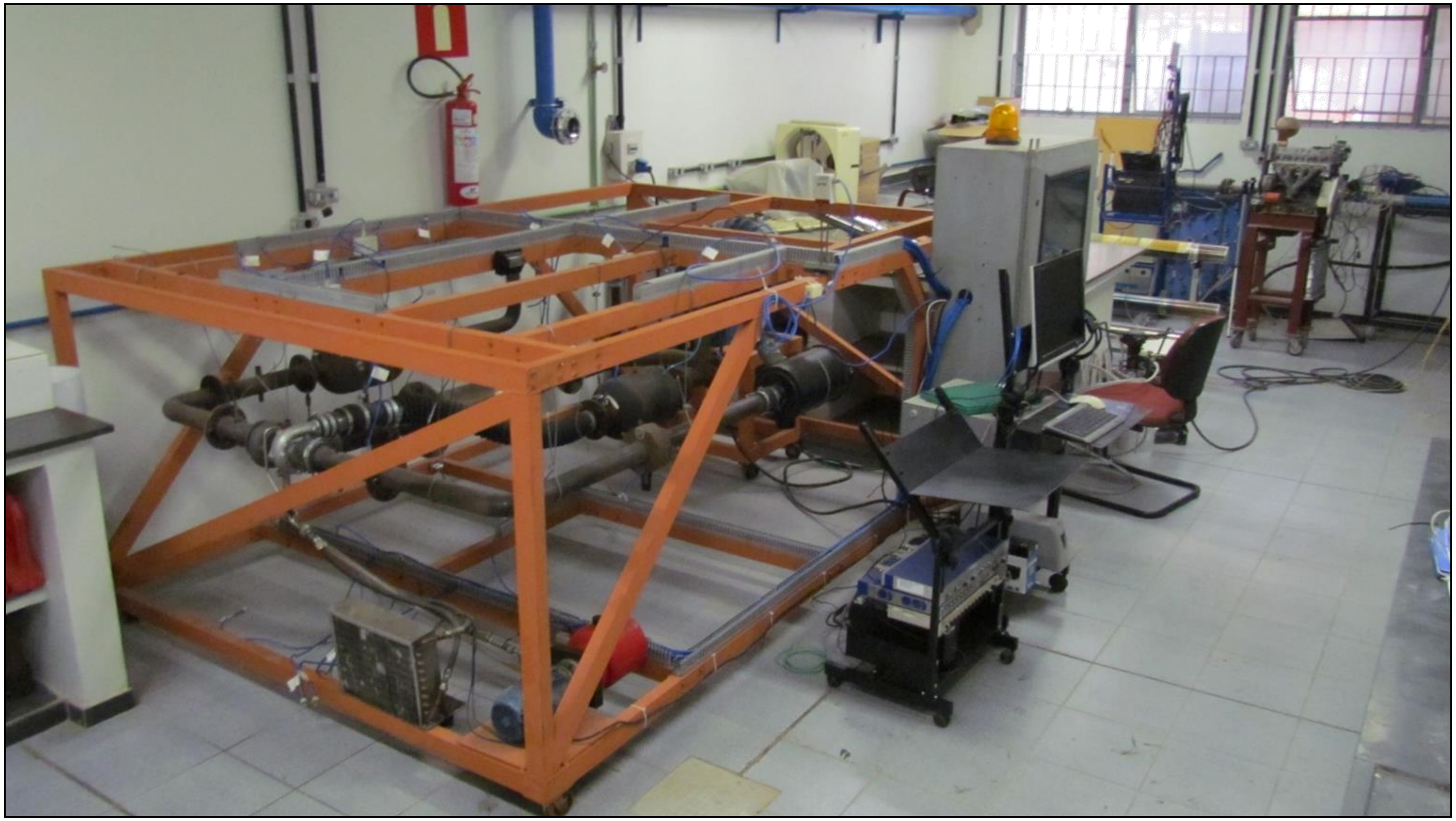
1. CTM Labs. Infrastructure

- **Turbochargers Characterization Lab.**



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1. CTM Labs. Infrastructure

- **CFD Lab.**

Software Available

CAD	Solidworks, AutoCad
3D Simulation Solver	Star-CD, Converge, Star-CCM, Ansys Fluent
3D Post Processing	ParaView, Ensight
1D Simulation Solver	Gt-Power

Hardware Available

2 *Clusters* | *Solver*	4 Racks with 32 processors 3 Racks with 72 processors Racks with InfiniBand Linux and Windows operating system
Desktops | Post-Processing	5 Desktops, 4 Processors each PC. Linux and Windows operating system

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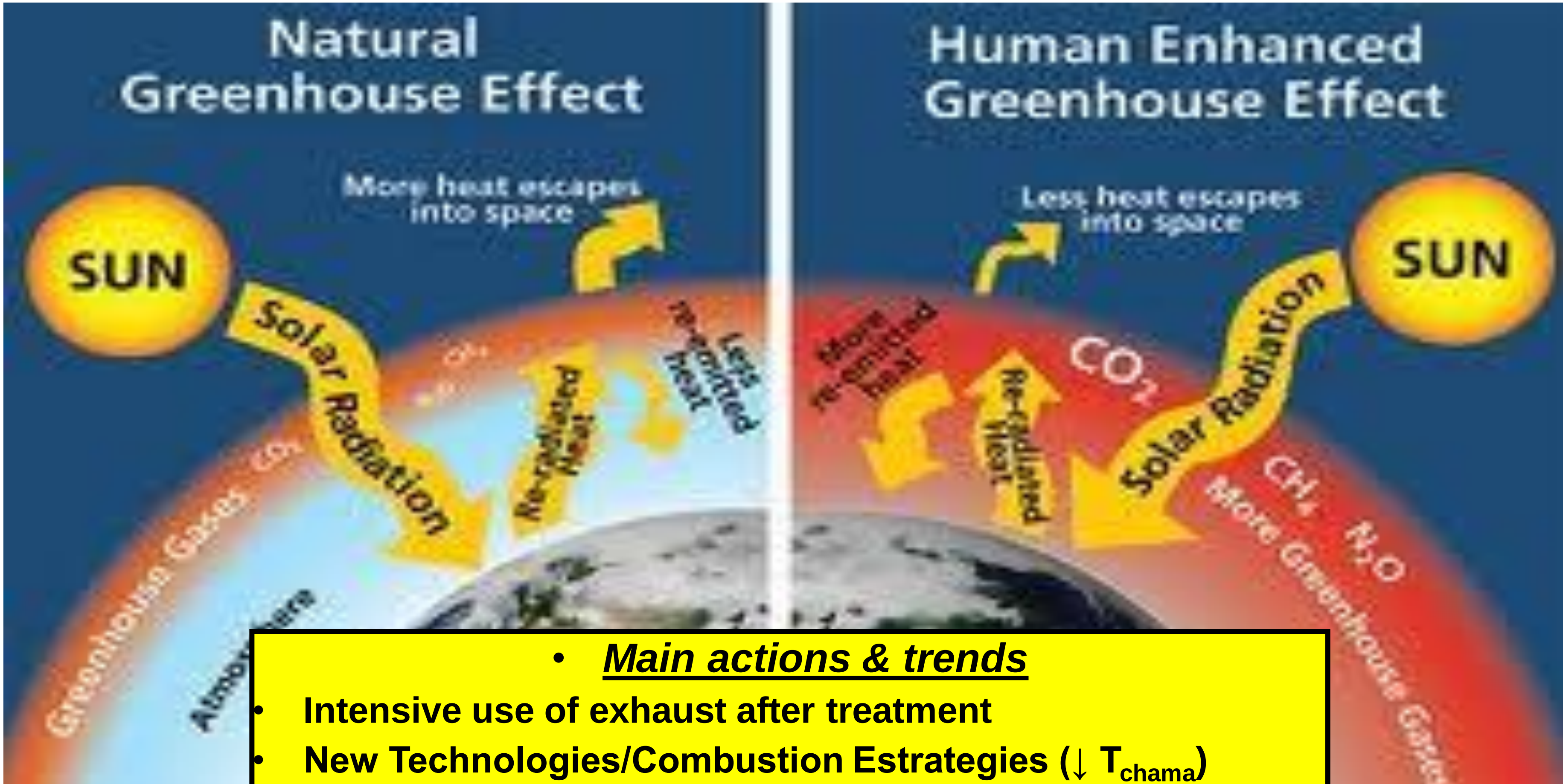
1. CTM Labs. Infrastructure

- **Engine Combustion Analysis Lab.**

2. Developed and Current Projects in CTM

1. **Development of a jet ignition system with stratified mixture for SI engine;**
2. **Technological innovation in the sustainable chain of power generation in Genset using biofuels;**
3. **Three-dimensional computational simulation of a concept engine running on ethanol, involving characterization of air, spray, mixture formation and combustion with experimental validation;**
4. **Three-dimensional computational simulation of new concept of ethanol engine configuration for characterization of performance parameters;**
5. **Basic research on ethanol combustion including analysis of fuel spray and direct injection system in a pressurized spray chamber bench and single-cylinder research engine;**
6. **Methodology for Combustion Analysis in Otto Cycle Engines by Monitoring the Ionization Current in the Ignition Coil Secondary Circuit;**
7. **Study of the compression ratio in internal combustion engines, aiming to improve the fuel conversion efficiency for the fuels used in the Brazilian market;**
8. **Performance of gasoline formulation in single cylinder research engine with DI system;**
9. **Study of a variable compression system;**
10. **Analysis of different fuel blends between E00 and E100 with DI injection for analysis of combustion properties;**
11. **Full spark authority in highly boosted and efficient ethanol DISI engine.**

3. Why Ethanol?



- ***Main actions & trends***
- **Intensive use of exhaust after treatment**
- **New Technologies/Combustion Estrategies (↓ T_{chama})**
- **Renewable Fuels – Ethanol / Biodiesel**
- **Renewable sources – Solar / Eolic**
- **Electrification/Hibridization**

NOx: Acid rain (mainly Diesel)

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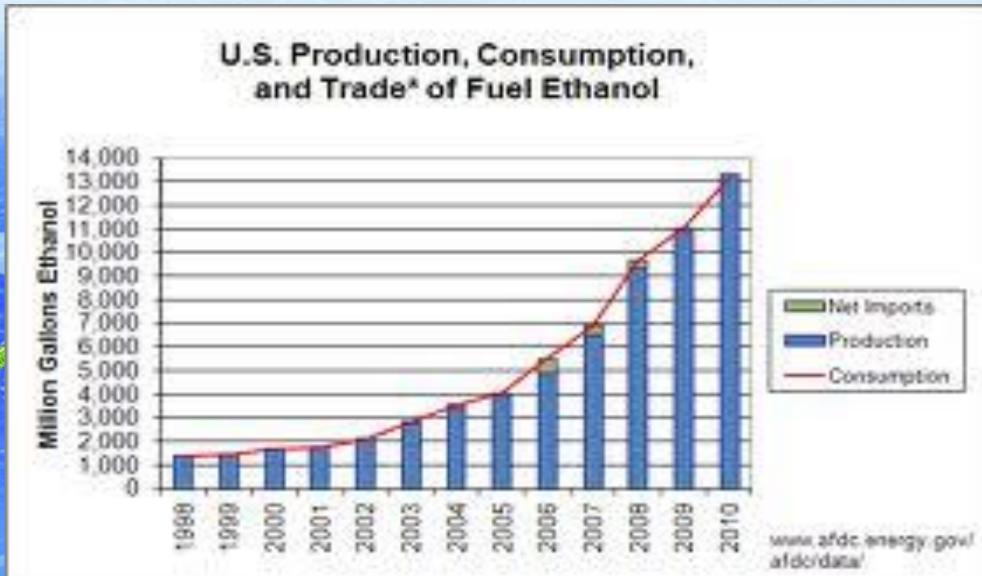
3. Why Ethanol?

World Scenario – Fuel Comsumption



Ethanol

asoline

iesel

Ethanol from corn - E85

RFS2 – Minimum

1 MJ → 1,7 MJ

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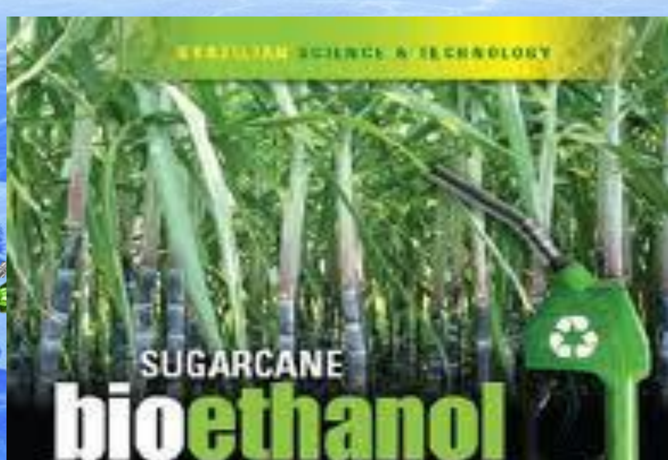
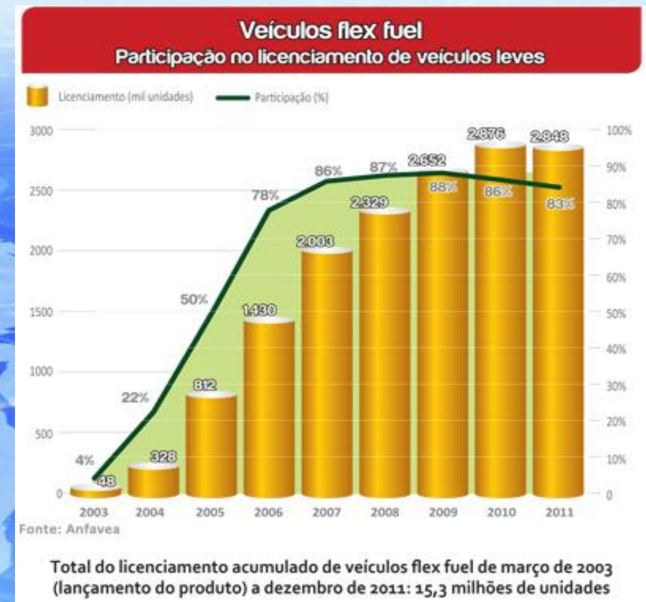
3. Why Ethanol?

World Scenario – Fuel Comsumption





Ethanol
Gasoline
Diesel

Ethanol from sugar cane E94 e E22 1 MJ → 8 MJ
Compared to Ethanol from Corn 1 MJ → 1,7 MJ
Use of bagasse use to produce

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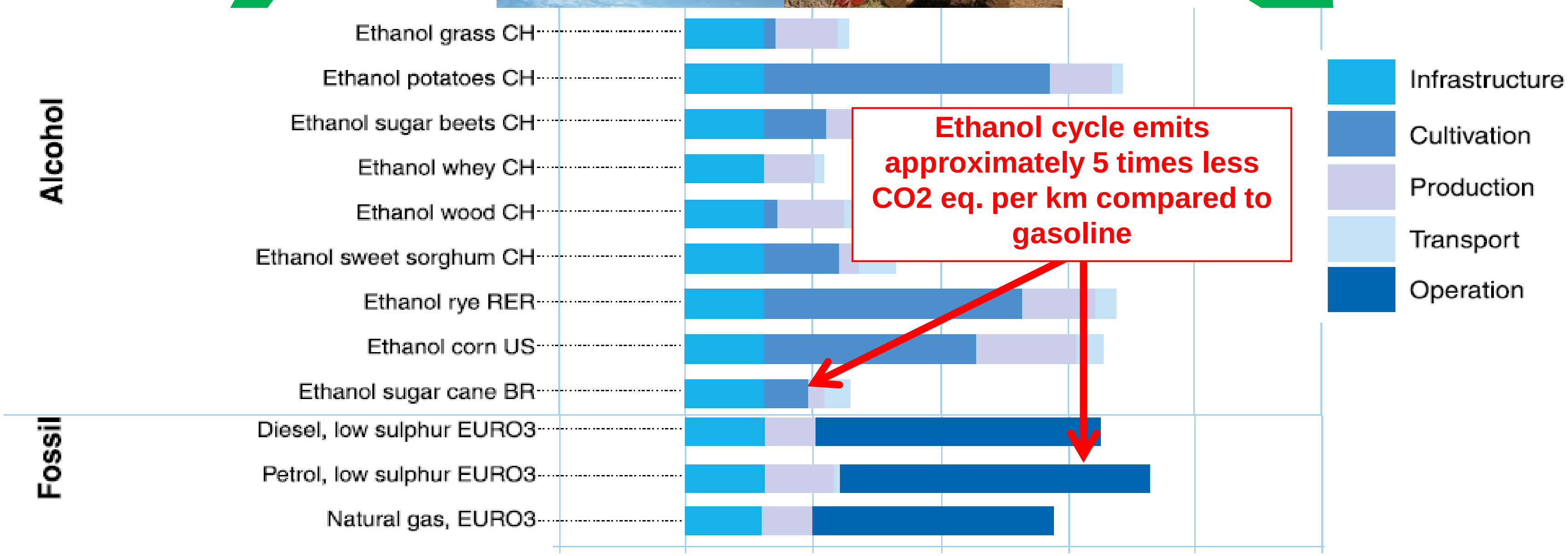
3. Why Ethanol?

Harvest



May reach over 100% reduction in CO_2 eq due to production of co-products

2009, Assessing Biofuels - ONU

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3. Why Ethanol?

Exportation (Fossil-Fuels x Bio-Fuels)

Saccharine Sorghum

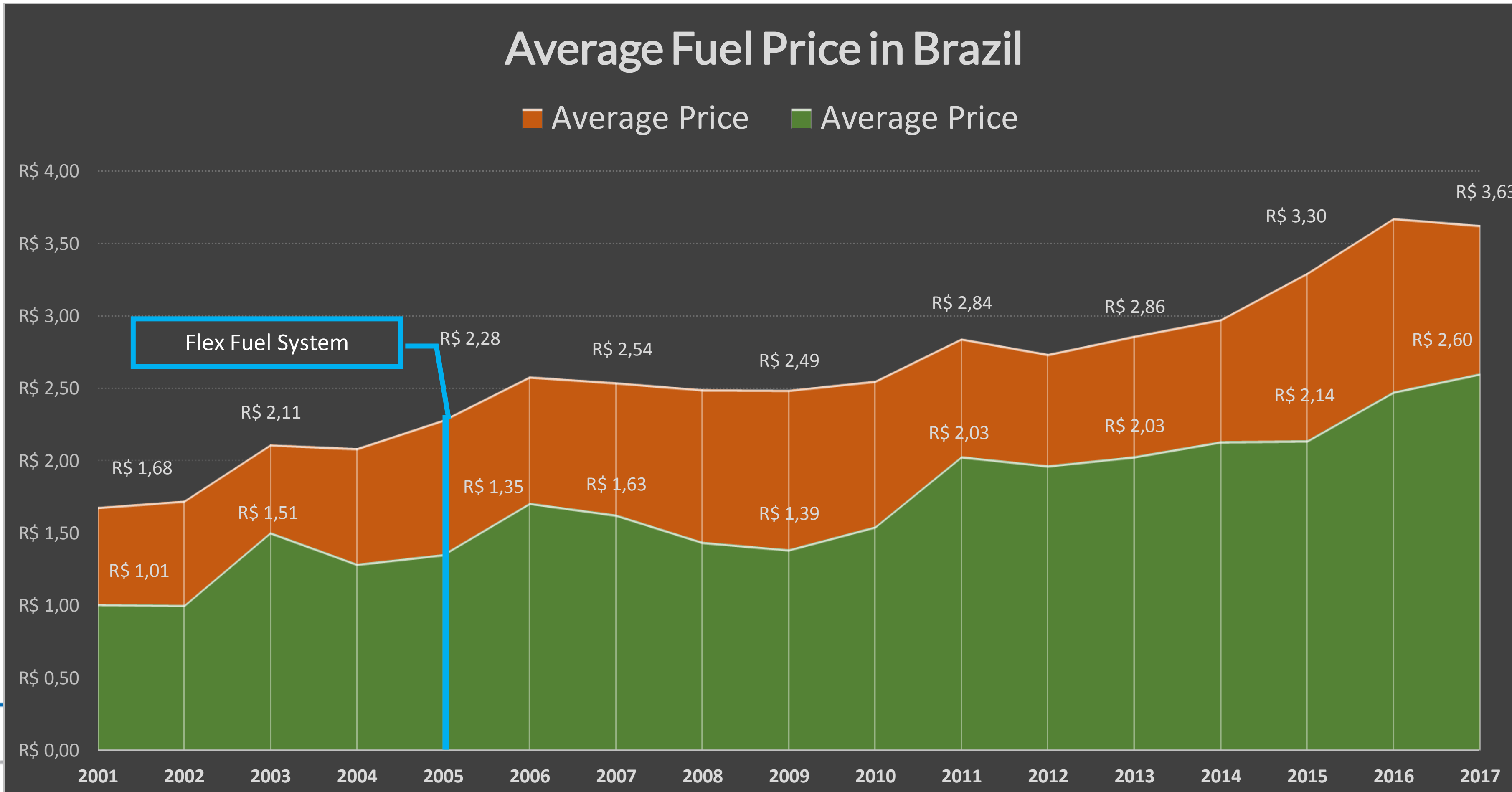
Complementary alternative to sugar cane for ethanol production;

Fast cycle → 4 months to competitive cost due to sharing investments;

May decrease variation in the price of ethanol between harvests.

3. Why Ethanol?

Source: ANP



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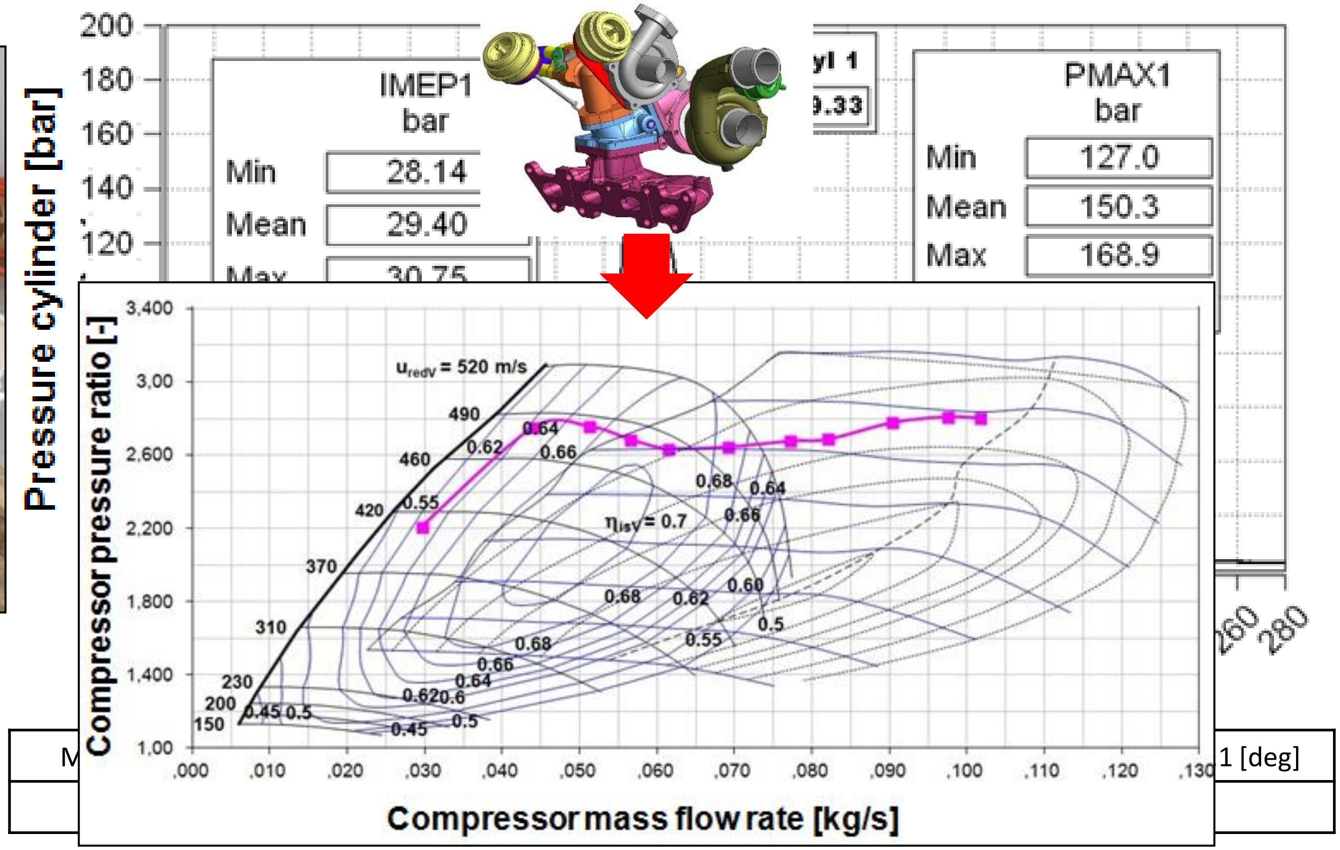
4. Twin-Stage Turbocharger Downsized and Downspeeding Ethanol DISI Engine Project

Twin-Stage Turbocharger set in order to almost double engine power output range to evaluate the maximum downsizing capability (~ 58% downsizing – No turbolag)



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4. Twin-Stage Turbocharger Downsized and Downspeeding Ethanol DISI Engine Project

Twin-Stage Turbocharger set in order to almost double engine power output range to evaluate the maximum downsizing capability (~ 58% downsizing – No turbolag)

Full Results Published in a High Factor Impact Elsevier Journal

Overall engine

Engine type	... (CAD) ... power at ... iency (%)]
Standard E	[28,2]
Standard E	[27,7]
Baseline E2	[21,2]
Prototype	[37,8]
Prototype	[41,3]
Prototype	[42,5]

Contents lists available at ScienceDirect

Energy Conversion and Management

journal homepage: www.elsevier.com/locate/enconman

ELSEVIER

Exploring the limits of a down-sized ethanol direct injection spark ignited engine in different configurations in order to replace high-displacement gasoline engines

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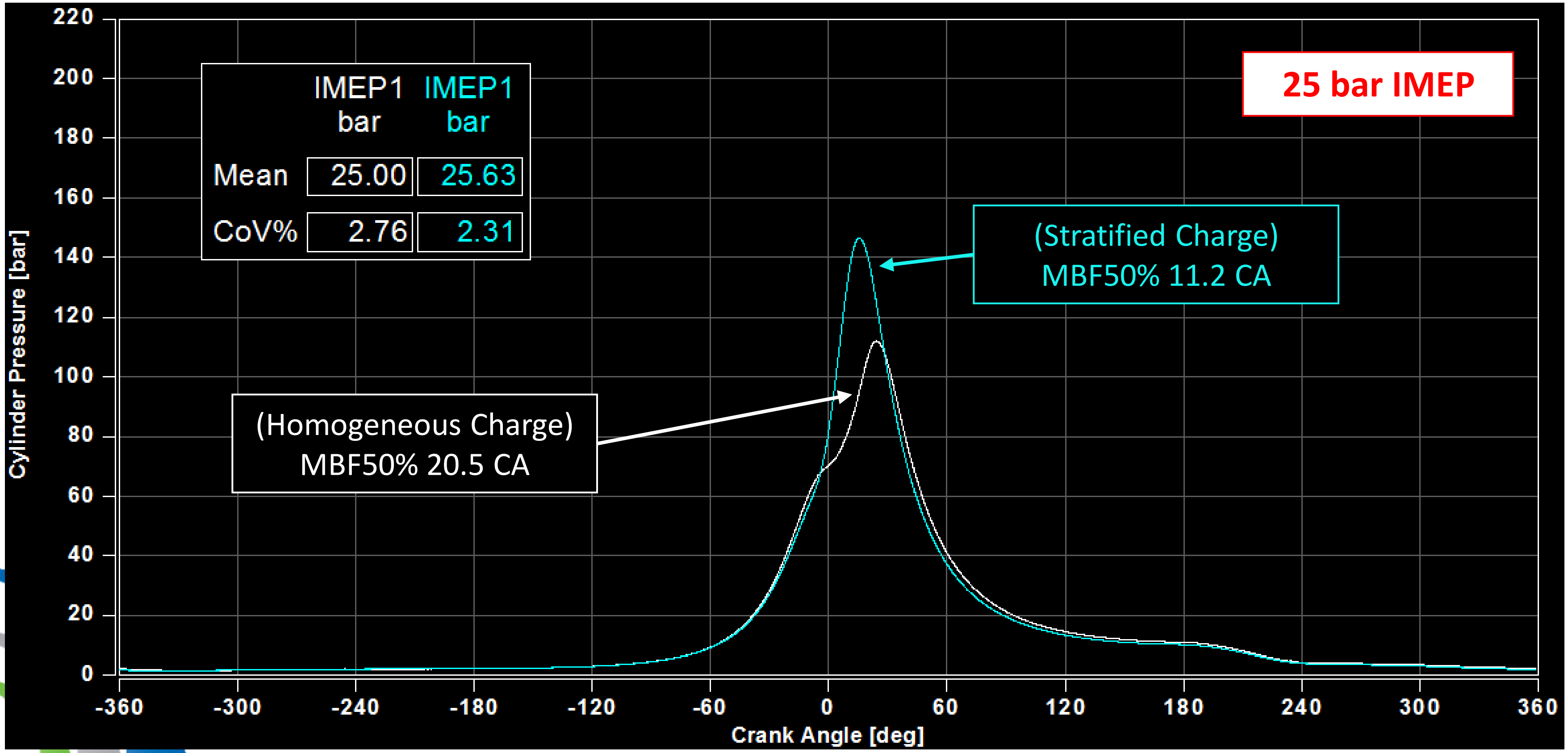
[b] Numidis S.a.r.l., France

5. Full Spark Authority in Highly Boosted Ethanol DISI Engine Project

Investigated the engine operation limits for each injection strategy at 2500 rpm

Homogeneous Charge strategy limit / Split injection used to restore the optimum combustion timing



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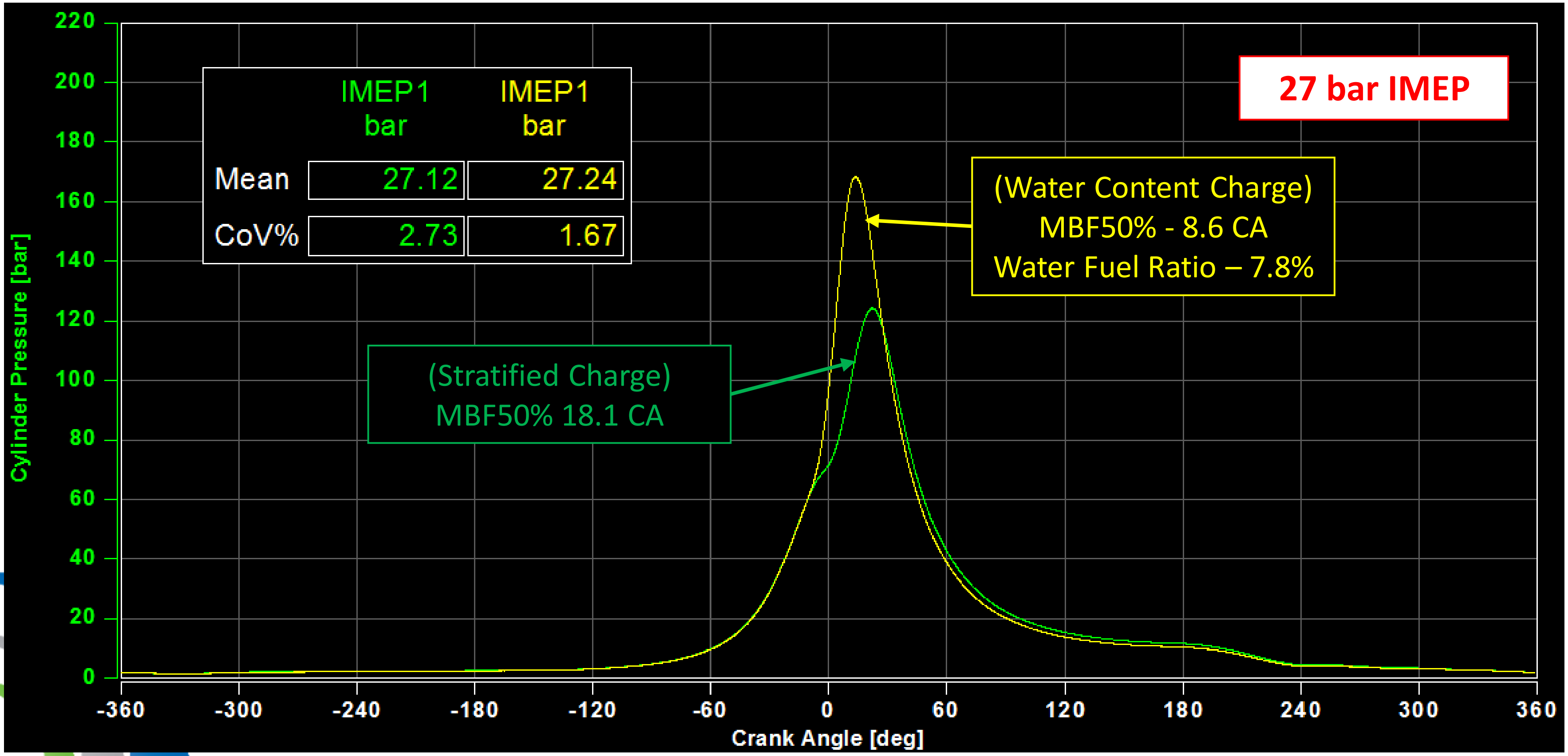
5. Full Spark Authority in Highly Boosted Ethanol DISI Engine Project

Investigated the engine operation limits for each injection strategy at 2500 rpm

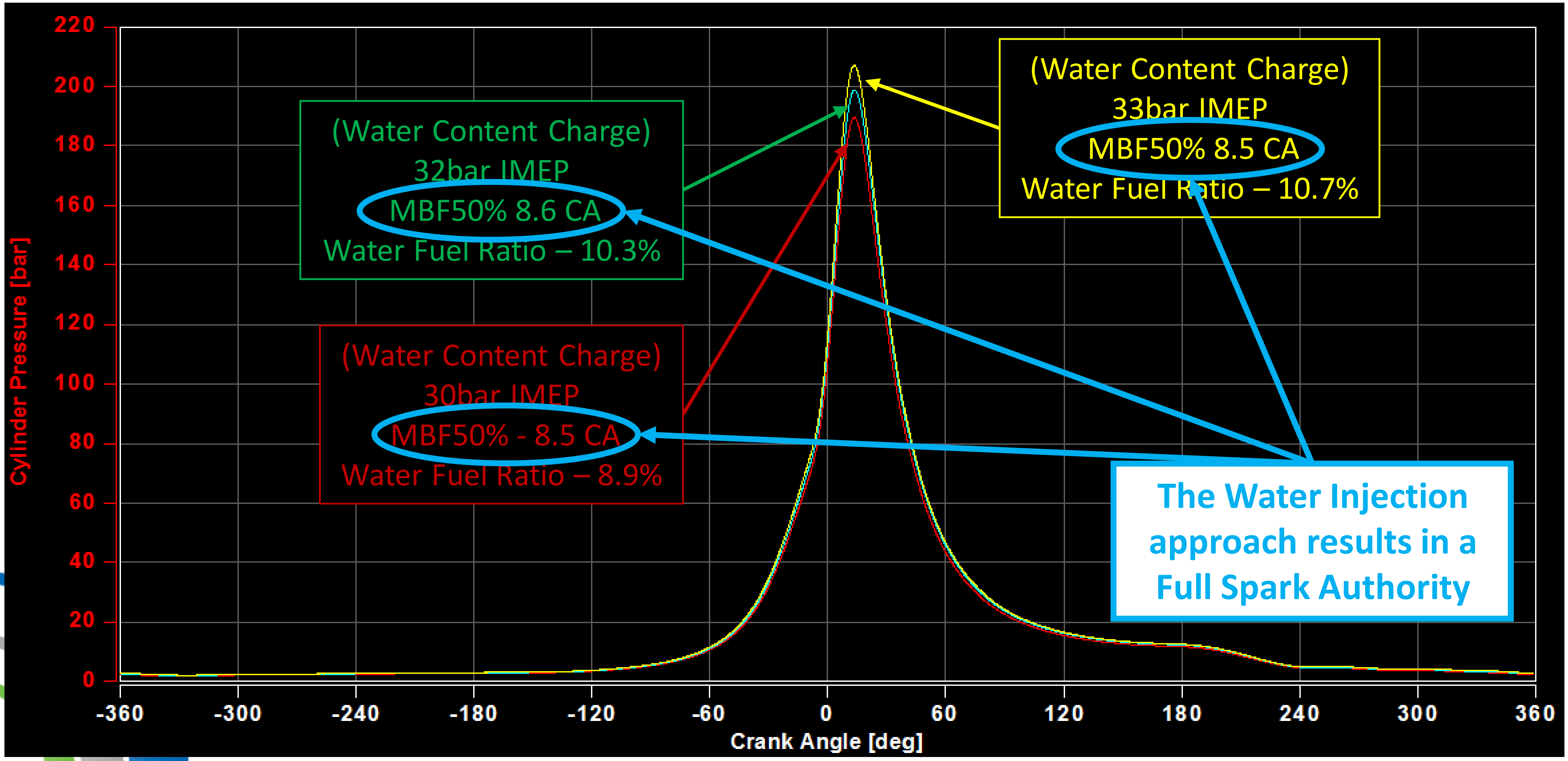
Stratified Charge strategy limit / Water Injection used to restore the optimum combustion timing



5. Full Spark Authority in Highly Boosted Ethanol DISI Engine Project

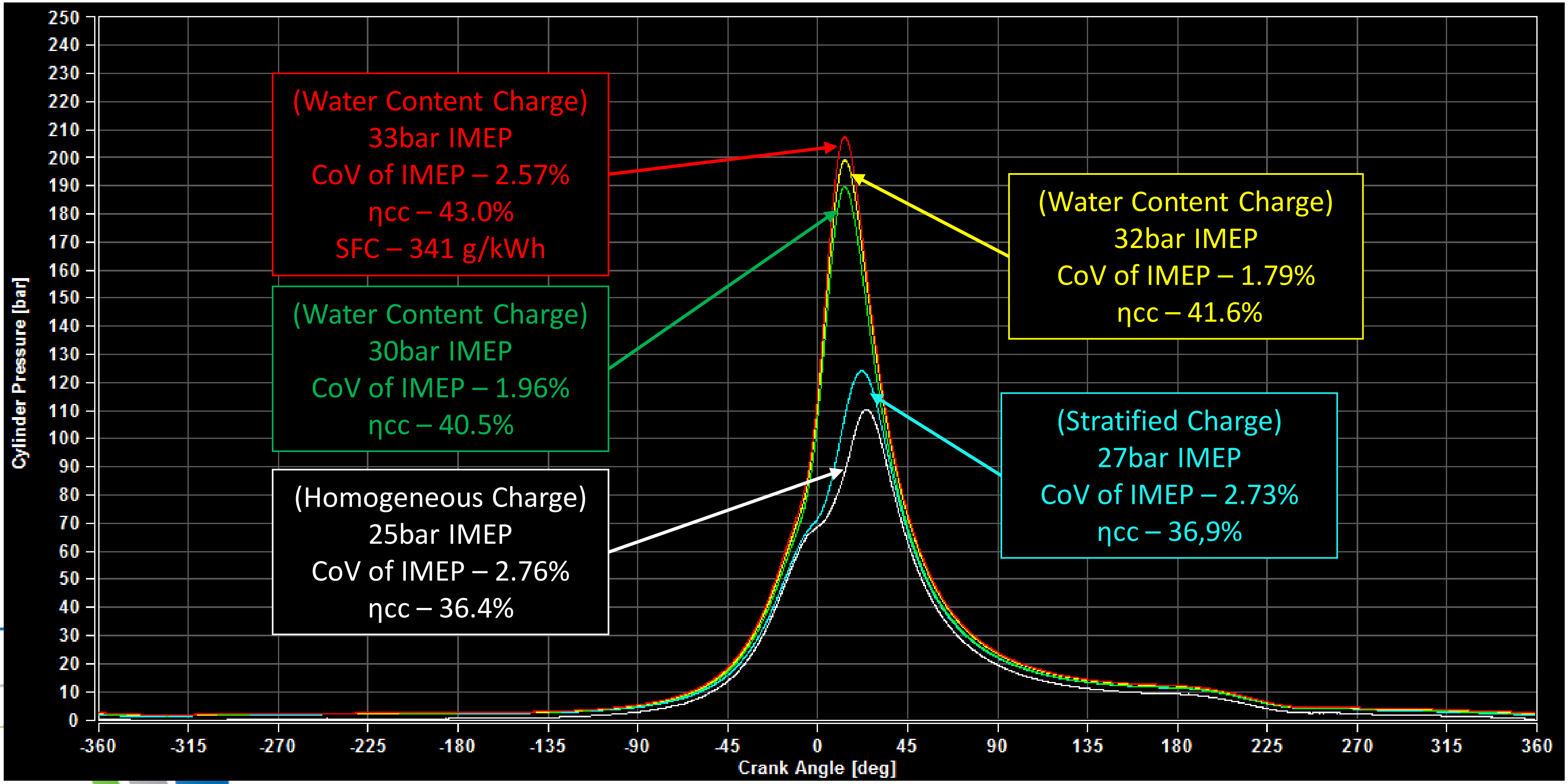
Investigated the engine operation limits for each injection strategy at 2500 rpm

Water Injection used aiming to maintain the optimum combustion timing



5. Full Spark Authority in Highly Boosted Ethanol DISI Engine Project

Overall indicated engine efficiency by injection strategy boundary (2500 rpm)



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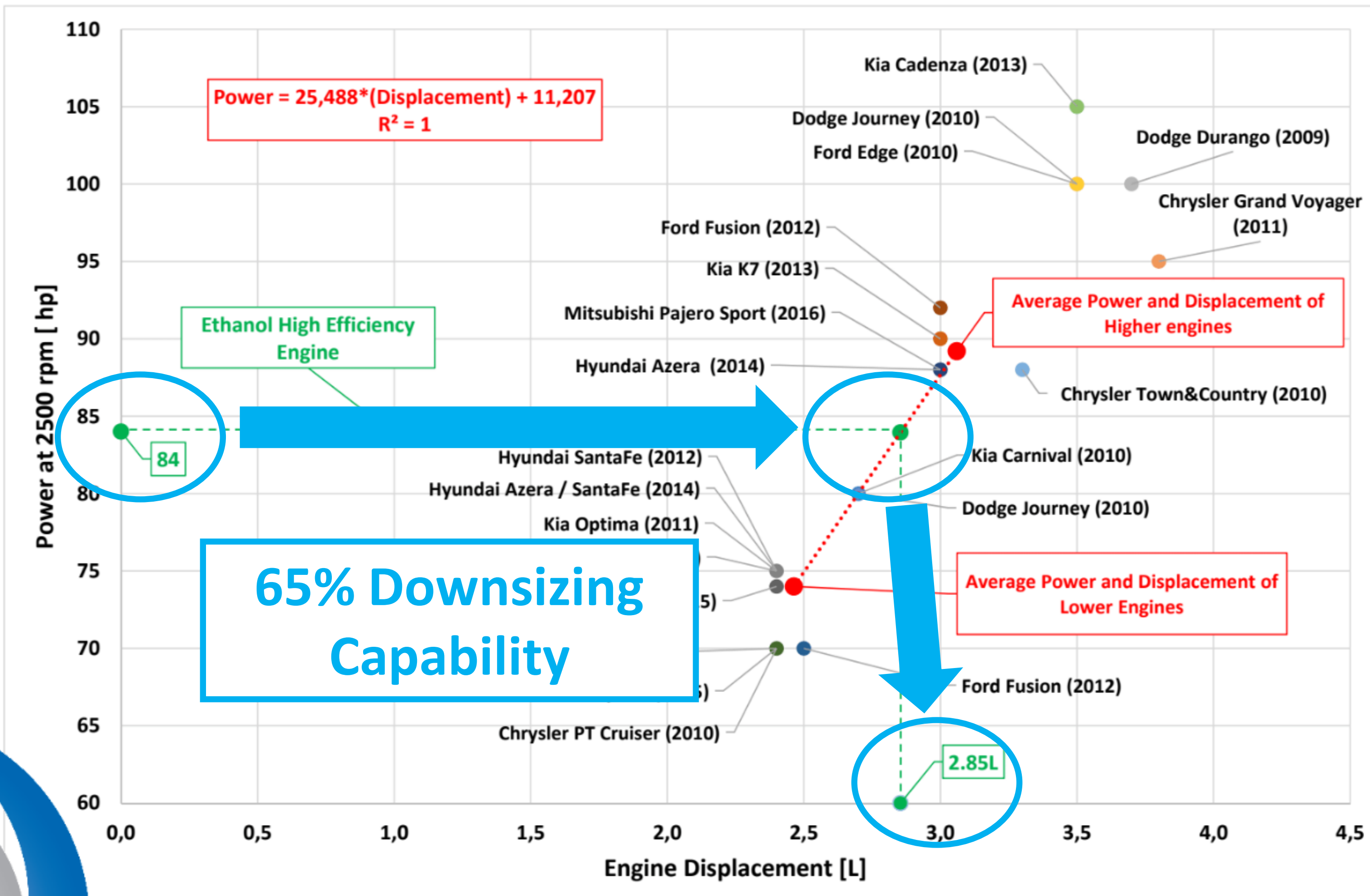
5. Full Spark Authority in Highly Boosted Ethanol DISI Engine Project

Achieved 65% downsizing capability (at 2500 rpm)



5. Full Spark Authority in Highly Boosted Ethanol DISI Engine Project

Power output at 5500 rpm – *184,67 hp* / *134,77 kW*

Specific fuel consumption – *342,96 g/kWh*

Fuel conversion efficiency – *42,4 %*

6. Conclusion

1. *There is an ample room to optimize the use of brazilian fuel energy matrix by means of the development of "national" ICE technologies ;*
2. *Ethanol fuel properties make possible to match diesel efficiency in an Otto highly Boosted Engine by means of combustion techniques implementation;*
3. *Test results demonstrate feasibility of this engine technology concept. A fully optimized intake boost system will allow to achieve extra efficiency gains.*
4. *Highly Boosted Downsized Ethanol Engine can match E27 fuel mileage;*
5. *The Spray guided DI implementation could lead to an extra fuel consumption reduction increasing the downsizing capability. (no need of any cold start system due to DI system)*
6. *The small-scale water injection implementation gives full spark authority making possible to achieve the MBT and consequently the highest efficiency for a given combustion system;*
7. *A hybrid powertrain with a downsized ethanol heat engine can be also developed to increase the global powertrain efficiency.*

THANK YOU!

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