FUNDAMENTOS DA GERAÇÃO DISTRIBUIDA

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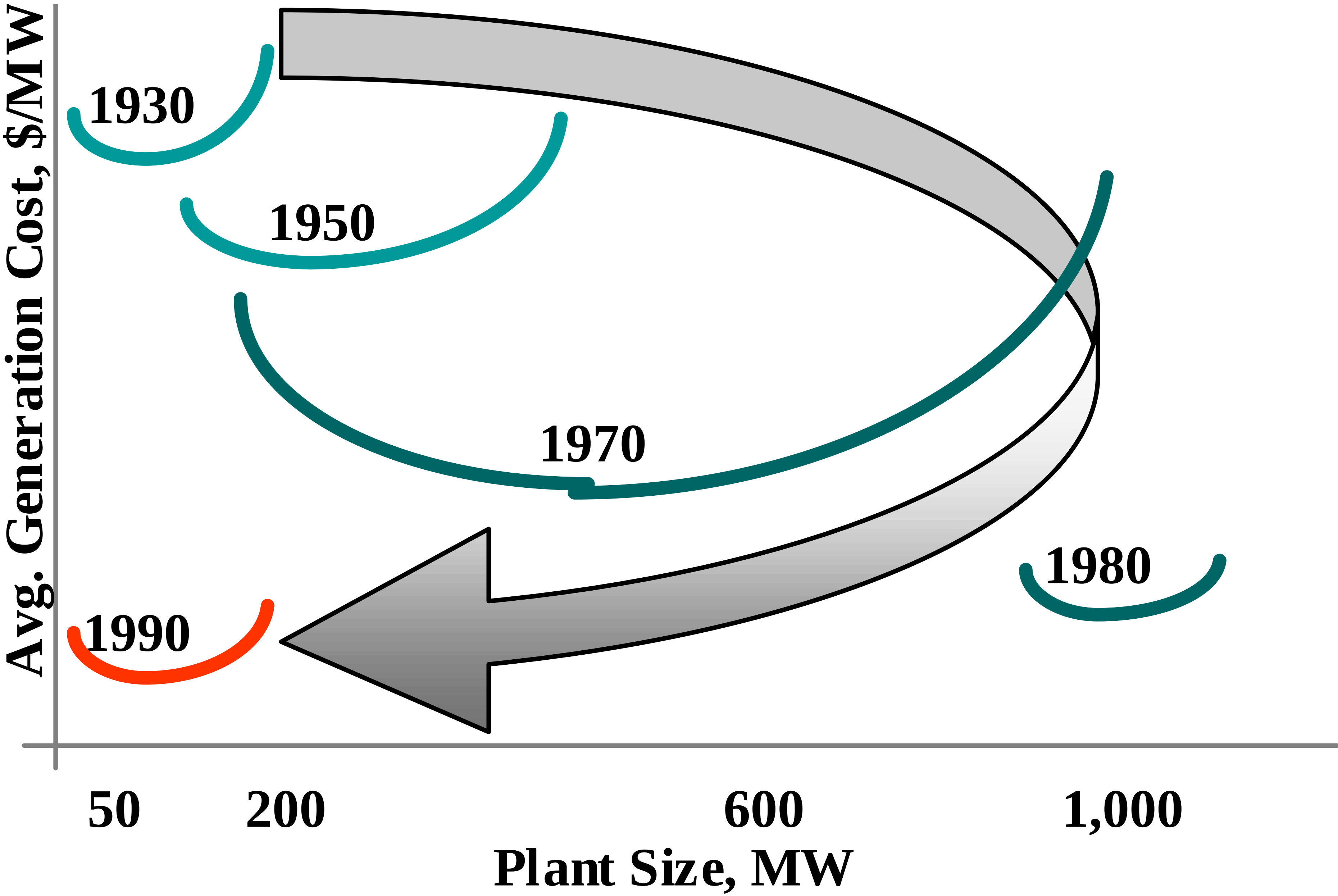
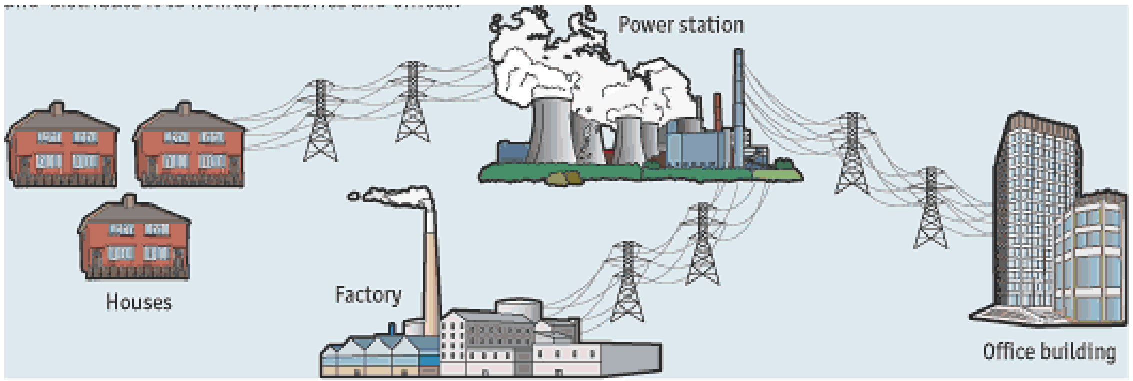
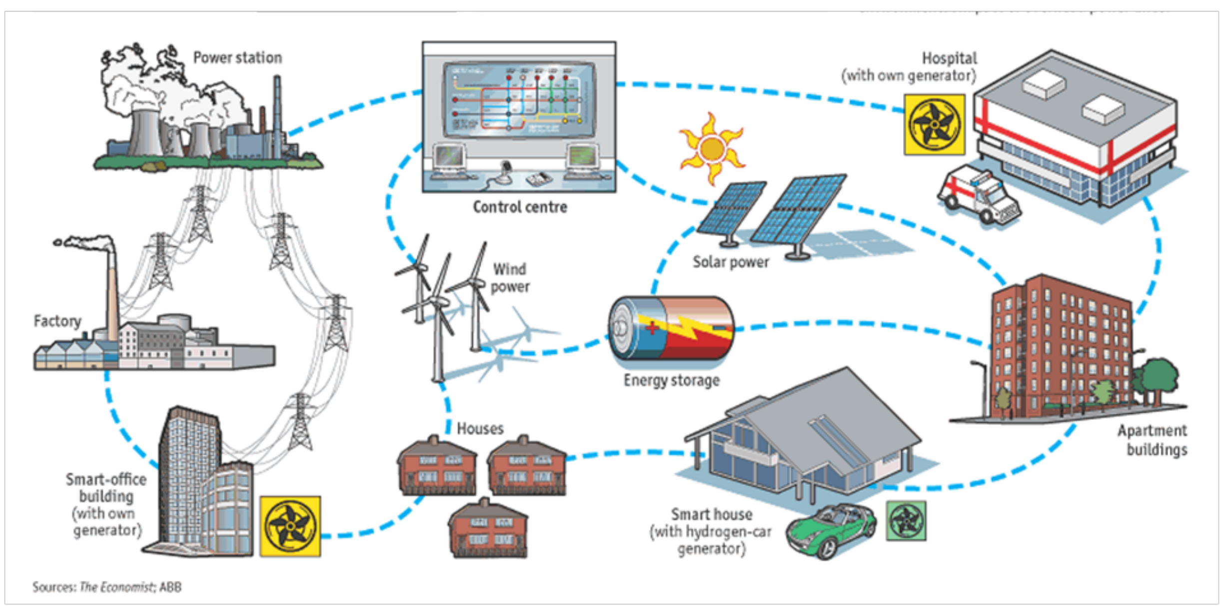
Núcleo de Excelência em Geração Termelétrica e Distribuída


Avg. Generation Cost, $/MW
1930
1950
1970
1980
1990
50
200
600
1,000
Plant Size, MW

O retorno às ideias de Edison – Segurança e confiabilidade no fornecimento de energia.





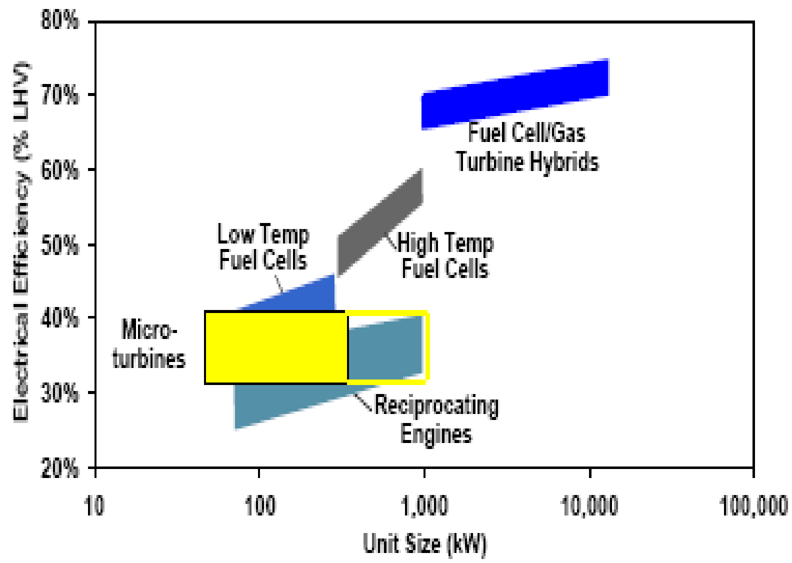
Geração distribuída

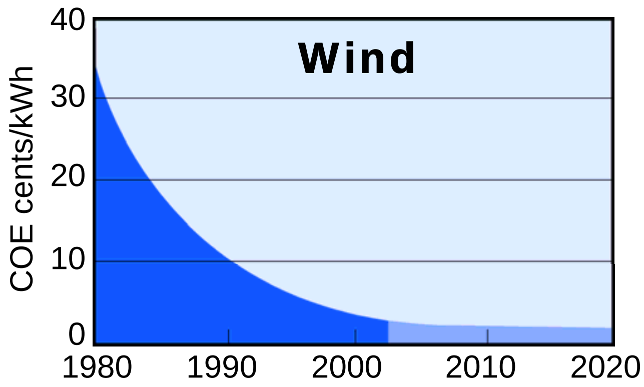
Conceito:

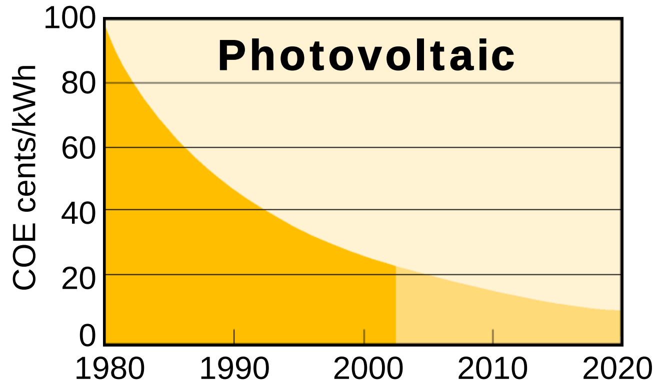
Geração de eletricidade em pequena escala conectada (ou não) na rede de distribuição perto dos centros de carga ou, no próprio local do consumidor.

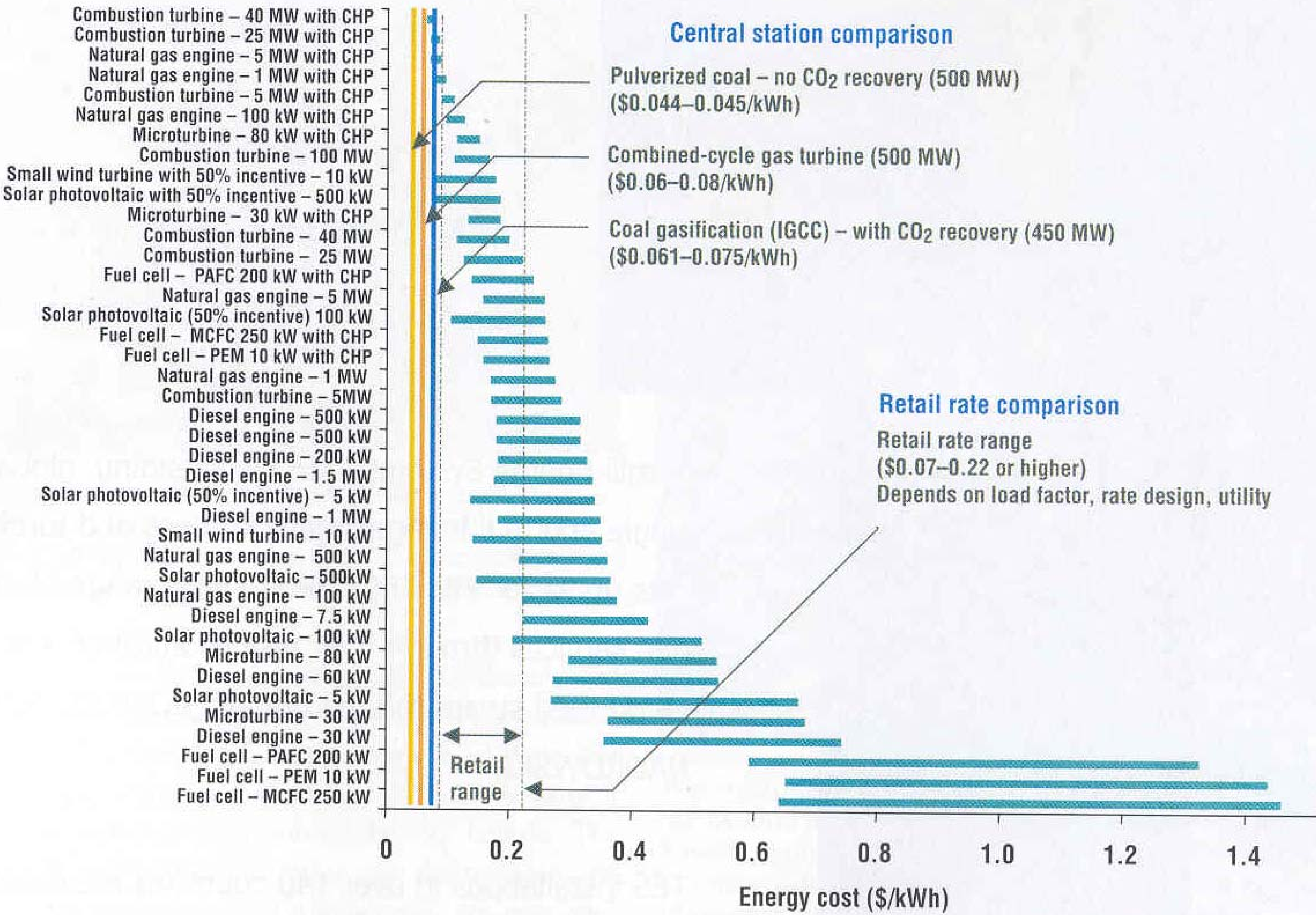
Seleção dos acionadores primários

Generator	Range	Approx. Cost	Ton/kW
Gas Turbine	> 1 MW	$500 /kW	.60
IC Engine	.1 to 3 MW	$500 /kW	.35
Microturbine	< .4 MW	$1,000 /kW	.35
Fuel Cell	> .25 MW	$3,700 /kW	.16

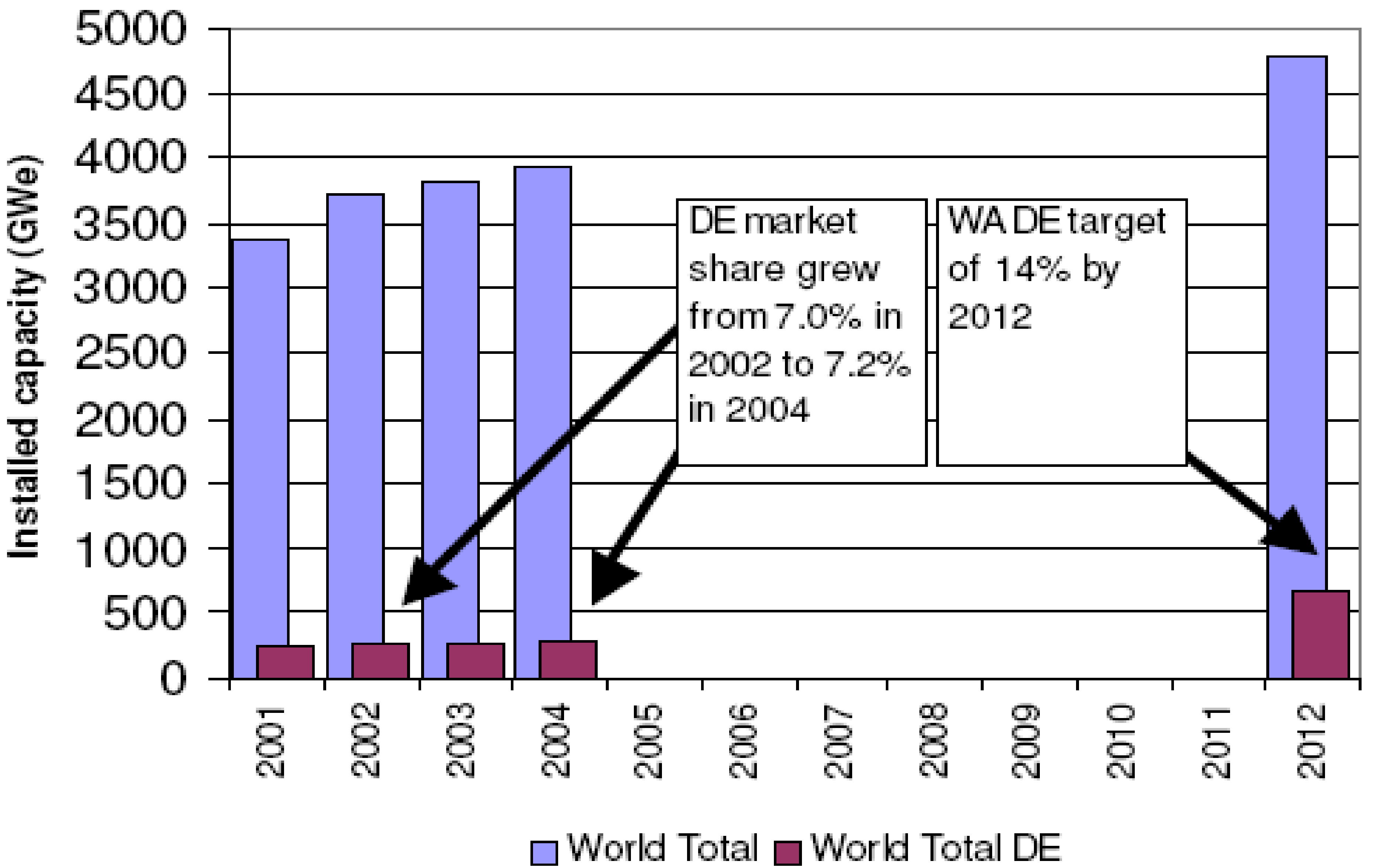








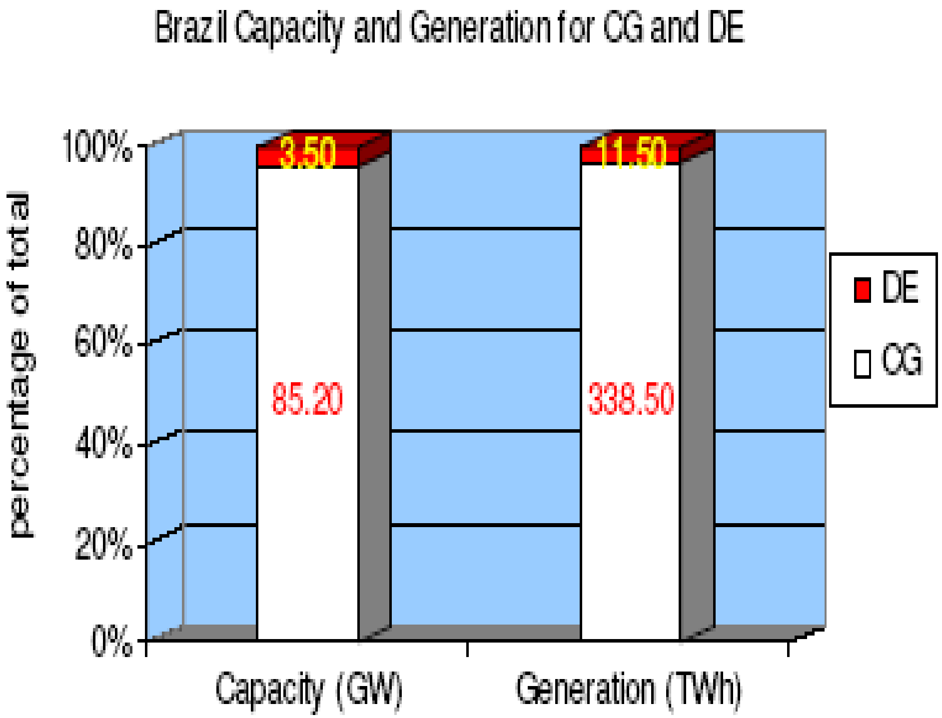
Combustion turbine – 40 MW with CHP
Combustion turbine – 25 MW with CHP
Natural gas engine – 5 MW with CHP
Natural gas engine – 1 MW with CHP
Combustion turbine – 5 MW with CHP
Natural gas engine – 100 kW with CHP
Microturbine – 80 kW with CHP
Combustion turbine – 100 MW
Small wind turbine with 50% incentive – 10 kW
Solar photovoltaic with 50% incentive – 500 kW
Microturbine – 30 kW with CHP
Combustion turbine – 40 MW
Combustion turbine – 25 MW
Fuel cell – PAFC 200 kW with CHP
Natural gas engine – 5 MW
Solar photovoltaic (50% incentive) 100 kW
Fuel cell – MCFC 250 kW with CHP
Fuel cell – PEM 10 kW with CHP
Natural gas engine – 1 MW
Combustion turbine – 5MW
Diesel engine – 500 kW
Diesel engine – 500 kW
Diesel engine – 200 kW
Diesel engine – 1.5 MW
Solar photovoltaic (50% incentive) – 5 kW
Diesel engine – 1 MW
Small wind turbine – 10 kW
Natural gas engine – 500 kW
Solar photovoltaic – 500kW
Natural gas engine – 100 kW
Diesel engine – 7.5 kW
Solar photovoltaic – 100 kW
Microturbine – 80 kW
Diesel engine – 60 kW
Solar photovoltaic – 5 kW
Microturbine – 30 kW
Diesel engine – 30 kW
Fuel cell – PAFC 200 kW
Fuel cell – PEM 10 kW
Fuel cell – MCFC 250 kW
Central station comparison
Pulverized coal – no CO2 recovery (500 MW)
($0.044–0.045/kWh)
Combined-cycle gas turbine (500 MW)
($0.06–0.08/kWh)
Coal gasification (IGCC) – with CO2 recovery (450 MW)
($0.061–0.075/kWh)
Retail rate comparison
Retail rate range
($0.07–0.22 or higher)
Depends on load factor, rate design, utility
Retail
range
0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
Energy cost ($/kWh)



Installed capacity (GWe)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
DE market share grew from 7.0% in 2002 to 7.2% in 2004
WA DE target of 14% by 2012
World Total
World Total DE

No Brasil (2004)

Eletricidade total gerada	350 TWh
Capacidade instalada	88,7 GWe
Eletricidade gerada GD	11,5 TWh
Capacidade Instalada GD	3,5 GWe
% Geração total	3,3 %
% Capacidade instalada	3,9 %

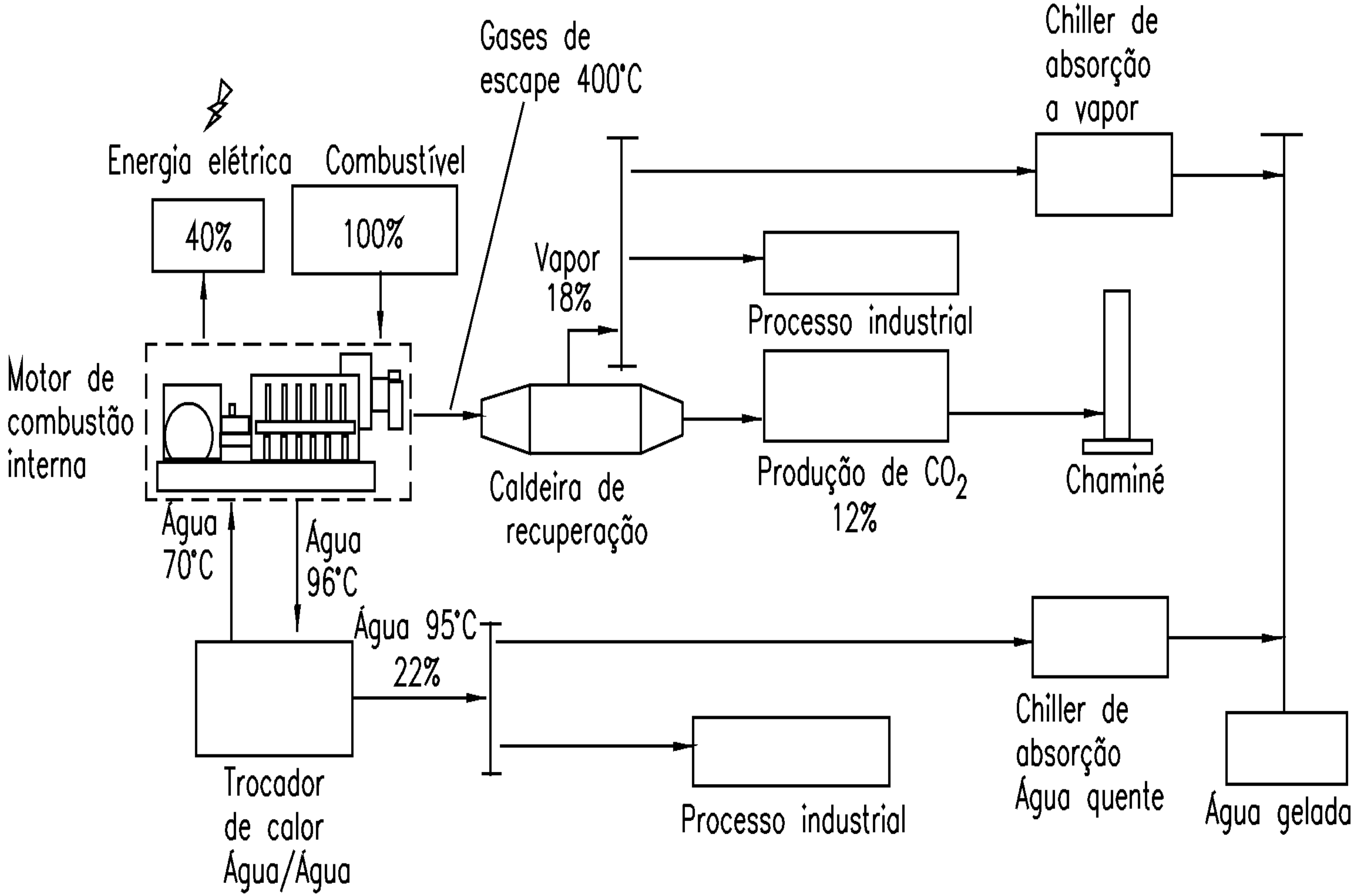


- Forças motrizes
  - Nova legislação
  - Risco hídrico
  - Aumento da demanda de energia de qualidade
  - Potencial para CDM
  - Necessidade de novas plantas geradoras
  - Necessidade do aumento de eficiência (cogeração)

- Barreiras
  - O preço do combustível acompanha o internacional
  - Cultura hídrica centralizada
  - Pobre infra-estrutura para o gás
  - Necessidade de novas regras de interconexão
  - Incentivo à venda de excedentes

Estado-da-arte dos motores de combustão interna

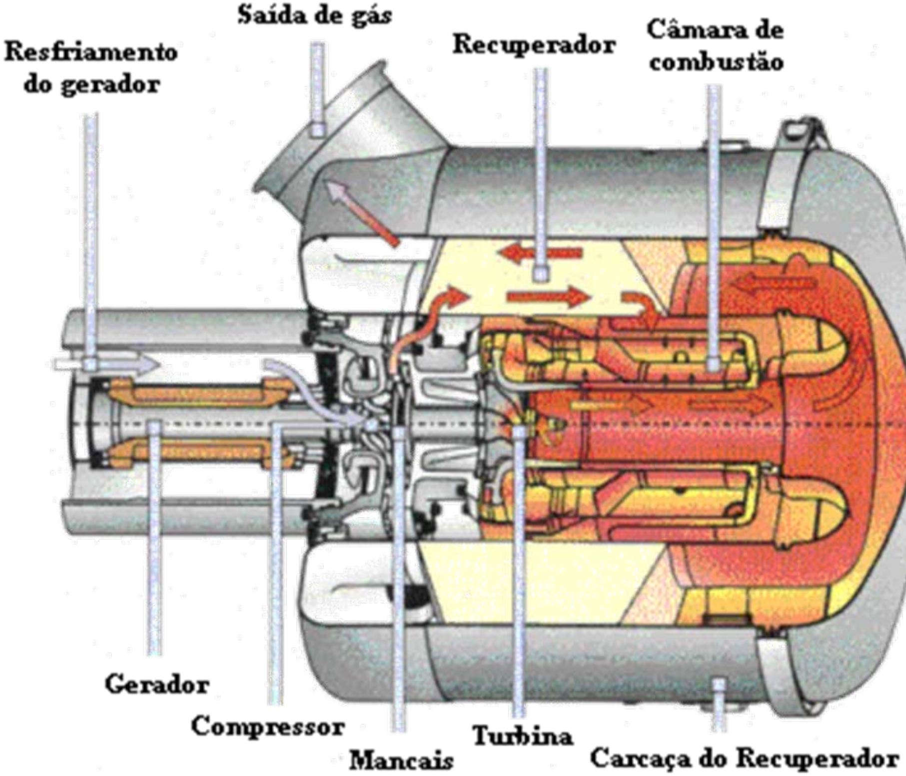
Disponível comercialmente	Sim
Faixa de capacidades	5 kW a 30 MW ou maiores
Combustíveis	Gás natural, óleo diesel, gás de aterro sanitário, etc.
Eficiência	25 a 45%
Emissões de poluentes	Pode necessitar de controle das emissões para NO_X e CO
Outras características	Adequação aos sistemas de cogeração (a eficiência pode ultrapassar 80%)
‘Status’ comercial	Produto amplamente disponível



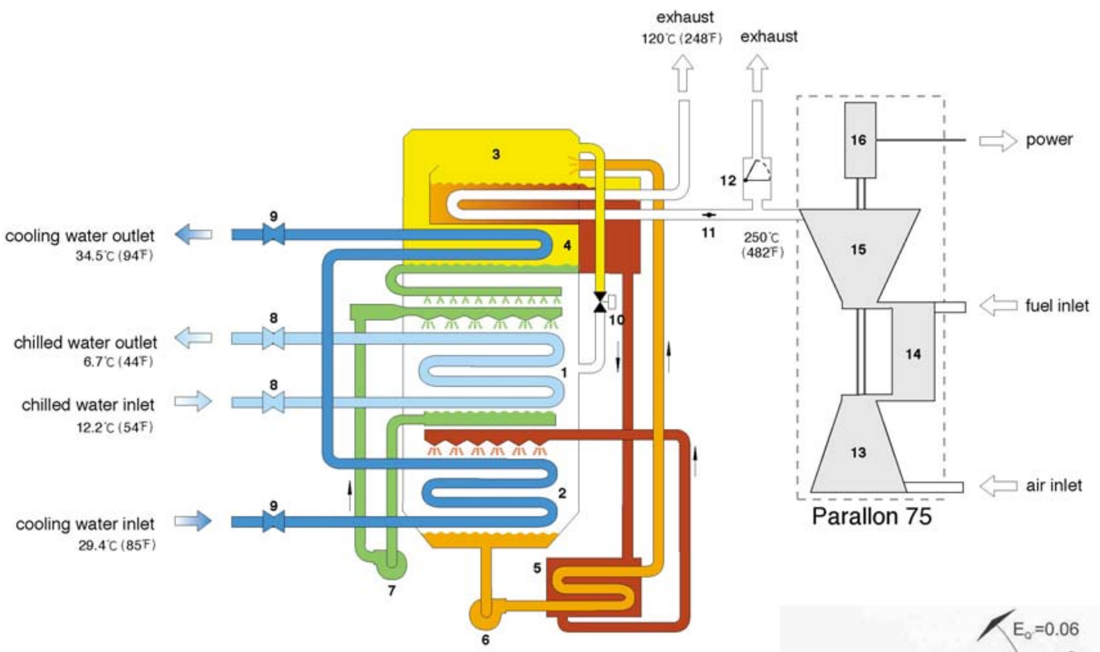
Gases de escape 400°C
Chiller de absorção a vapor
Energia elétrica
Combustível
40%
100%
Vapor 18%
Processo industrial
Motor de combustão interna
Produção de CO_2 12%
Chaminé
Caldeira de recuperação
Água 70°C
Água 96°C
Água 95°C 22%
Trocador de calor Água/Água
Processo industrial
Chiller de absorção Água quente
Água gelada

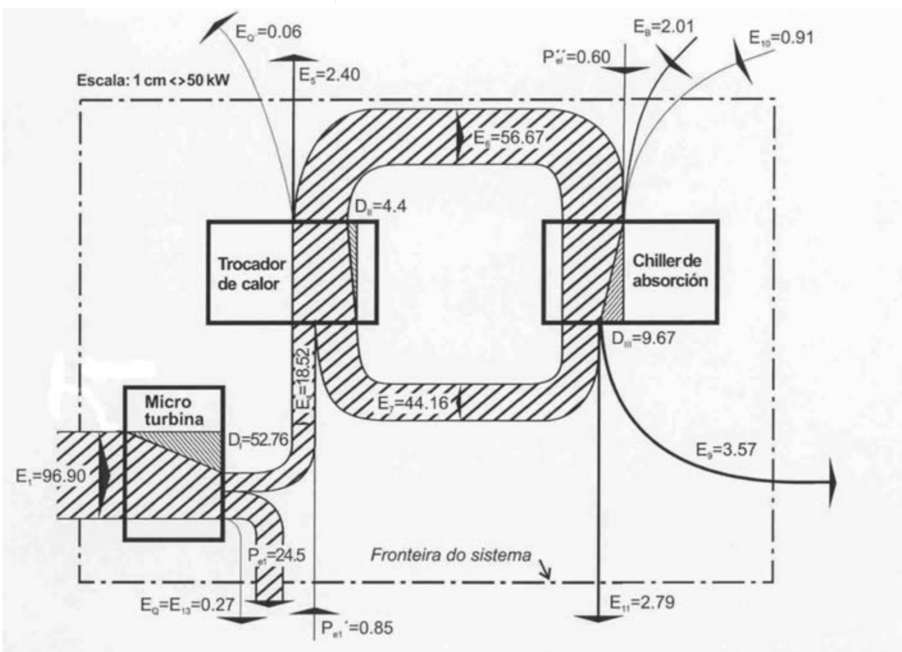
Estado-da-arte das microturbinas a gás

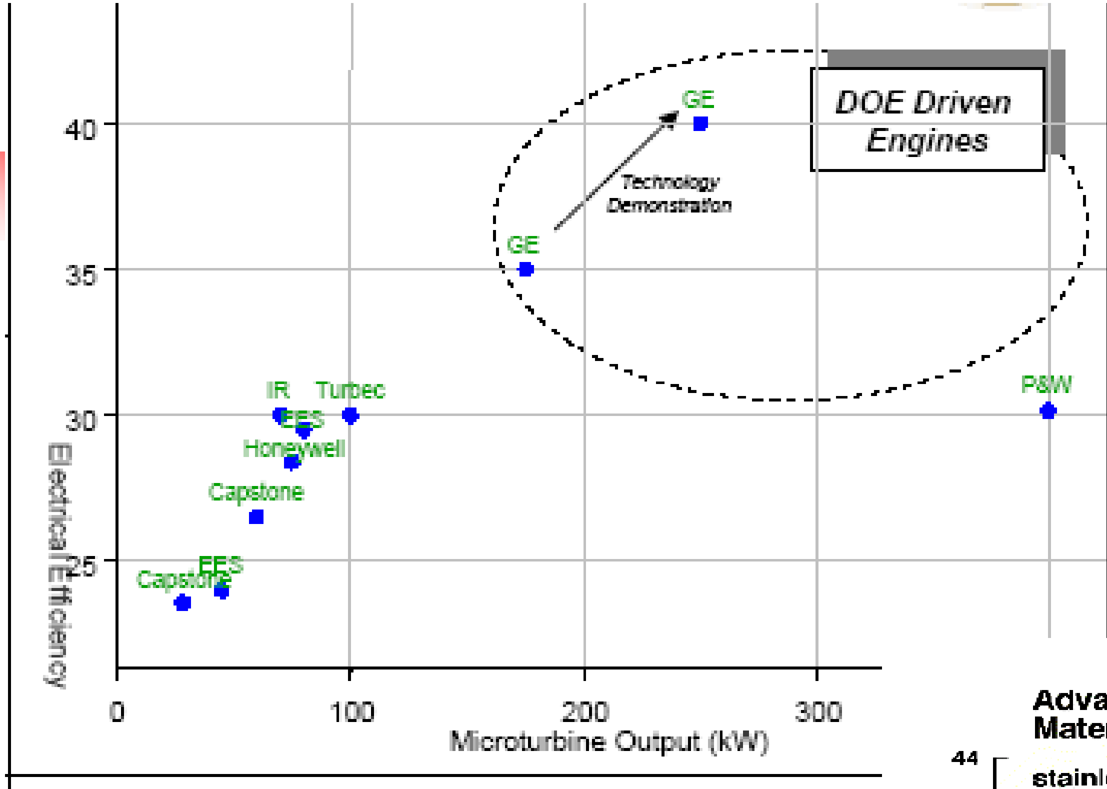
Microturbinas	
Disponibilidade comercial	Sim (Limitada)
Faixa de capacidade	25 a 500 kW
Combustíveis empregados	Gás natural, GLP (ou propano), hidrogênio, Diesel, etc.
Eficiência	20 a 30% (com recuperador de calor)
Emissões de poluentes	Baixa (<9-50 ppm) NO_X
Outras características	Cogeração (água entre 50 e 80 °C - com recuperador)
'Status' comercial	Produção de pequenos volumes, novos protótipos comerciais

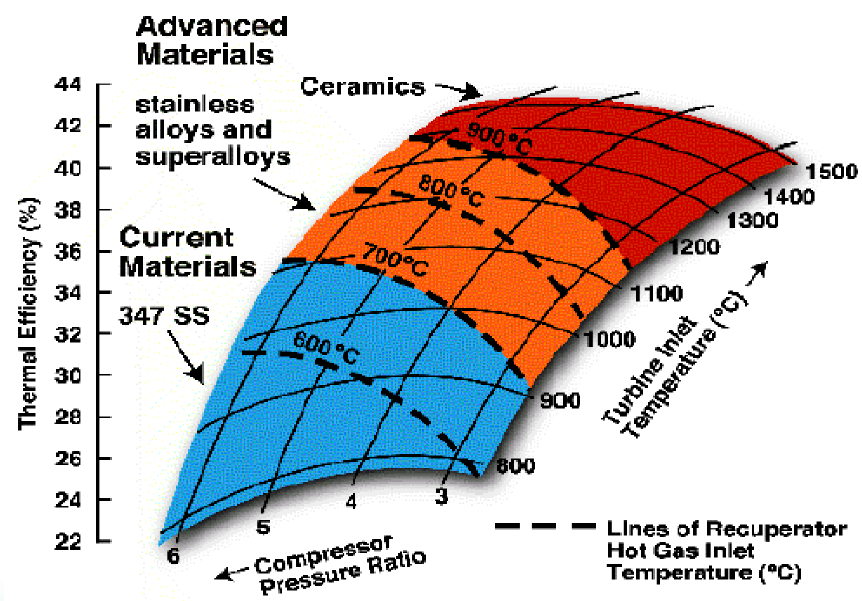

Saída de gás
Resfriamento do gerador
Recuperador
Câmara de combustão
Gerador
Compressor
Mancais
Turbina
Carcaça do Recuperador

Single Stage Lo-Temp Exhaust Fired



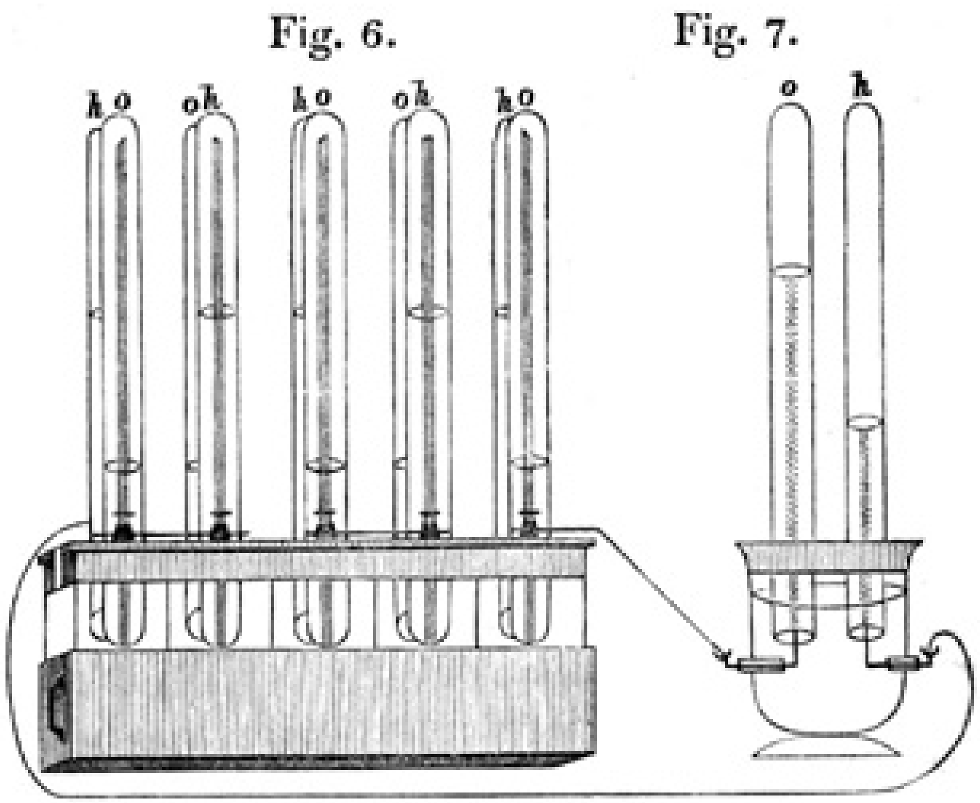



DOE Driven Engines
Technology Demonstration
GE
GE
IR
Turbec
EES
Honeywell
Capstone
EES
Capstone
P&W
40
35
30
25
Electrical Efficiency
0
100
200
300
Microturbine Output (kW)


Advanced Materials
Ceramics
stainless alloys and superalloys
Current Materials
347 SS
900 °C
800 °C
700 °C
600 °C
Thermal Efficiency (%)
44
42
40
38
36
34
32
30
28
26
24
22
1500
1400
1300
1200
1100
1000
900
800
Turbine Inlet Temperature (°C)
6
5
4
3
Compressor Pressure Ratio
Lines of Recuperator Hot Gas Inlet Temperature (°C)

CÉLULAS A COMBUSTÍVEL

William Robert Grove (1811 -1896), used a platinum electrode immersed in nitric acid and a zinc electrode in zinc sulfate to generate about 12 amps of current at about 1.8 volts.



	PAFC	SOFC	MCFC	PEMFC
Disponível Comercialmente	Sim	Não	Não	Não
Capacidades	100-200 kW	1kW - 10 MW	250 kW - 10 MW	3-250 kW
Combustível	Gás Natural, Biogás, propano.	Gás Natural, Hidrogênio, óleo combustível.	Gás Natural, Hidrogênio	Gás Natural, Hidrogênio, propano, diesel.
Eficiência	36-42%	45-60%	45-55%	30-40%
Emissões	Praticamente zero	Praticamente zero	Praticamente zero	Praticamente zero
Cogeração	Água quente	Água quente e vapor de baixa e alta pressão	Água quente e vapor de baixa e alta pressão	Água a 80°C
Produção Comercial	Algumas já estão disponíveis	2004	2004	2003/2004

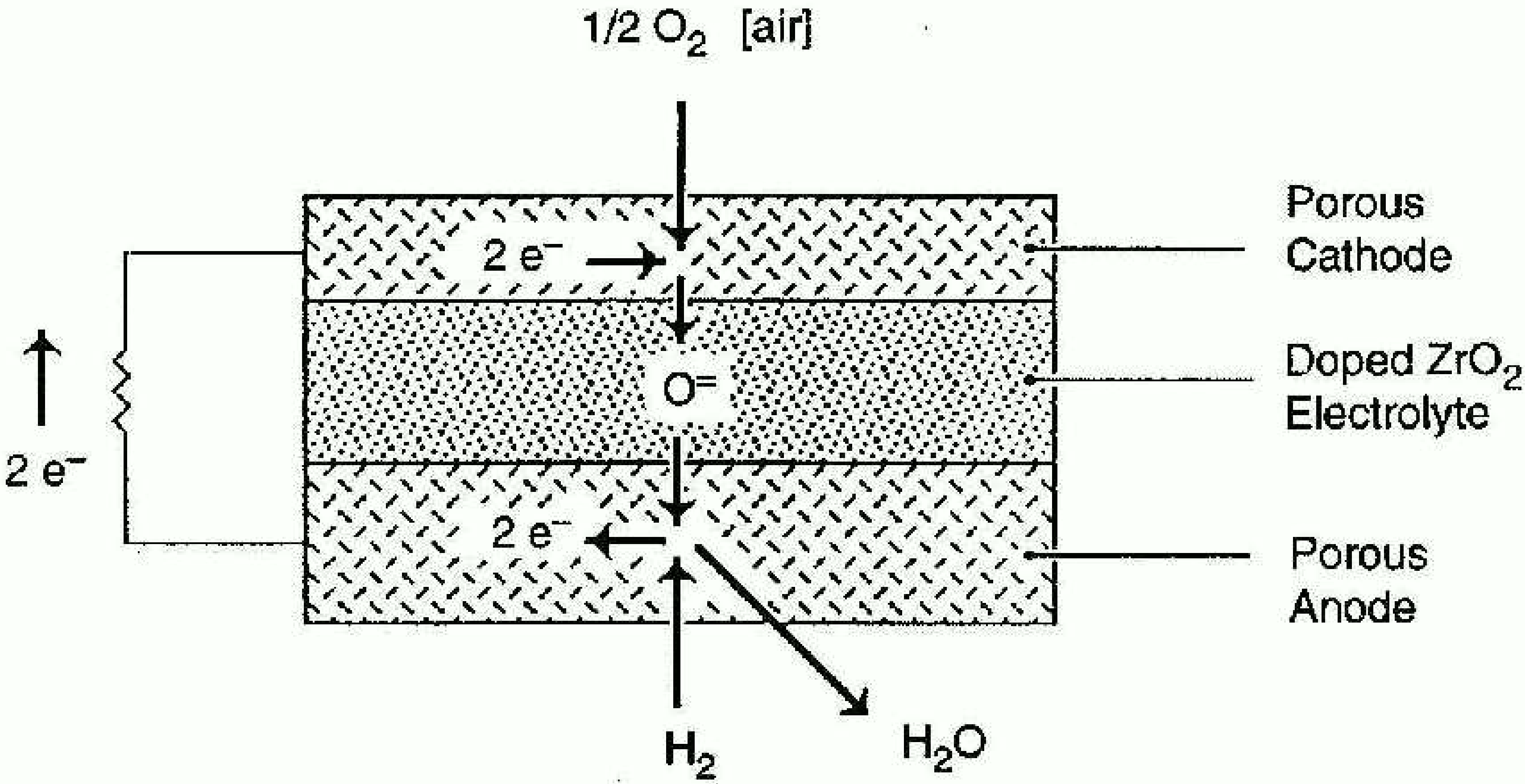
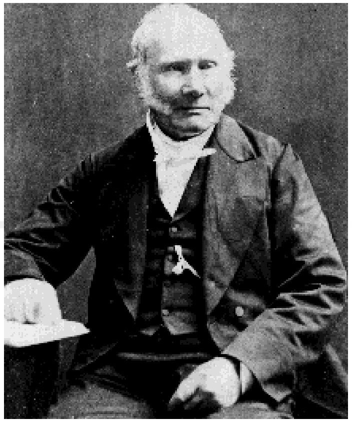
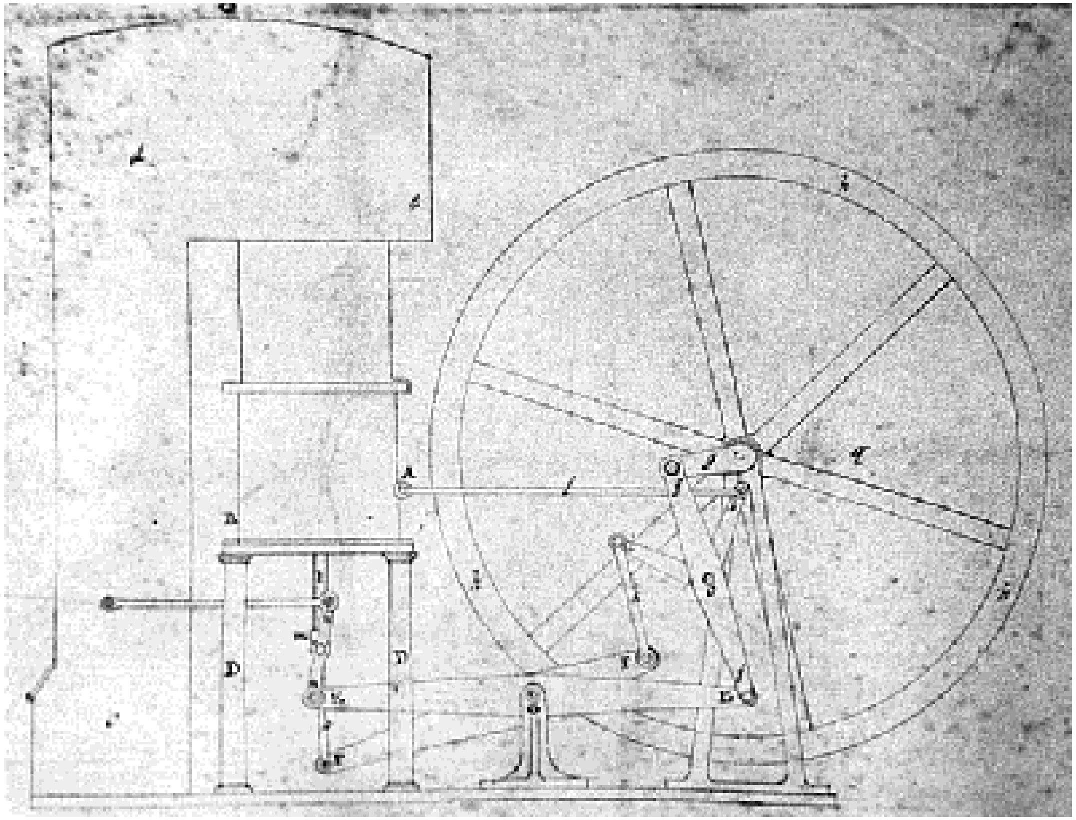


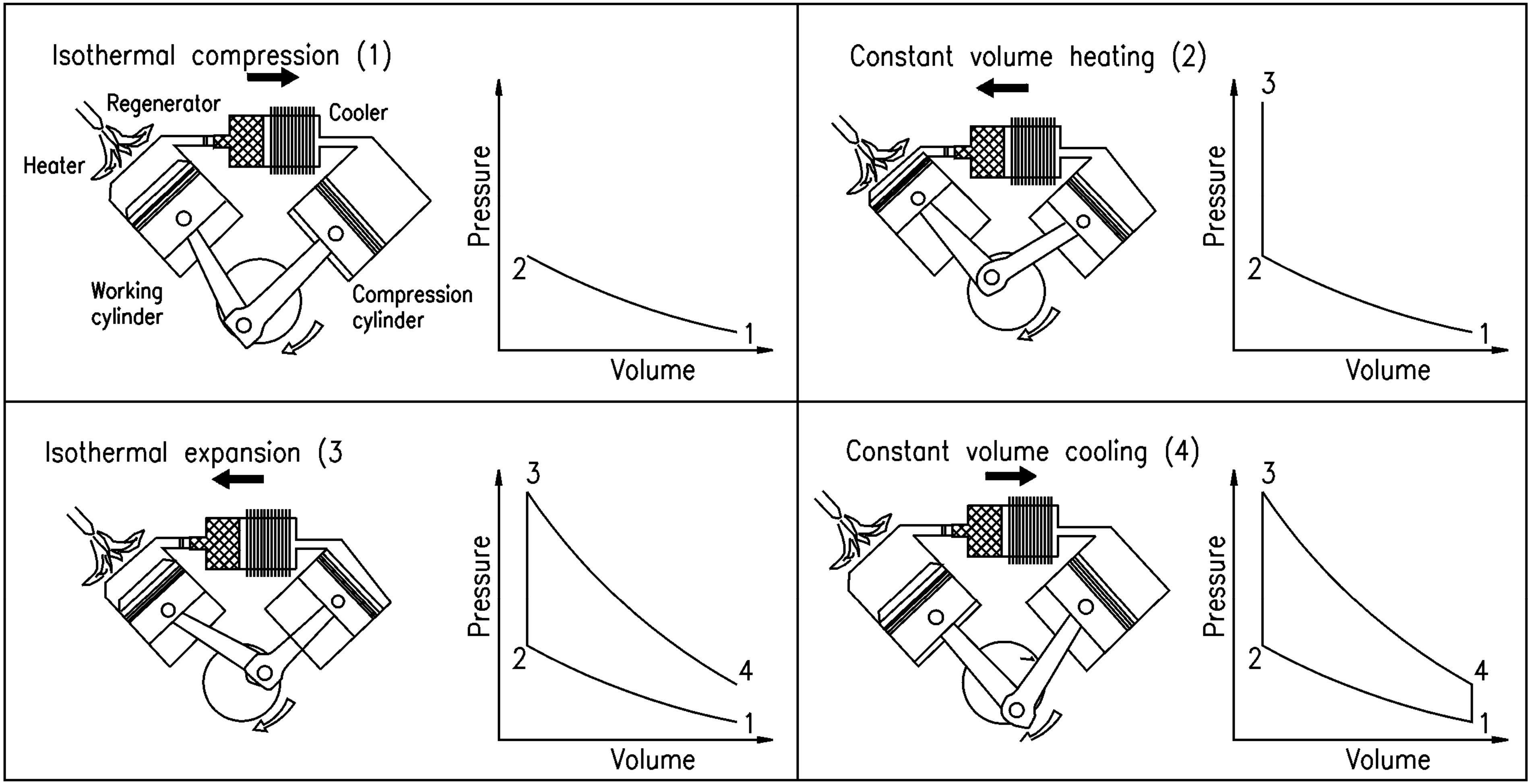
Figure 3.14 Operation principles of a solid oxide fuel cell (SOFC) (Source: ref. [17])

MOTORES STIRLING



- O motor Stirling é um motor de combustão externa alternativo, desenvolvido por Robert Stirling em 1817.

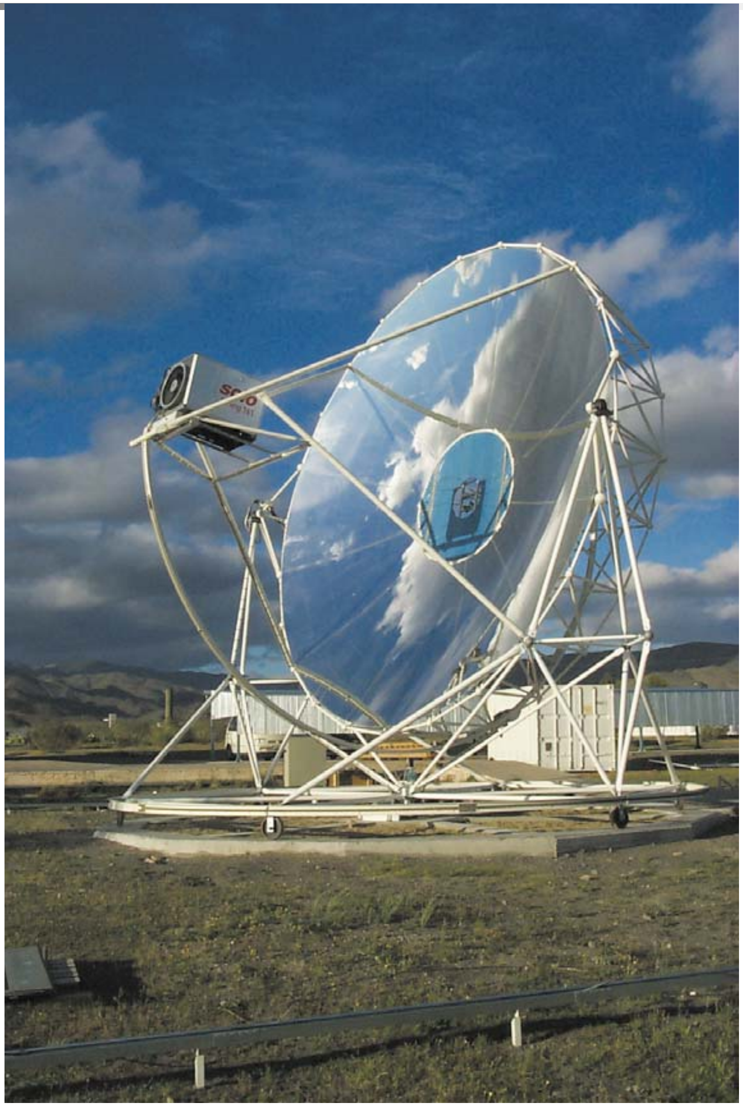



Isothermal compression (1)
Regenerator
Cooler
Heater
Working cylinder
Compression cylinder
Pressure
Volume
2
1
Constant volume heating (2)
Pressure
Volume
3
2
1
Isothermal expansion (3
Pressure
Volume
3
2
4
1
Constant volume cooling (4)
Pressure
Volume
3
2
4
1

Características dos motores Stirling

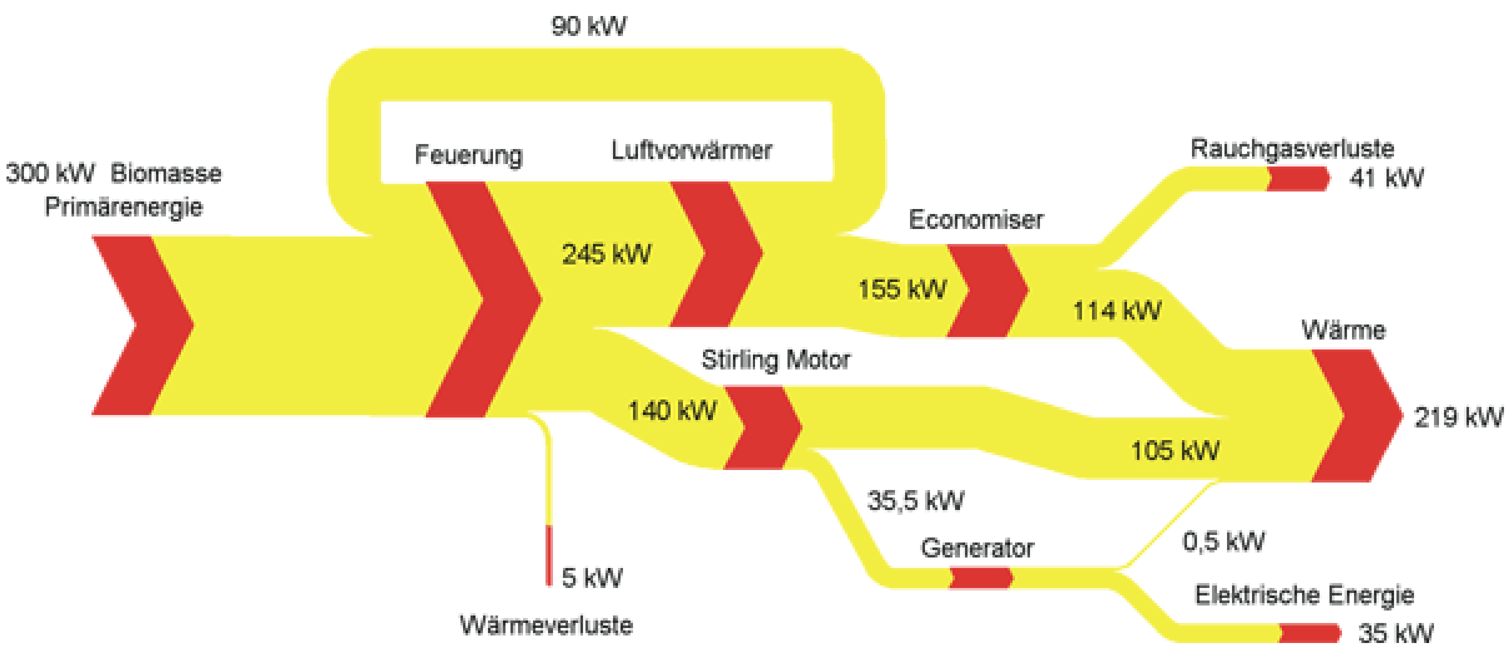
Estado da arte	Não comercial
Capacidade	1-75 kW
Combustível	Preferencialmente gás natural, mas com grande flexibilidade
Eficiência	12-20% (Prognóstico 30%)
Emissões	Potencial de emissões muito baixo
Situação comercial	Comercialmente disponível para 2002-2005
Outras características	Alguns modelos são projetados para cogeração

Tecnologia Stirling Solar



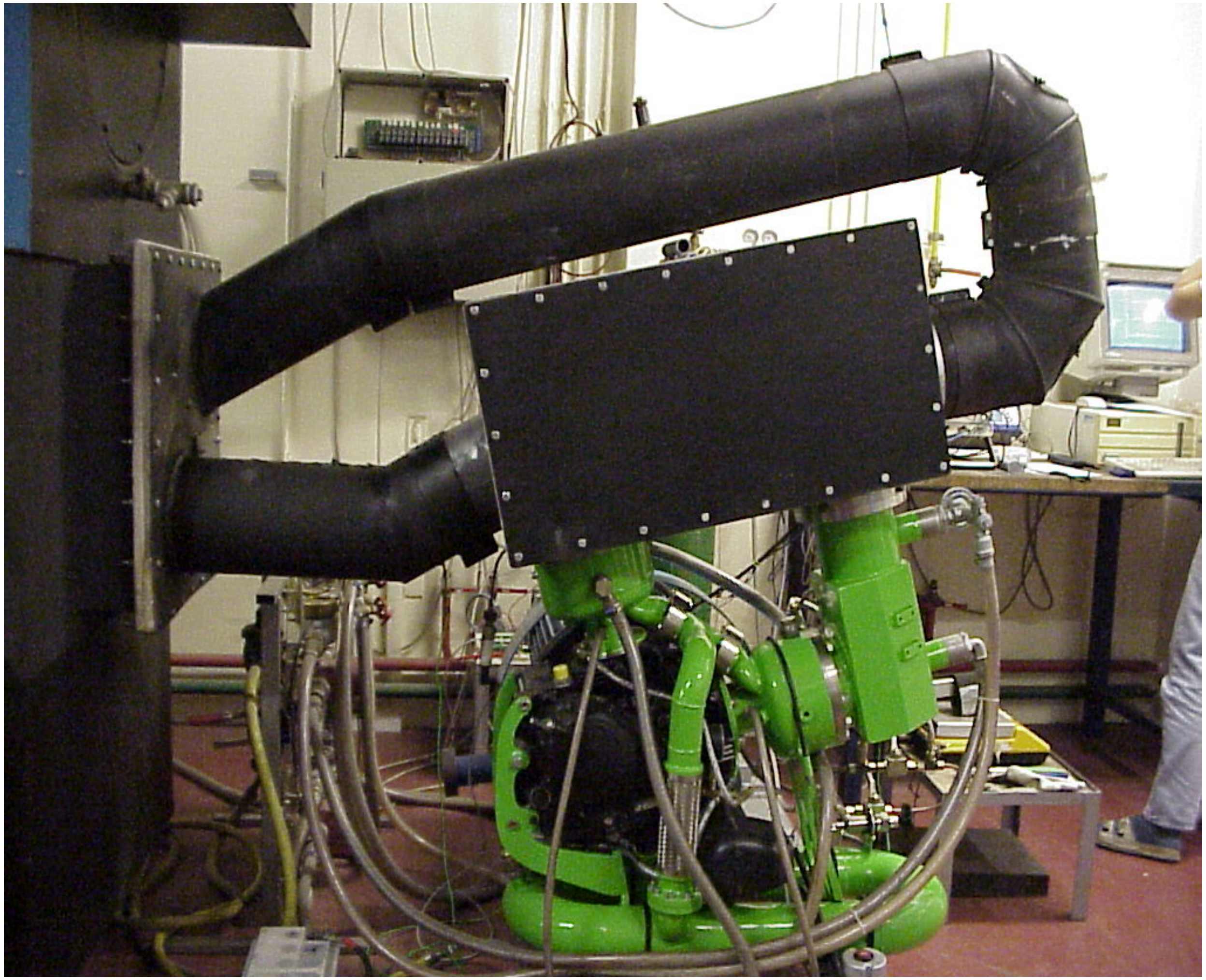
BIOS
BIOENERGIESYSTEME /
DTU

AUSTRIA

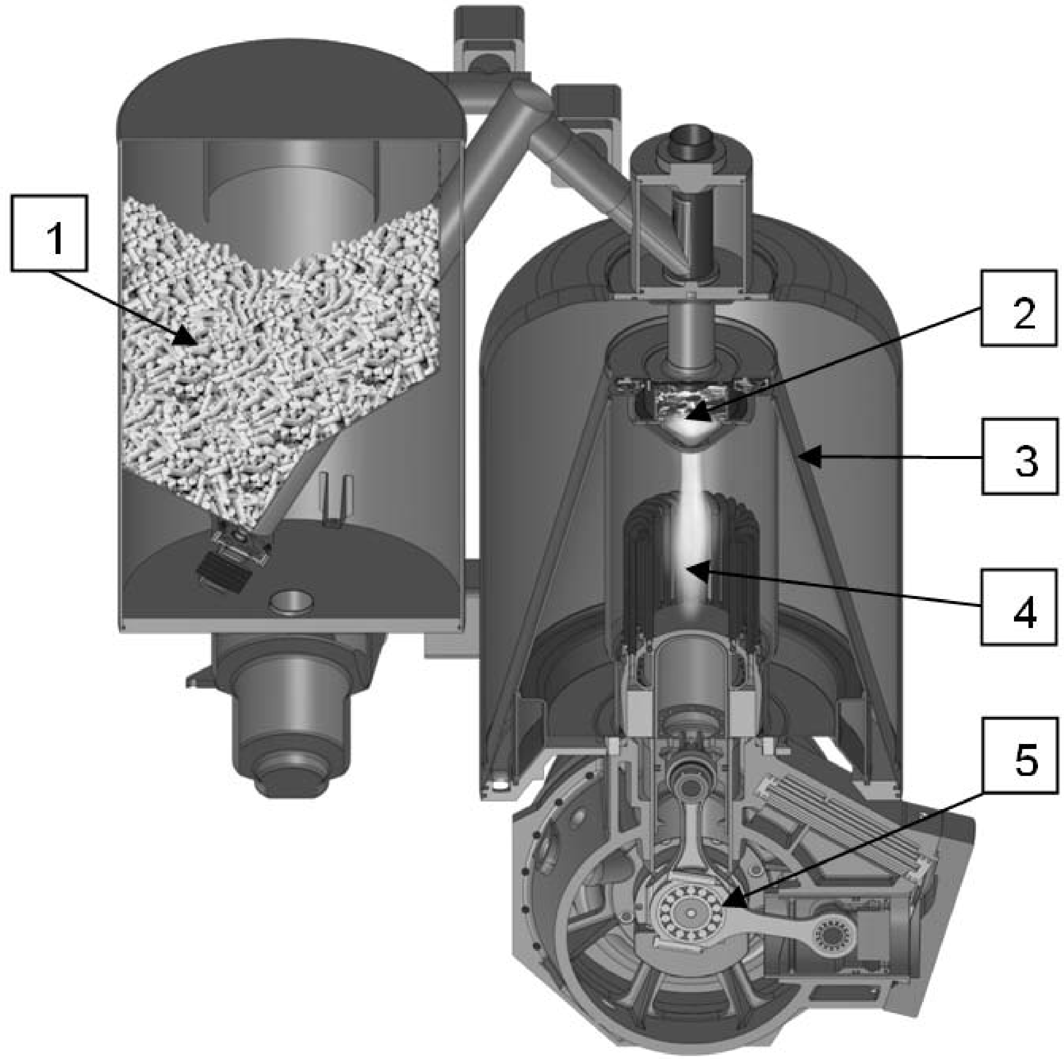


JOANNEUM RESEARCH

AUSTRIA



SUNPOWER



Legenda:

1. Silo de biomassa
2. Pirolizador
3. Recuperador de calor
4. Trocador de calor
5. Motor Stirling

Figura 3-27. Modulo gerador de 3kW para biomassa da Sunmachine (Schlappa, 2006).

SISTEMAS HÍBRIDOS

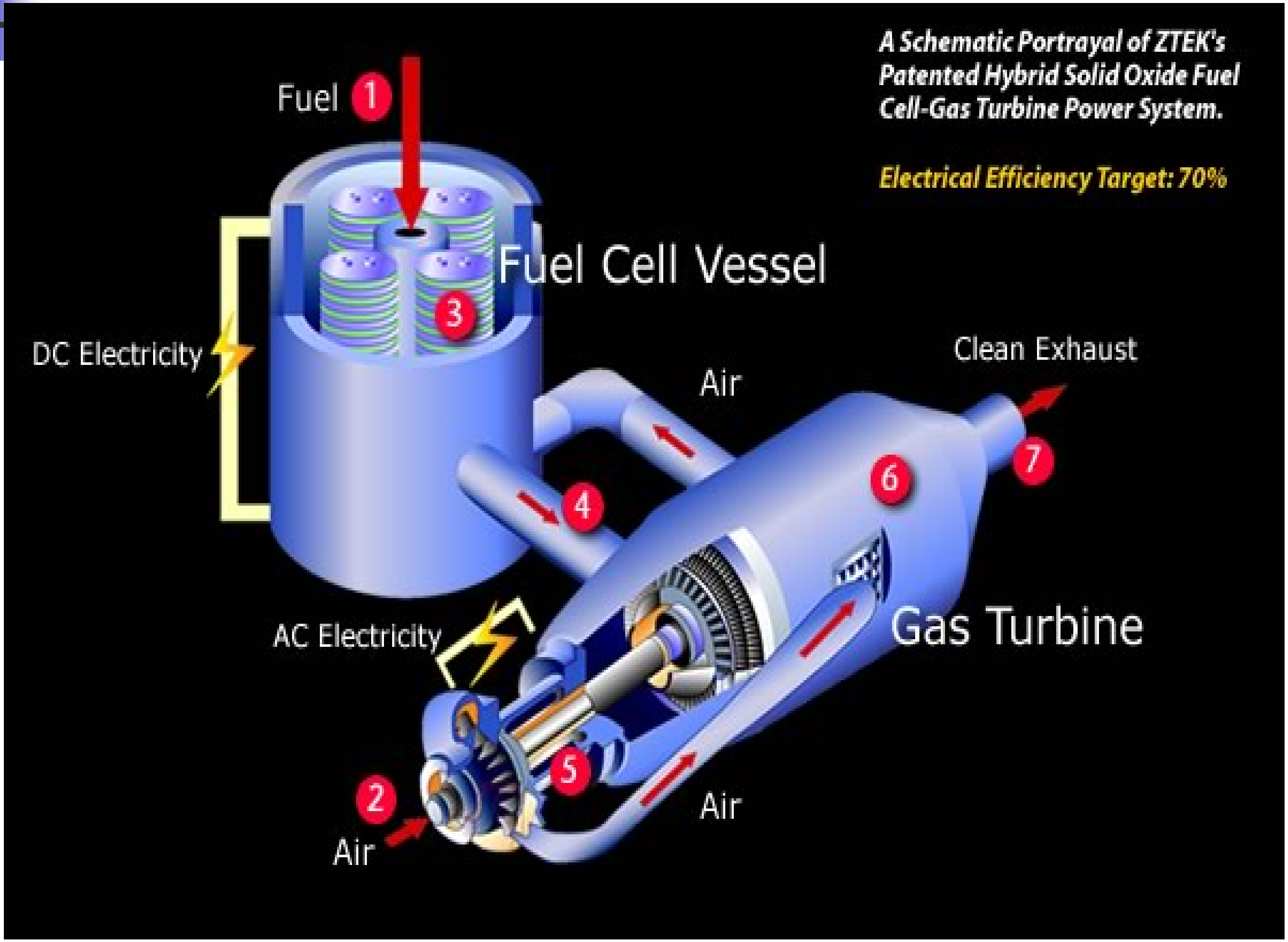
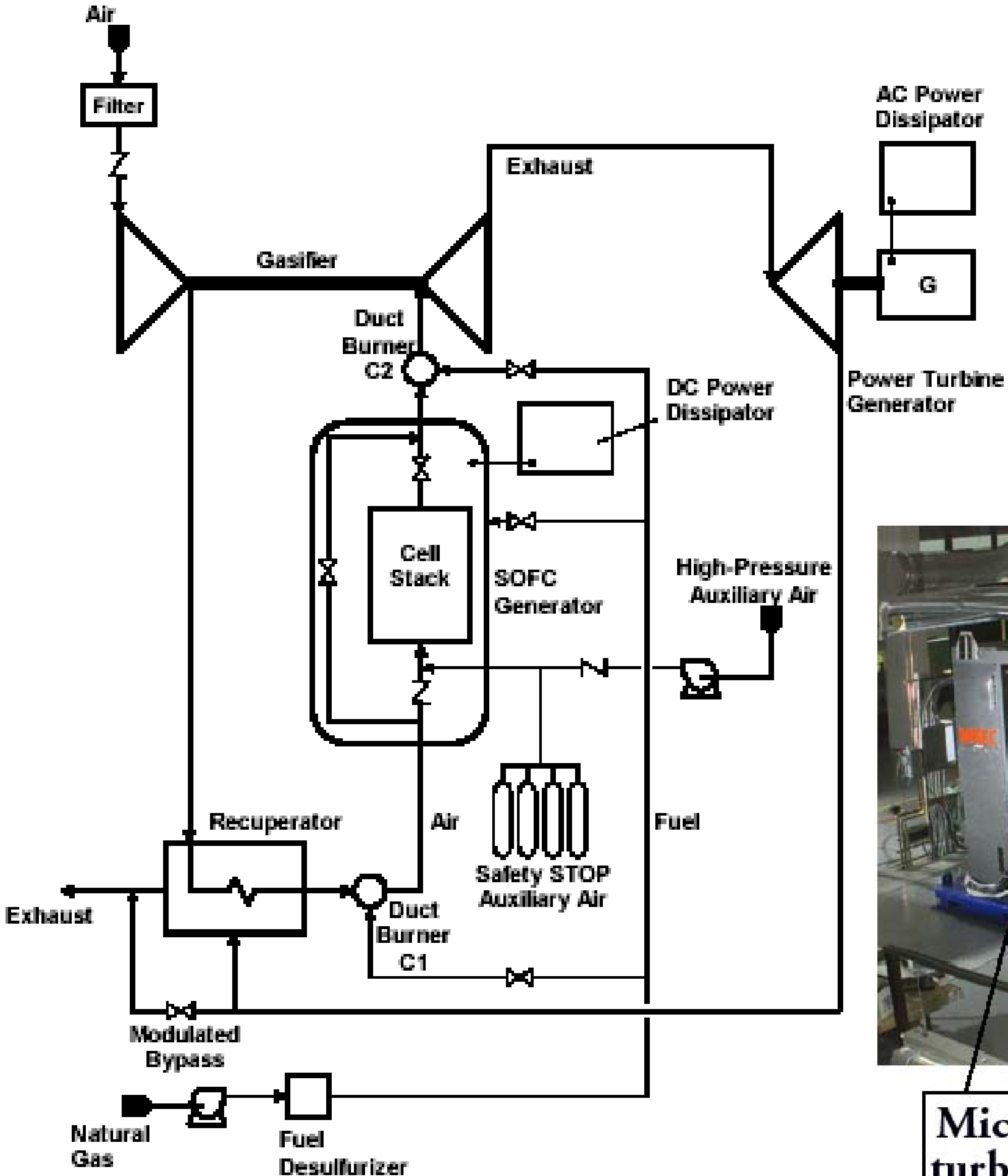


Tabela 20- Dados de desempenho do sistema híbrido SCE de 220 kW (Forbes e Veyo, 2000)

SCE Hibrid System	
Relação de pressão	2,9:1
Vazão de ar na entrada do compressor	0,6 kg/s
Temperatura na entrada da turbina	1050 K (777 °C)
Potência SOFC	176 kW (CA)
Potência microturbina	47 kW (CA)
Eficiência	57% (PCS)

Ciclo do sistema de 220 kWe PSOFC/GT



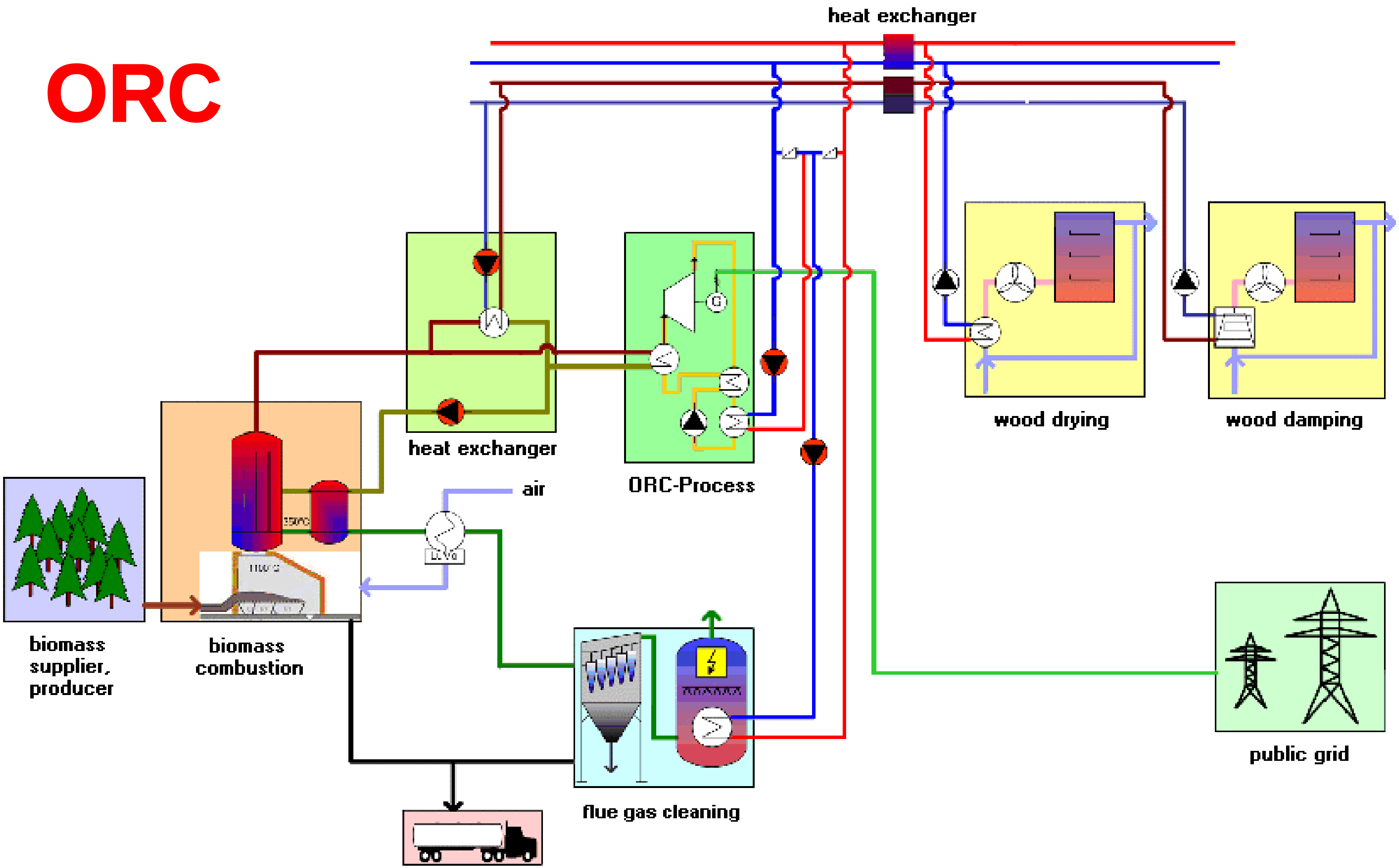
BIOMASSA
Perspectivas Futuras

MTG com queima externa de biomassa

Eficiência elétrica 15%
Eficiência de cogeração: 85 %
Horas de operação: 4000
BOWMAN TG50 50 KWe
20-30 KWe em operação

CICLO ORGANICO RANKINE: 0,4-2,0 MW

ORC



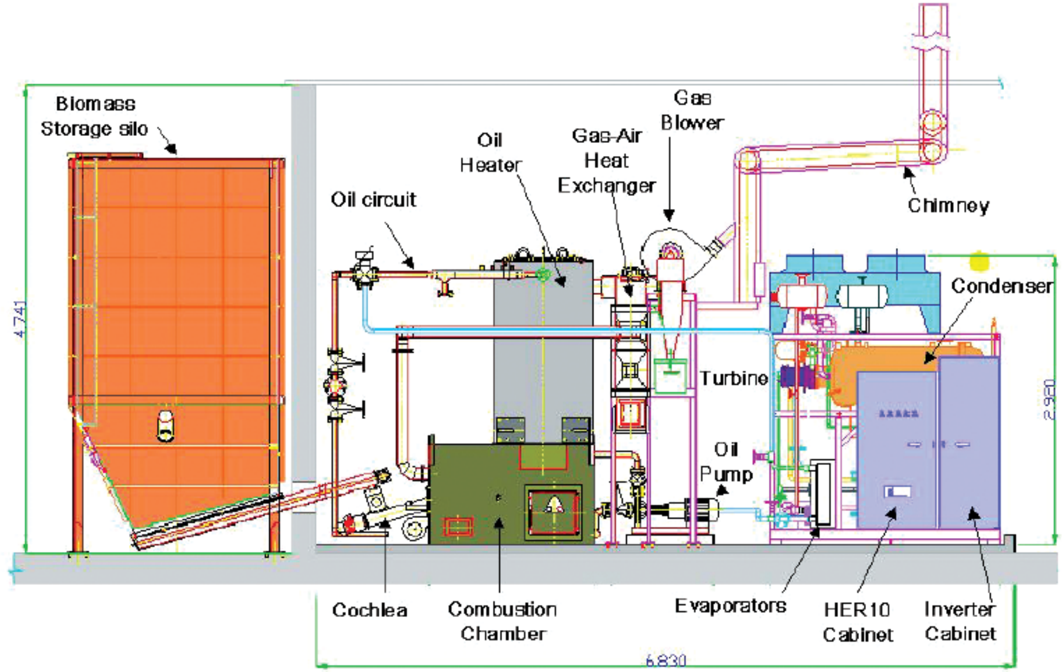
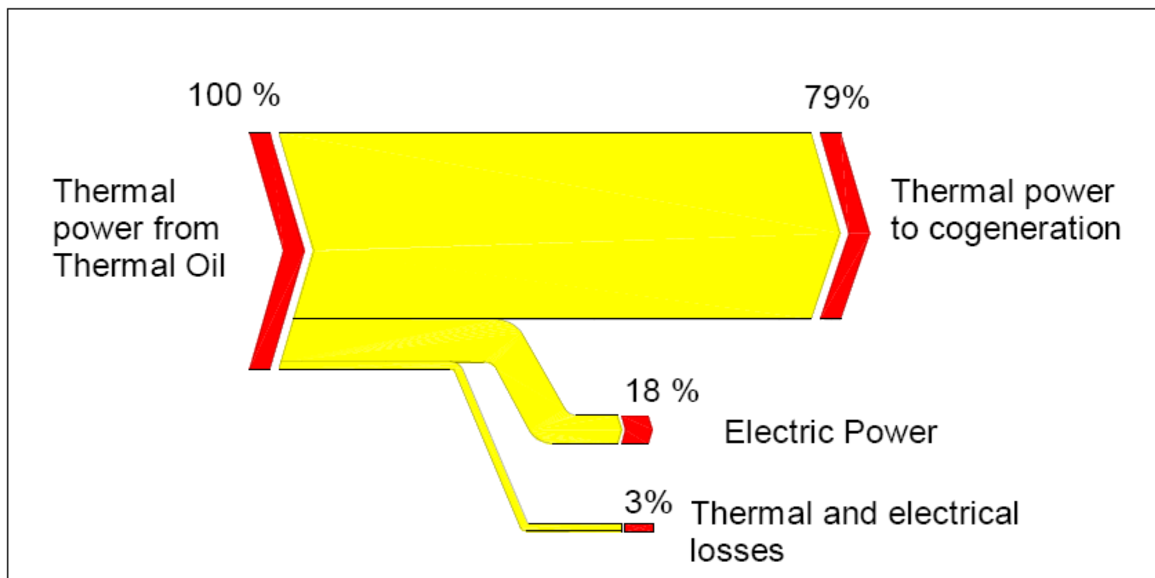


Fig. 1: The lay out of the SBTG installed at CESI



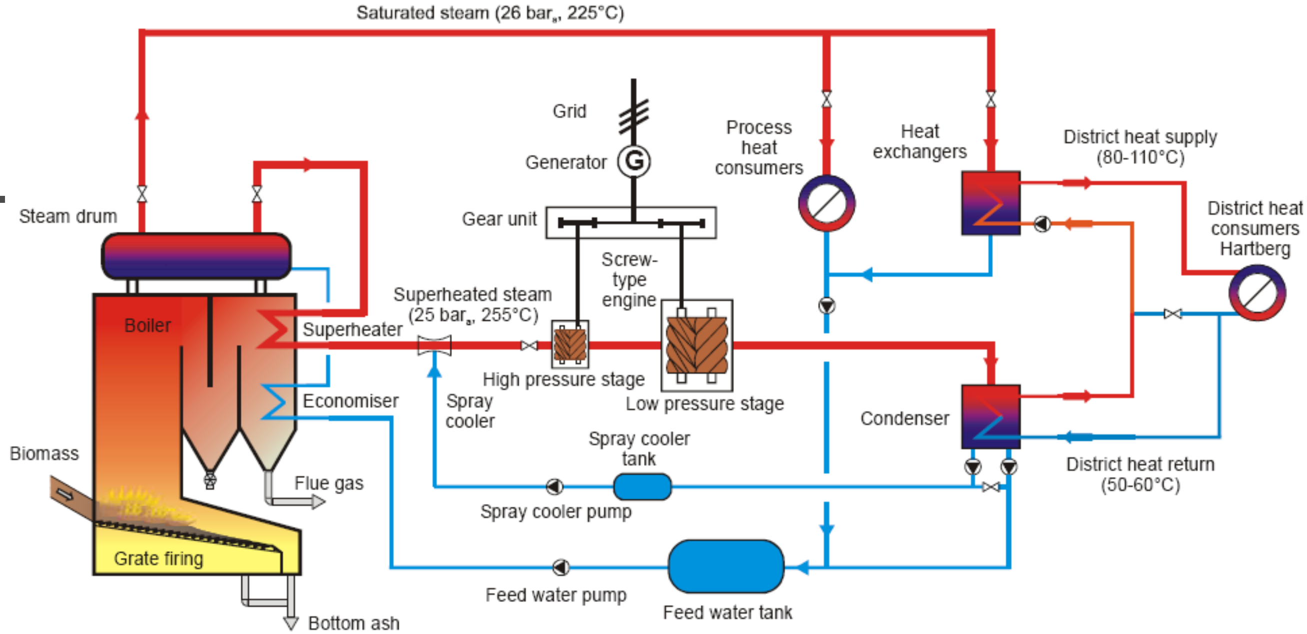


Figure 1: Process flow diagram of the biomass CHP plant Hartberg

Ciclo a vapor com motor tipo rosca sem-fim

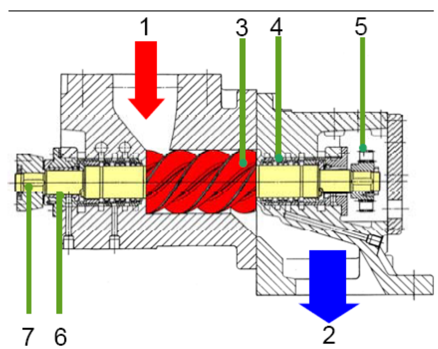


Figure 4: Section drawing of a screw-type engine (1…live steam inlet, 2…exhaust steam outlet, 3…male rotor, 4…shaft seal, 5…synchronisation gearwheels, 6…friction type bearing, 7…output shaft)

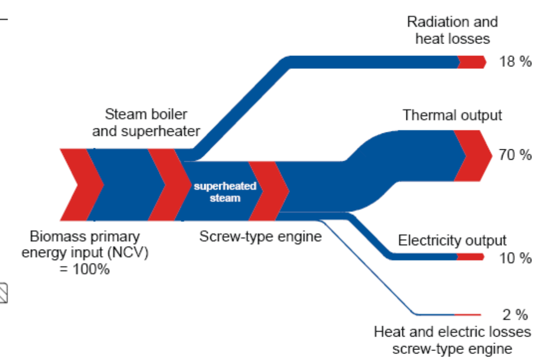
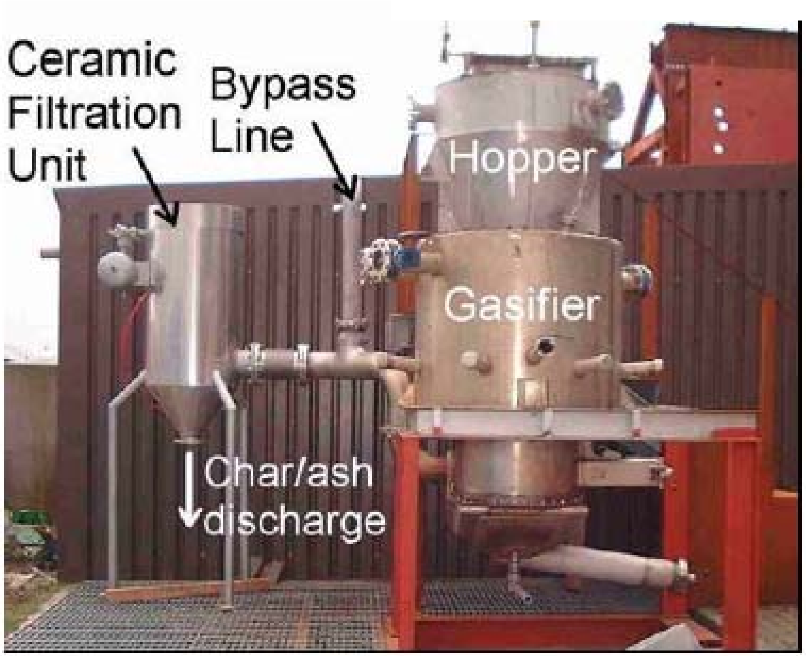
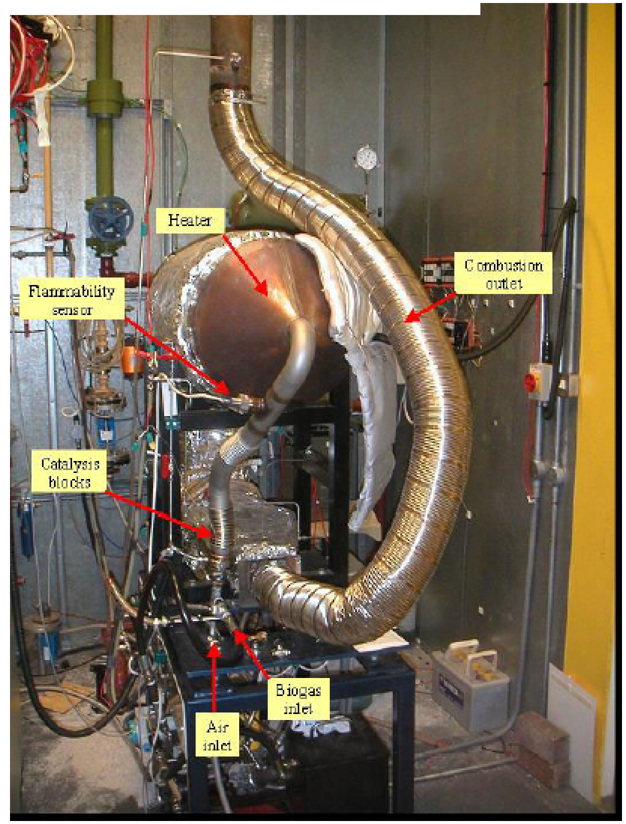


Figure 5: Energy flow chart of the biomass CHP plant in Hartberg

GASEIFICADOR / MTG



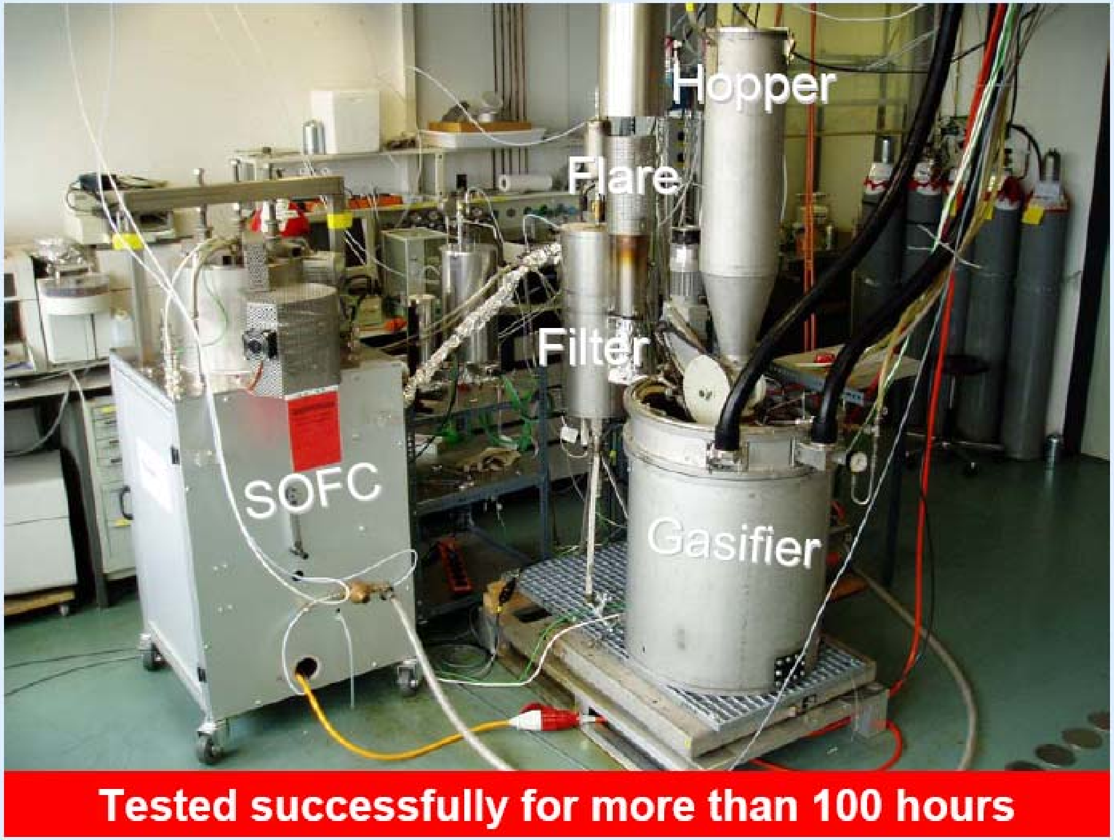
Photograph 1. Gasifier and Test filtration unit without feed conveyor addition of char/ash bin)



Photograph 4. Advantica Catalytic test rig

Photograph 3. Gas compressor model HV07

GASEIFICADOR / SOFC



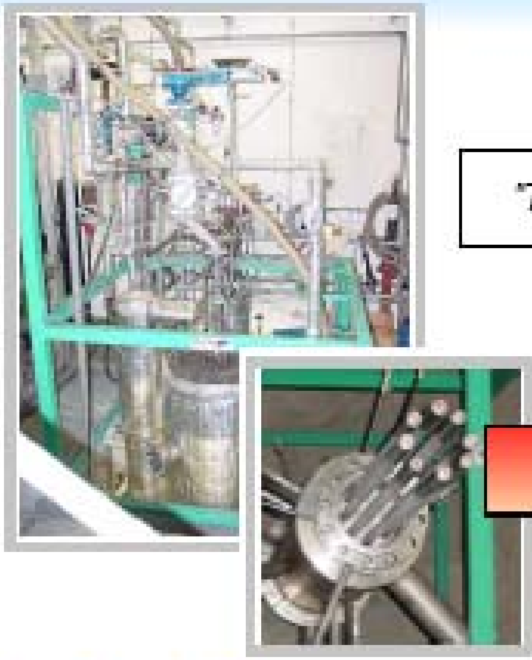
Source: F. P. Nagel, M. Künstle, S. Biollaz, "Link-Up of a Solid Oxide Fuel Cell with a Wood Gasi-fier", Proceedings of 14th European Biomass Conference, pp. 746-748, Paris, France, 17th-21st October 2005

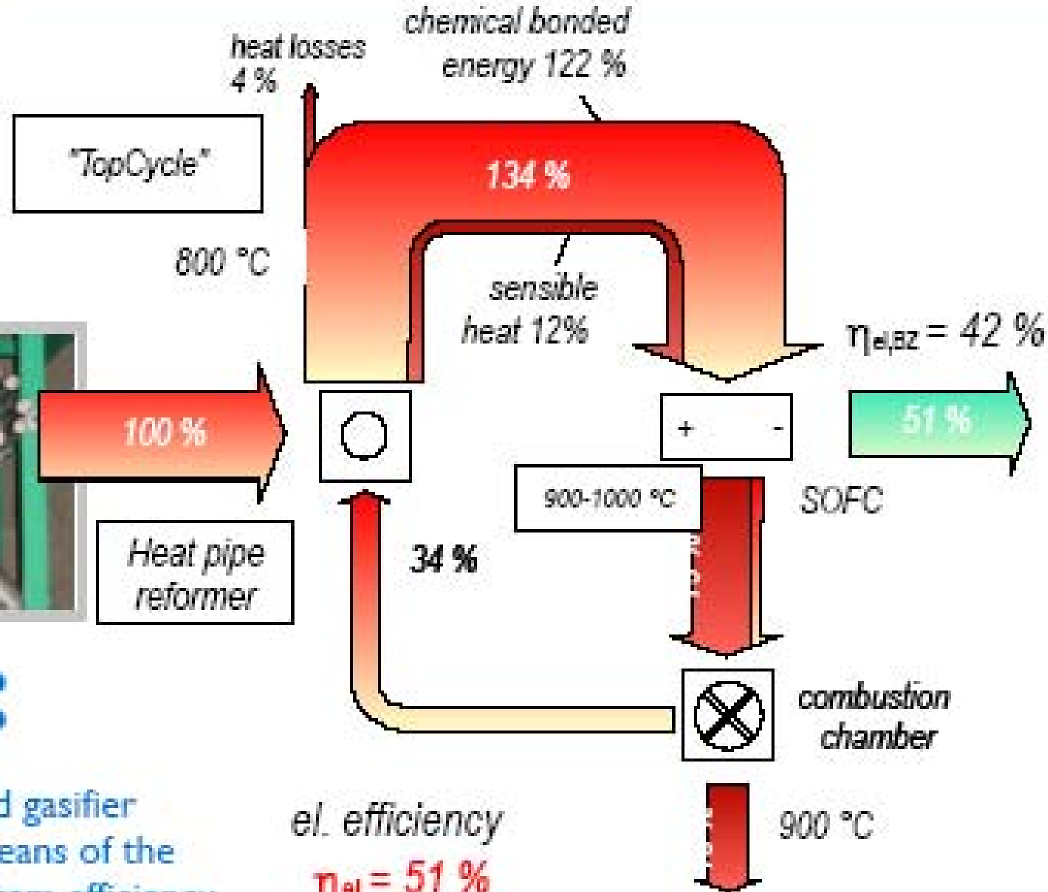
Experimental setup

- ❑ Lab scale up-draft gasifier
- ❑ Ceramic particle filter
- ❑ Jet stream pump
- ❑ 60W- SOFC short stack

Results

- ❑ Non-stop experiments up to 16 h
- ❑ Gas analysis of producer gas with up to 150 g/m_n^3 tar load
- ❑ Normal deactivation





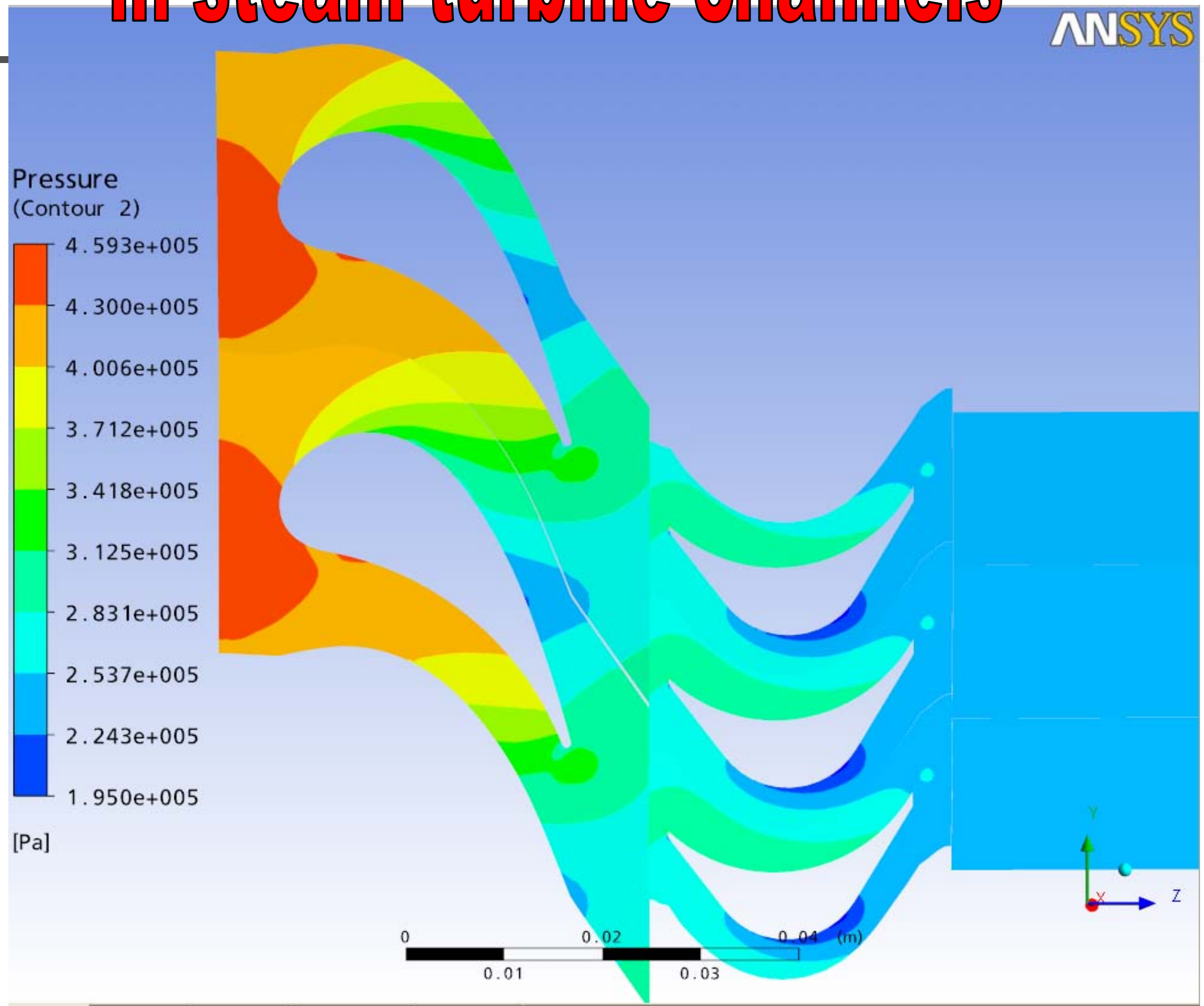
Solution:

- heating of an indirectly heated gasifier (**Heatpipe reformer**) by means of the SOFCs exhaust increases system efficiency significantly

PROJETOS EM ANDAMENTO NO NEST

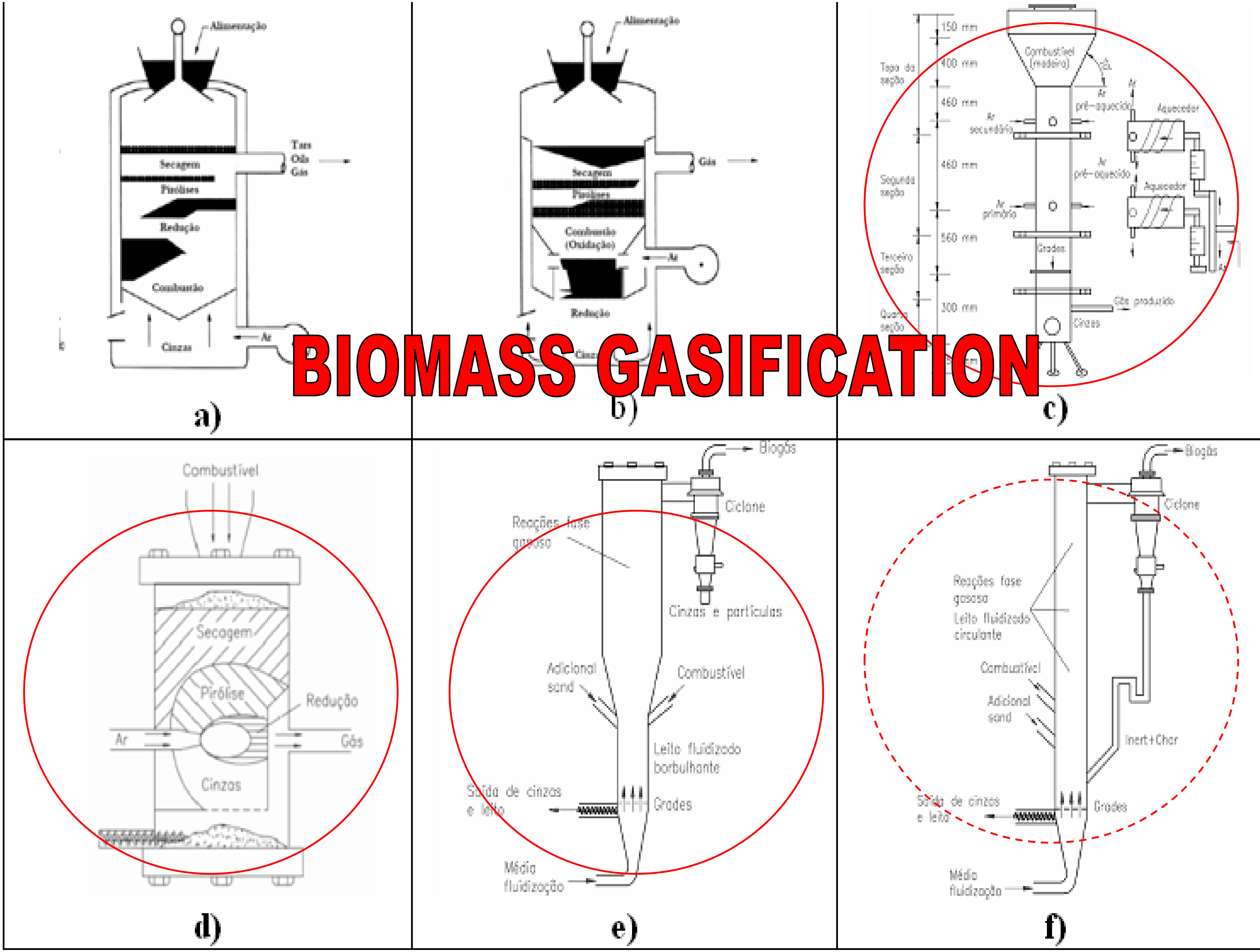
- Modulo Gaseificador/MCI de 10 kWe.
- Modulo fornalha/Stirling 10 kWe.
- Microturbina a gás 600 kWe.
- Projeto ISBUC BIG/GT de 3 MWe.
- Testes de MTG operando com biodiesel (soja, mamona e dendê) e etanol.
- Análise do ciclo de vida do biodiesel.

CFX simmulation of processes in steam turbine channels

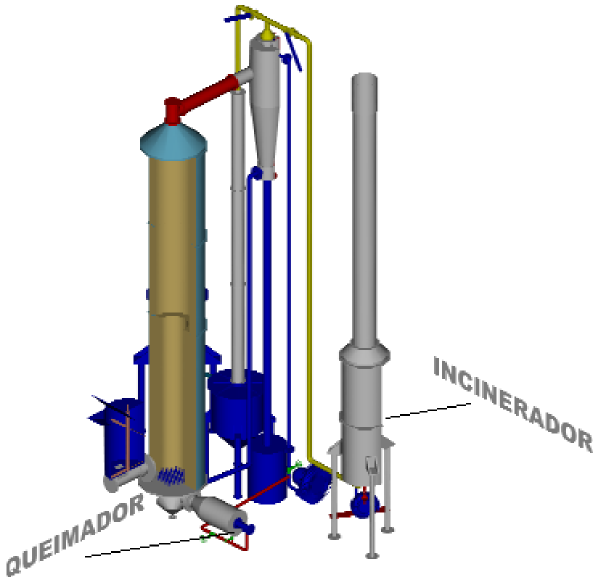


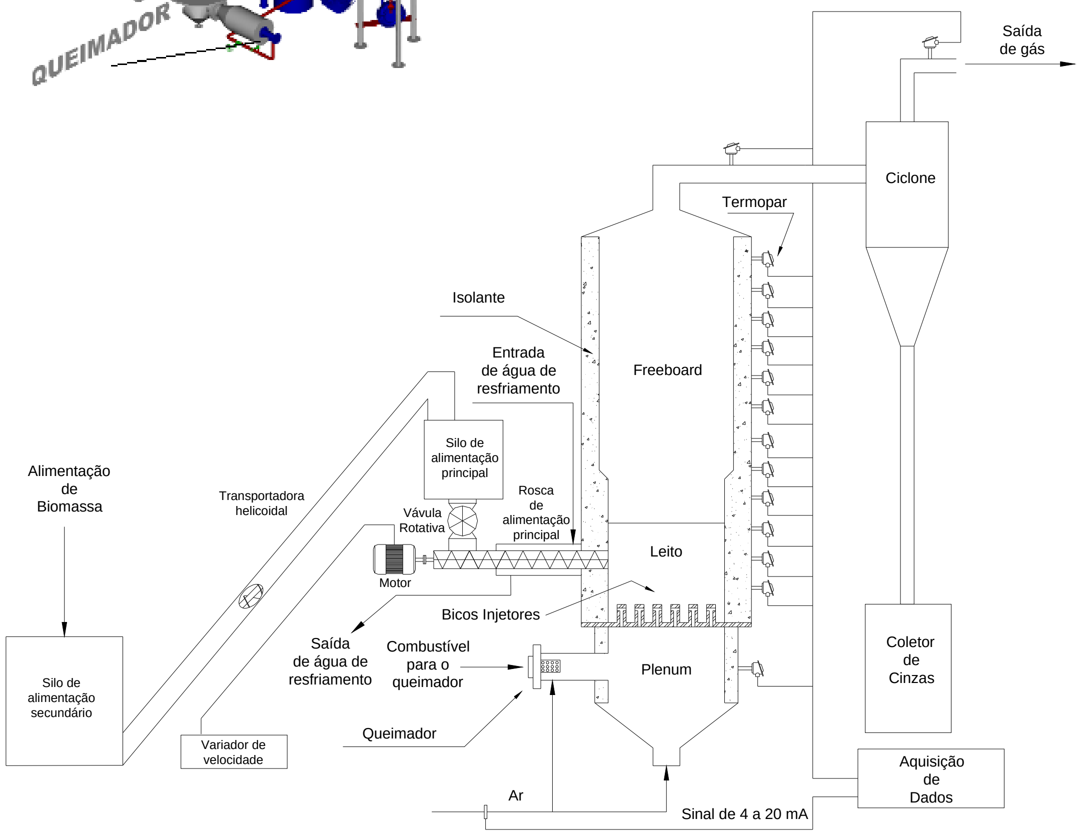
Distribuição de **pressão** ao longo do canal.

BIOMASS GASIFICATION

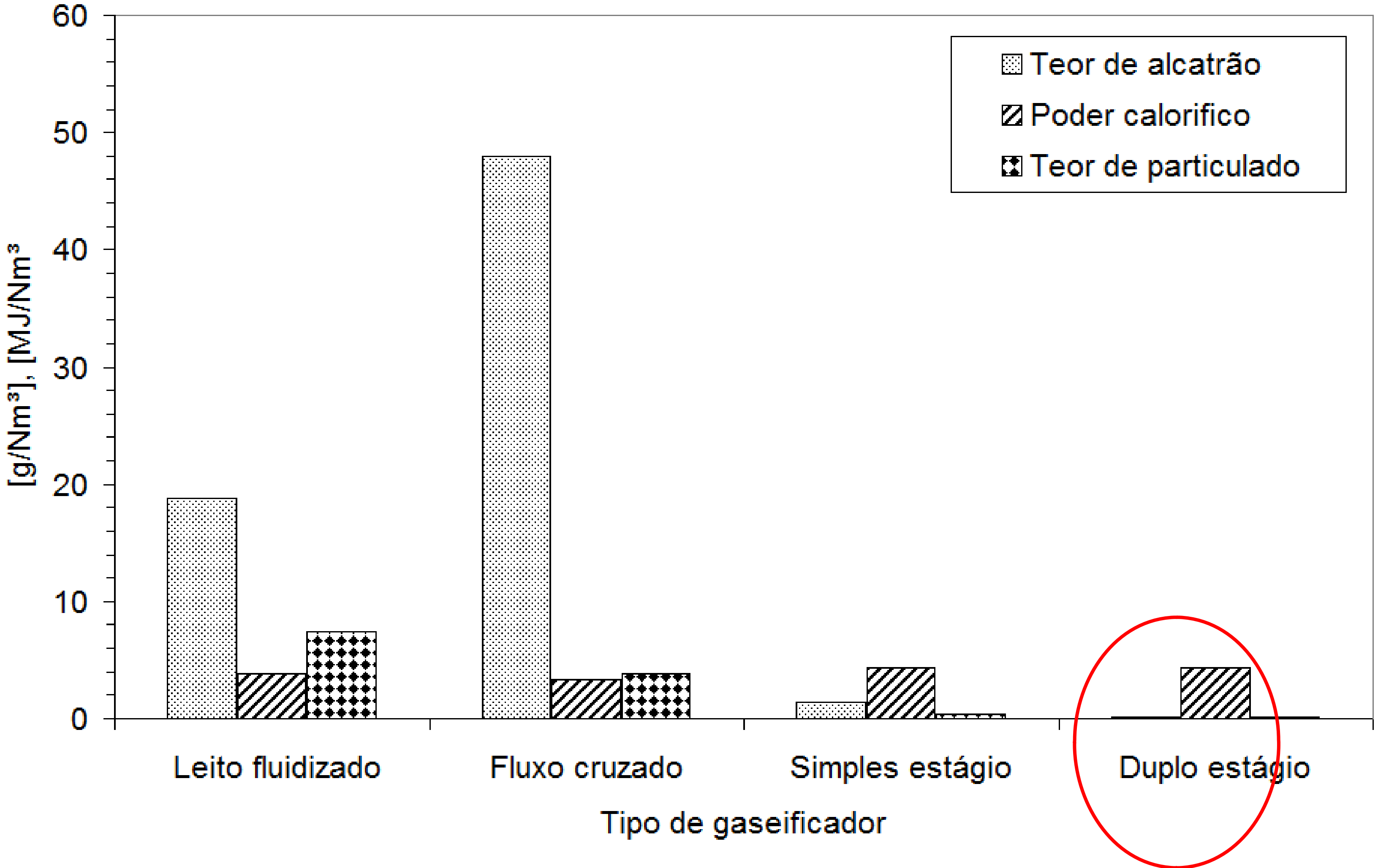


Esquema do Sistema de Gaseificação

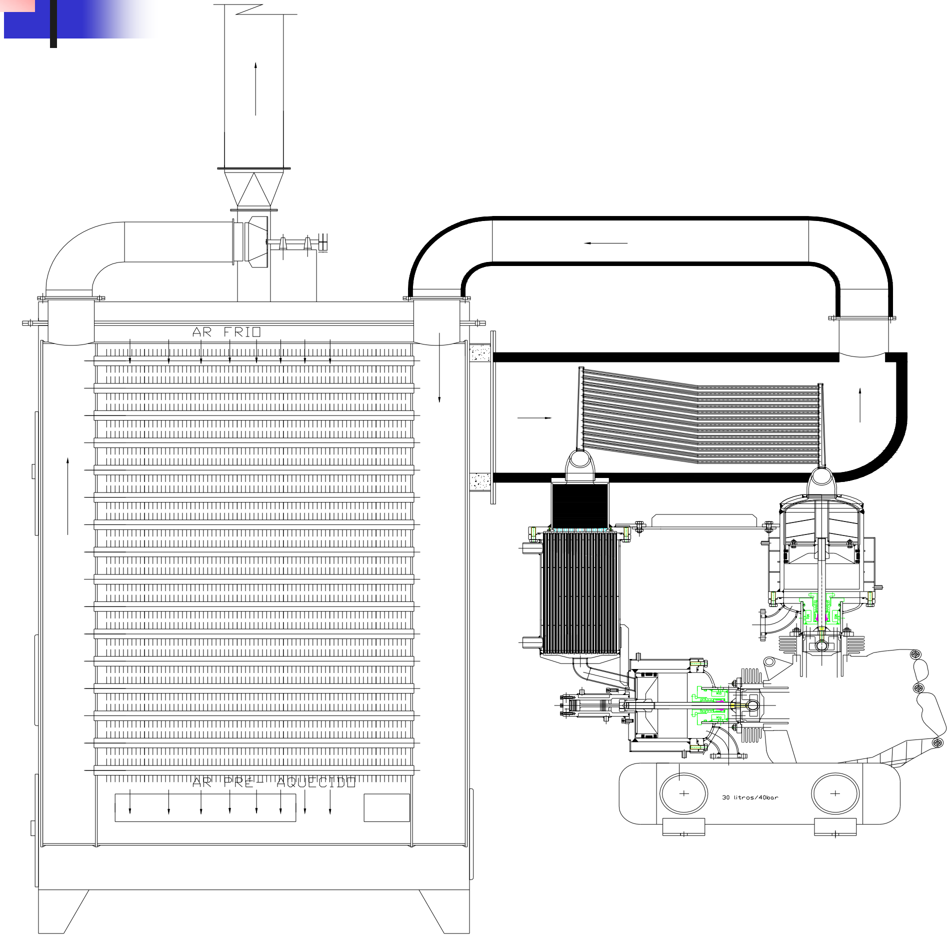




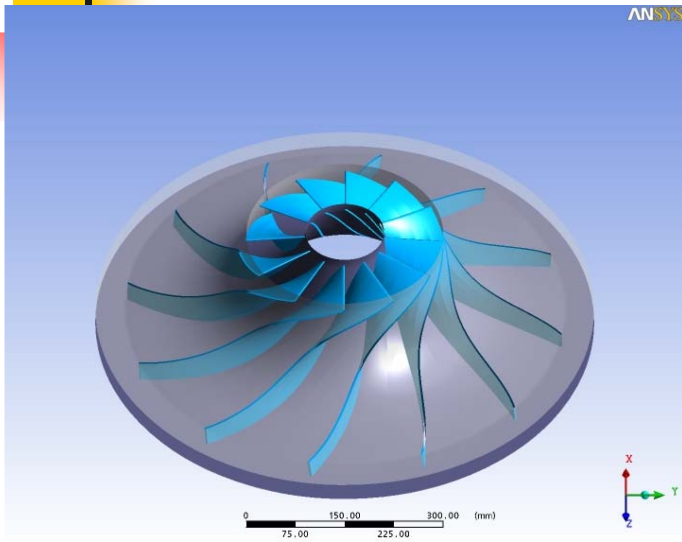
Tests results

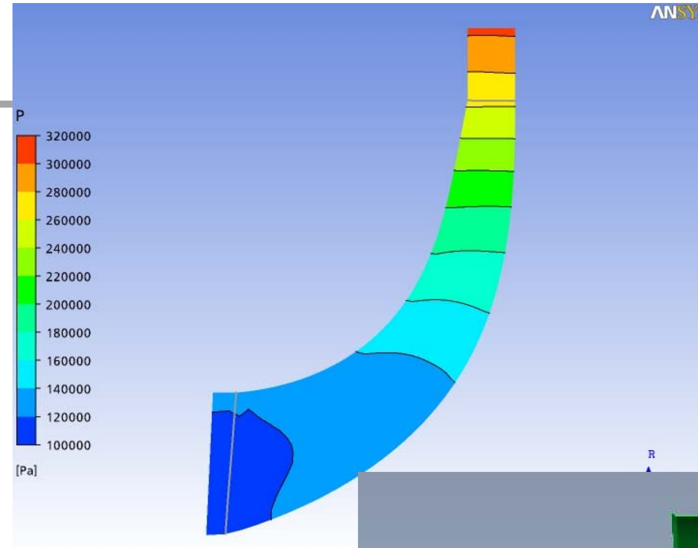


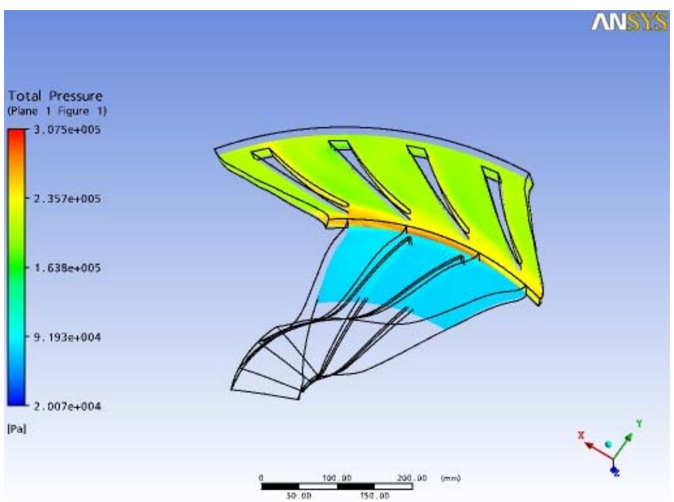
BIOMASS STIRLING AMAZON

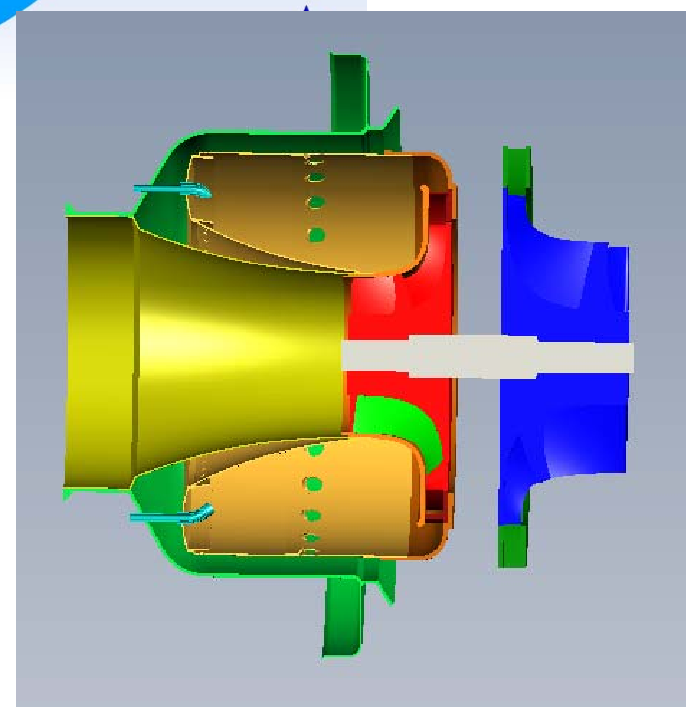


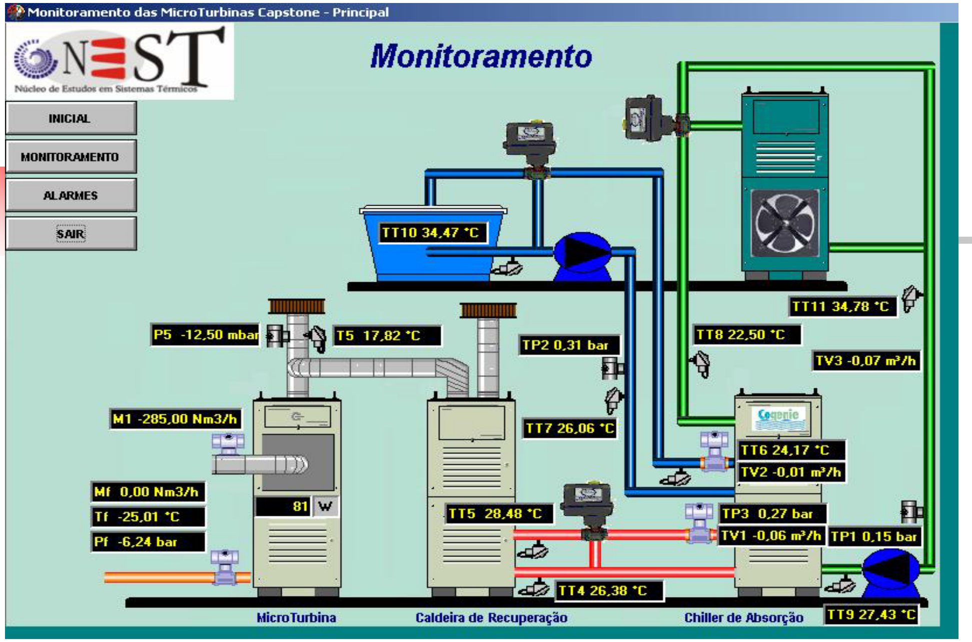
NEST 600 Gas turbine





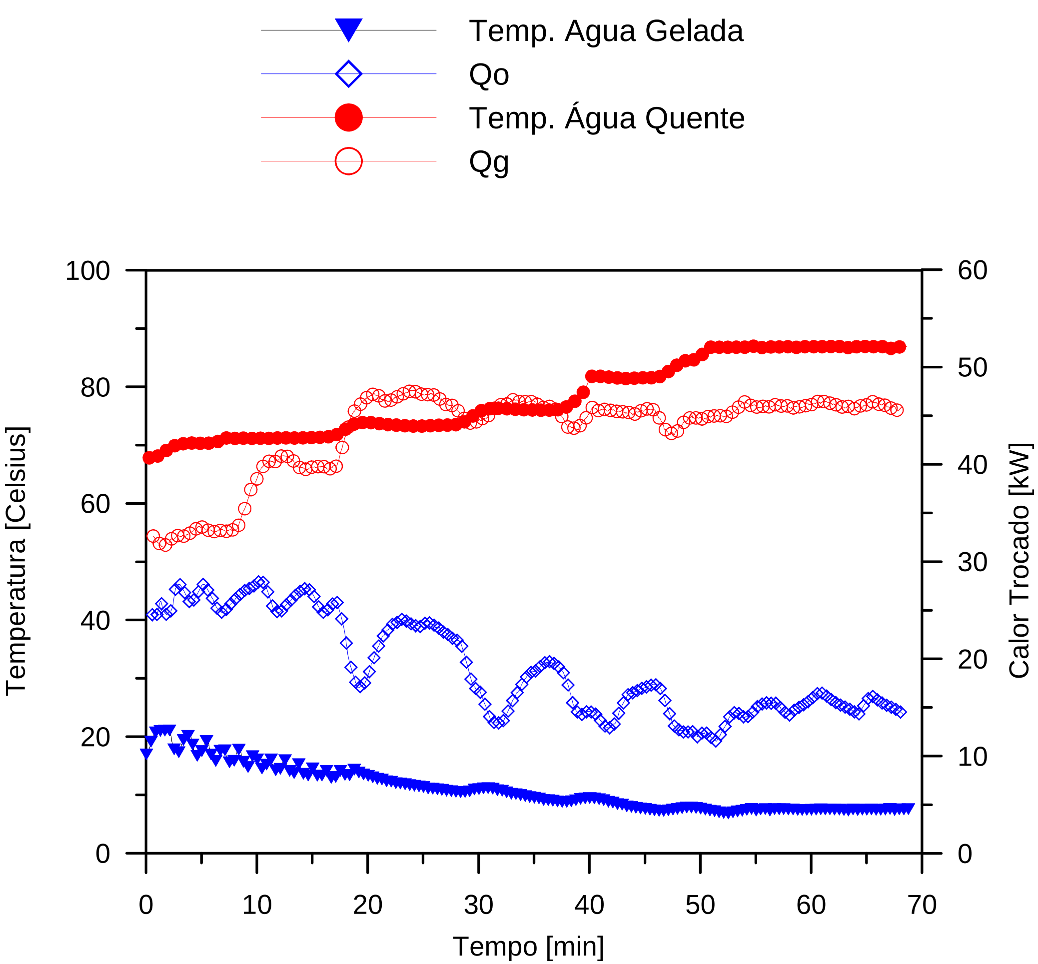


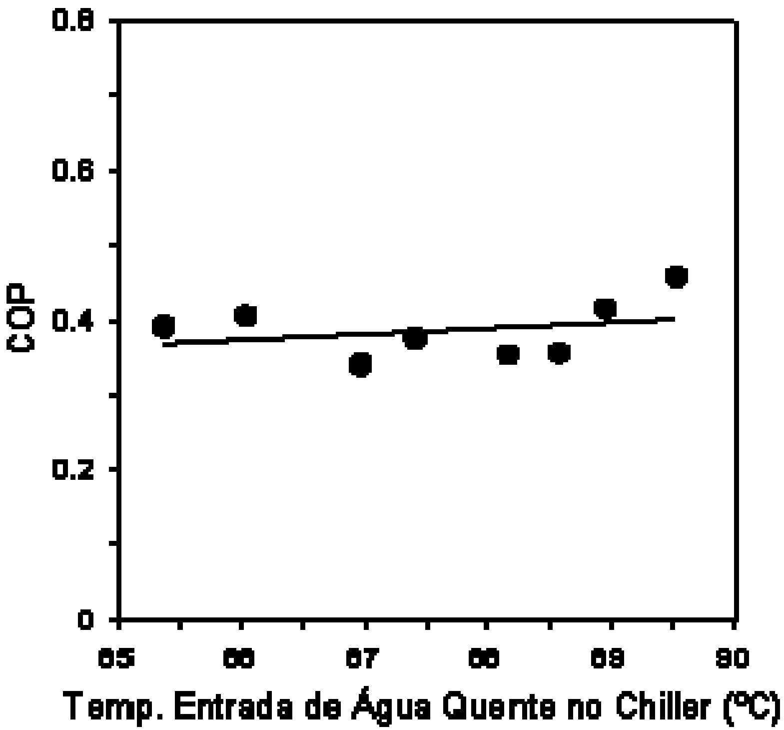




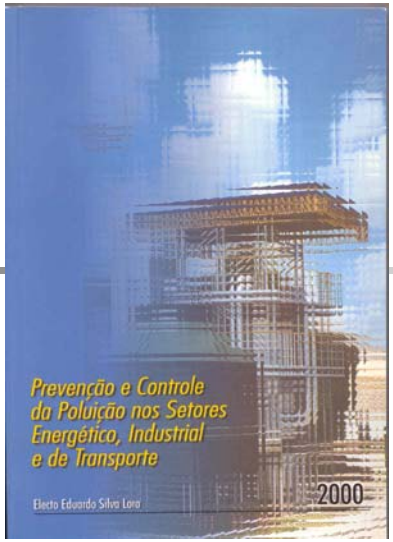
COGENERATION SYSTEM MGT/ABSORPTION CHILLER

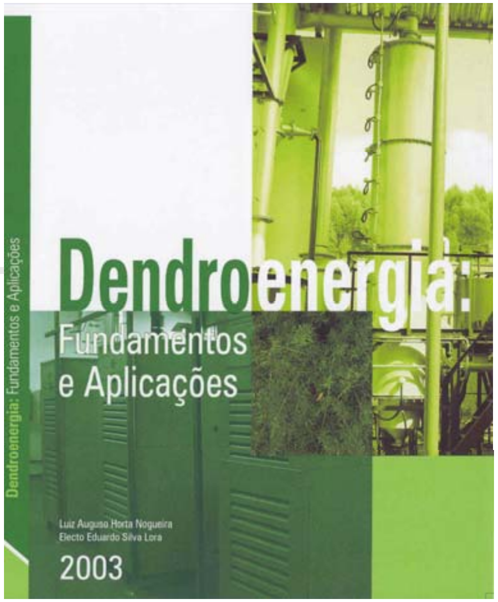
Análise dos Dados Experimentais

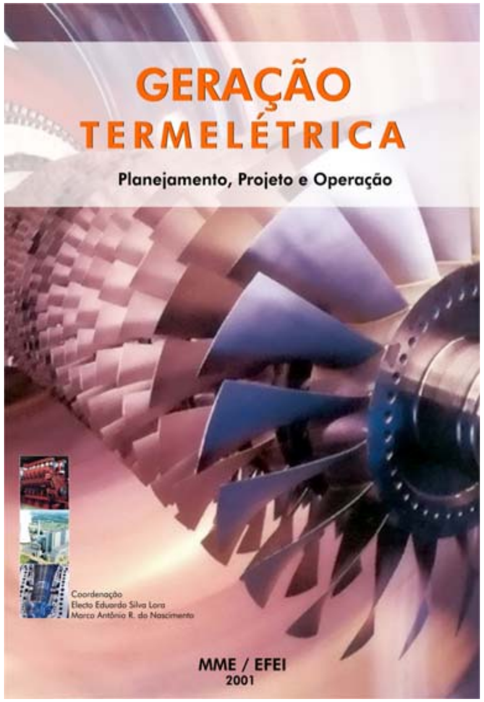




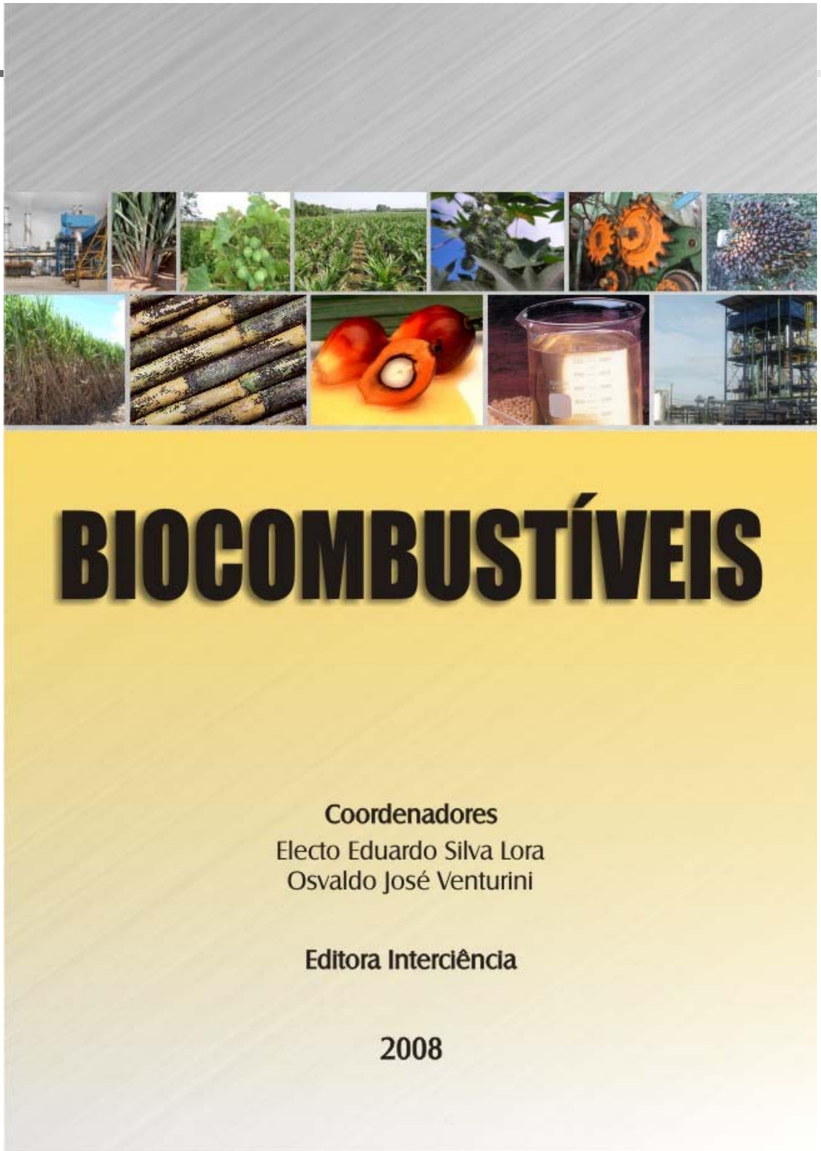
PUBLICAÇÔES DO NEST







Nova publicação 2008



Obrigado!

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