



ERIN,
The 9th International Conference for Young Researchers
and PhD Students
May 4-6, 2015, Moníneć, Czech Republic



EXPERIENCE WITH OPERATION OF TWO-STAGE FIXED BED GASIFIERS

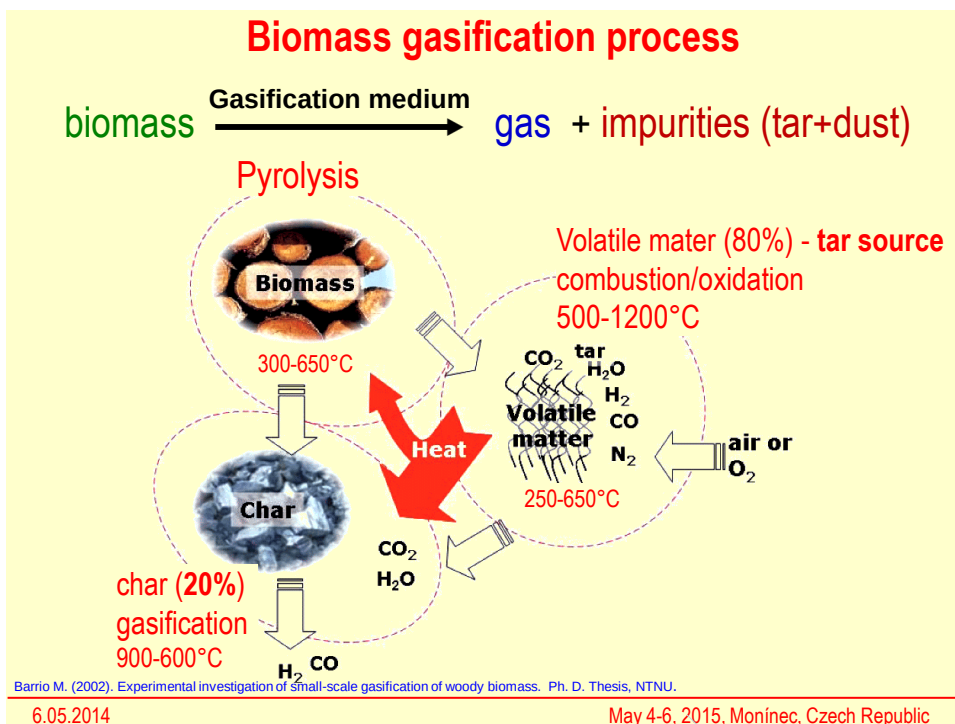
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The efficiency of electricity generation

$$\eta_t = \eta_{CE} * \eta_{CU}$$

η_t -

overall electricity production efficiency

η_{CE} -

cold gas efficiency which takes into account only the chemical energy stored in the gas

η_{CU} -

cogeneration unit efficiency (IC motor+ el. gen.)

Type of CHP generation	cold gas efficiency η_{CE} , %	gas to electricity efficiency, η_{CU} , %	Overall el. efficiency η_p , %	Inst. costs thousd. EUR /kW _e
1. power plant with steam turbine (11 MW _e) Green boiler (Zeleny kotel, 33 MW _e), 2010, Plzeň	-	-	27,6	3.2
2. downdraft „Imbert“ gasifier (100 kW _e) Boss engineering ltd, Louka, 2005, Staré město, 2009	65	max. 30 liaz M1.2, 12dm ³ , 6C	max. 19,5	2.4
3. downdraft gasifier „GP300“ with adv. heat recovery (200 kW _e) Tarpo ltd, Kněževs, 2009	75	~ 32 ČKD 6S160, 27 dm ³ , 6C	~ 24	2.4-2.8
4. Prototype of Two Stage gasifier (200kW _e) Tarpo ltd, Kněževs, 2011/2012	~ 85	~ 32 (see 3) max. 36 (see 5)*	~ 27,2 ~ 30,6	3.2-3.6 3.2-4.0
5. Two Stage gasifier (2x530kW _e) Tarpo ltd, Air Technic s.r.o. Odry, 2012	~ 90	~ 36*	~ 32,4	3.2***
6. Model: Two Stage gasifier, 3,5-8 MW _e	max. 95	42-44 **	~ 40	????

* Jenbacher AB, J316 GC

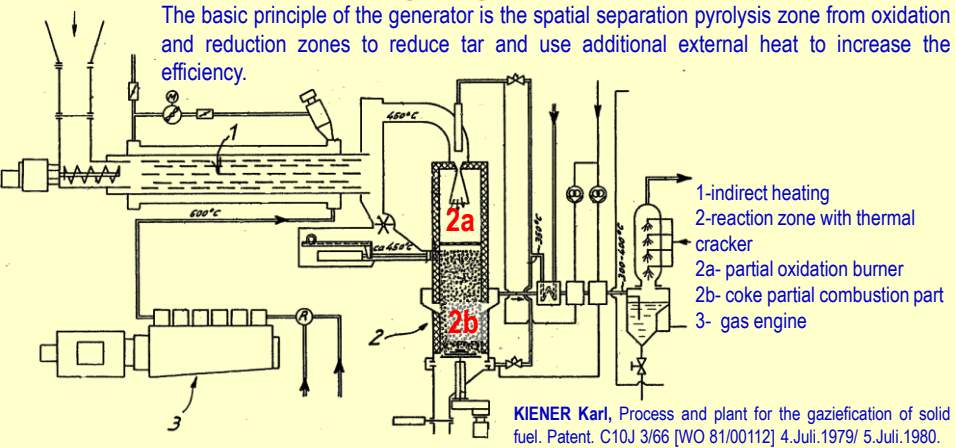
** Jenbacher, J624* GC with 2 stage turbocharger η_{CU} = 46,1% 4,35 MW_e, J920* GC with 2 stage turbocharger η_{CU} = 48,7%(NG) 9,5MW_e

*** The first commercial implementation in CR, Power plant Odry (25 CZK=1 EURO)

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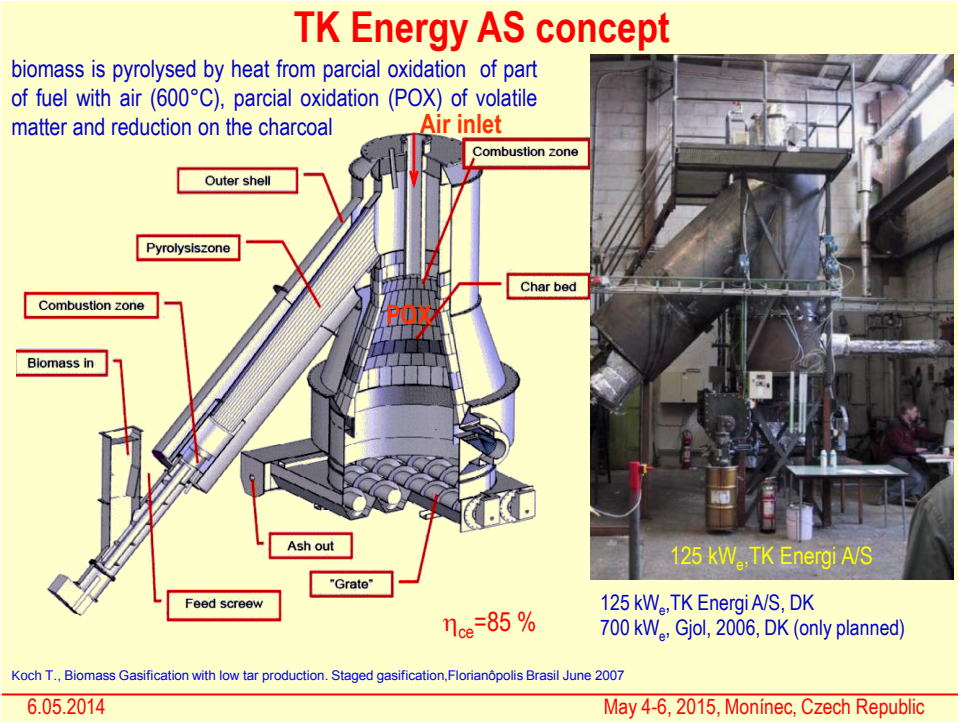
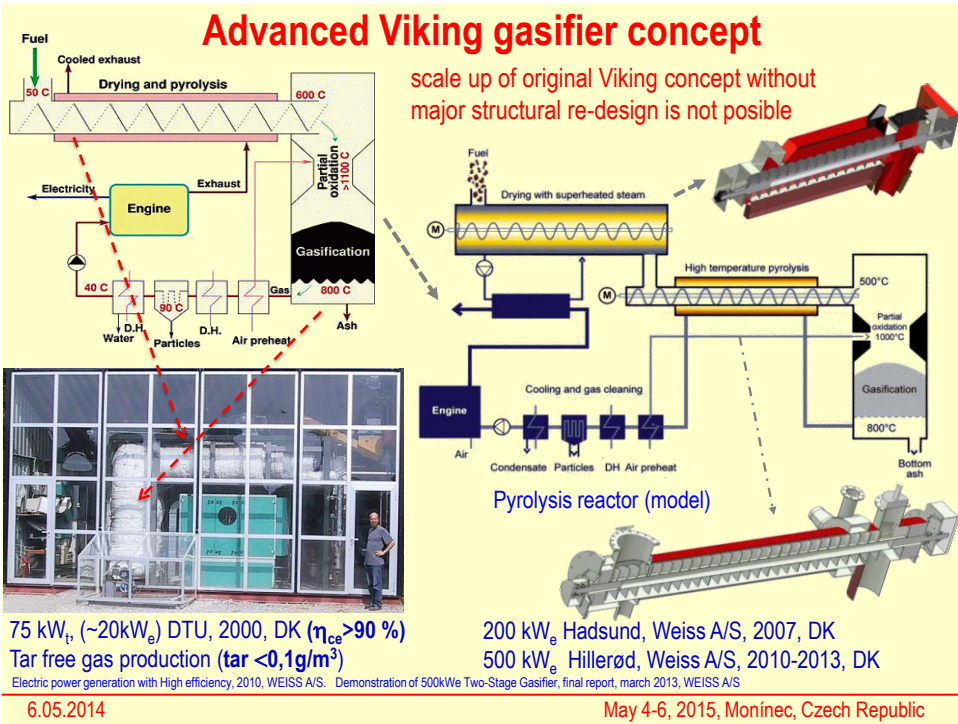
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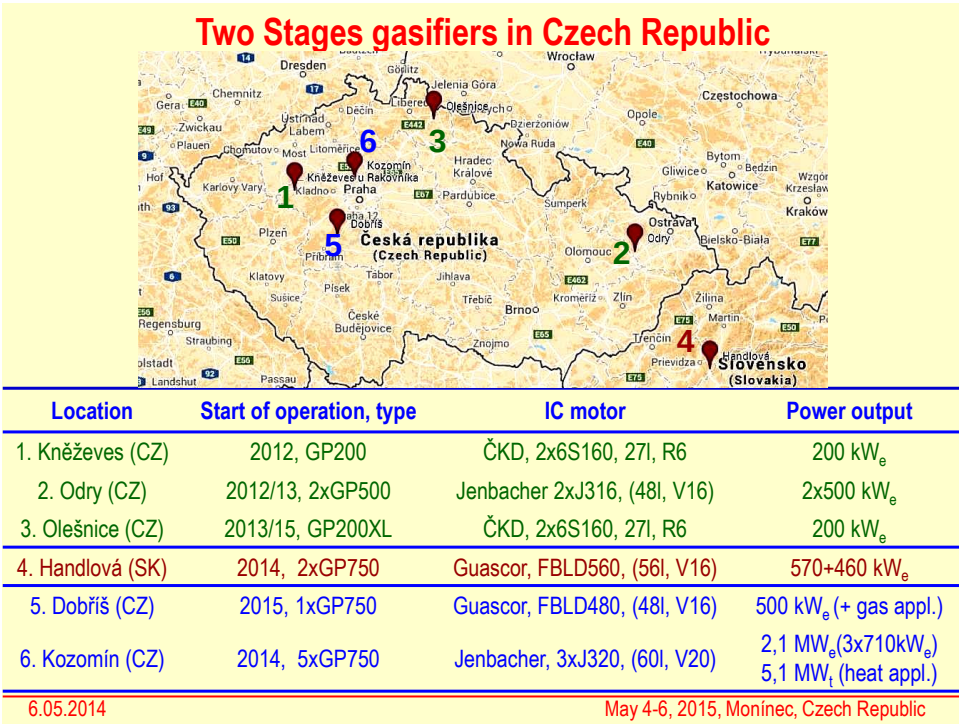
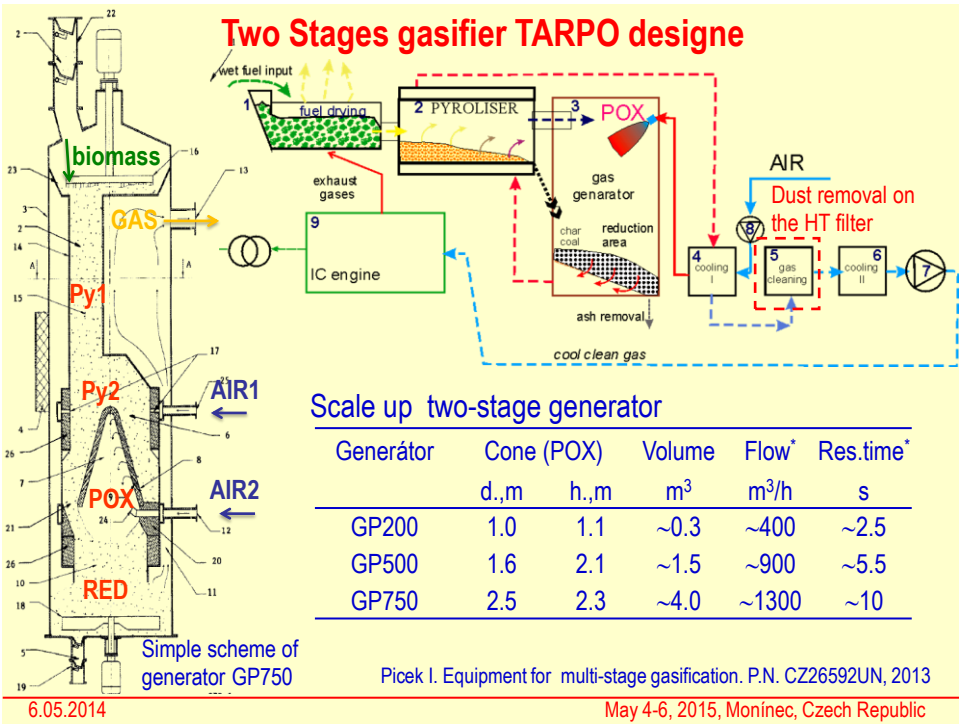
Staged gasifiers



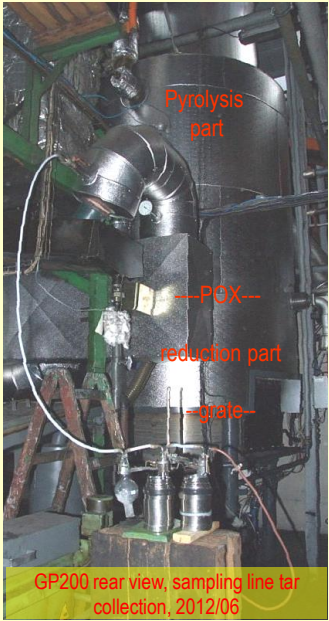
Advantage of sub process separation:

- increase of cool gas efficiency (η_{ce} >85%)
- decrease of **tar content** on safe level (< 0,1 g/m³)
- better gas quality (higher heating value)
- better process parameters control and heat management



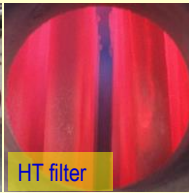


Prototype of Two-Stage gasifier, GP200, TARPO ltd. Kneževes



Basic parameters

Gas generator: GP200, 200kW_e, (from march 2012)
Dust removal: ceramic candle filters, 390-550°C
Tar removal (3/2013-disconnected): org. liq. scrubber 60°C/air reg.at 120°C
Final gas treatment: water washing/cooling tower
Cold gas efficiency (η_{CE}): ~85 %
Gas to electricity efficiency (η_{CU}): ~32 %
Overall el. efficiency (η): ~27,2 %
IC motors S160 ČKD Hořovice, vol 27 dm³
Cylinder/compression ratio: 6/11.5
Electrical output: 100 kW_e



Skobla S. Schemes and new developments in combinations of gasification with fuel gas cleaning for power generation in gas piston engines and gas turbines, Fecundus International Workshop, Prague, Czech Republic, June 12-14, 2013.

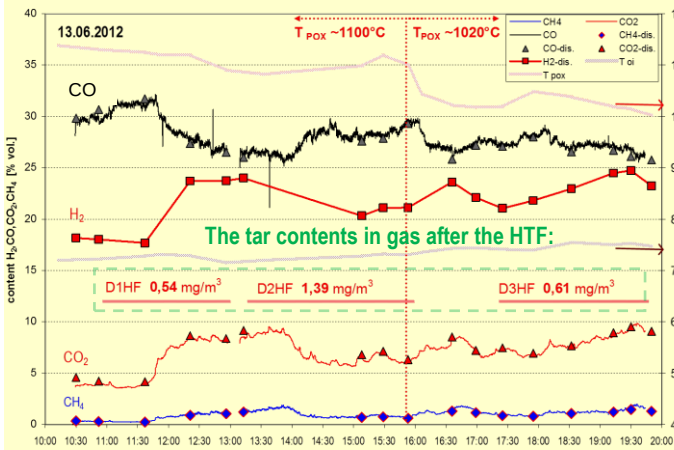
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Prototype of Two Stage gasifier, 200kW_e, gas composition

Selected data record

Average gas composition



components	Conc. % vol.
O ₂ in sample	0.84
CO ₂	7.72
H ₂	22.37
CO	27.31
CH ₄	0.97
N ₂	41.14
Ar	0.48
ethane	0.0017
ethylene	0.0018
acetylene	0.0002
propene	-
benzene	0.0005
toluene	0.00003
Other	0.0002
Sum	100
LHV(15/15C), MJ/m ³	5.89
LHV(0/0C), MJ/m ³	6.21

POX temperature: (1000 - 1150°C). Raw gas from generator contains minimum amount of tar and hydrocarbons (BTX).

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The basic parameters of the Power plant, Odry, 2012

Number of units:	2, GP500
Gas generator	
maximum power output (good quality fuel)	1700 (2500 kW _l)
temperature in pyrolysis chamber	500-650°C
temperature in POX chamber	1000-1100°C (1250°C)
exit gas temperature from the reducing zone	<750°C
Calorific value of gas (LHV)	5,5-6,5 MJ/m ³
Cogeneration unit (engine with el. generators)	
Manufacturer	Jenbacher AG (GE)
Type	J316 GS (LEANOX)
Number of cylinders/capacity	16/48dm ³
Rated el. Power	500 (550) kW_e
Fuel	
Consumption of wood chips (abs. dry)	~360 (400) kg/hod
Chip size	20 až 80 mm (1-50mm)
Ash content (dry basis)	< 2 % mass (<5 mass)
Maximal moisture content, before drying, max.	50 % (60%)
Moisture content, after drying	<10 hm. (20 hm. %)
The waste heat of cooling water (80°-90°C)	650 kW_t
The electrical efficiency	min. 32%
Specific fuel consumption (abs. dry)	~ 0,7 kg/kWh_{el}
Specific el. output	~ 1,43 kWh_{el}/kg

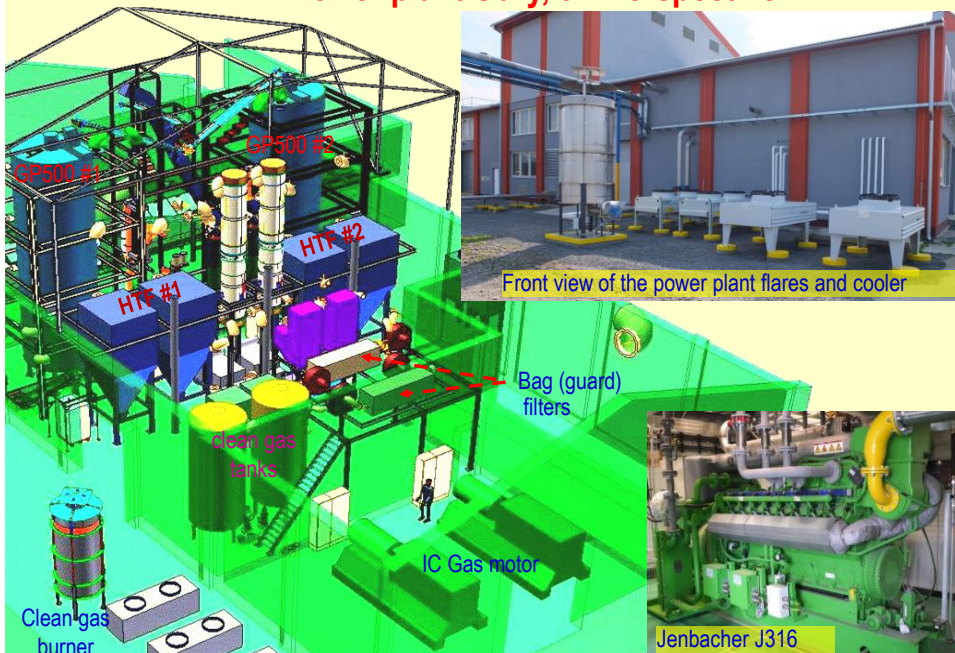


GP500 #1, November 2012

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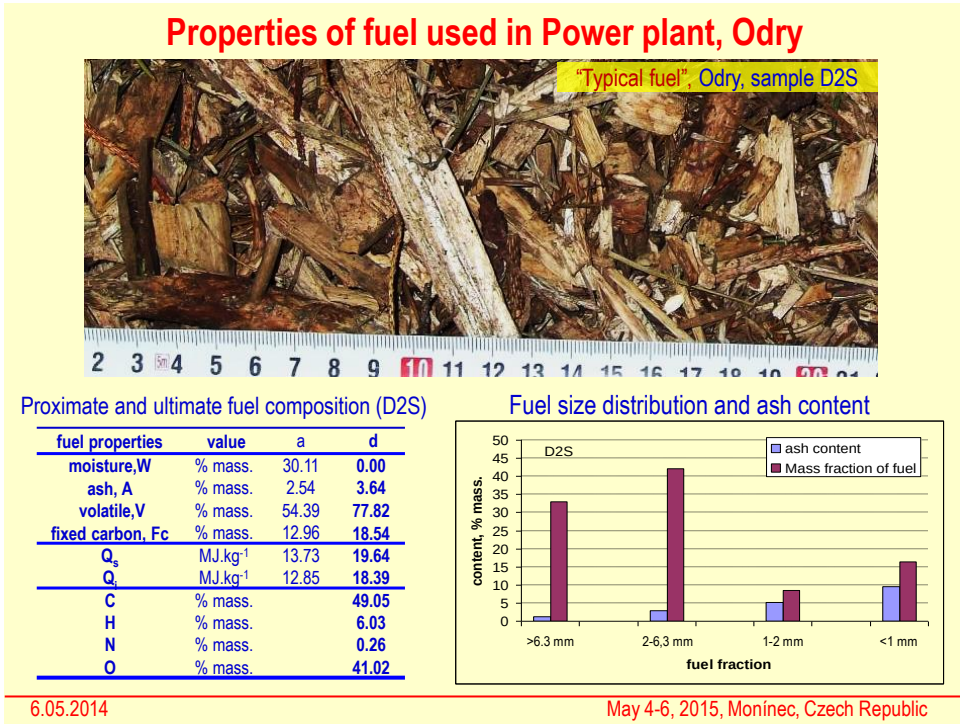
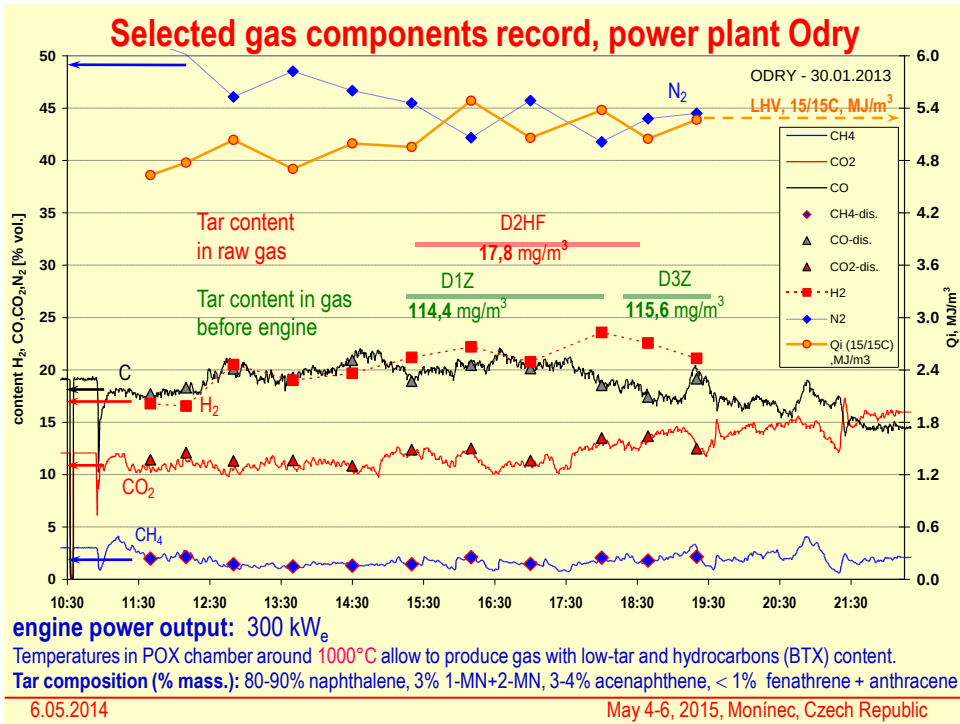
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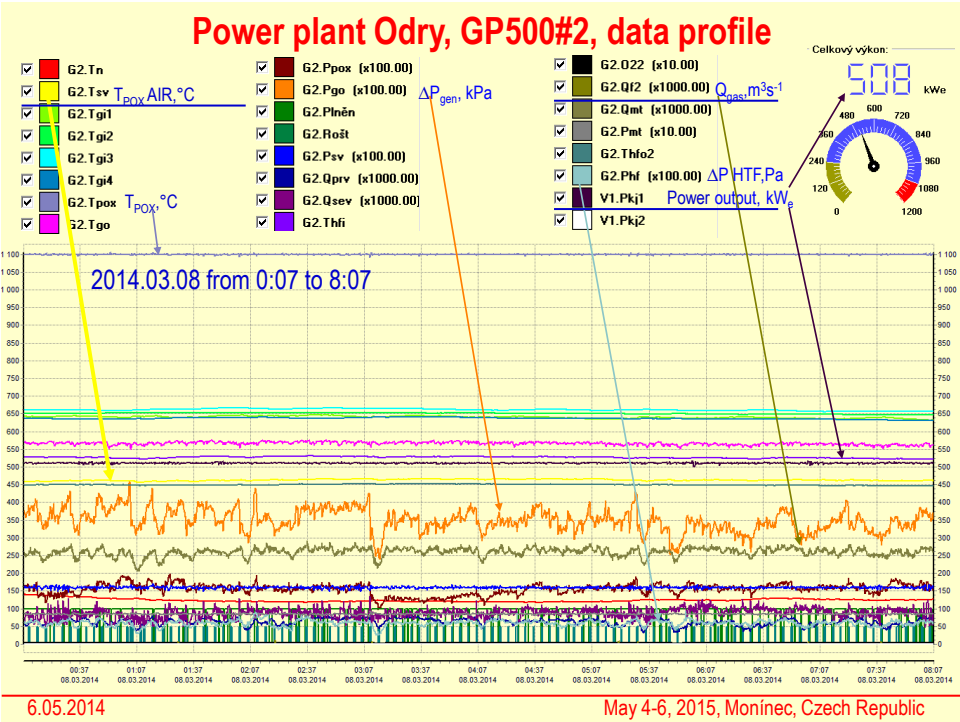
Power plant Odry, 3D Perspective



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Power plant, Kozomín

Reactors hall, 5xGP750, March, 2014

Filtr units, February, 2015

Gas generator:
Dust removal:
Final gas treatment:

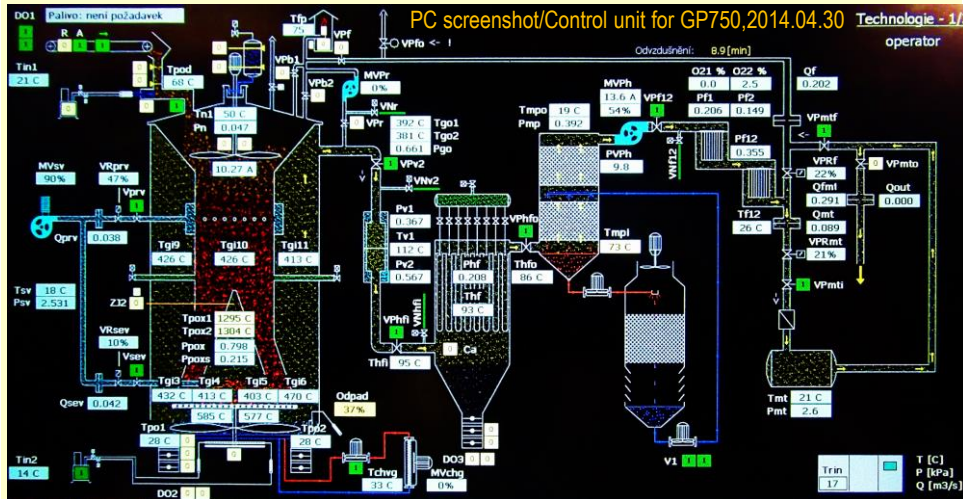
5 x GP750, (3x710kW_e, +4,2MW_j)
fabric bag filters, 120-150°C
water washing/cooling tower

IC motors: Jenbacher, 3xJ320

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Power plant, Handlová (SK), 2014

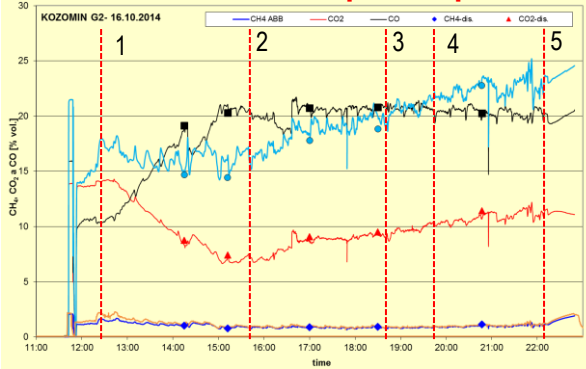


Gas generator: 2 x GP750, (2x750kW_e) IC motors: Guascor, FB LD560, (56l, V16)
Dust removal: fabric bag filters, 120-150°C
Final gas treatment: water washing/cooling tower
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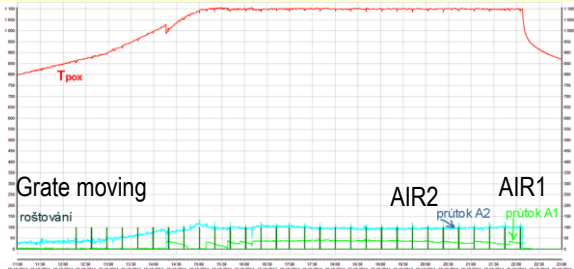
Power plant, Handlová (SK)



Start up and operation of GP750



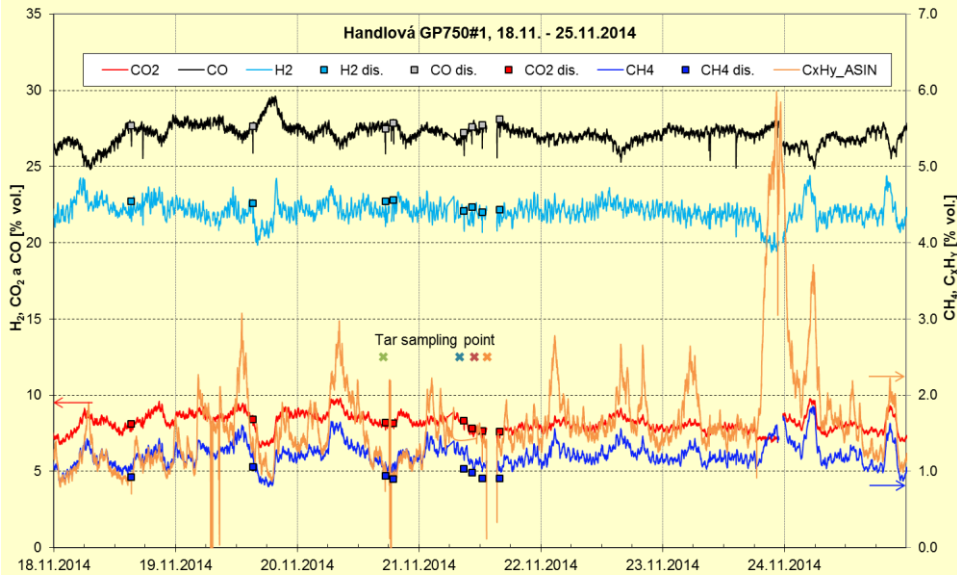
1. 12:37 switching to gasification
2. 15:37 filter operation
3. 18:45 motor (J320) start
4. 19:45 $P_w=450kW_e$
5. 18:45 master shot down (circulation cooling water pump ;)



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Long time operation of GP750



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Conclusion

	co-current Imbert	GP300	Viking DTU 75kW	GP200	GP500	GP750
Chips moisture, % hm.	<10	<10	35-45	<10	<10	<10
CO	25,5	24,6	19,6	26,7	25,0	27,7
H ₂	17,2	16,4	30,5	23,0	22,3	22,4
CH₄	3,0	2,2	1,2	1,1	2,0	1,0
CO ₂	9,6	9,6	15,4	8,0	9,5	8,1
N₂	43,5	46,1	33,3	40,6	41,1	40,4
Other	1,2	1,1	0	0,6	0,1	0,2
Tar content, mg/m³	1000-2000	1300-2000	<5	0,5- 2,0	5,0- 40,0	30-100
Q _i (15°C) MJ/m ³	6,3	5,7	5,6	5,9	5,9	6,3

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Odry 2012, November,
Clean gas burning
during generators
stress tests (2,5WMT)

**Thank you for your
attention**

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