

Combustíveis fósseis

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Combustíveis e biocombustíveis

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Setor Palotina



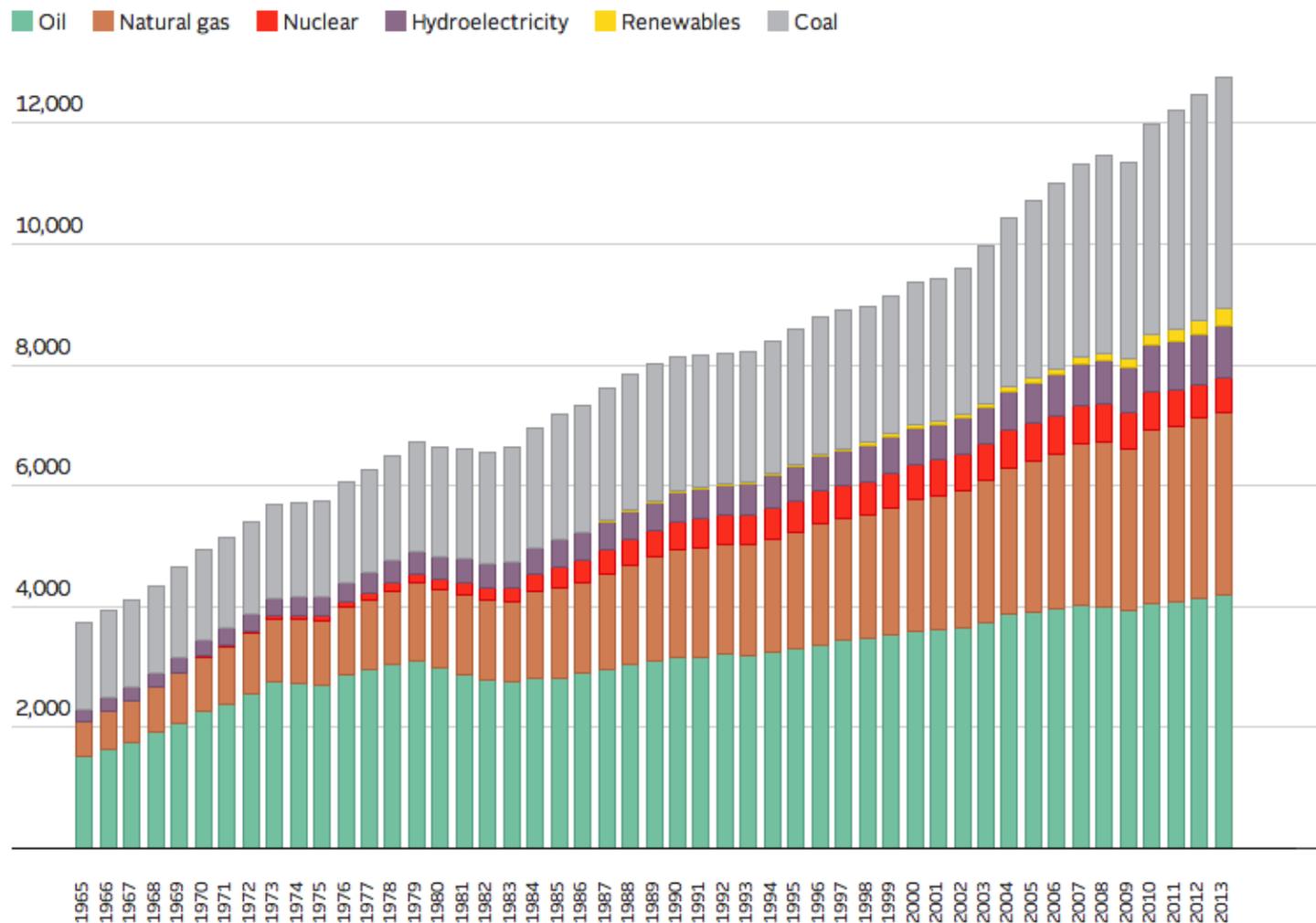
- Parte 1
 - Energia no mundo
 - Formação
 - Características gerais
 - Reservas no mundo e no Brasil
 - Modos de exploração

- Parte 2
 - Uso final
 - Impactos ambientais e desafios

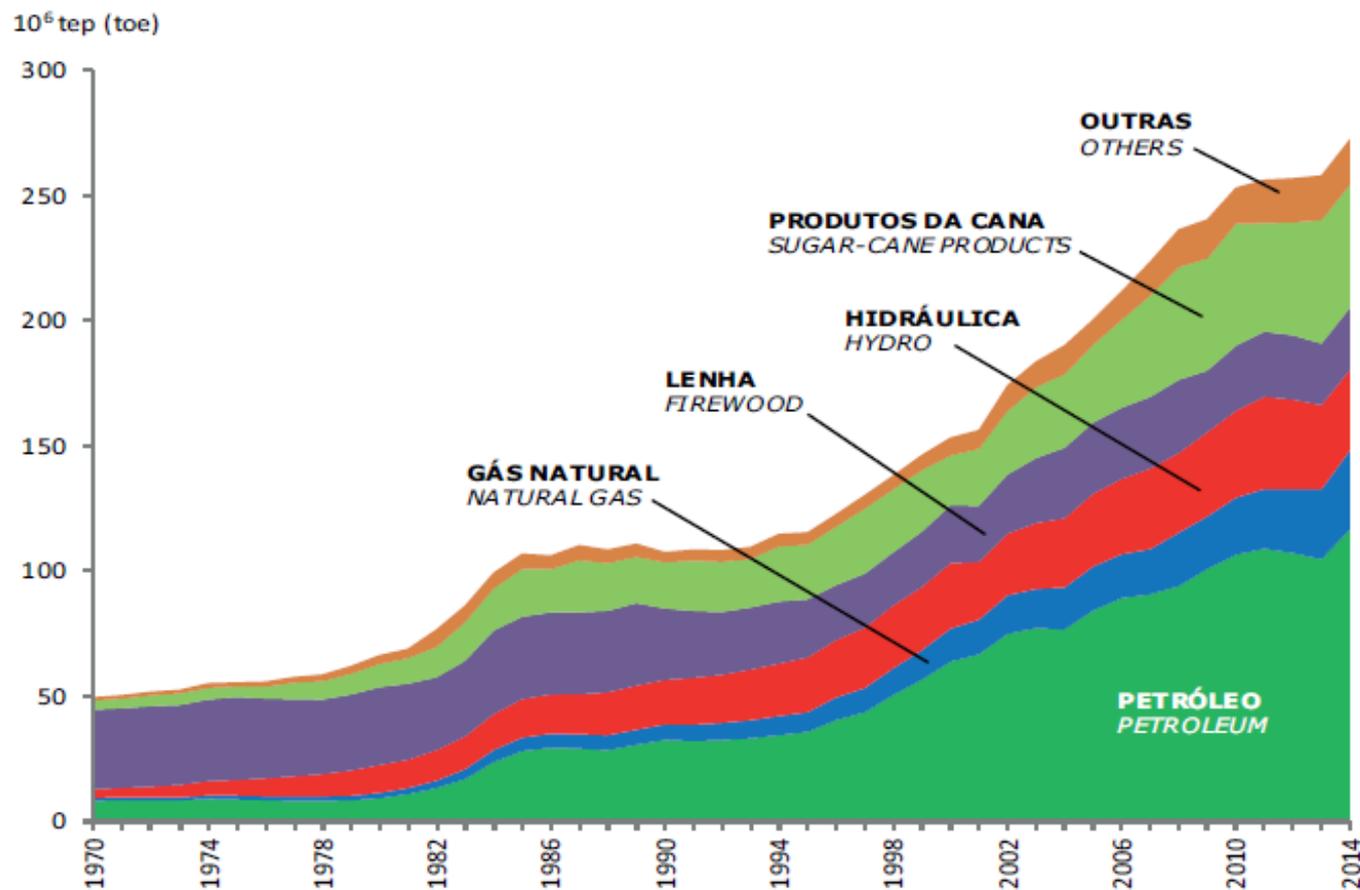
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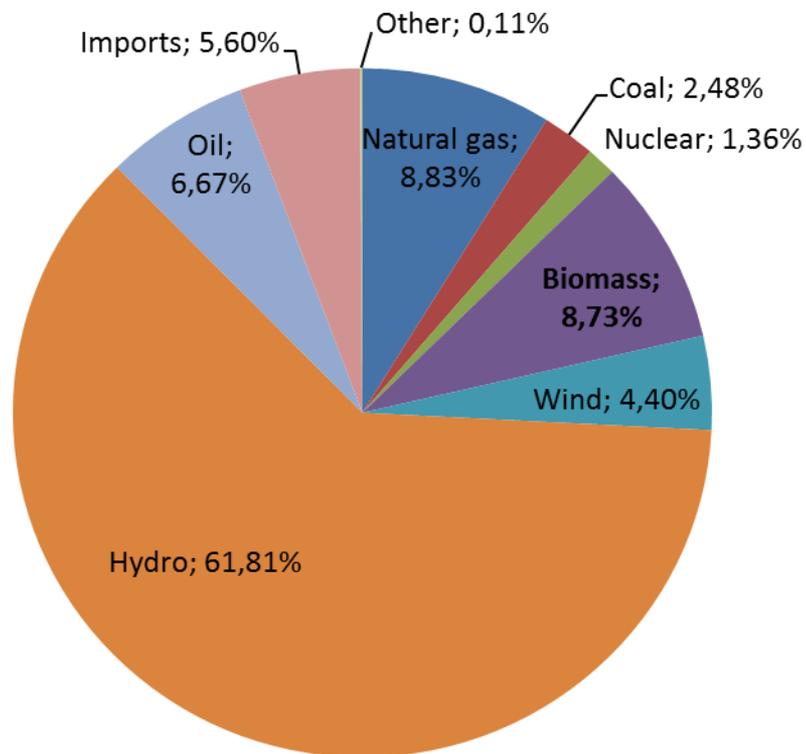
Oferta de energia primária – mundo [Mtoe]



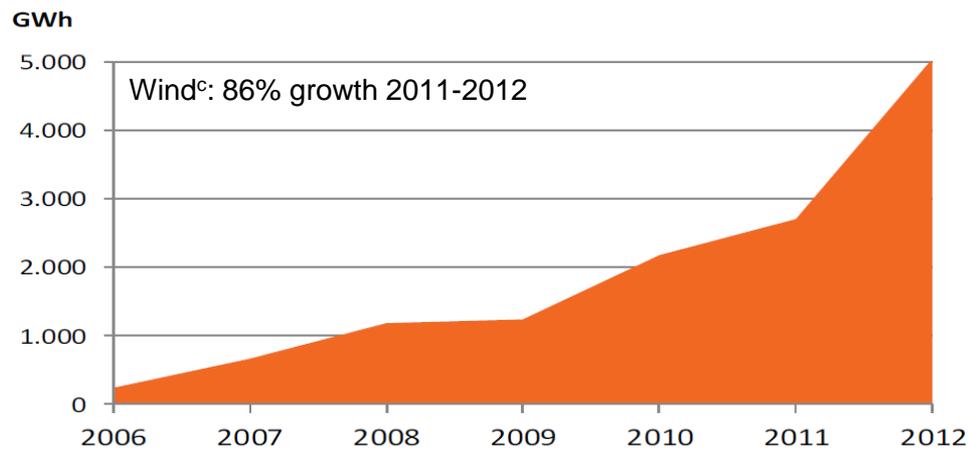
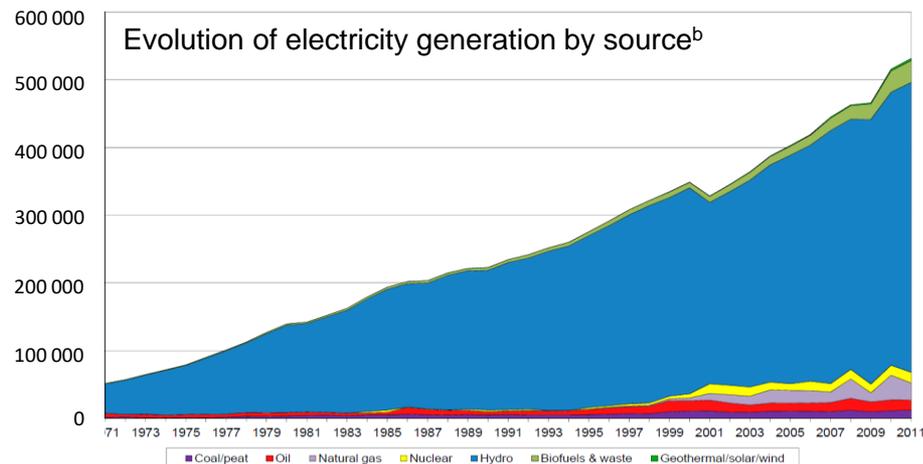
- Oferta de energia primária – Brasil [Mtoe]



▪ Energia elétrica – capacidade instalada no Brasil



•Brazil 2015^a: 146.0 GW

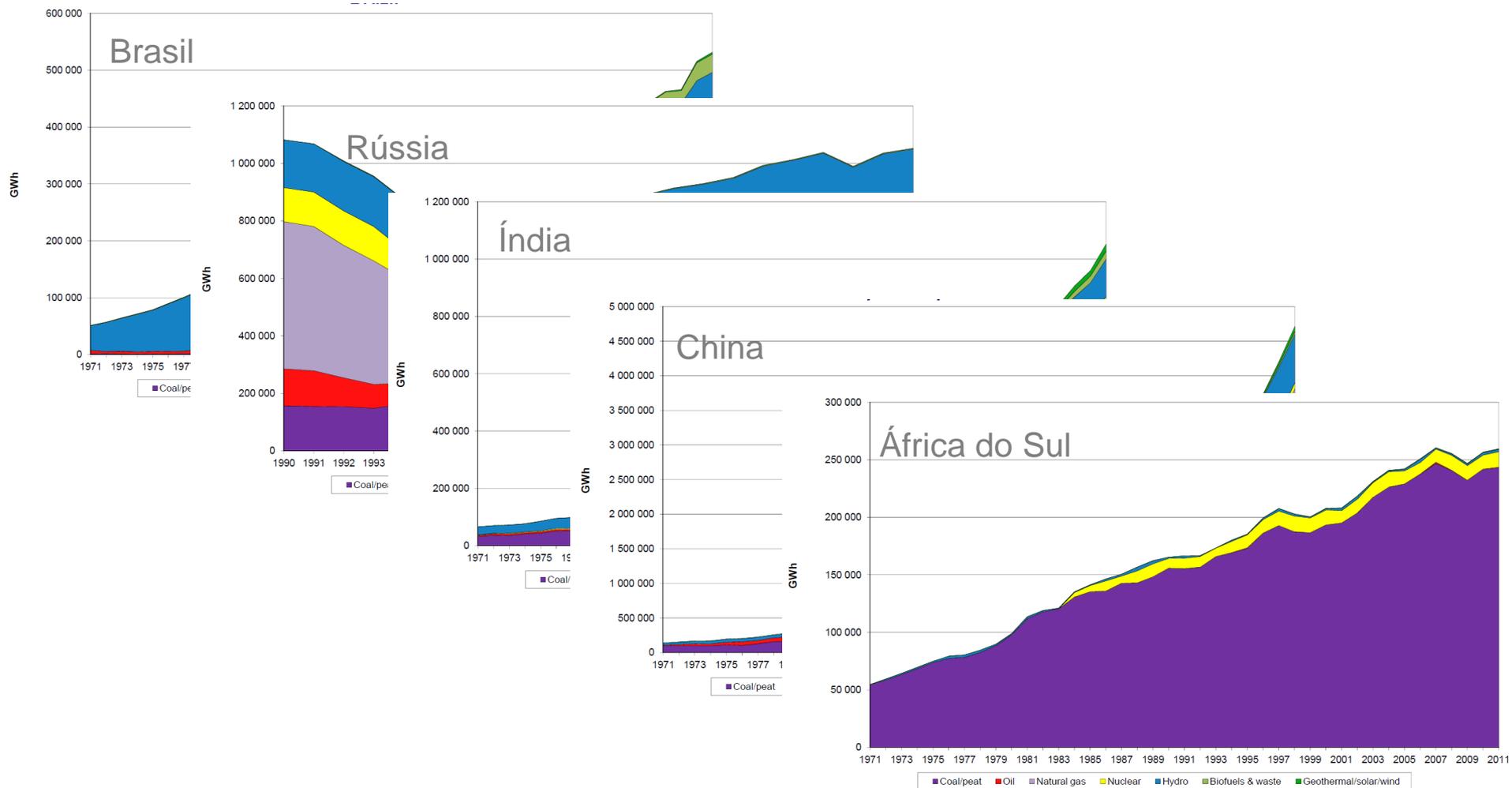


^aANEEL. October 2015. In: <<http://www.aneel.gov.br/15.htm>>.

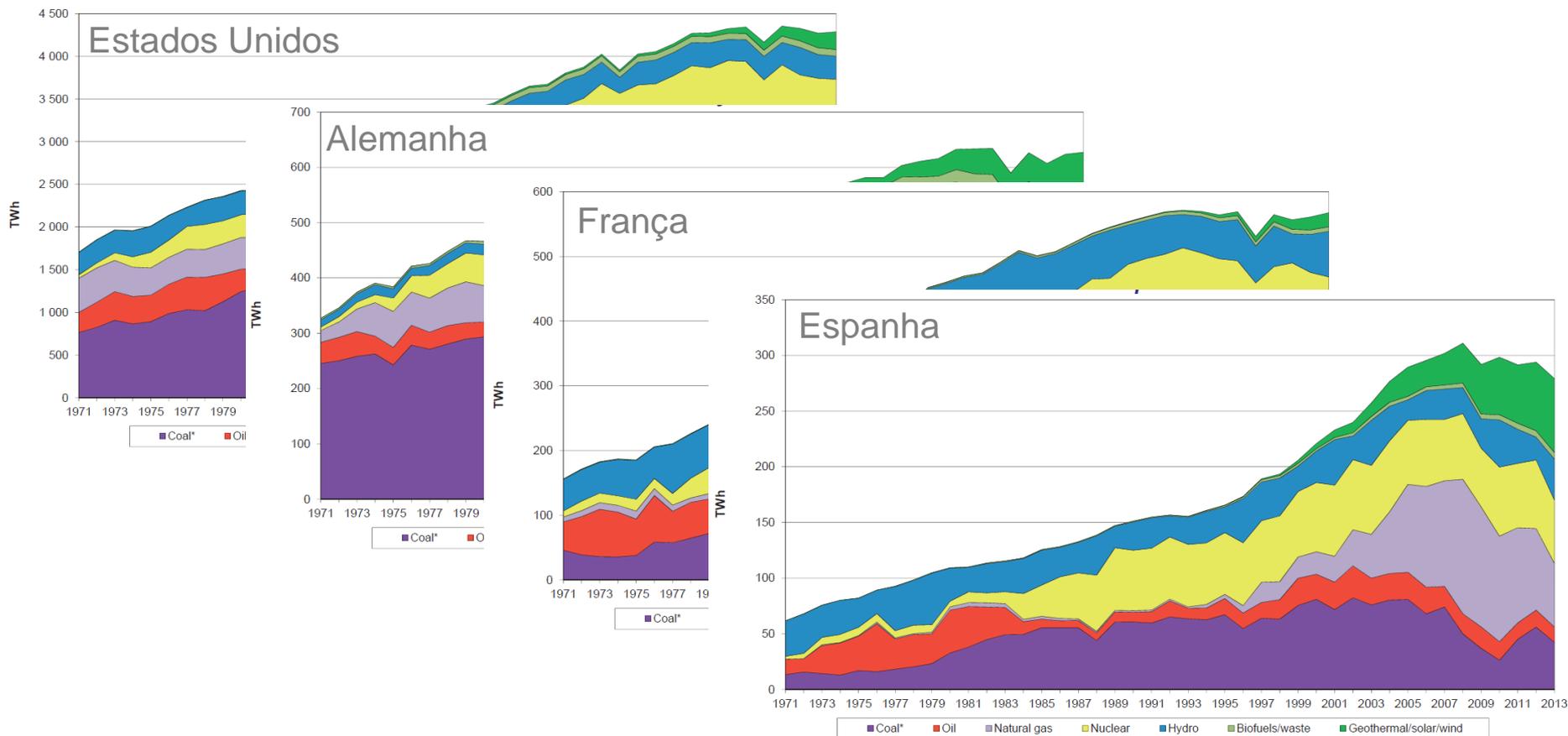
^bIEA. October 2013. In: <<http://www.iea.org/statistics/>>.

^cMME. 2013. Balanço energético nacional (2012).

■ Energia elétrica – geração por tipo

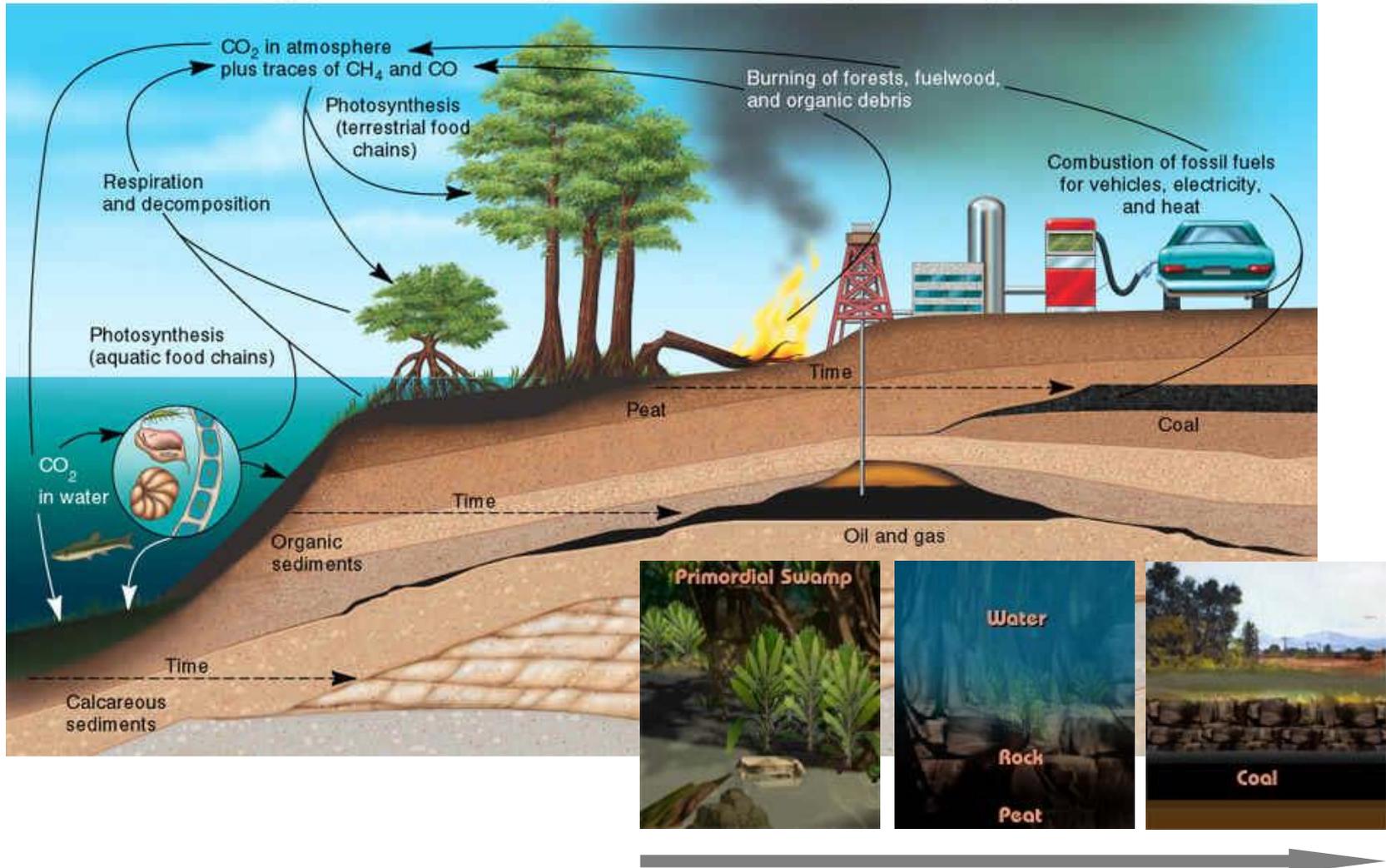


■ Energia elétrica – geração por tipo



Formação

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- Turfa



Campo de turfa¹

Carvão linhito



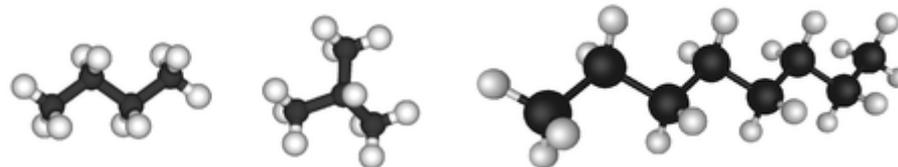
¹<http://carlosrabello.org/geografia/biogeografia/flora/turfa/>

■ Petróleo

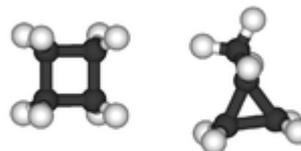
Composição química [% (m/m)]

Componentes	Faixa
Carbono	83-87
Hidrogênio	10-14
Enxofre	0,05-6,0
Nitrogênio	0,1-2,0
Oxigênio	0,05-1,5
Metais	0,00-0,14

Alcanos:



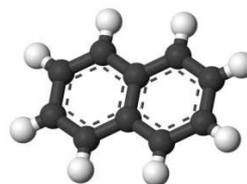
Naftênicos (cicloalcanos):



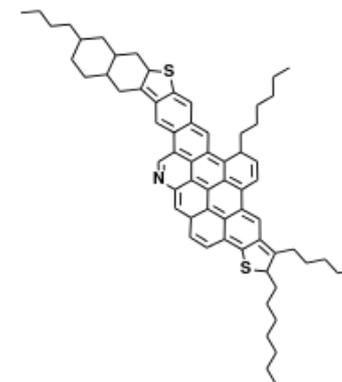
Composição química [% (m/m)]

Hidrocarbonetos	Média	Faixa
Alcanos	30	15-60
Naftênicos	49	30-60
Aromáticos	15	3-30
Asfálticos	6	Complem.

Aromáticos



Asfaltenos

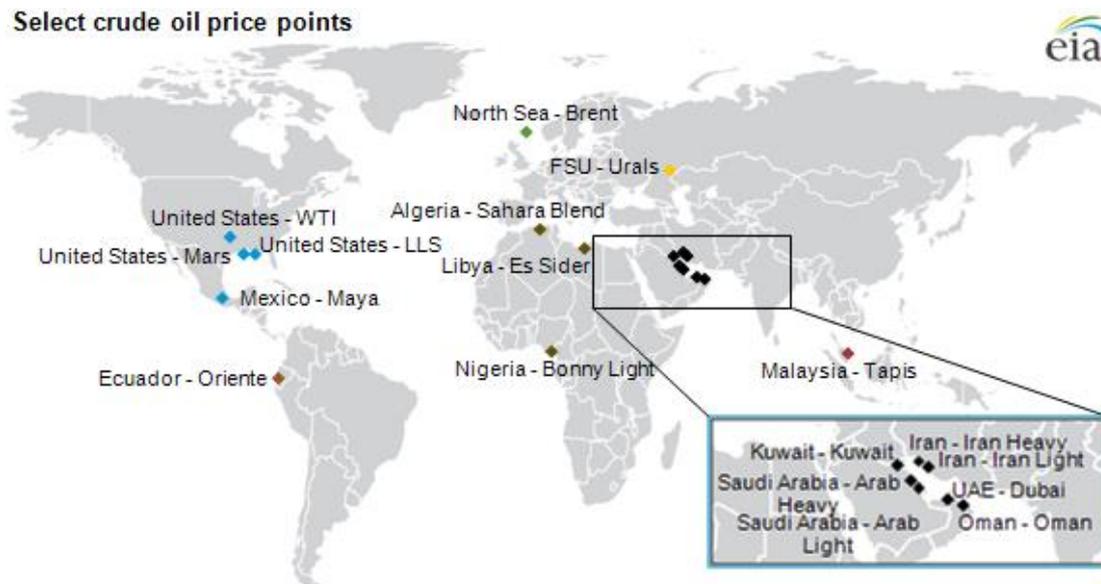


■ Petróleo

Classificação do Petróleo¹

$$^{\circ}\text{API} = 141,5/\rho - 131,5$$

- a) **Densidade:** Leves (acima de 30 °API); Médios (entre 21 e 30 °API) e Pesados (abaixo de 21 °API);
- b) **Constituintes:** base naftênica; base aromática; base parafínica;
- c) **Local de origem²:**

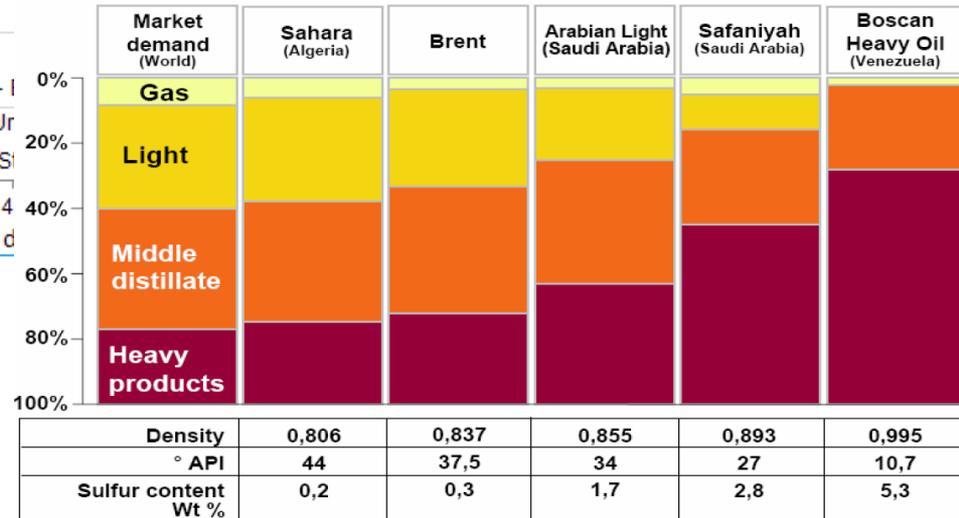
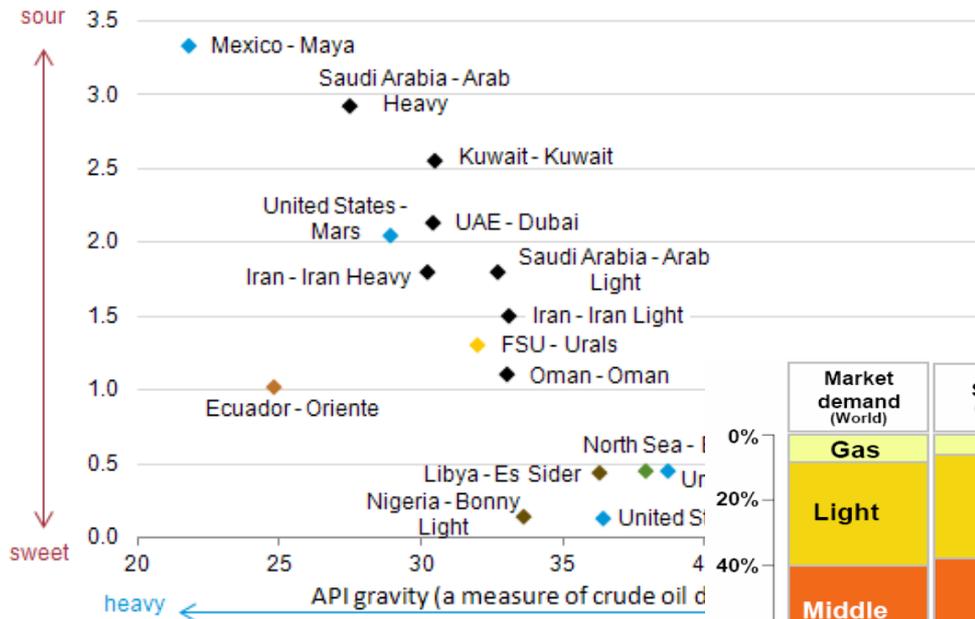


¹http://www.ufrgs.br/lapol/materias_primas/II_26.html

²<http://www.eia.gov/todayinenergy/detail.cfm?id=7110>

■ Petróleo

Density and sulfur content of selected crude oils
sulfur content (percentage)



■ Gás natural

Composição química [% (v/v)]

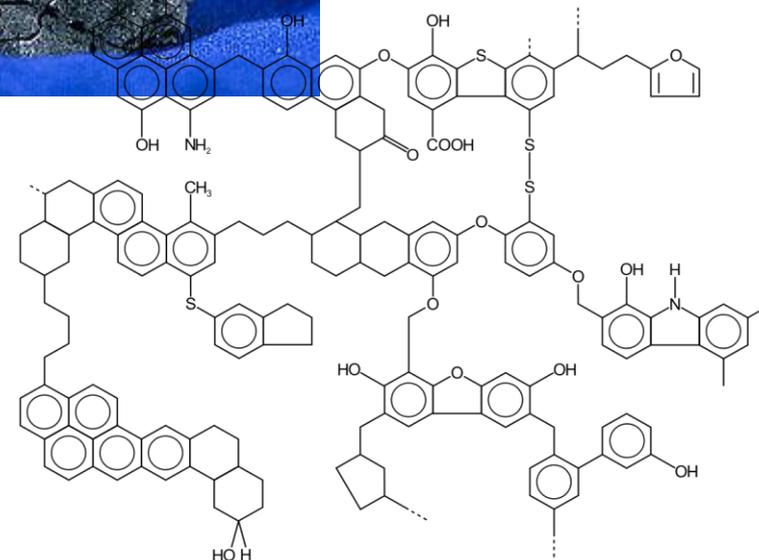
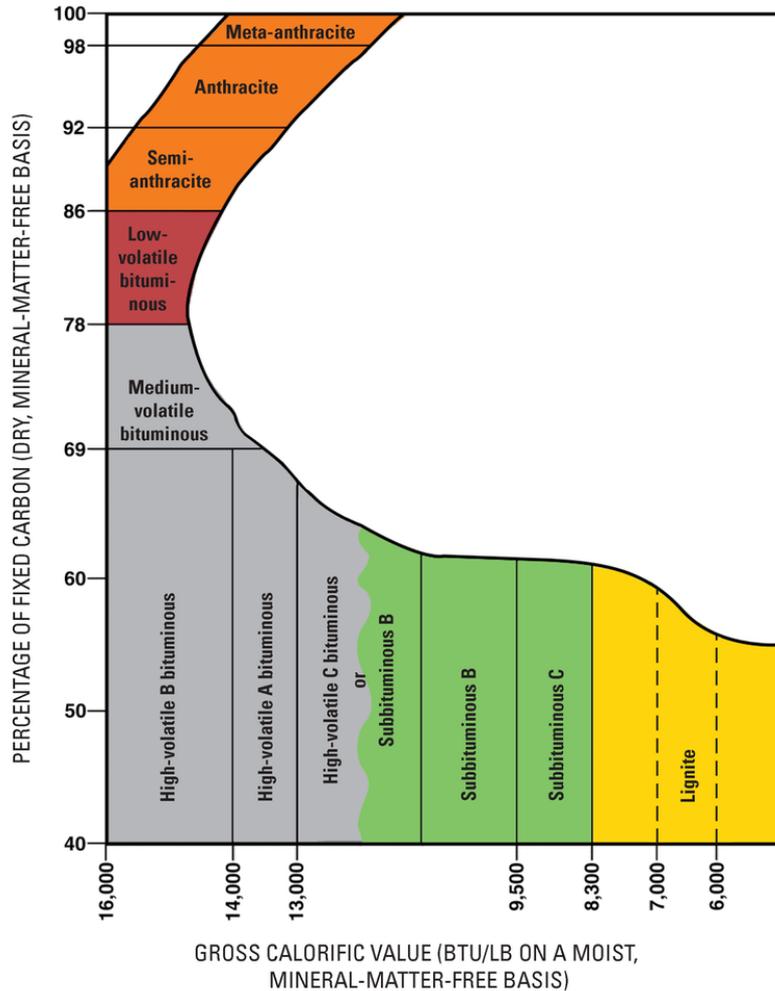
Component	Typical Analysis (mole %)	Range (mole %)
Methane	95.0	87.0 - 97.0
Ethane	3.2	1.5 - 7.0
Propane	0.2	0.1 - 1.5
iso - Butane	0.03	0.01 - 0.3
normal - Butane	0.03	0.01 - 0.3
iso - Pentane	0.01	trace - 0.04
normal - Pentane	0.01	trace - 0.04
Hexanes plus	0.01	trace - 0.06
Nitrogen	1.0	0.2 - 5.5
Carbon Dioxide	0.5	0.1 - 1.0
Oxygen	0.02	0.01 - 0.1
Hydrogen	trace	trace - 0.02
Specific Gravity	0.58	0.57 - 0.62
Gross Heating Value (MJ/m ³), dry basis *	38.0	36.0 - 40.2

■ Carvão mineral

Composição química [% (m/m)]

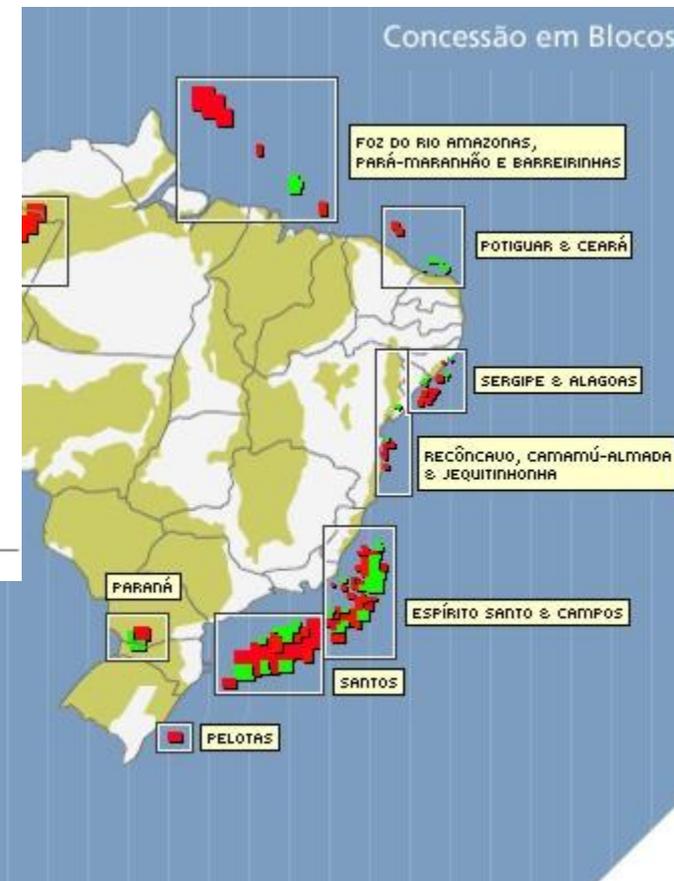
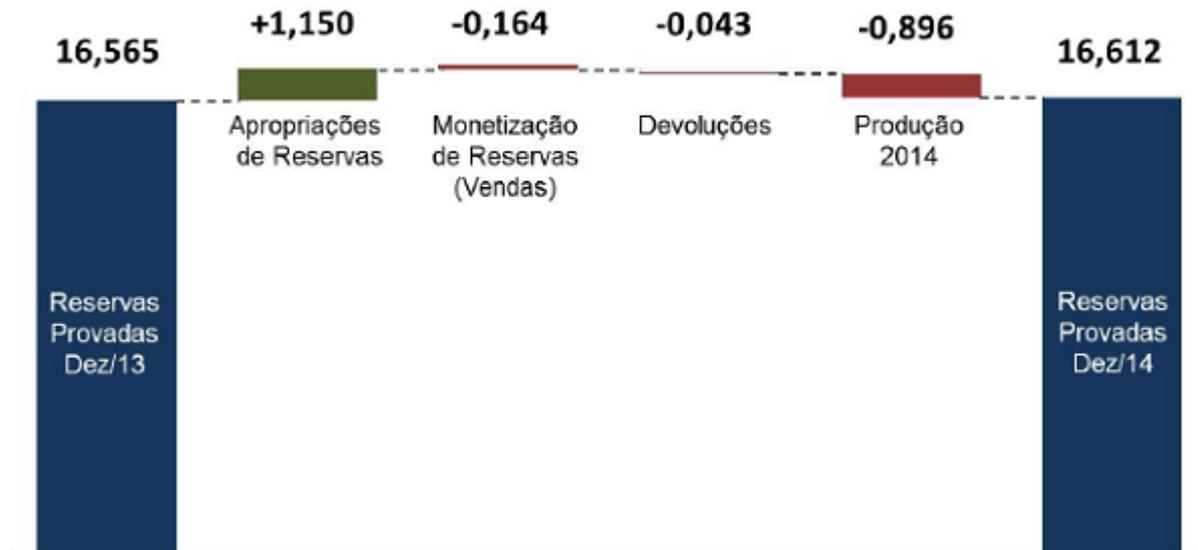
Types	Volatiles %	C %	H %	O %	S %	Heat content kJ/kg
Lignite (brown coal)	45–65	60–75	6.0–5.8	34-17	0.5-3	<28,470
Flame coal	40-45	75-82	6.0-5.8	>9.8	~1	<32,870
Gas flame coal	35-40	82-85	5.8-5.6	9.8-7.3	~1	<33,910
Gas coal	28-35	85-87.5	5.6-5.0	7.3-4.5	~1	<34,960
Fat coal	19-28	87.5-89.5	5.0-4.5	4.5-3.2	~1	<35,380
Forge coal	14-19	89.5-90.5	4.5-4.0	3.2-2.8	~1	<35,380
Nonbaking coal	10-14	90.5-91.5	4.0-3.75	2.8-3.5	~1	35,380
Anthracite	7-12	>91.5	<3.75	<2.5	~1	<35,300

Carvão mineral



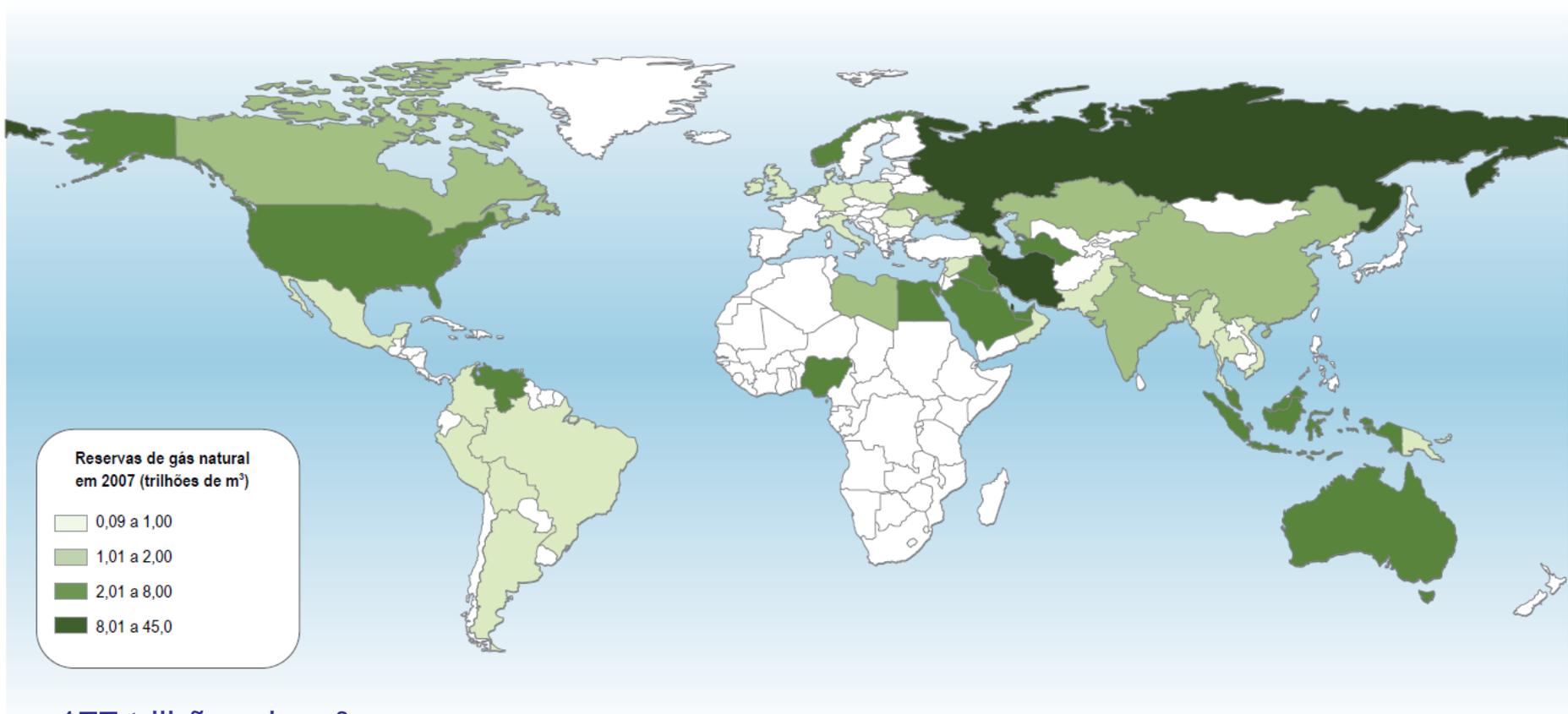
■ Petróleo

Gráfico 1 - Evolução das Reservas Provasdas em 2014:
Consolidado (critérios ANP/SPE, bilhões de boe)



Reservas no mundo e no Brasil

- Gás natural (convencional)

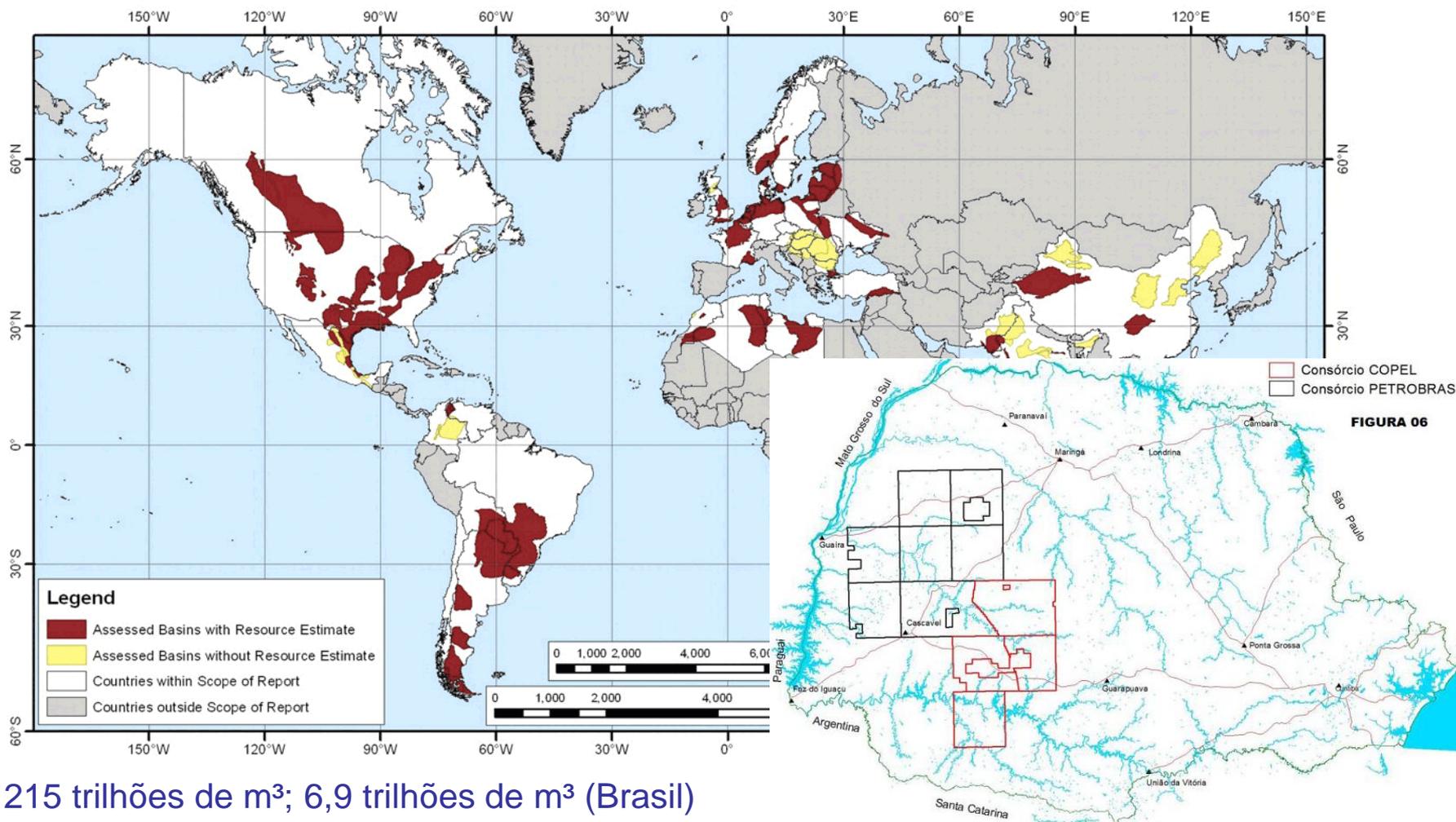


177 trilhões de m³

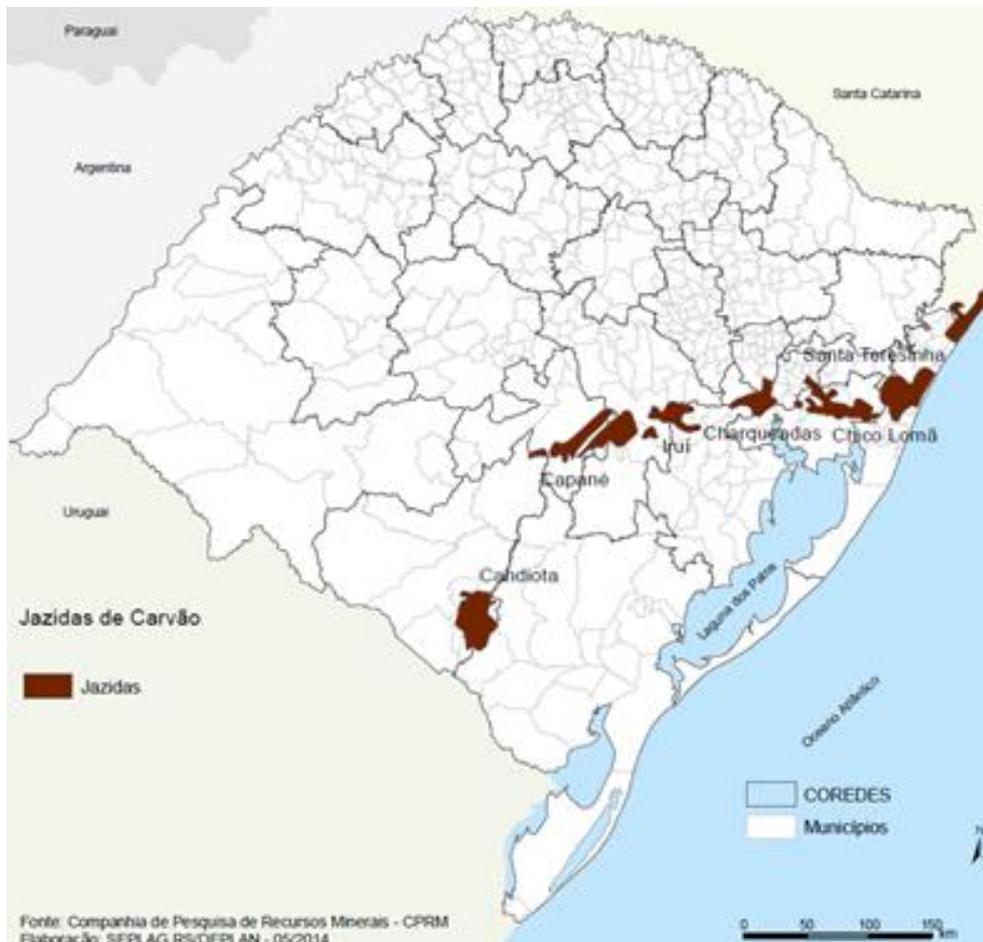
0,4 trilhões de m³ (Brasil)

Reservas no mundo e no Brasil

■ Gás natural (shale, gás de xisto)



■ Carvão mineral



Reservas RS

28,8 bilhões de toneladas

(89% das reservas nacionais)

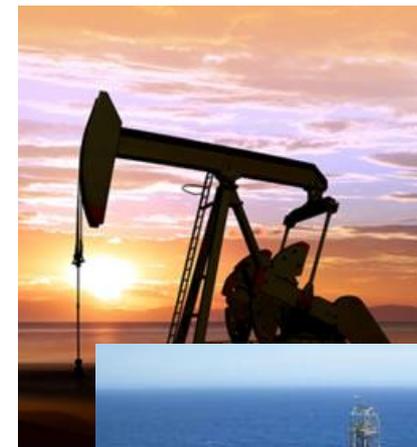
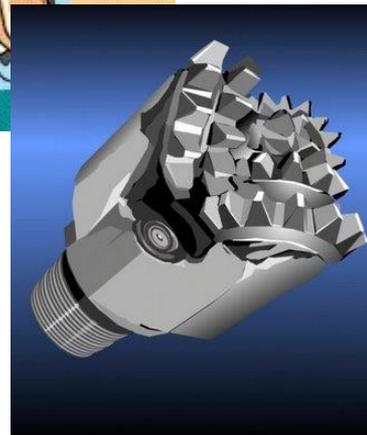
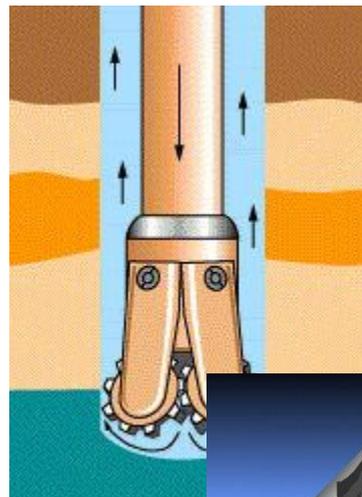
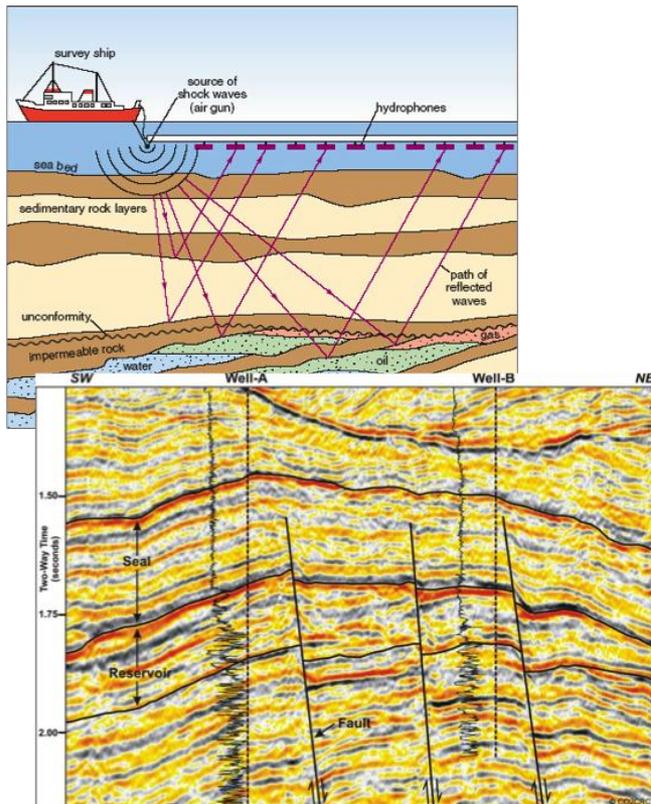
Modos de exploração

■ Petróleo

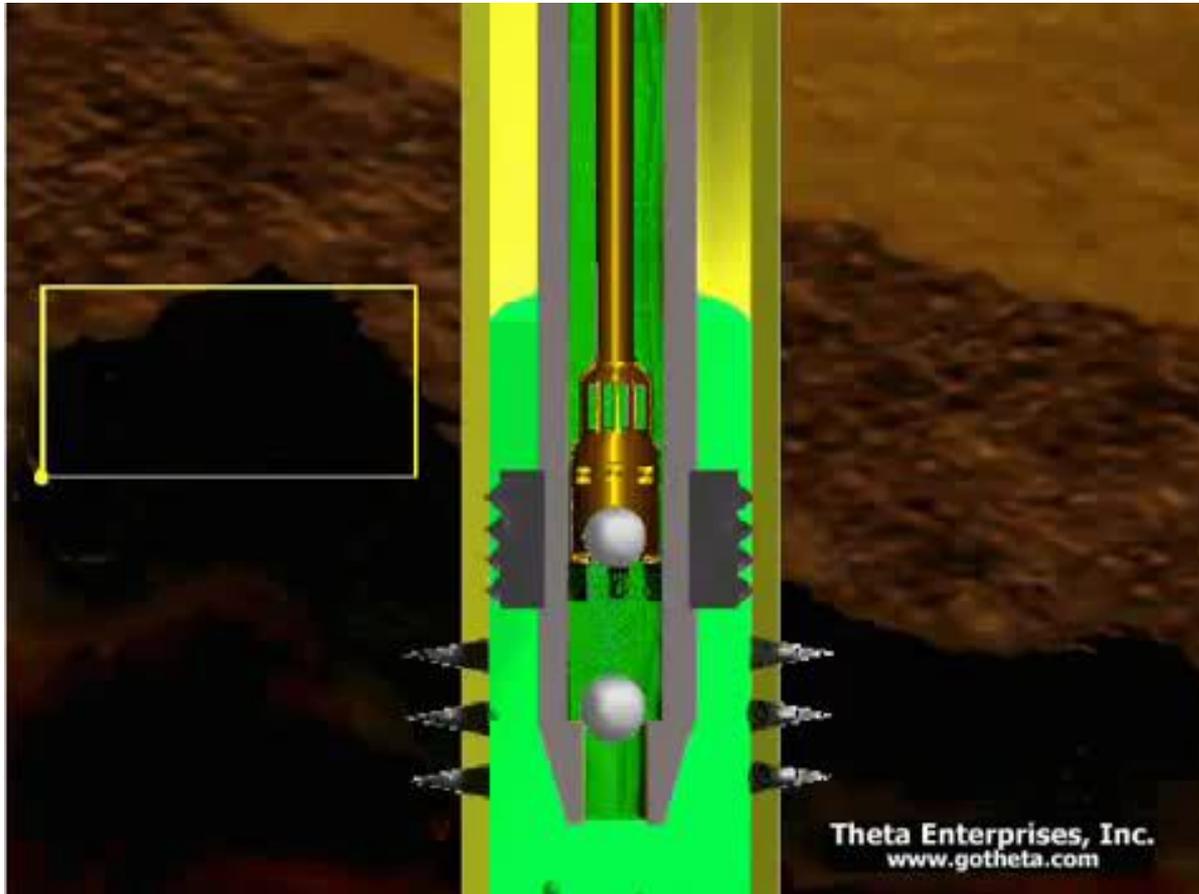
Prospecção

Perfuração

Extração



- Petróleo



Modos de exploração

■ Gás natural

Gás convencional



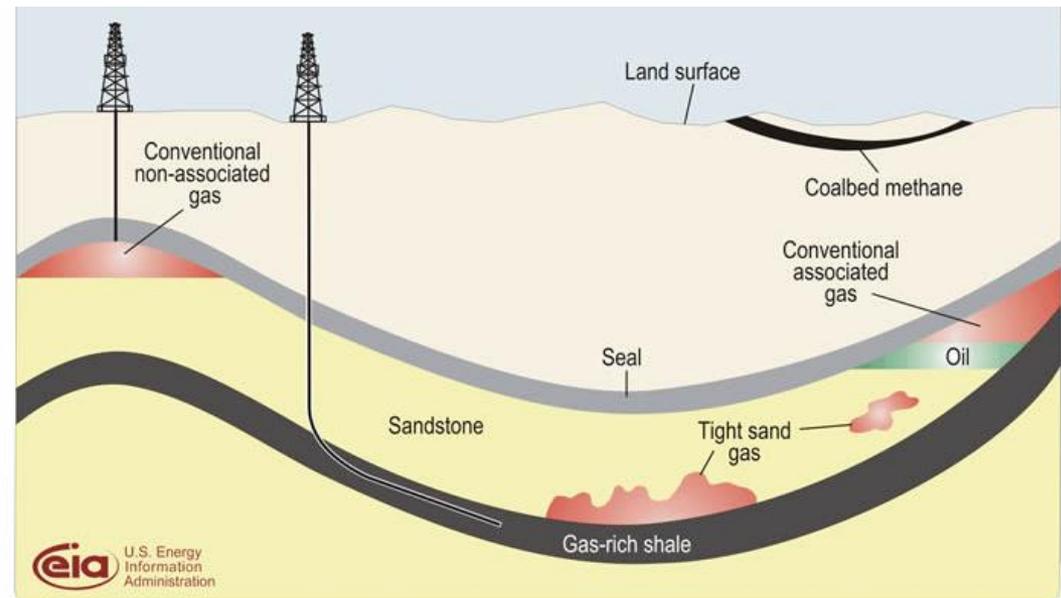
Gás associado

Gás não associado

Gás não convencional



Fracking



Modos de exploração

Carvão mineral

Lavra do carvão

Céu aberto

Subterrânea



Beneficiamento

Extração de materiais inertes

Secagem

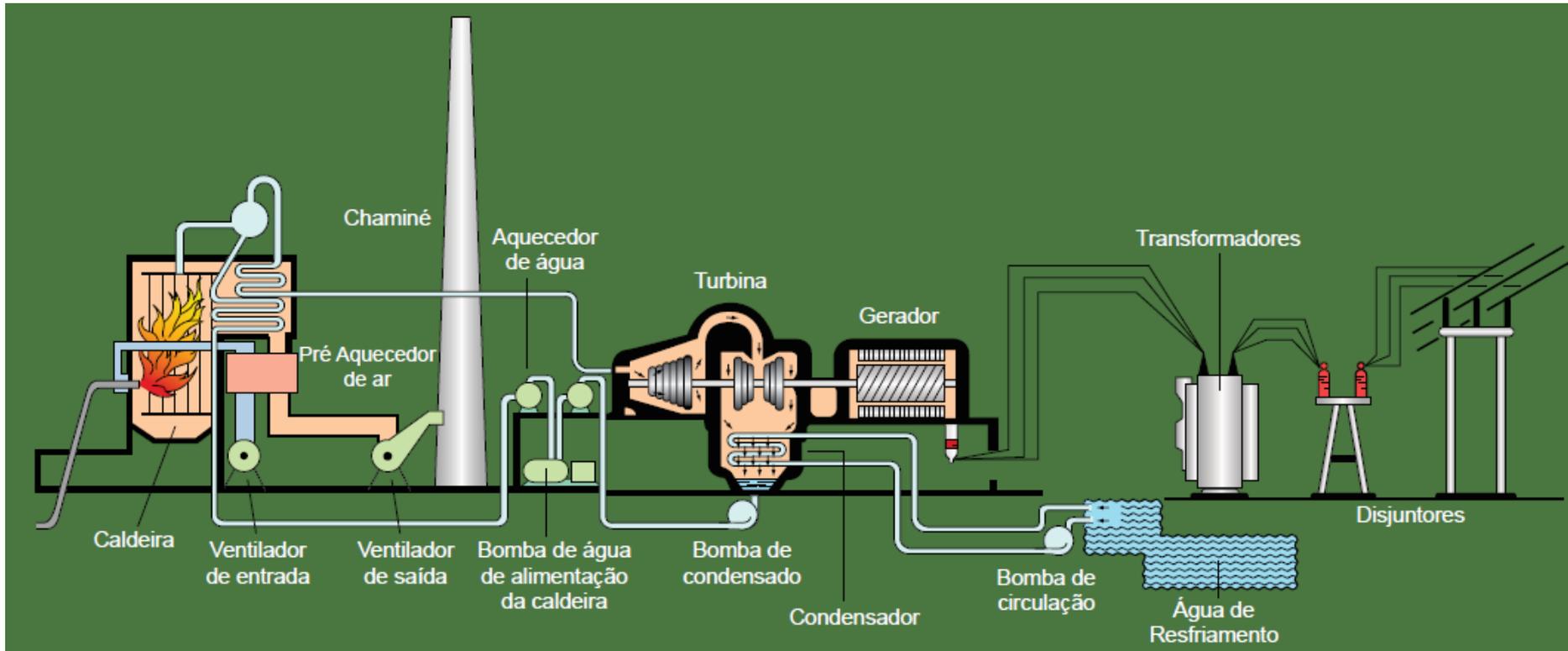
- Carvão mineral



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- Diagrama de Sankey (International Energy Agency)
 - Avaliar consumo final (transporte, geração termelétrica, outros usos);
 - [http://www.iea.org/sankey/#?c=IEA Total&s=Balance](http://www.iea.org/sankey/#?c=IEA%20Total&s=Balance)

■ Petróleo



Uso final

- Petróleo



SUAPE: 381 MW; FC=0,70

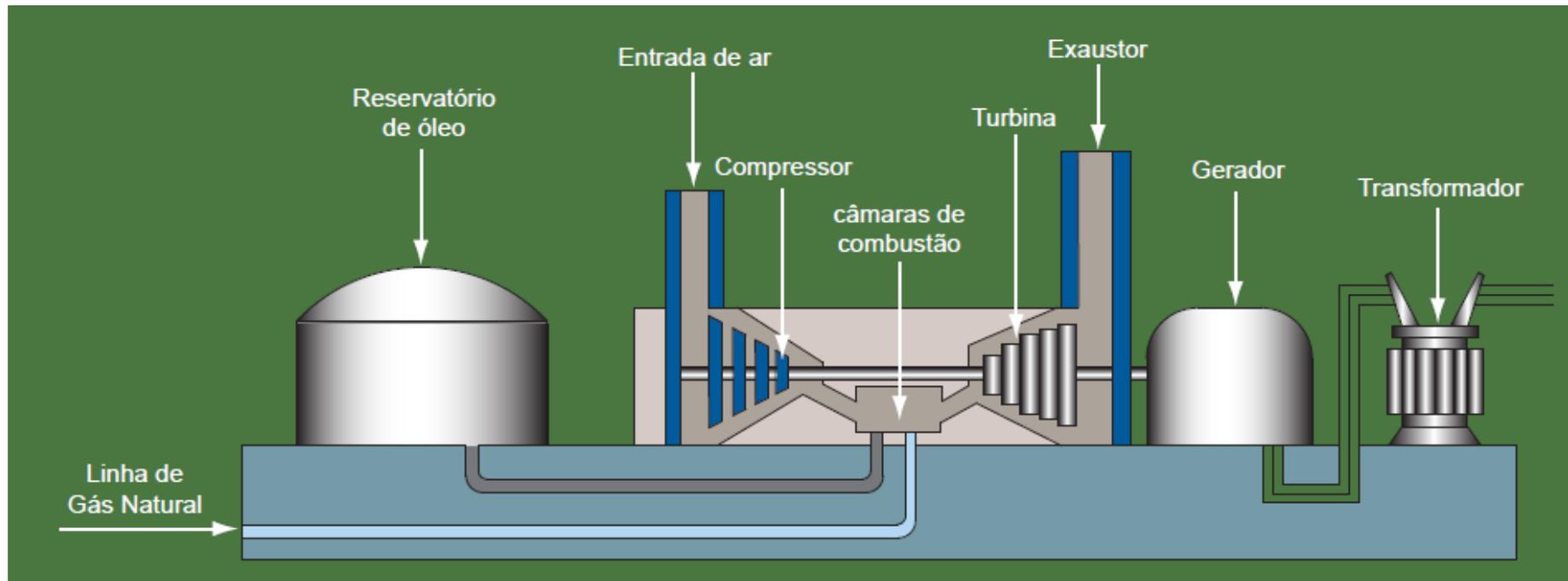


Borborema Energética: 169 MW; FC=0,76

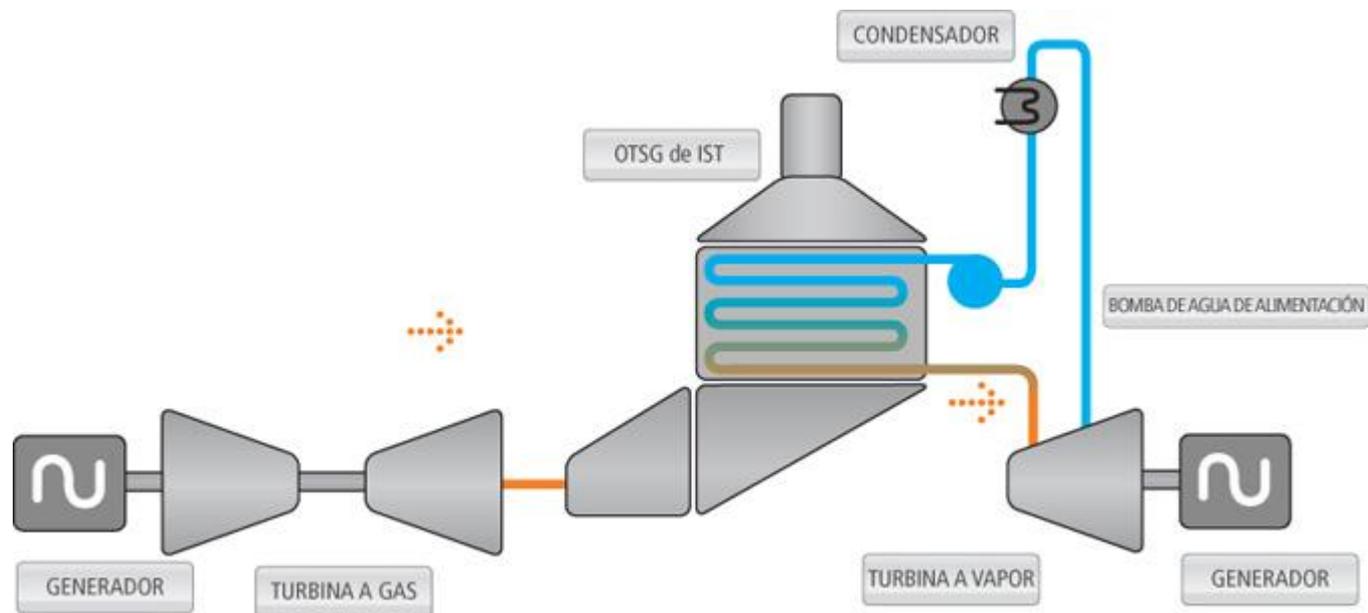
- Petróleo



- Gás natural



- Gás natural

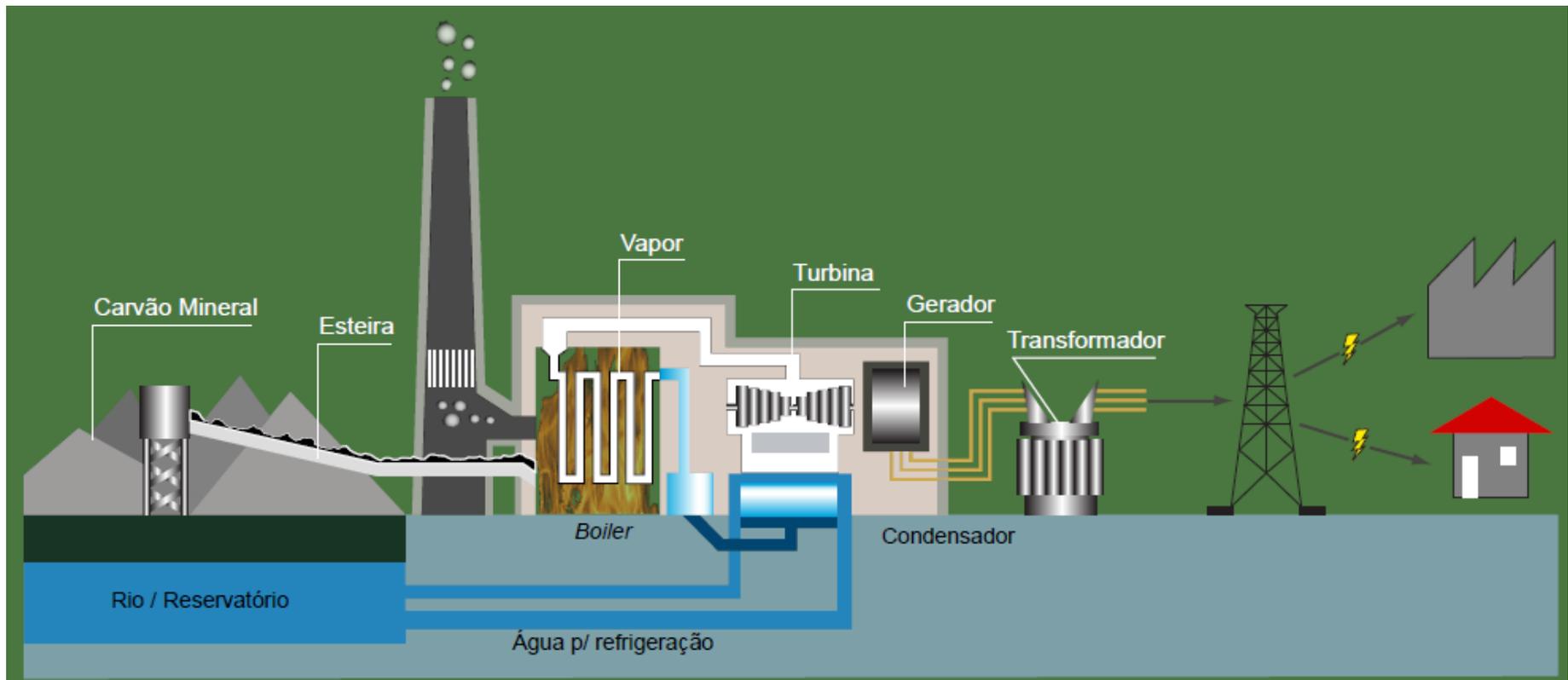


- Gás natural



TERMOPE: 530 MW; FC=0,81

- Carvão mineral



- Carvão mineral



Jorge Lacerda, Unidade C, Santa Catarina

363 MW

170 bar; 538 C

- Carvão mineral

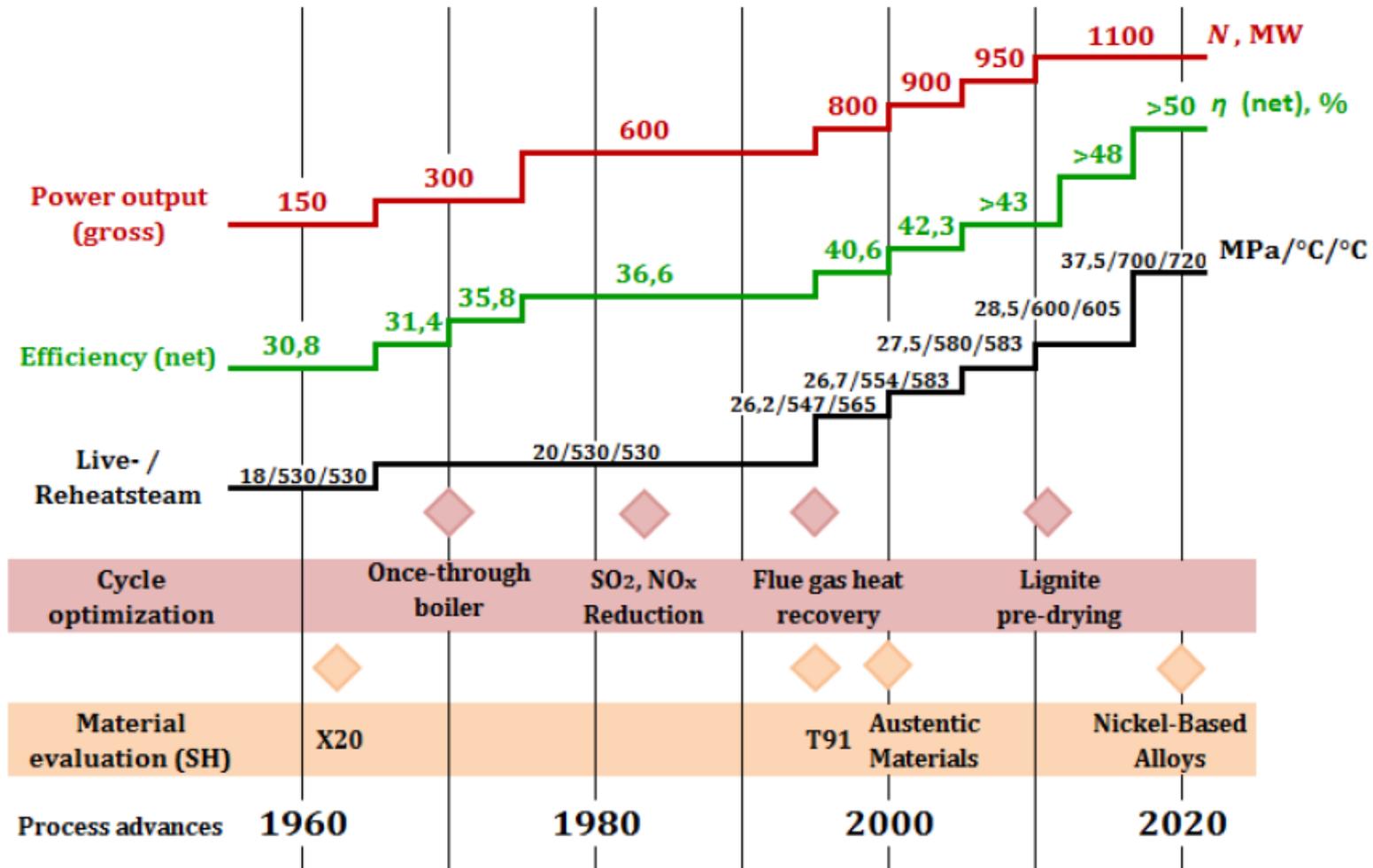


Boa 2 e 3; Nordrhein-Westfalen, Alemanha

1.060 MW + 1.060 MW; 280 bar / 600 C

Uso final

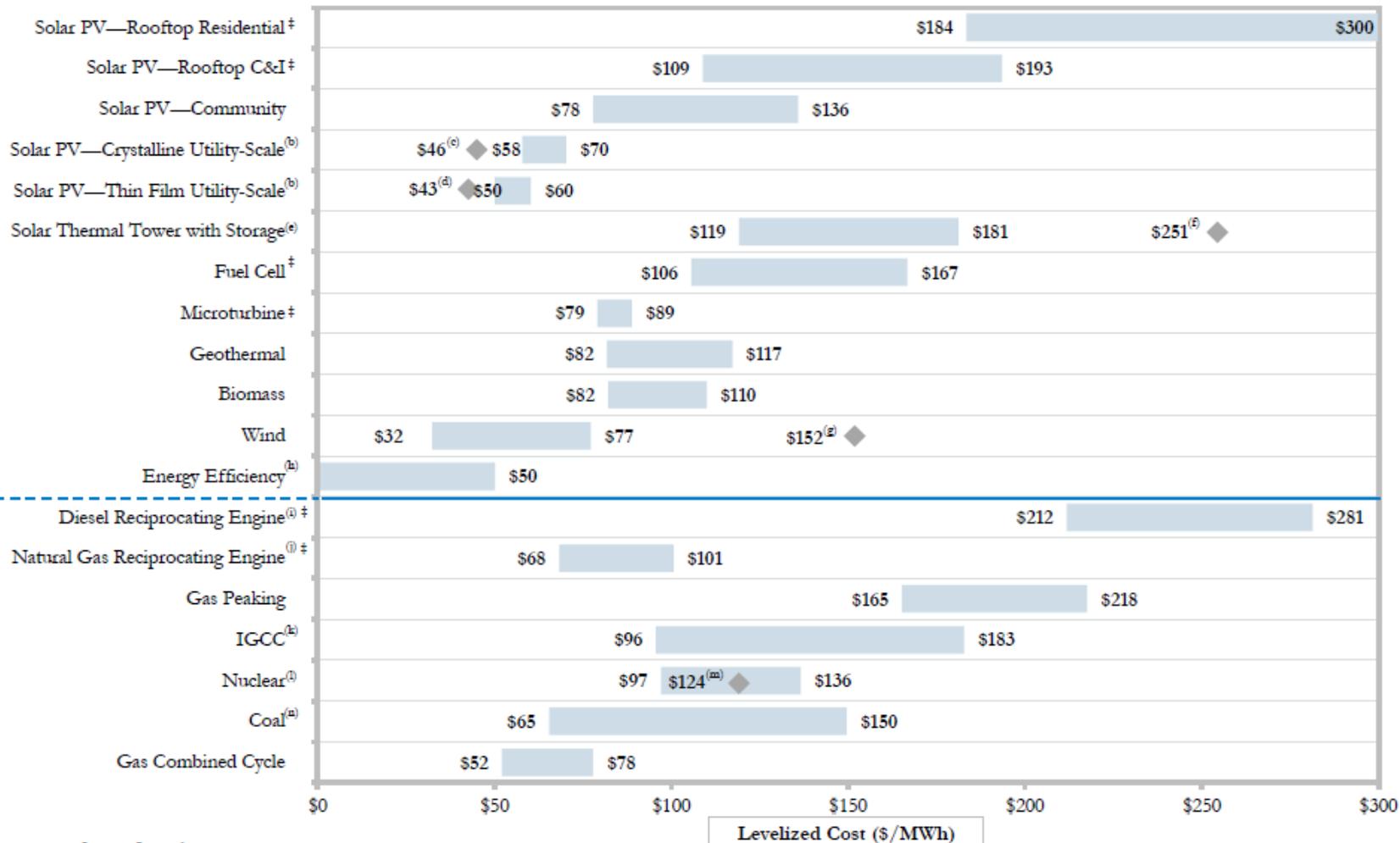
Carvão mineral



■ Custo de geração nos USA, LCOE [US\$/MWh]

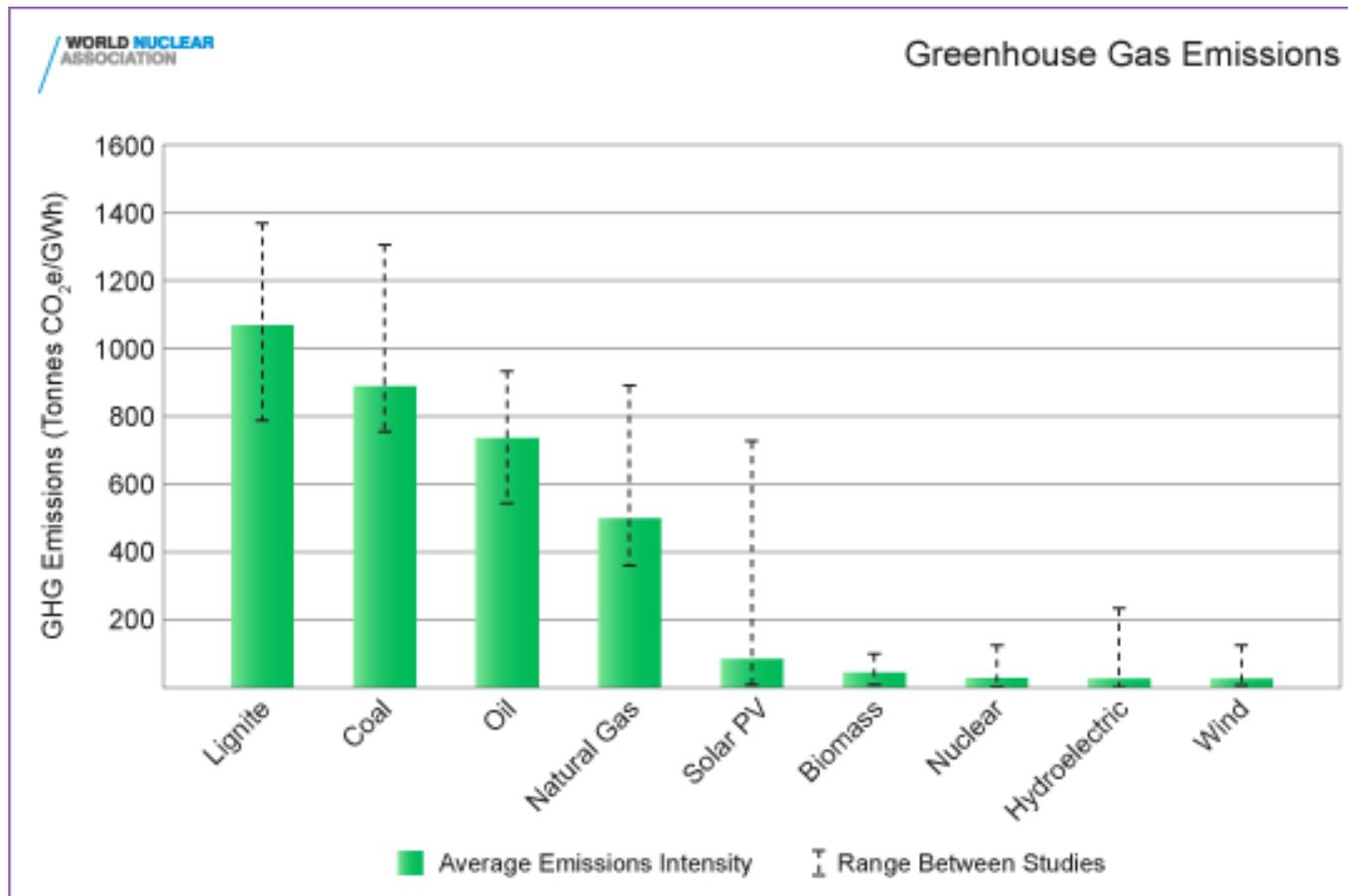
ALTERNATIVE ENERGY^(*)

CONVENTIONAL



Source: Lazard estimates.

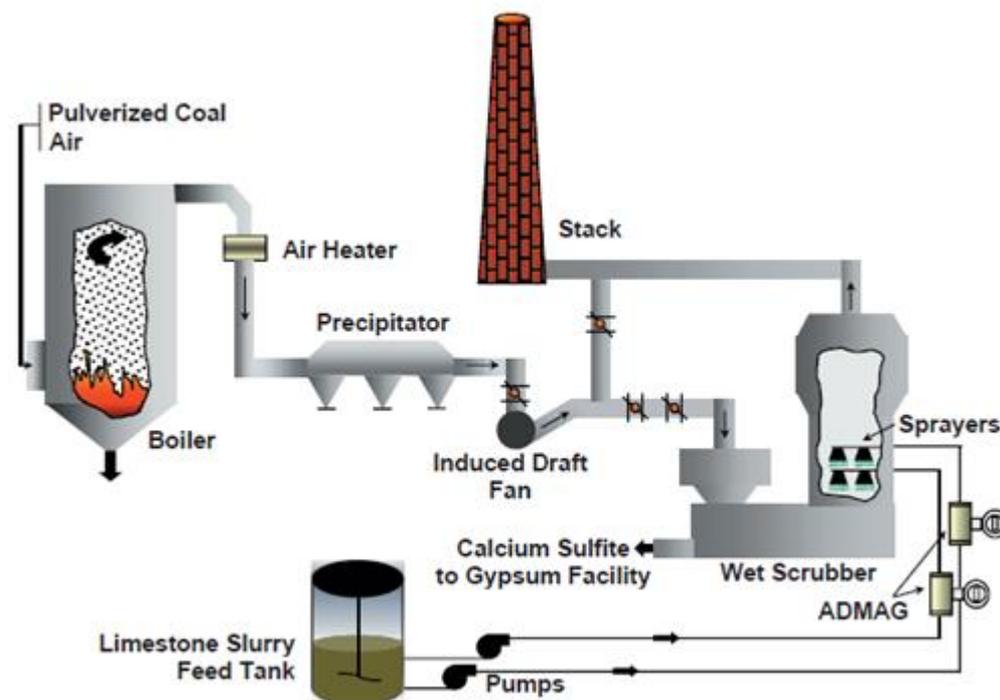
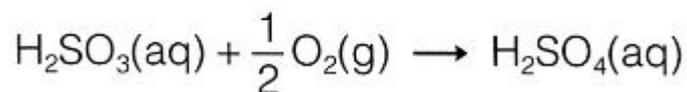
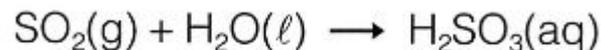
- Emissão de gases do efeito estufa



■ Emissões de SO_x

- Queimar combustíveis com menor teor de S;
- Tratar gases de combustão

Formação de chuva ácida

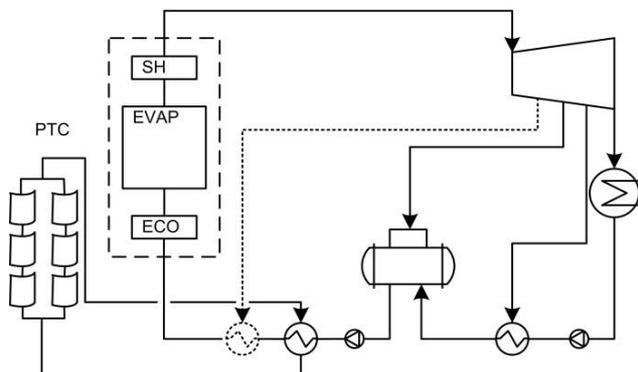


- Emissões de NOx
 - NOx combustível
 - NOx térmico (>1400 C)

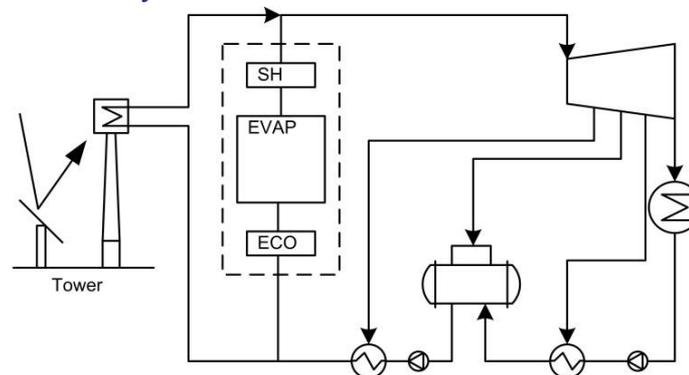
- Desafios
 - Aumentar a eficiência dos sistemas de geração termelétrica
 - Desenvolvimento de combustíveis com baixo teor de S
 - Encontrar substitutos para os fósseis

■ Geração Solar+Fossil

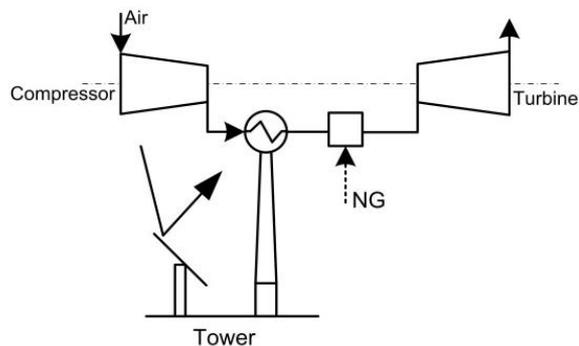
SAFWH: Solar-Aided Feedwater Heating



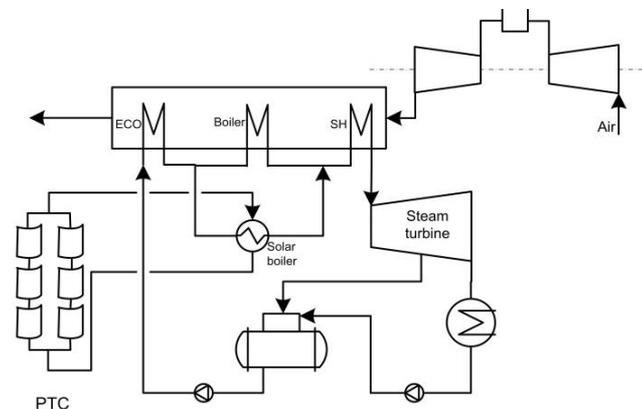
HSG: Hybridized Steam Generators



SGT: Solar-Gas Turbines



ISCC: Integrated Solar Combined Cycles



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