EXPERIENCY WITH THE PRACTICAL TRIALS OF NANOADDITIVE IN FUELS

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KEY WORDS

Catalytic process, reduction of emission and consumption, savings, liquid and solid fuels, hydrocarbons, carbonoxide, carbondioxide, sulphurdioxide, nozzle, combustion chamber, exhaust gases, environmental,

1. INTRODUCTION

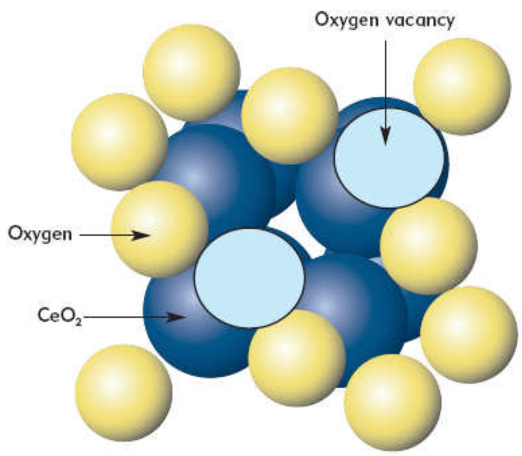
Since the start of the industrial revolution, the population in developed economies faces with the emission outputs and environmental burdens. Technological advancement of each country is compared not only to the assesses of the capacity and efficiency of industrial production, but also the capability to reduce and minimize the burden in recent years. My work is focused on reducing emission output, resulting from the combustion of fuels, both liquid (used in engines, aggregates, plants and other plants combustion of diesel, biodiesel, fuel oil and others) and solid fuels, coal combustion, biomass and others in medium and large technological units but mainly in boilers and heating plants using additives based on nanotechnology. Monitored and evaluated emission gases were checked mainly in field trials to monitor the O_2, CO, CO_2, SO_2, NOx and THC emission. The economy of combustion process and effect of additives on the purity of nozzles or burners were also observed.

Own work proceeds in the form of research and interpretation of data from available sources of technical web portals but mostly getting output from its own trials and practical implementation.

2. A BIT OF THEORY

Cerium oxide as a fuel additive [1]

Cerium is a common naturally occurring element and is characterised chemically by having two valence states, +3 and +4. The +4 state is the only non-trivalent rare earth ion which is stable in an aqueous environment. It is, therefore a strong oxidising agent. The +3 state closely resembles the other trivalent rare earths. There are numerous commercial applications for cerium including metallurgy, glass and glass polishing, ceramics, phosphors and catalysts. In catalysis, cerium is used in the form of cerium (IV) oxide, CeO_2. Cerium oxide is a highly stable, nontoxic, refractory ceramic material with a melting point of 2600ºC and a density of 7.13 g.cm^{-3}. The crystal structure is fluorite face centred cubic with a lattice constant of 5.11Å [2]. The rare earth oxides are generally some of the most thermally stable of all known materials and as such may be used in extremely high temperature applications without decomposition of the oxide [3].



Fluorite structure of CeO_2 present in Envirox™

***Pict No. 1:** Catalytic mechanism*
***Source:** Flyer, Oxonica Energy Ltd.*

The efficacy of cerium oxide as a catalyst is related to its ability to undergo a transformation from the stoichiometric CeO_2 (+4) state to the Ce_2O_3 (+3) valence state via a relatively (at least in comparison with other oxides) low energy reaction. This is in turn related to the general property of fluorite oxide structures to deviate strongly from stoichiometry. Even at a loss of considerable amounts of oxygen from the crystal lattice, and the formation of a large number of oxygen vacancies as a result, the fluorite structure is retained. Such sub-oxides may readily be reoxidised to CeO_2 in an oxidising environment. Because no crystal structure phase change is involved in the supply and re-absorption of oxygen from the CeO_2 lattice, CeO_2 may be used as an oxygen storage material in catalysis via the following reaction [4]

$$2CeO_2 \leftrightarrow Ce_2O_3 + 0.5O_2$$

Cerium oxide has found an important application in exhaust three-way catalytic converters where harmful emissions from fuel burning are converted to harmless gases by the following series of reactions.

Hydrocarbon combustion:

$$(2x+y)CeO_2 + CxHy \rightarrow [(2x+y)/2]Ce_2O_3 + x/2\ CO_2 + y/2\ H_2O$$

Soot burning:

$$4CeO_2 + C_{soot} \rightarrow 2Ce_2O_3 + CO_2$$

NOx reduction:

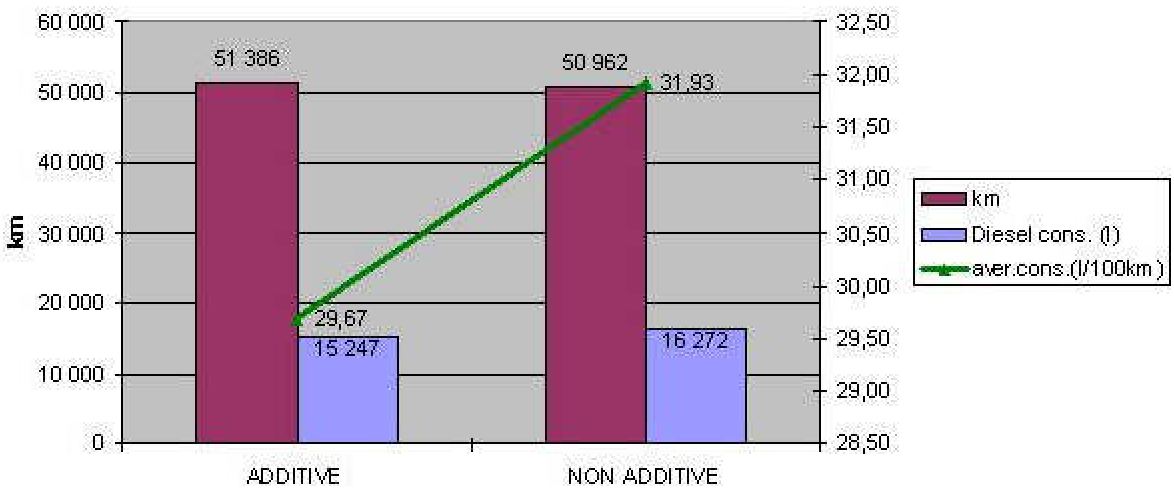
$$Ce_2O_3 + NO \rightarrow 2CeO_2 + 1/2\ N_2$$

Unburnt fuel, particulates and harmful gases are reduced when cerium oxide is used as an exhaust catalyst [5]

3. PRACTICAL TRIALS

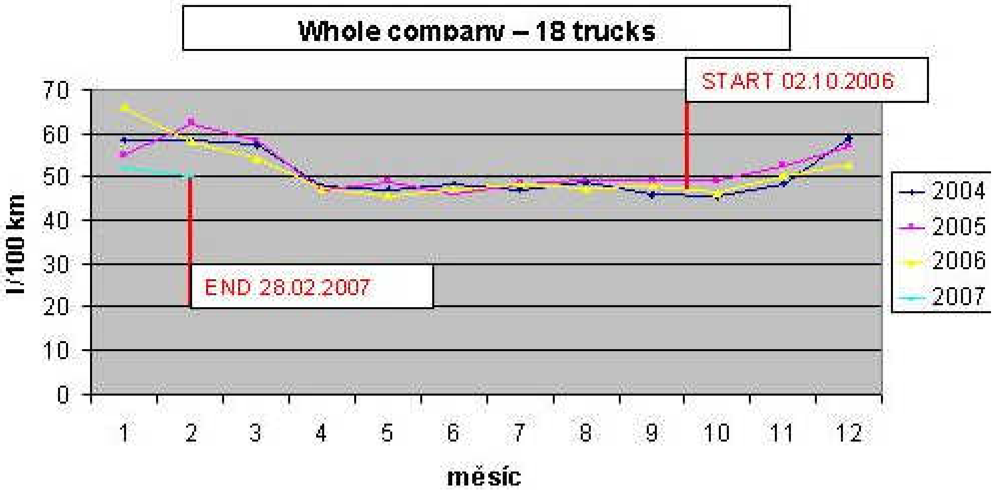
3.1 „3 Truck Trials“

Trial No. 1
Vehicle mark: Renault 480 Magnum
Engine mark: VOLVO DXI 12 EC01
Test period: April – July 2007
Consumption savings: 7,08 %



Graph No. 1: *Consumption savings in trial for Diesel fuel with additive*
Source: *L. Torčík, NanoTrade* [6]

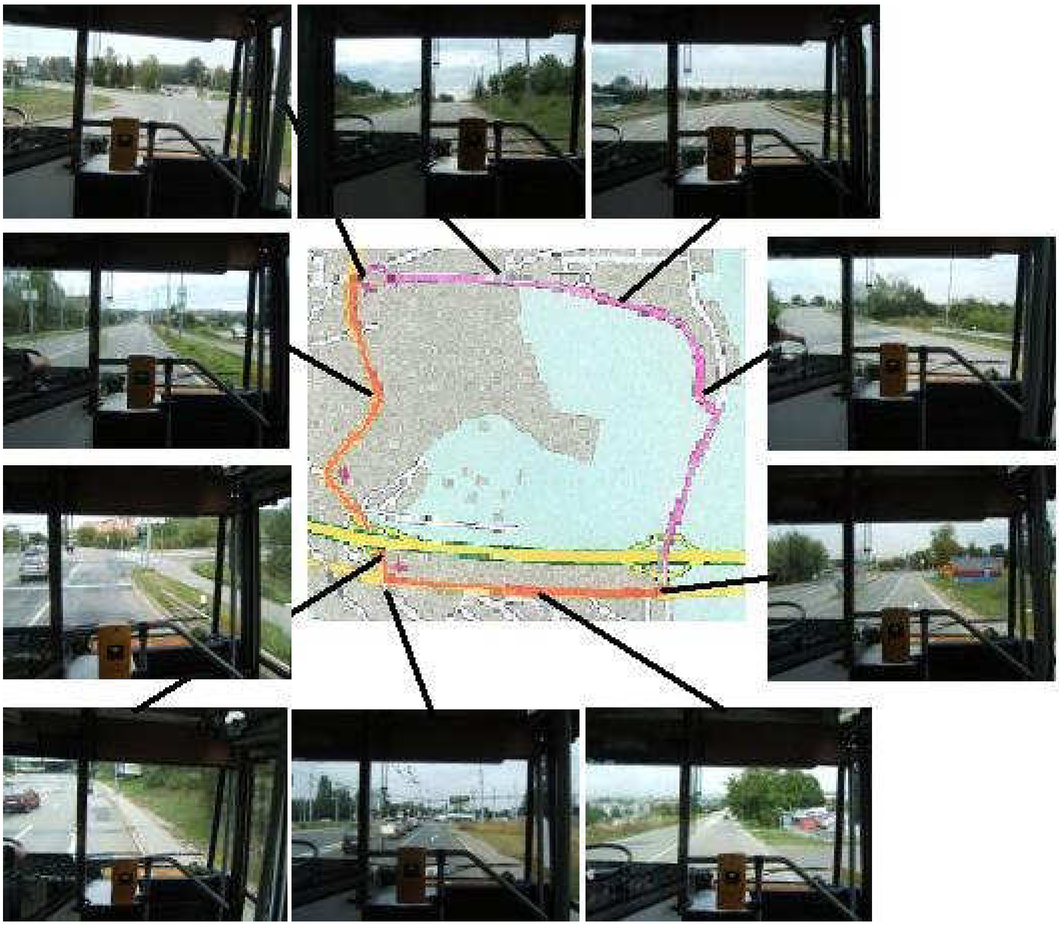
Trial No. 2
Vehicle marks: MAN, LIAZ, TATRA, AVIA, Renault
Engine mark: different marks
Test period: October 2006 – March 2007
Consumption savings: 7,28 %



***Graph No. 2:** Consumption savings in trial for Diesel fuel with additive*
***Source:** L. Torčík, NanoTrade* [7]

Trial No. 3

Vehicle marks: KAROSA B732
Engine mark: LIAZ ML 636
Test period: May – August 2008, City Circle, similar to SORT2 Standard
Measurements: Calibrated Flowtronic 206-208, Emission tester
Consumption savings: > 12 %



***Pict No. 2:** Trial City Circle, SORT 2*
***Source:** L. Torčík, NanoTrade* [8]

3.2 Test of Diesel (ON) B100 plus additive

Diesel fuel contaning BIO component varies according to experts overall properties of the fuel, so it is not recommended for long term storage such as the removal of vehicles or diesel aggregates used as an alternative source of electricity during outages. Due to the lower heating value mixture can be also expet a lower engine output and higher consumption.
In June 2010 we started our trial of additive with B100 fuel in Poland. Fisrt outputs show an increase of engine performance with reduced consumption. Final data are expected in the end of the year.

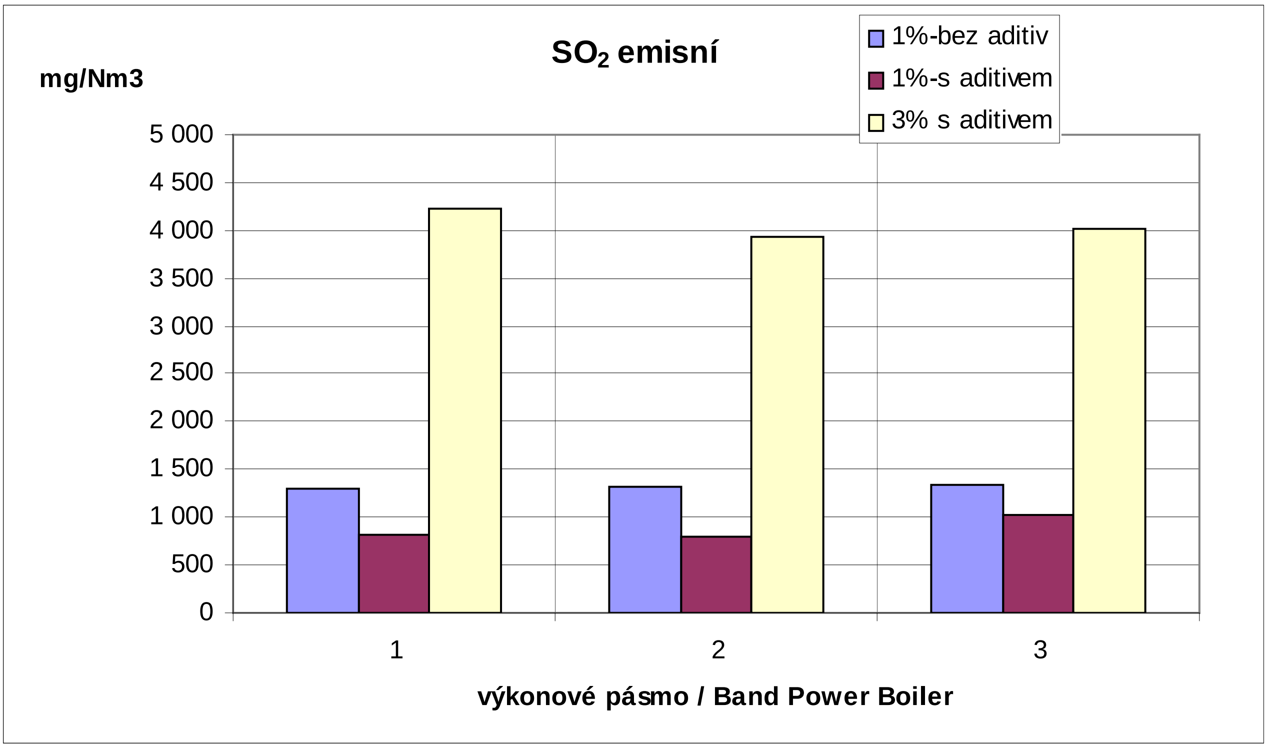
3.3 Trial of Mazut plus additive

Pict.No. 3: *deposits on the burner nozzle, from left to right: M*
Source: *L. Torcik, NanoTrade* [9]

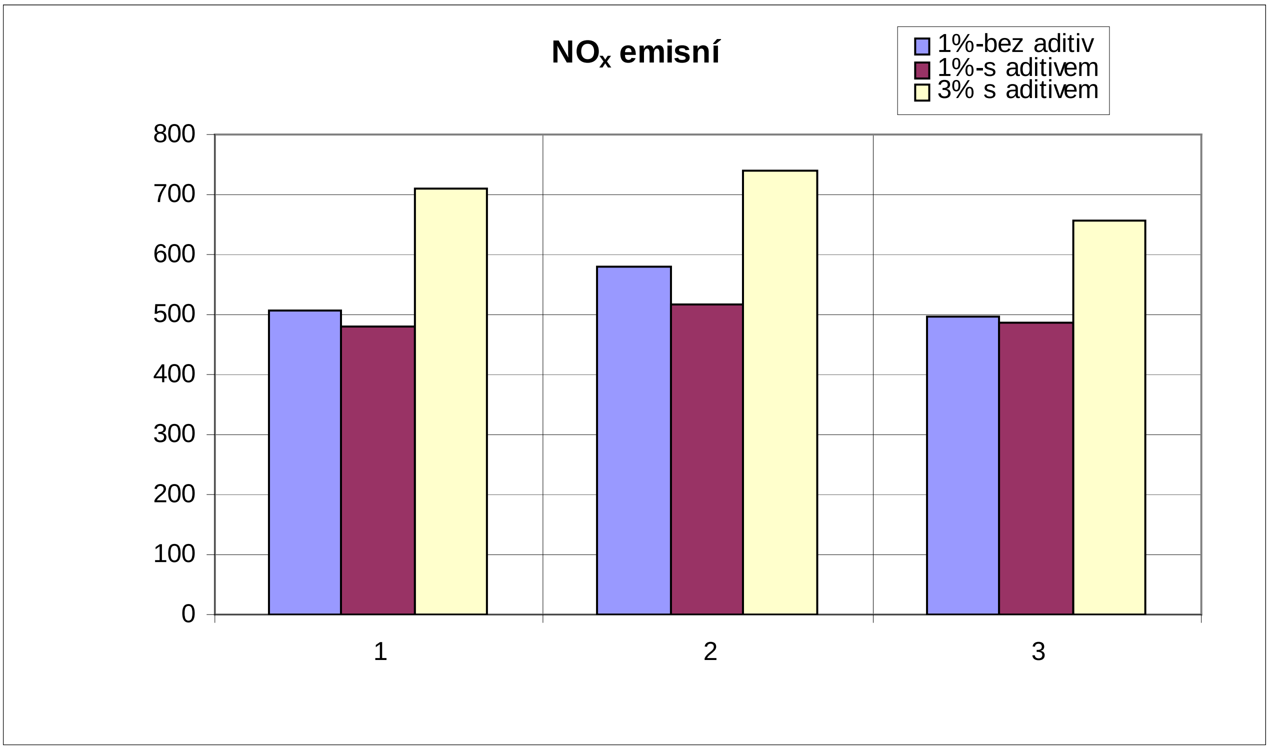
Boiler: K2 ČKD DUKLA, enterpriseTATRA Kolín, v.č. 1013, r.v. 1967
Fuel: Heavy Fuel Oil TOT-R2 M (Mazut)
Measurement: 13. May 2010, no additive
2. June 2010, Mazut 1% S with additive
23. June 2010, Mazut 3% S with additive

Pict. No. 4*: Deposits on the burner nozzle, from left to right: Mazut 1% S without additives, Mazut 1% S wit additives, Mazut 3% S with additives,*
Source: *L. Torcik, NanoTrade* [10]

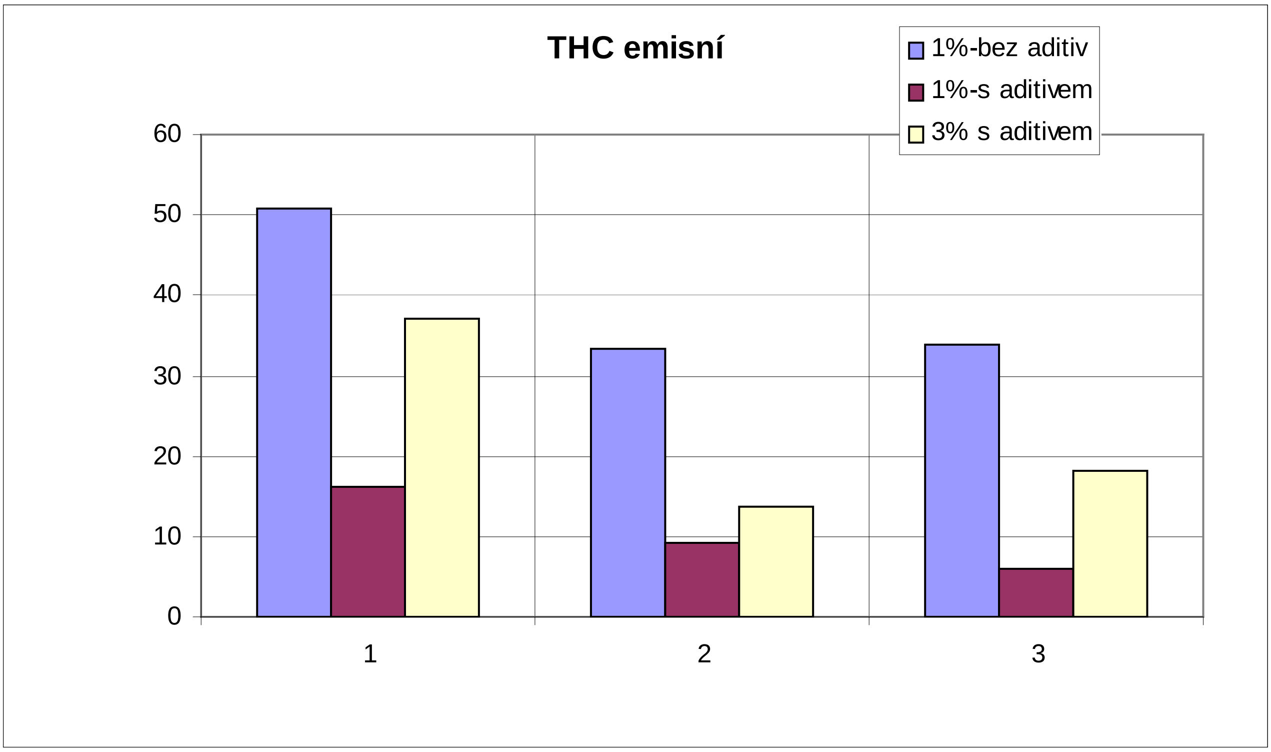
Band power boiler	superheated steam t/h
1	4,5 až 4,7
2	6,2 až 6,3
3	7,8 až 8,0



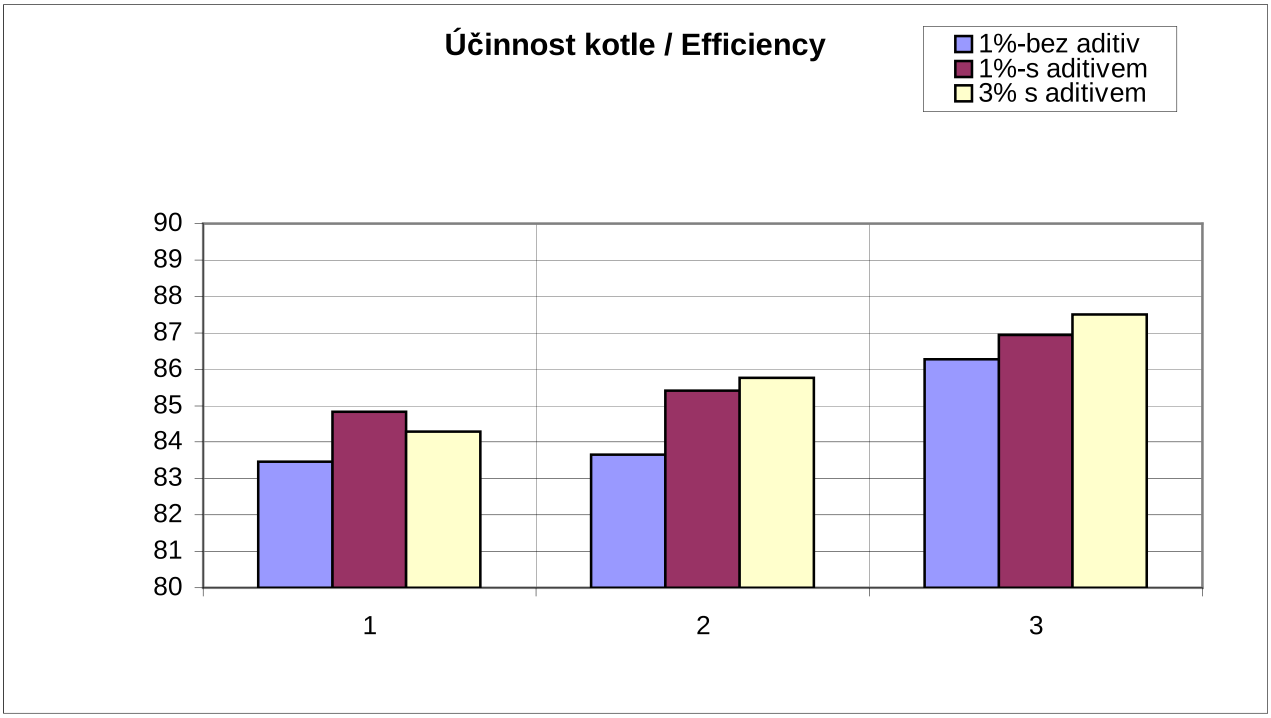
Graph No. 3: *Additive effect on $S0_2$ emission, columns from left to right: Mazut 1% S without additives, Mazut 1% S with additives, Mazut 3% S with additives,*
Source: *L. Torcik, NanoTrade* [11]



Graph No. 4: *Additive effect on N0$_x$ emission, columns from left to right: Mazut 1% S without additives, Mazut 1% S with additives, Mazut 3% S with additives,*
Source: *L. Torcik, NanoTrade* [12]



Graph No. 5: *Additive effect on THC emission, columns from left to right: Mazut 1% S without additives, Mazut 1% S with additives, Mazut 3% S with additives,*
Source: *L. Torcik, NanoTrade* [13]



Graph No. 6: *Additive effect on Efficiency of boiler, columns from left to right: Mazut 1% S without additives, Mazut 1% S with additives, Mazut 3% S with additives,*
Source: *L. Torcik, NanoTrade* [14]

4. MARKET POTENTIALS

Thanks to the possitive trial outputs in practical processes we could expect a wide potential in the segment of Transport (personal vehicles, trucks, coaches, diesel locomotives, generators and technology units), Heating and Boiling plants, Energy units. Simply everywhere the liquid fuel is using.
Our next effort is focussed on modification of additives to the new features that be useful for solid fuels too. A specific characterization of additive for application of coal and biomass burning is still demanded. NanoTrade collaborates on this project with Czech Universities and Professional firms. Other project partners are welcome. The following tables describe market potentials.

Change of CO_2 emissions and fuel combustion between 1990 and 2007 for EU-27 Member States

Relative Change (1990-2007)	CO2 emissions	Fuel Combustion
Austria	19.8%	1.0%
Belgium	7.2%	23.6%
Bulgaria	-83.4%	-78.8%
Cyprus	-	-
Czech Republic	-22.3%	-18.8%
Denmark	8.1%	9.5%
Estonia	56.3%	56.3%
Finland	22.0%	31.8%
France	14.6%	10.3%
Germany	10.0%	12.6%
Greece	61.8%	74.5%
Hungary	10.9%	12.9%
Ireland	97.9%	104.0%
Italy	58.3%	40.9%
Latvia	-	-
Lithuania	-3.5%	-6.6%
Luxembourg	-	-
Malta	-	-
Netherlands	-3.6%	-2.0%
Poland	179.2%	252.4%
Portugal	37.4%	33.6%
Romania	-	-
Slovakia	22.6%	27.2%
Slovenia	-99.8%	-99.9%
Spain	17.8%	29.2%
Sweden	8.0%	9.6%
United Kingdom	-17.9%	-20.7%

Table Nr. 1*. Change of CO_2 emissions and fuel combustion between 1990 and 2007 for EU-27 Members*

Note: *Romania reports emissions under 'Public electricity and heat production'. The following Member States reported that CO2 emissions from petroleum refining were not occurring: Latvia, Luxembourg and Malta (1990 and 2007) and Cyprus (2007).*

Grey marked cells label negative values.,
Source*: EEA, 2009a* [15]

Change of $C0_2$ emissions and fuel combustion from manufacturing of solid fuels between 1990 and 2007 for EU-27 Member States

Relative Change (1990-2007)	CO2 emissions	Fuel Combustion
Austria	22.9%	23.0%
Belgium	-84.4%	-63.1%
Bulgaria	25.1%	29.0%
Cyprus	-	-
Czech Republic	-44.6%	-27.9%
Denmark	199.7%	201.2%
Estonia	-	-
Finland	1.4%	51.9%
France	-25.2%	-43.4%
Germany	-69.8%	-67.6%
Greece	-14.7%	-14.9%
Hungary	-	-
Ireland	13.5%	14.7%
Italy	5.3%	-14.0%
Latvia	-76.9%	-42.8%
Lithuania	-20.1%	-8.4%
Luxembourg	-	-
Malta	-	-
Netherlands	44.6%	13.5%
Poland	57.9%	44.3%
Portugal	-	-
Romania	-	-
Slovakia	13824.0%	6432.0%
Slovenia	-98.0%	-98.0%
Spain	-8.9%	12.3%
Sweden	-9.1%	8.2%
United Kingdom	26.4%	51.6%

Table Nr. 2.: Change of $C0_2$ emissions and fuel combustion from manufacturing of solid fuels between 1990 and 2007 for EU-27 Member States

***Note**: Romania reports emissions under 'Public electricity and heat production'; Hungary includes emissions under 'Chemical industry' (1990). The following Member States reported that CO2 emissions from the manufacture of solid fuels and other energy industries were not occurring: Cyprus, Estonia, Luxembourg and Malta (1990 and 2007) and Portugal (2007).*

Grey marked cells label negative values.
***Source**: EEA, 2009a.* [16]

Change of CO2 emissions, fuel combustion, heating degree days and gross value added from services between 1990 and 2007 for EU-27 Member States

Relative Change (1990-2007)	CO2 emissions	Fuel Combustion	Heating degree days	Gross Value Added
Austria	-26.4%	-5.3%	-8.6%	49.8%
Belgium	28.7%	37.5%	-8.9%	-
Bulgaria	87.6%	118.2%	-4.4%	-
Cyprus	211.4%	217.3%	-9.4%	-
Czech Republic	-66.9%	-52.8%	-4.6%	-
Denmark	-43.7%	-28.5%	-2.7%	46.5%
Estonia	30.5%	22.6%	-0.8%	-
Finland	-43.4%	-35.6%	-4.6%	36.1%
France	-1.6%	4.3%	-3.3%	42.7%
Germany	-43.9%	-31.5%	-5.1%	-
Greece	184.8%	201.2%	-8.1%	-
Hungary	-0.6%	13.7%	-4.9%	-
Ireland	11.6%	20.5%	-9.9%	-
Italy	38.4%	49.6%	-9.0%	30.8%
Latvia	-80.8%	-62.0%	2.0%	109.9%
Lithuania	-86.7%	-83.9%	2.9%	-
Luxembourg	0.9%	6.4%	-10.4%	-
Malta	-16.3%	-28.1%	-23.9%	-
Netherlands	36.4%	38.7%	-6.3%	65.7%
Poland	-34.4%	-6.6%	0.6%	-
Portugal	220.2%	240.8%	-1.1%	-
Romania	149.7%	182.8%	-2.9%	-
Slovakia	-79.1%	-71.8%	-5.0%	-
Slovenia	-4.3%	-18.7%	-5.7%	82.9%
Spain	119.7%	138.0%	-1.2%	61.8%
Sweden	-67.0%	-57.4%	0.5%	41.0%
United Kingdom	-19.2%	-11.2%	-1.2%	77.4%

Table Nr. 3,: Change of CO_2 emissions, fuel combustion, heating degree days and gross value added from services between 1990 and 2007 for EU-27 Member States

***Note**: Grey marked cells label negative values.*
***Source**: EEA, 2009a* [17]

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