

Combustíveis fósseis

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Combustíveis e biocombustíveis

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Setor Palotina

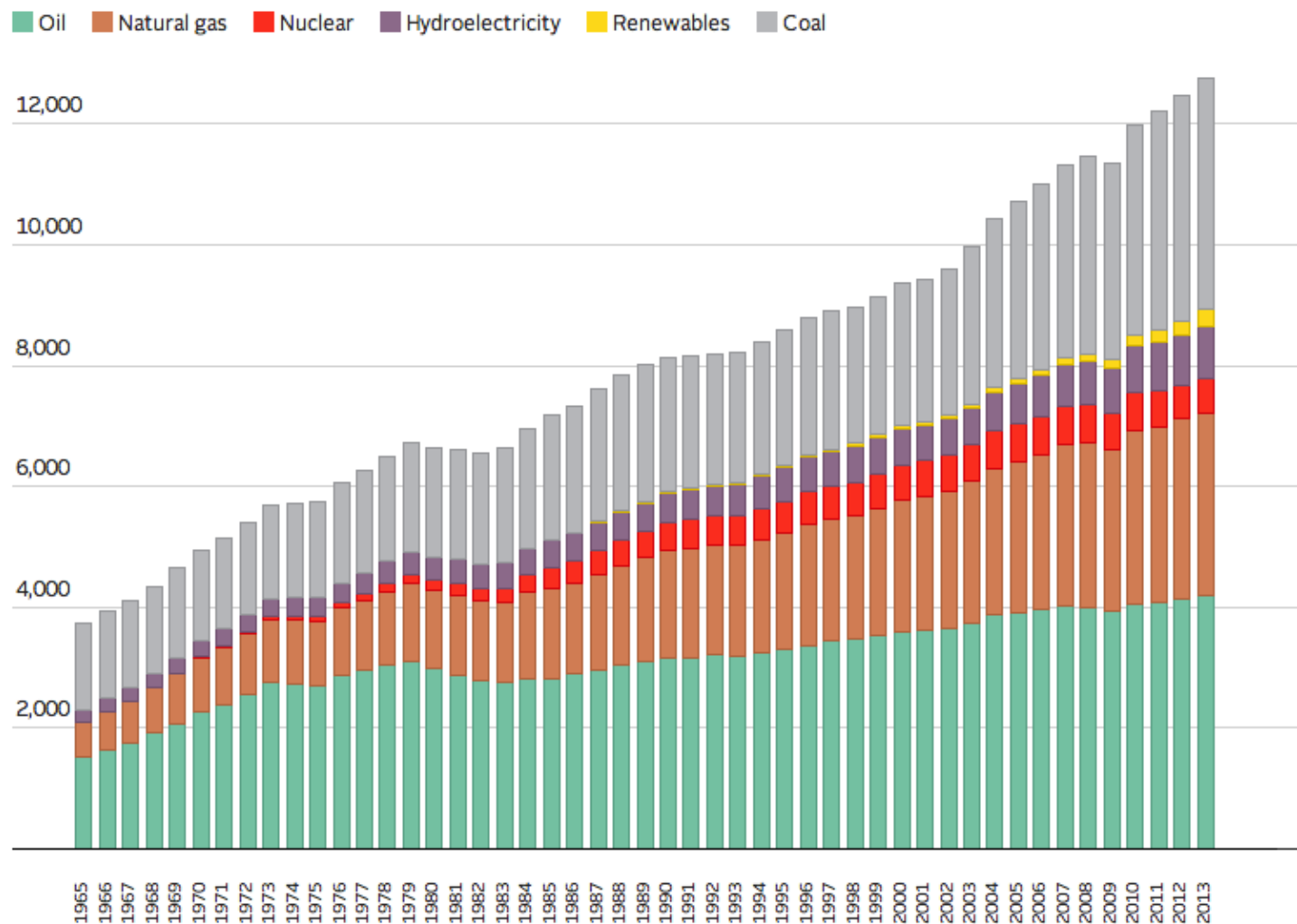


- Parte 1
 - Energia no mundo
 - Formação
 - Características gerais
 - Reservas no mundo e no Brasil
 - Modos de exploração
- Parte 2
 - Uso final
 - Impactos ambientais e desafios

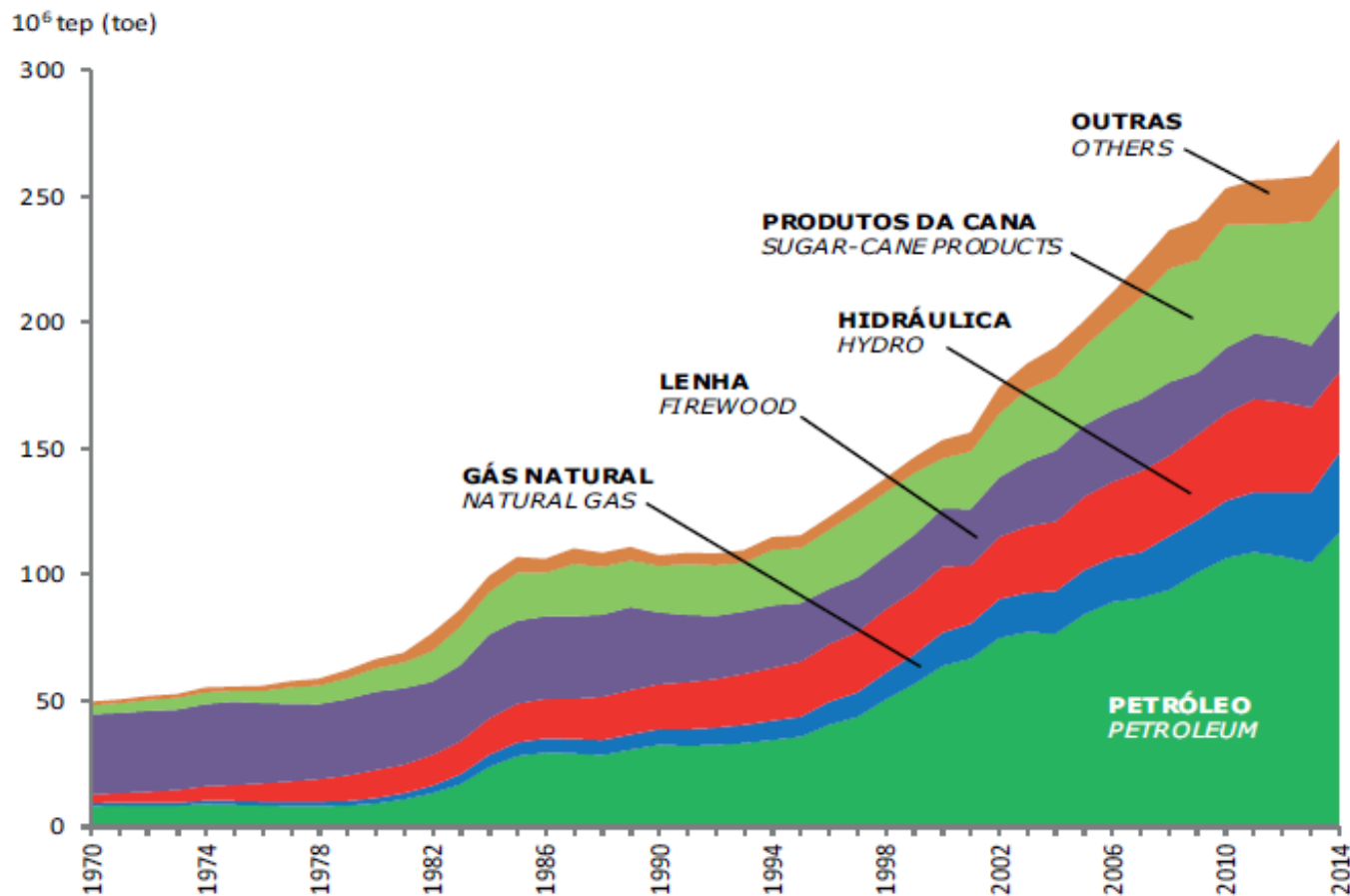
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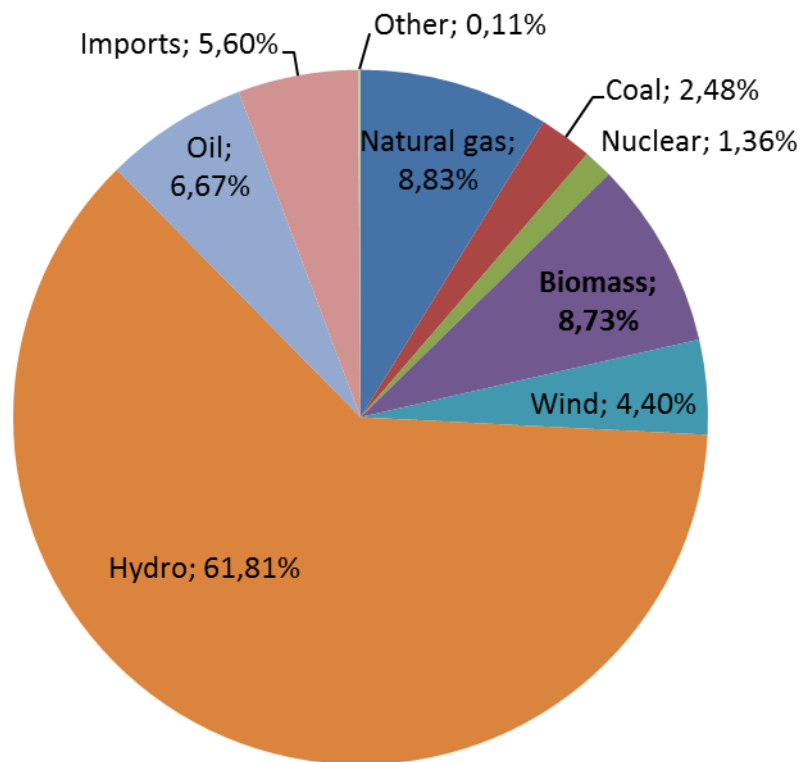
■ Oferta de energia primária – mundo [Mtoe]



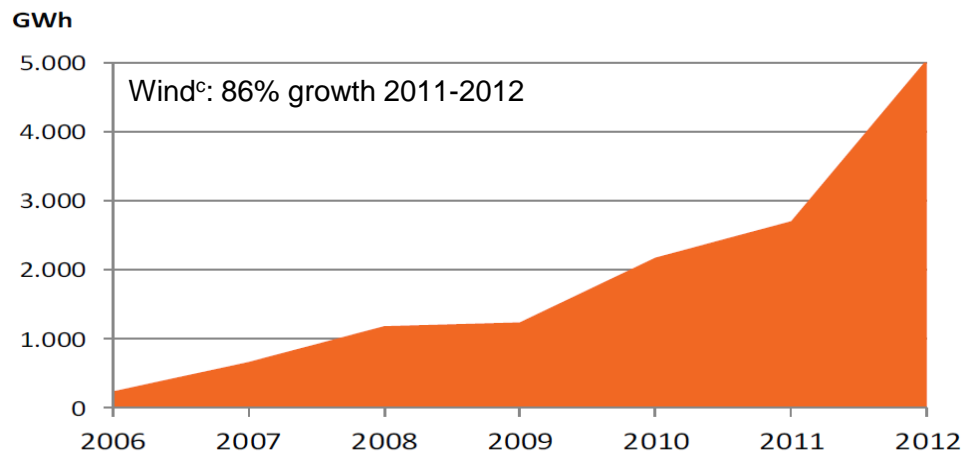
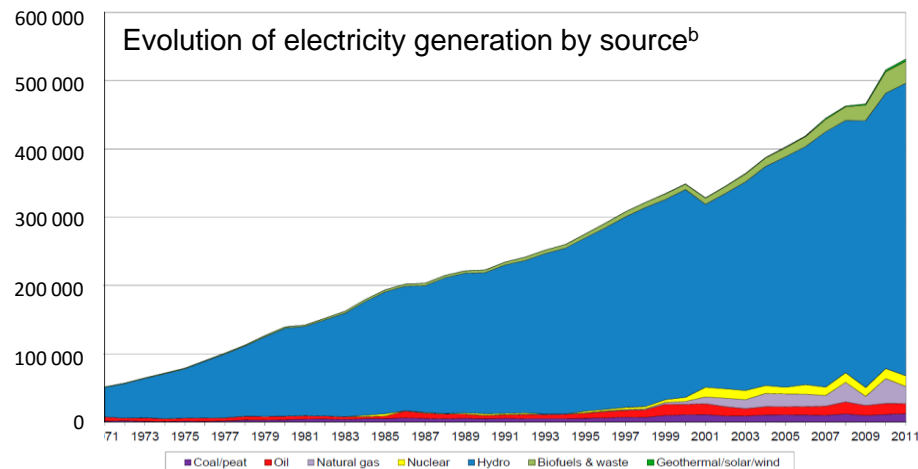
- Oferta de energia primária – Brasil [Mtoe]



▪ Energia elétrica – capacidade instalada no Brasil



•Brazil 2015^a: 146.0 GW

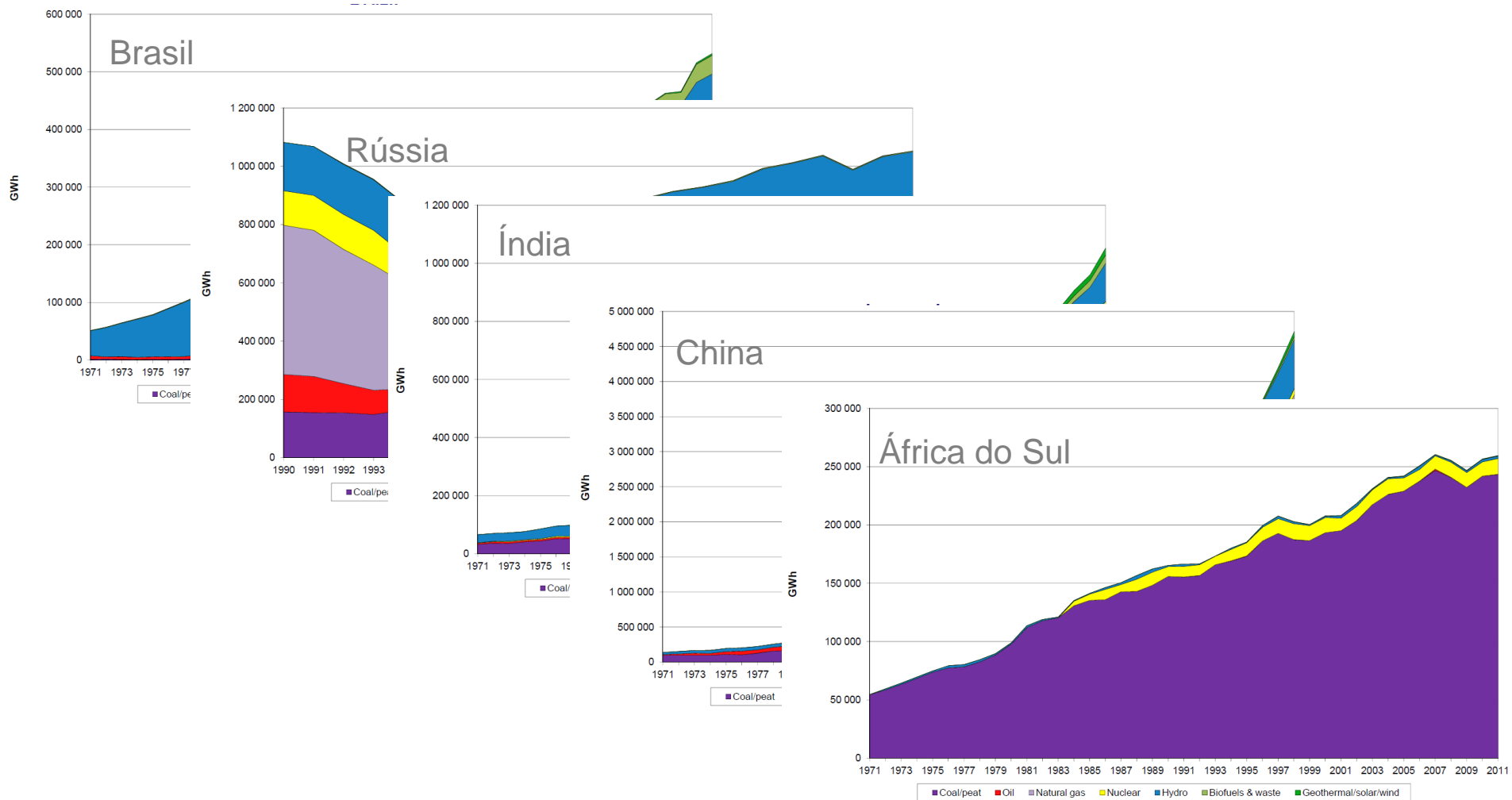


^aANEEL. October 2015. In: <<http://www.aneel.gov.br/15.htm>>.

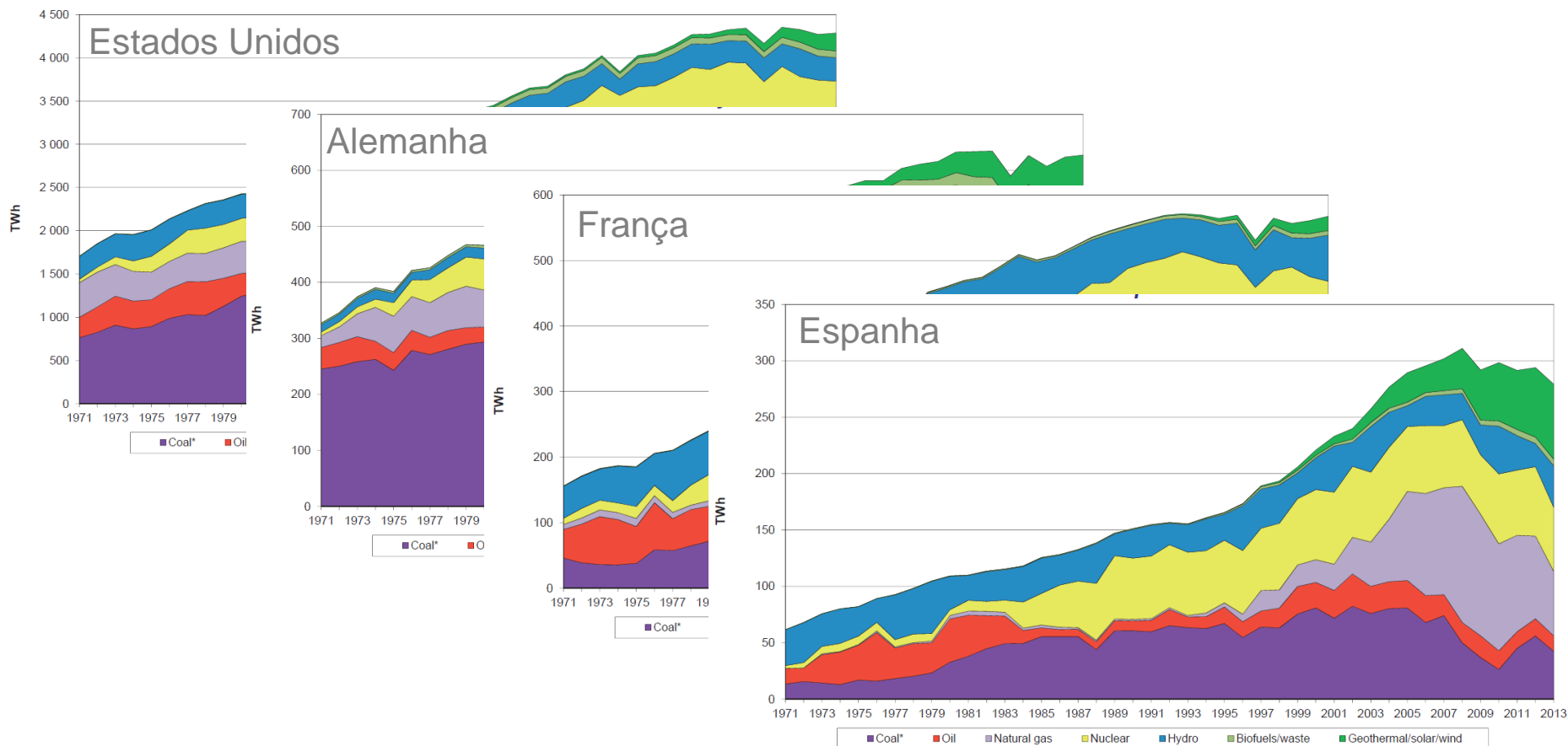
^bIEA. October 2013. In: <<http://www.iea.org/statistics/>>.

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

■ Energia elétrica – geração por tipo

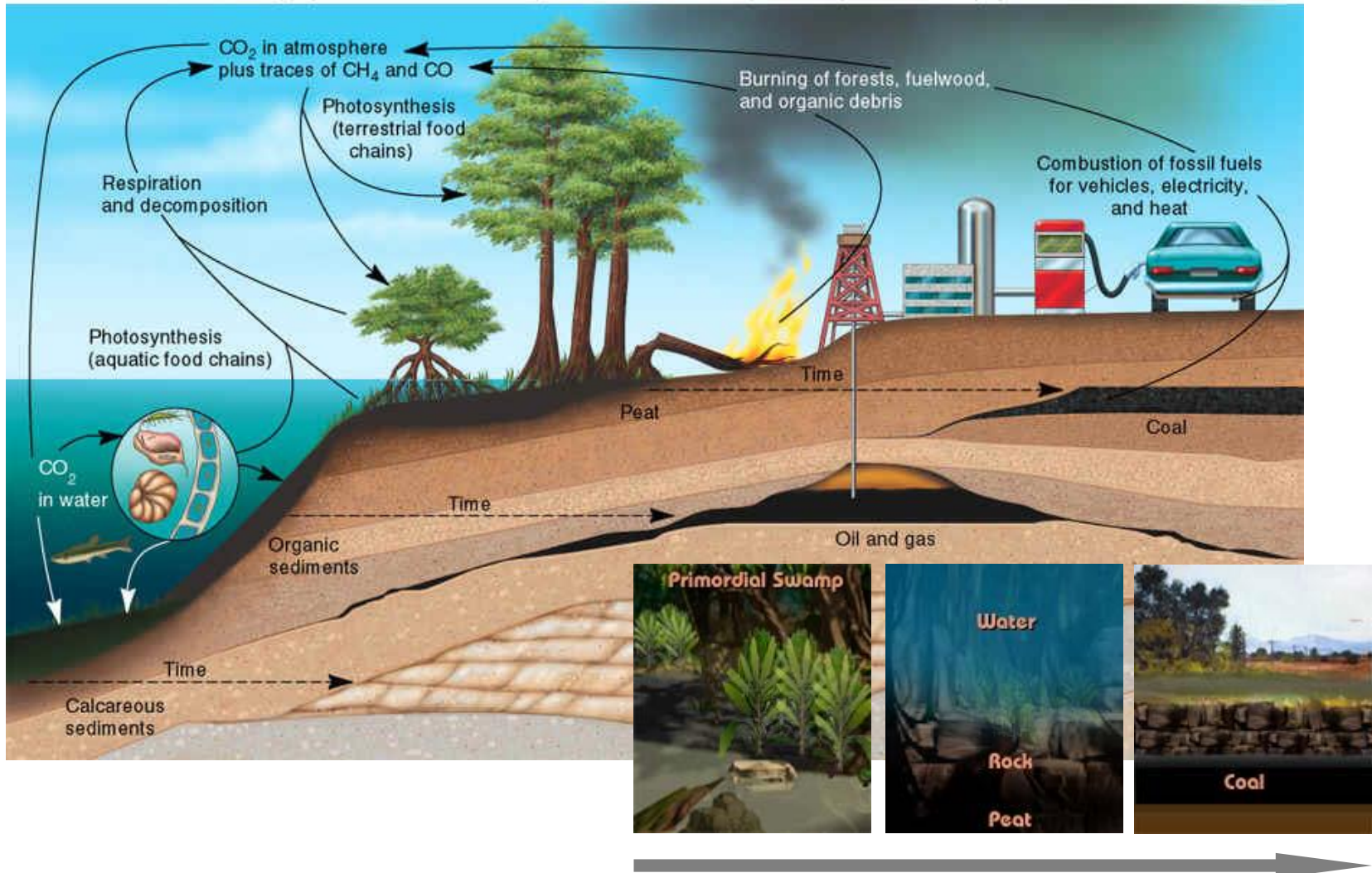


■ Energia elétrica – geração por tipo



Formação

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- Turfa



Campo de turfa¹

Carvão linhito



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

■ Petróleo

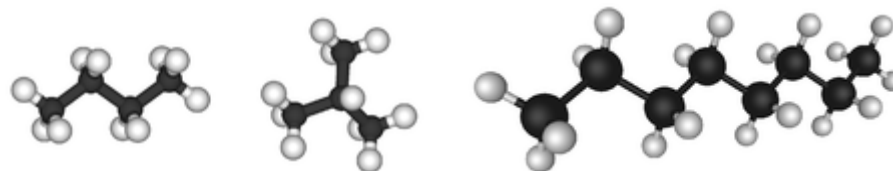
Composição química [% (m/m)]

| 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 |

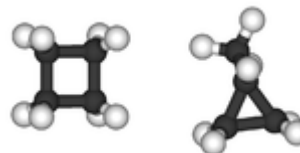
Composição química [% (m/m)]

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

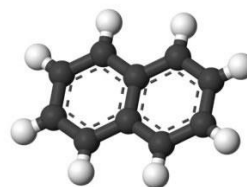
Alcanos:



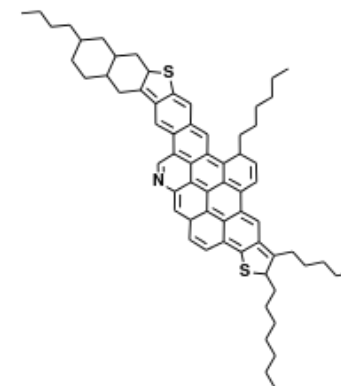
Naftênicos (cicloalcanos):



Aromáticos



Asfaltenos

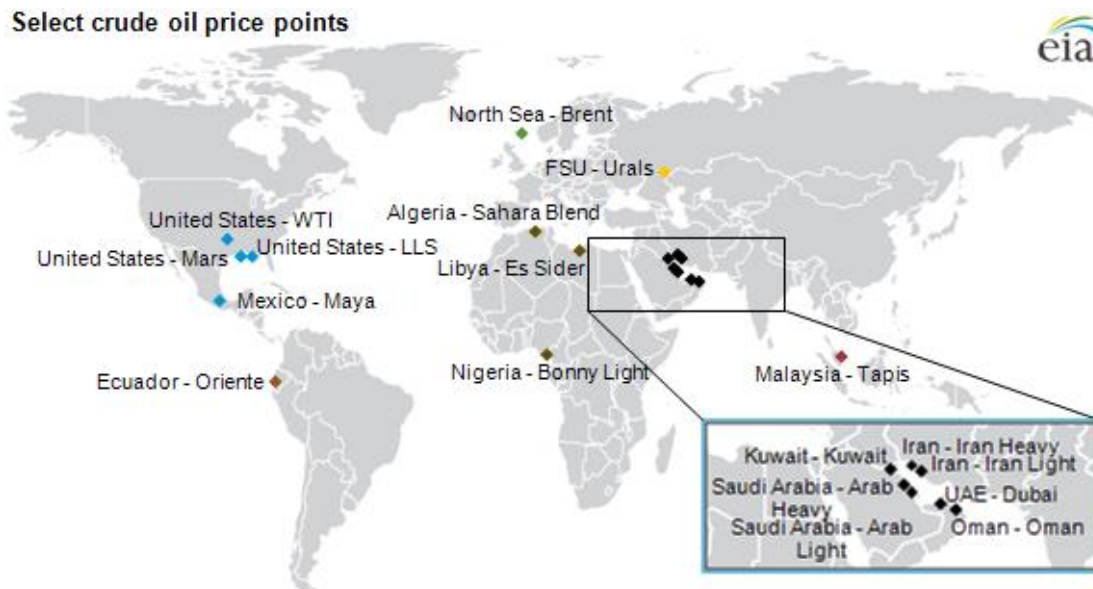


■ Petróleo

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:**

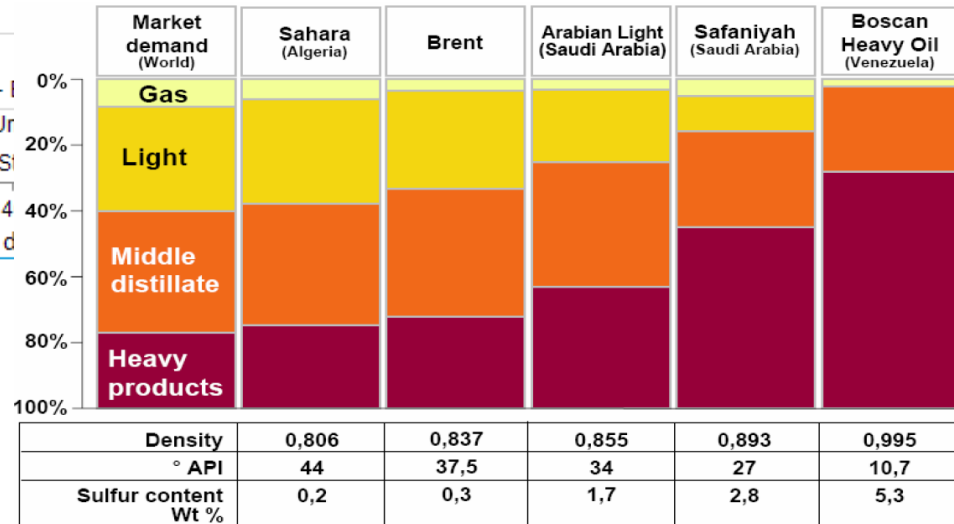
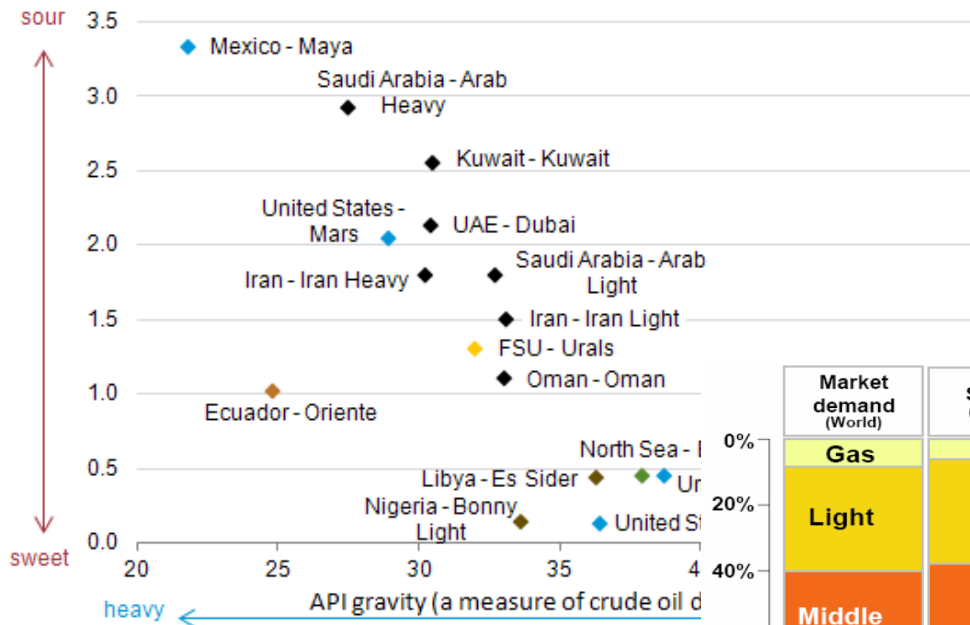


¹http://www.ufrgs.br/lapol/materias_primas/II_26.html

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)]

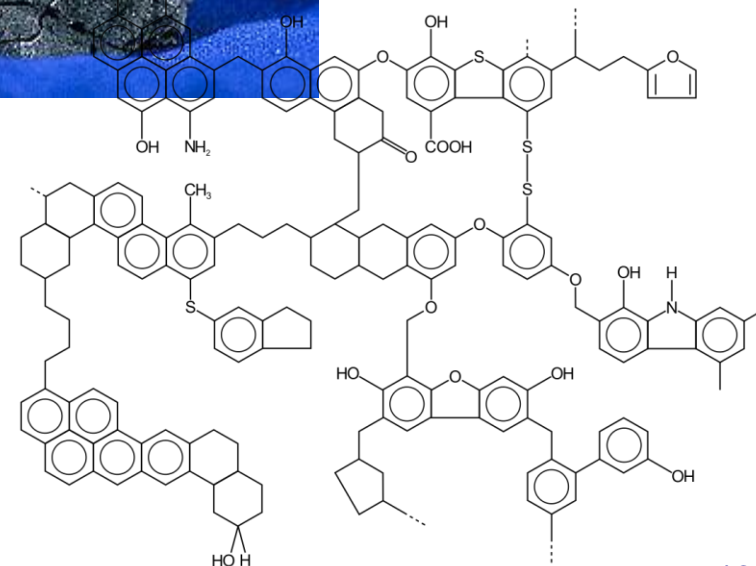
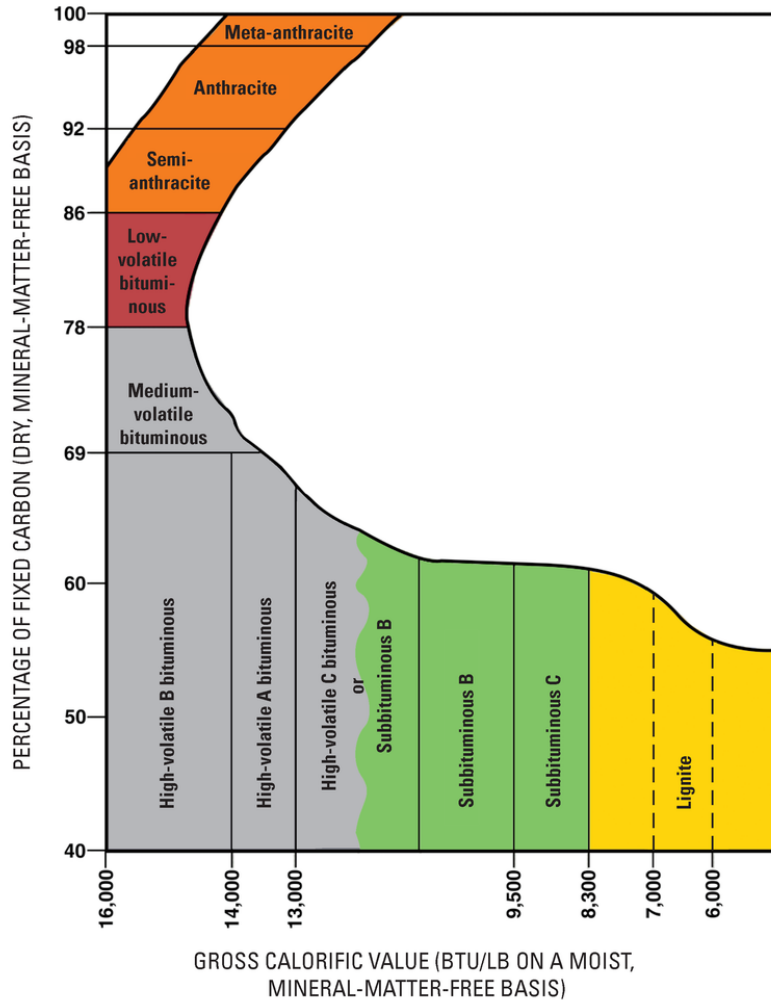
| Component | Typical Analysis (mole %) | Range (mole %) |
|---|---------------------------|----------------|
| Methane | 95.0 | 87.0 - 97.0 |
| Ethane | 3.2 | 1.5 - 7.0 |
| Propane | 0.2 | 0.1 - 1.5 |
| iso - Butane | 0.03 | 0.01 - 0.3 |
| normal - Butane | 0.03 | 0.01 - 0.3 |
| iso - Pentane | 0.01 | 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

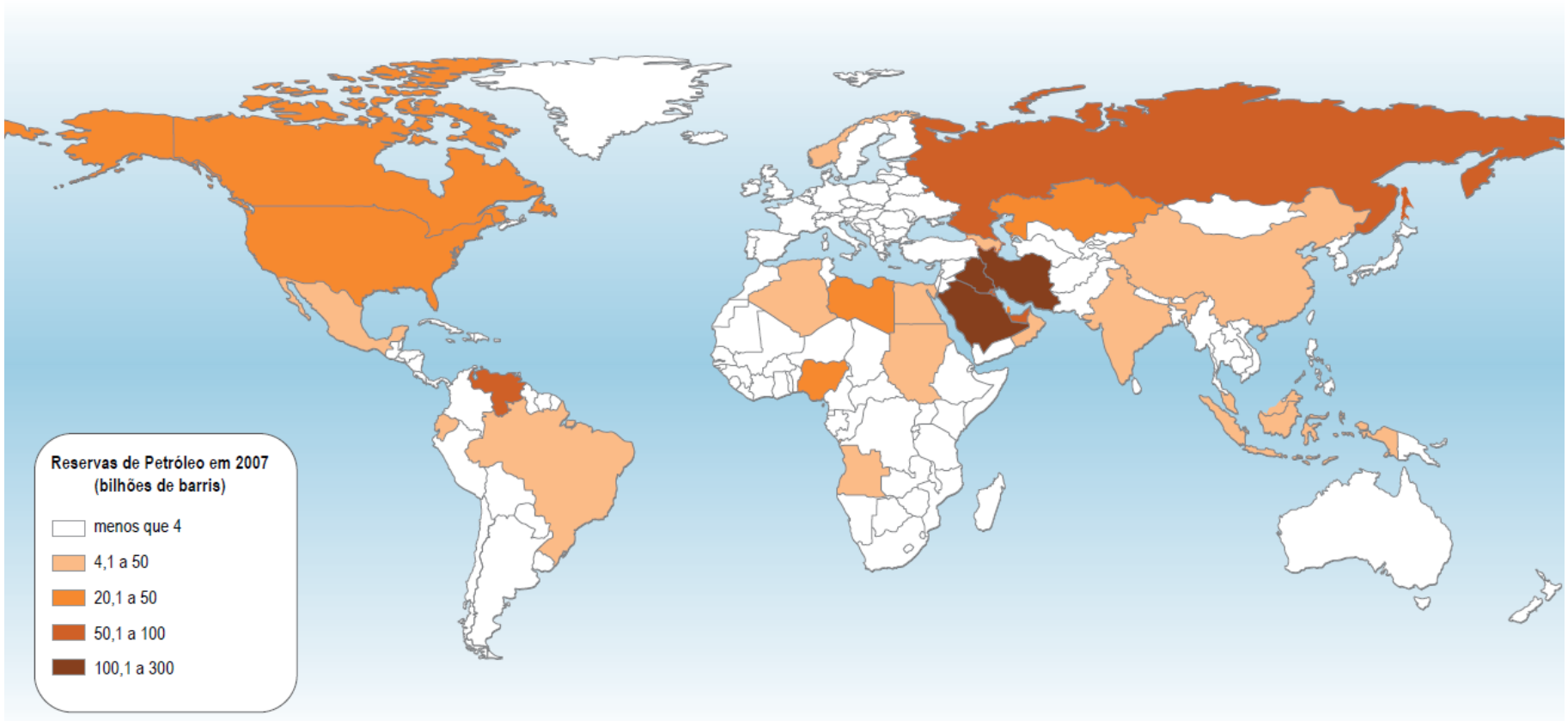
Composição química [% (m/m)]

| 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

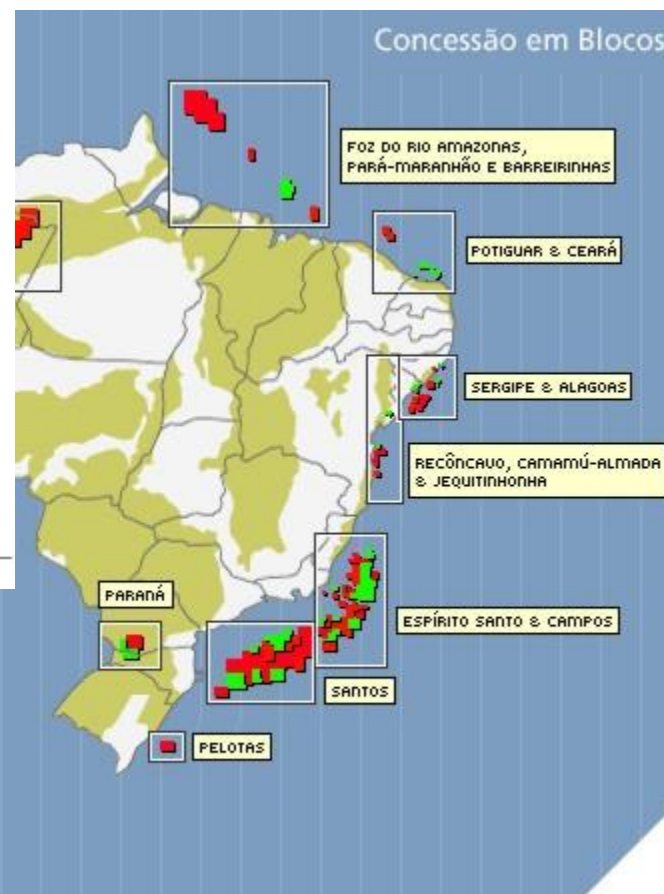
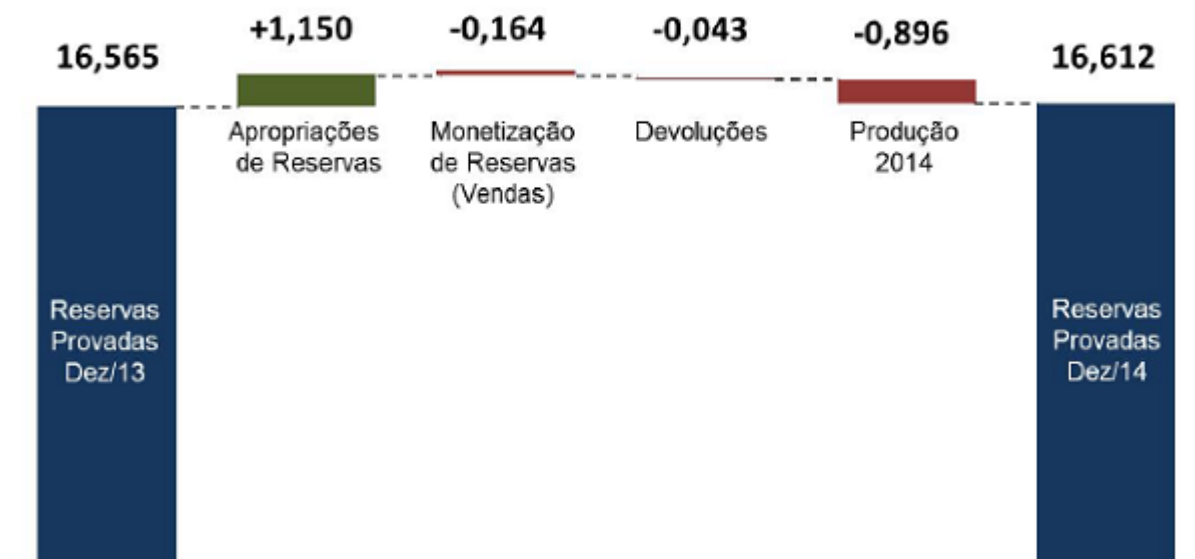


1238 bilhões de barris

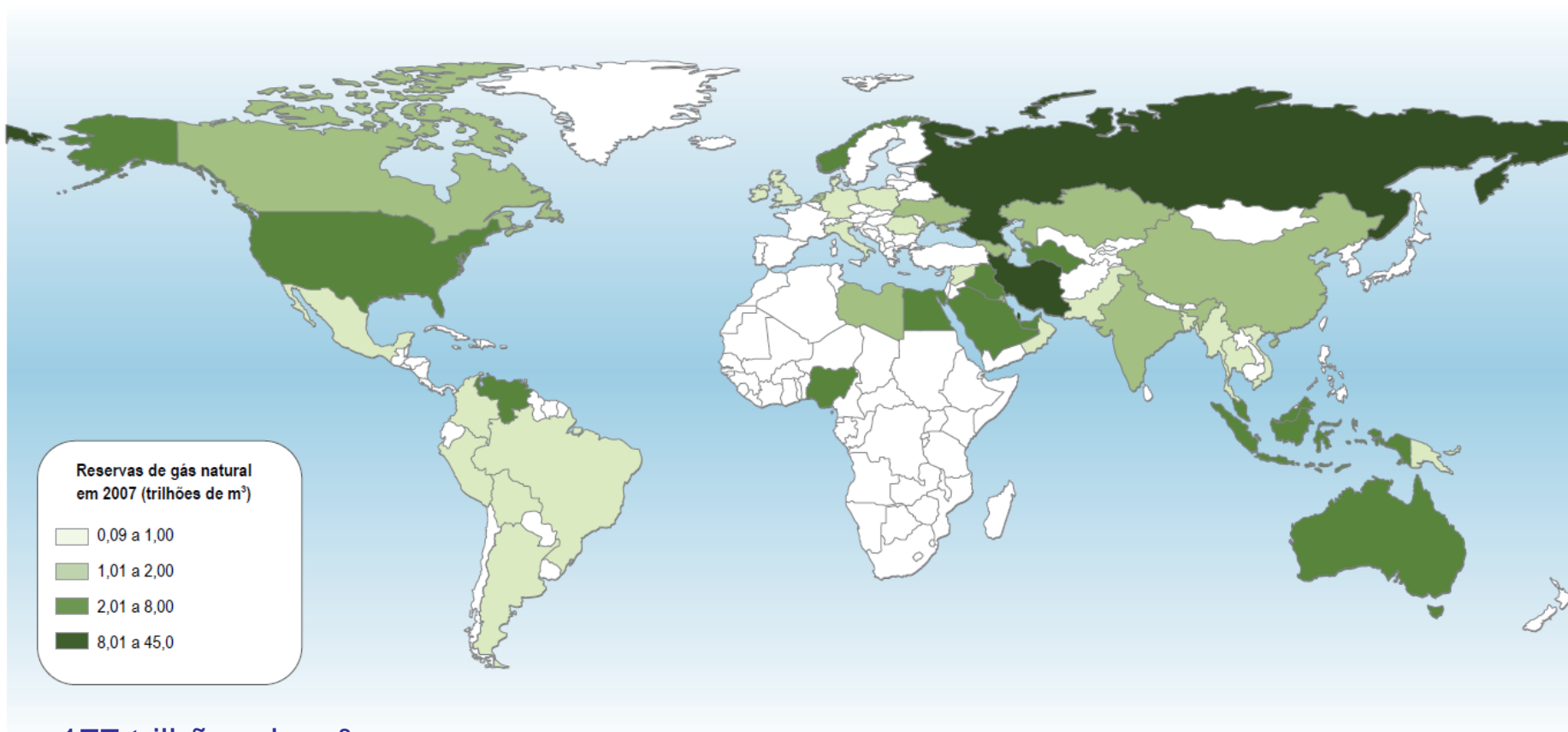
17 bilhões de barris (Brasil)

■ Petróleo

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



- Gás natural (convencional)

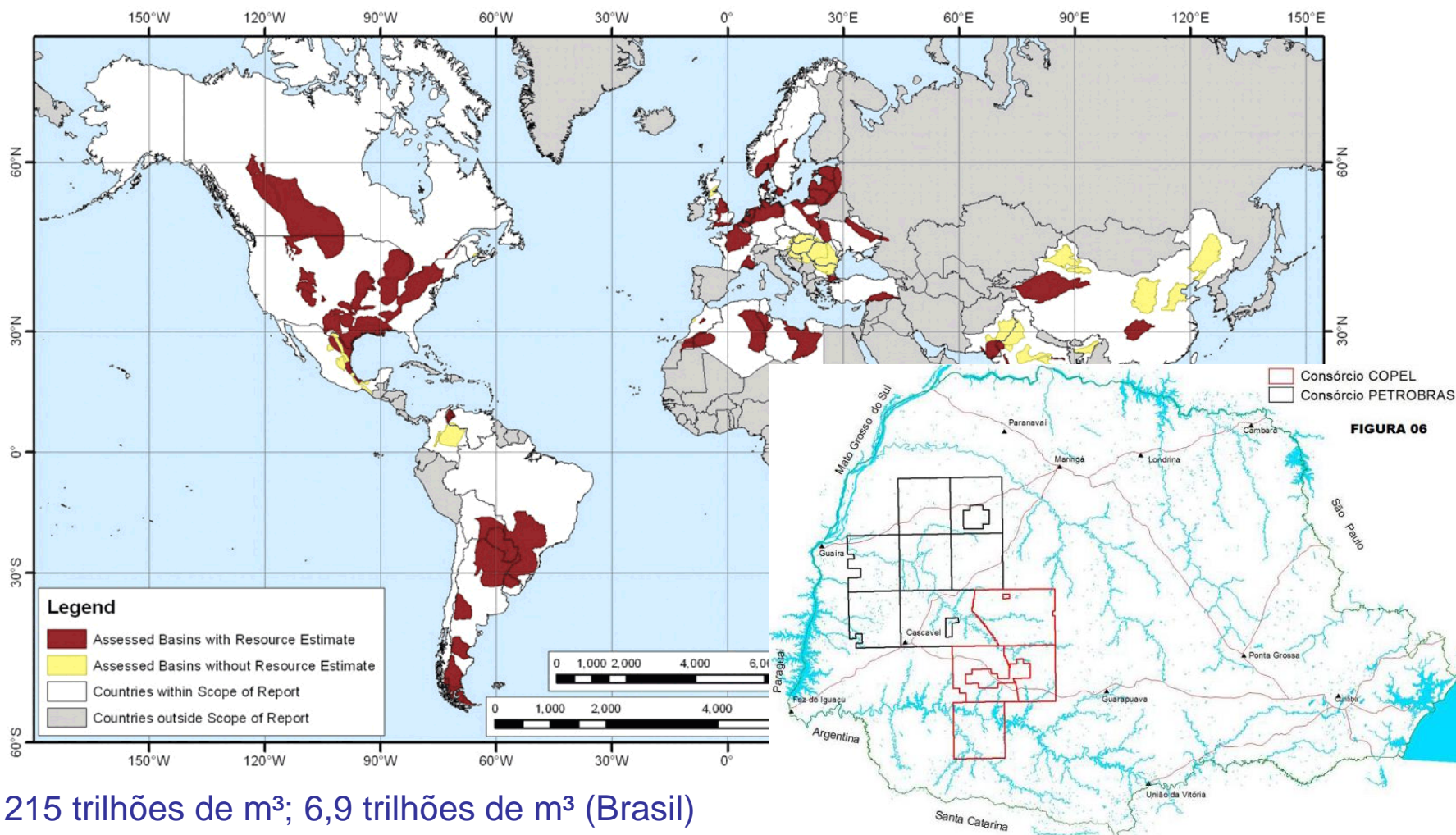


177 trilhões de m³

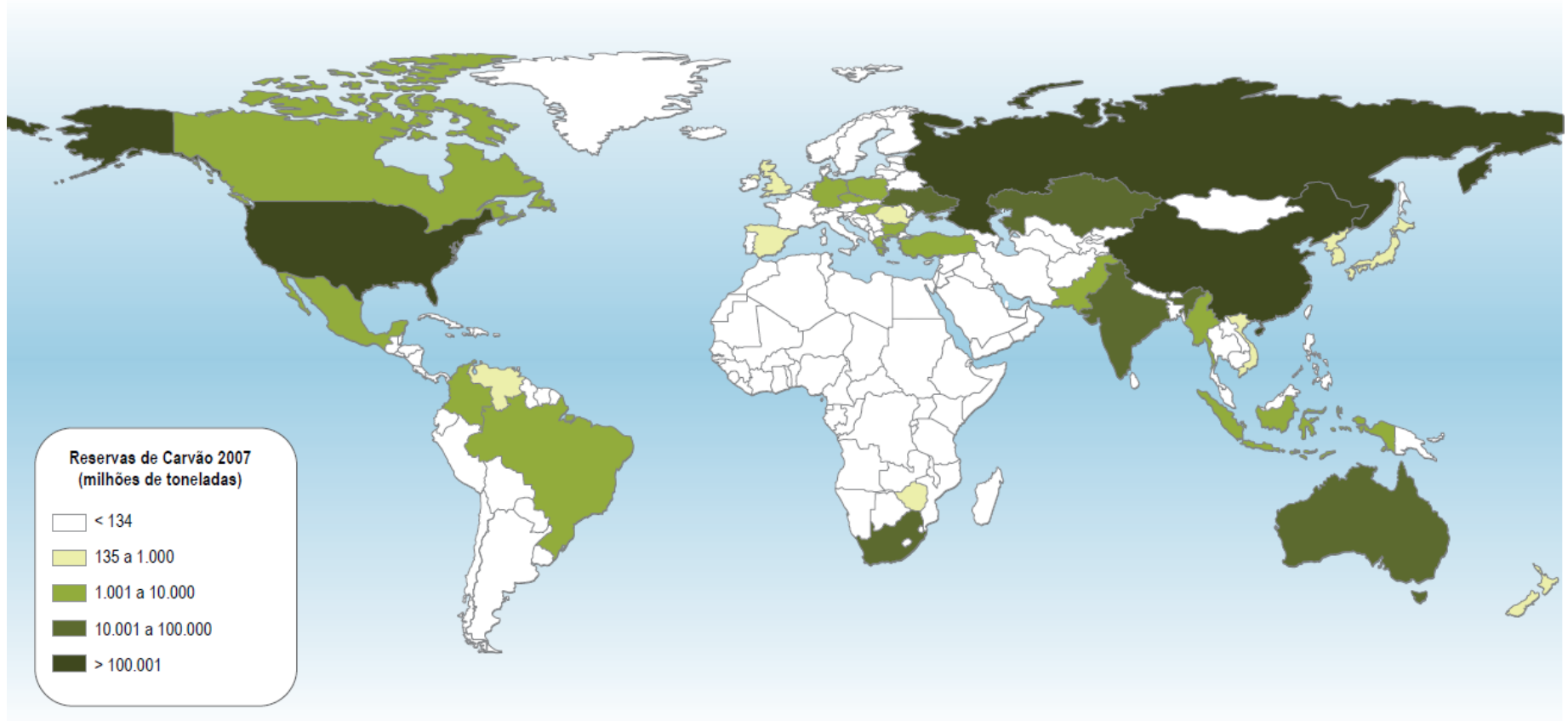
0,4 trilhões de m³ (Brasil)

Reservas no mundo e no Brasil

■ Gás natural (shale, gás de xisto)

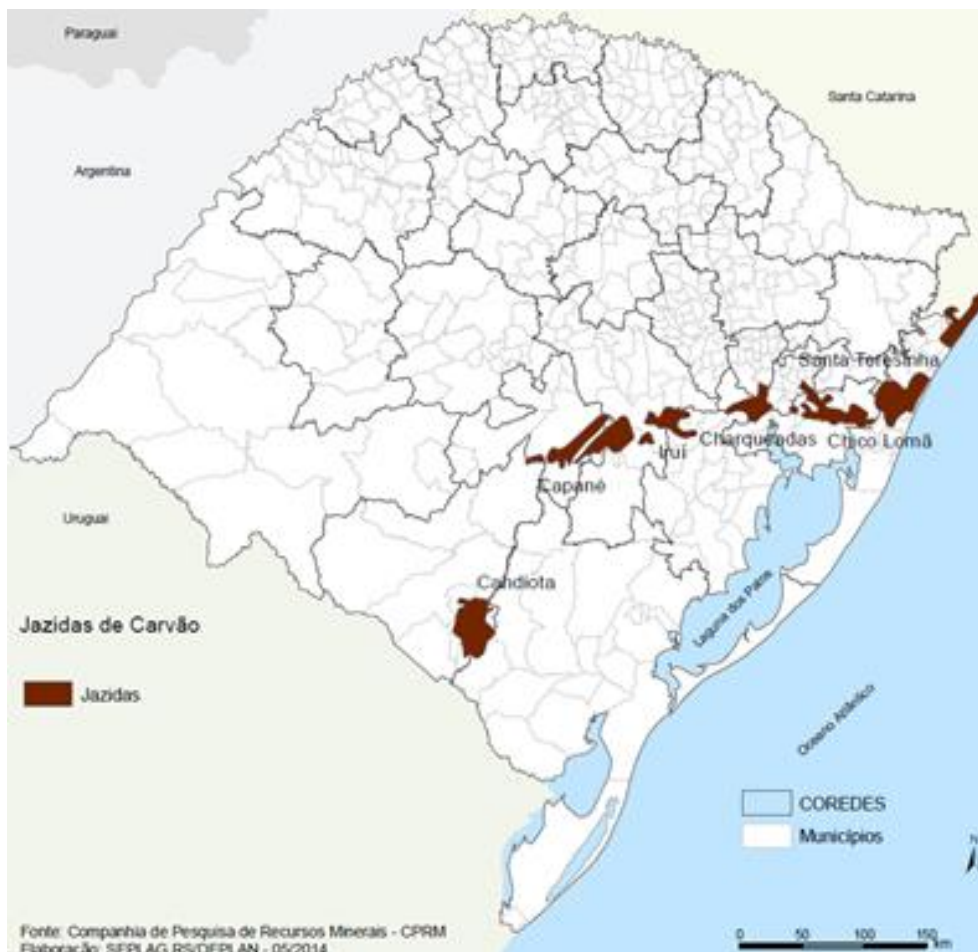


Carvão mineral



847 bilhões de toneladas

■ Carvão mineral



Reservas RS

28,8 bilhões de toneladas

(89% das reservas nacionais)

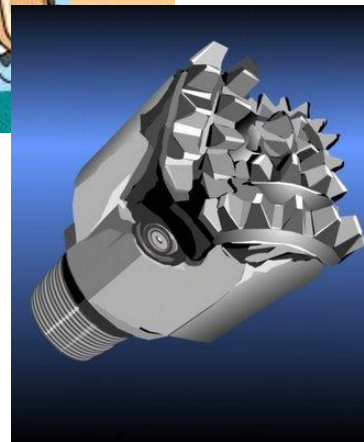
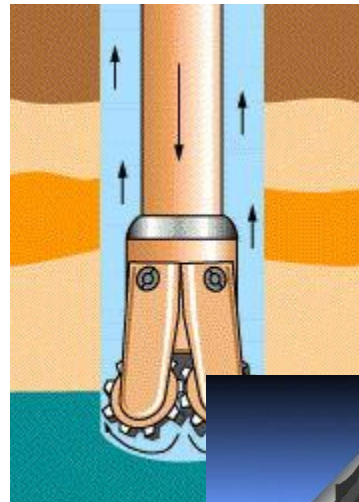
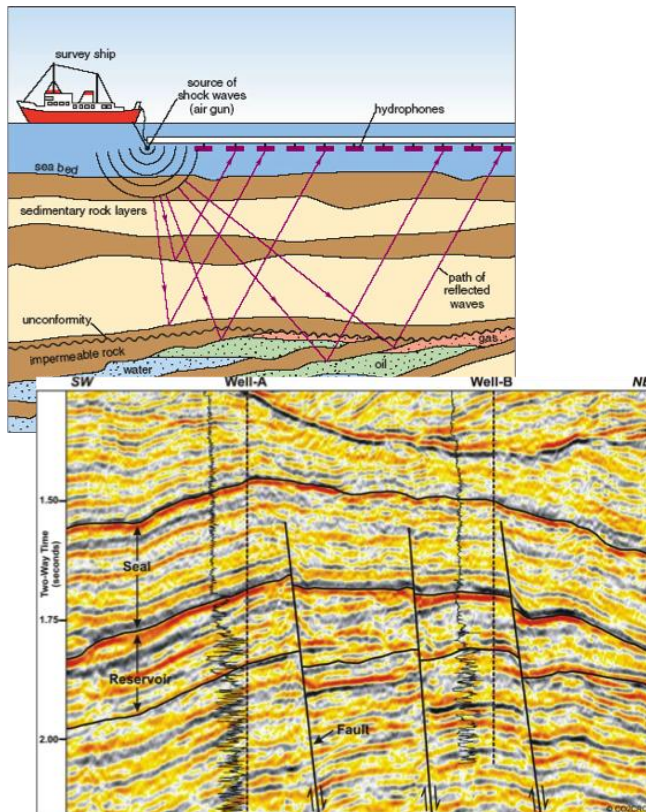
Modos de exploração

■ Petróleo

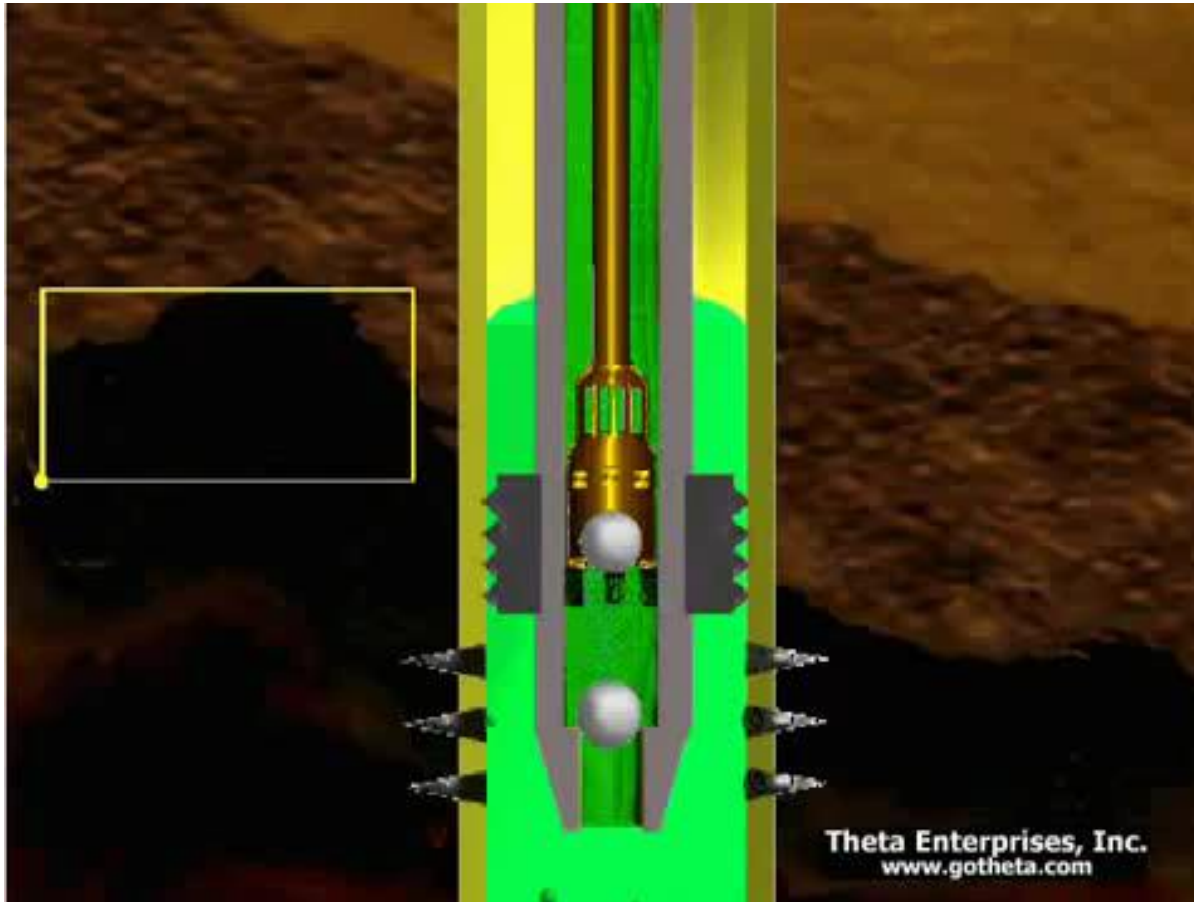
Prospecção

Perfuração

Extração



- Petróleo



■ Gás natural

Gás convencional



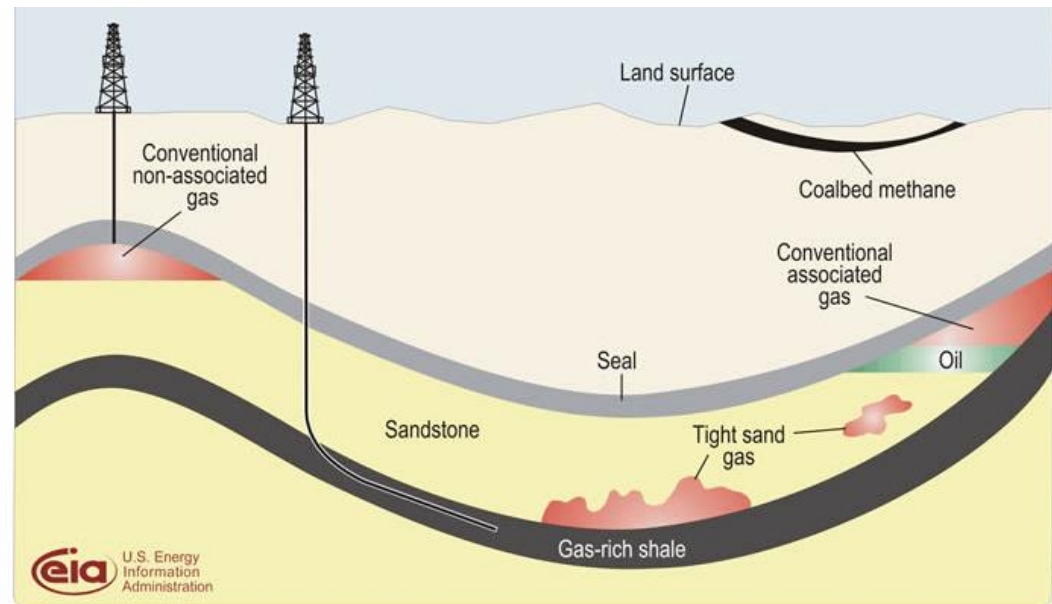
Gás associado

Gás não associado

Gás não convencional



Fracking



Modos de exploração

▪ Carvão mineral

Lavra do carvão

Céu aberto

Subterrânea



Beneficiamento

Extração de materiais inertes

Secagem

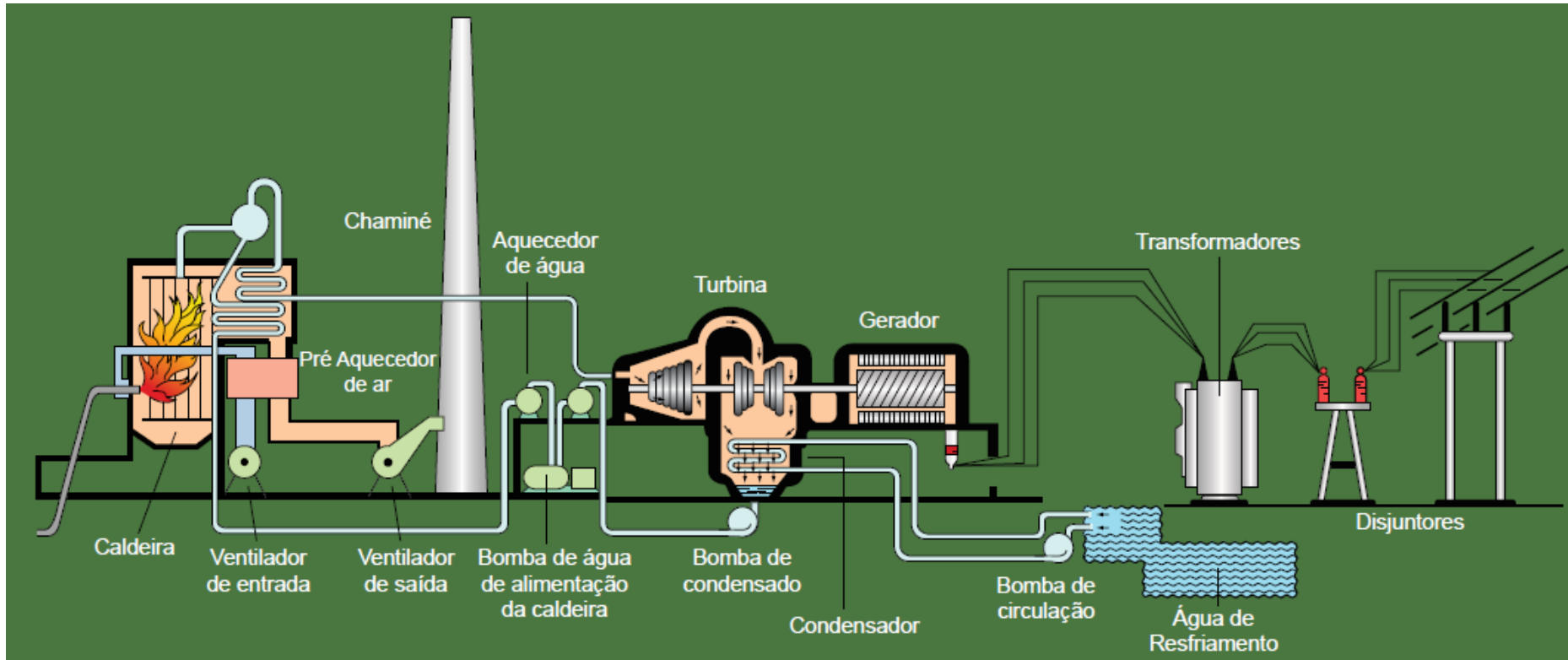
- Carvão mineral



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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

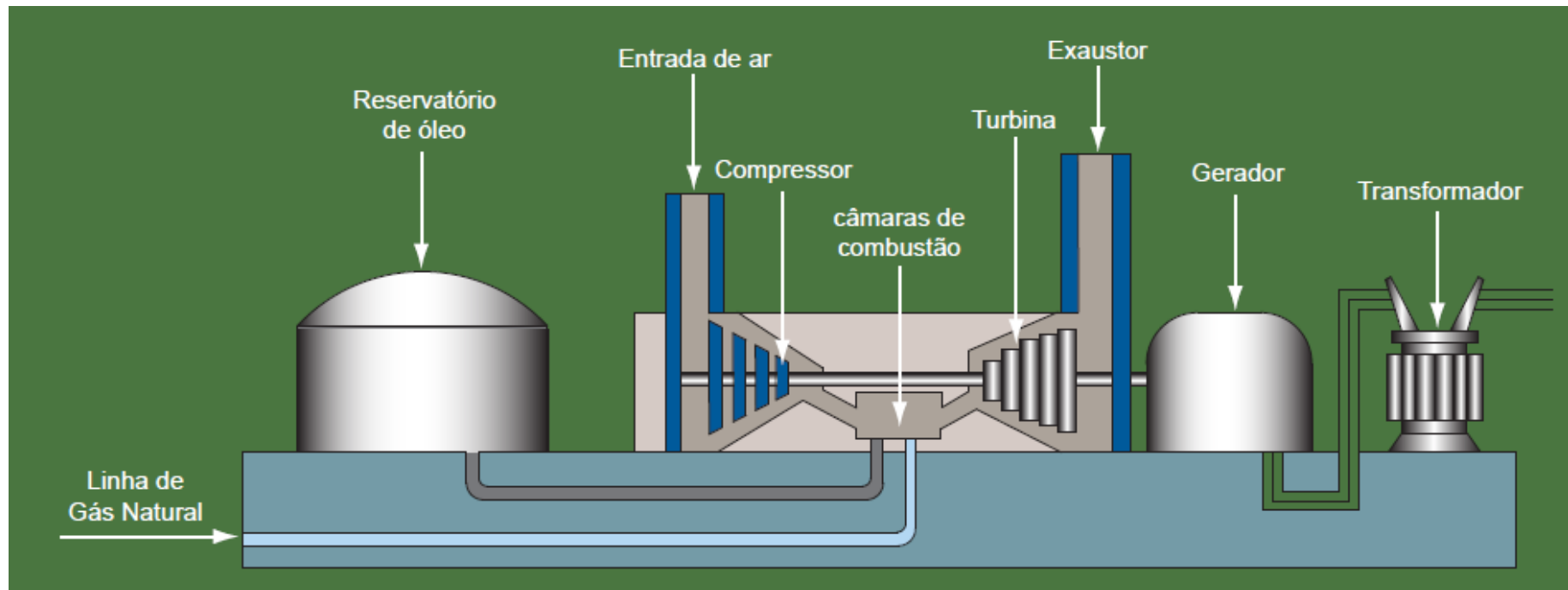


Borborema Energética: 169 MW; FC=0,76

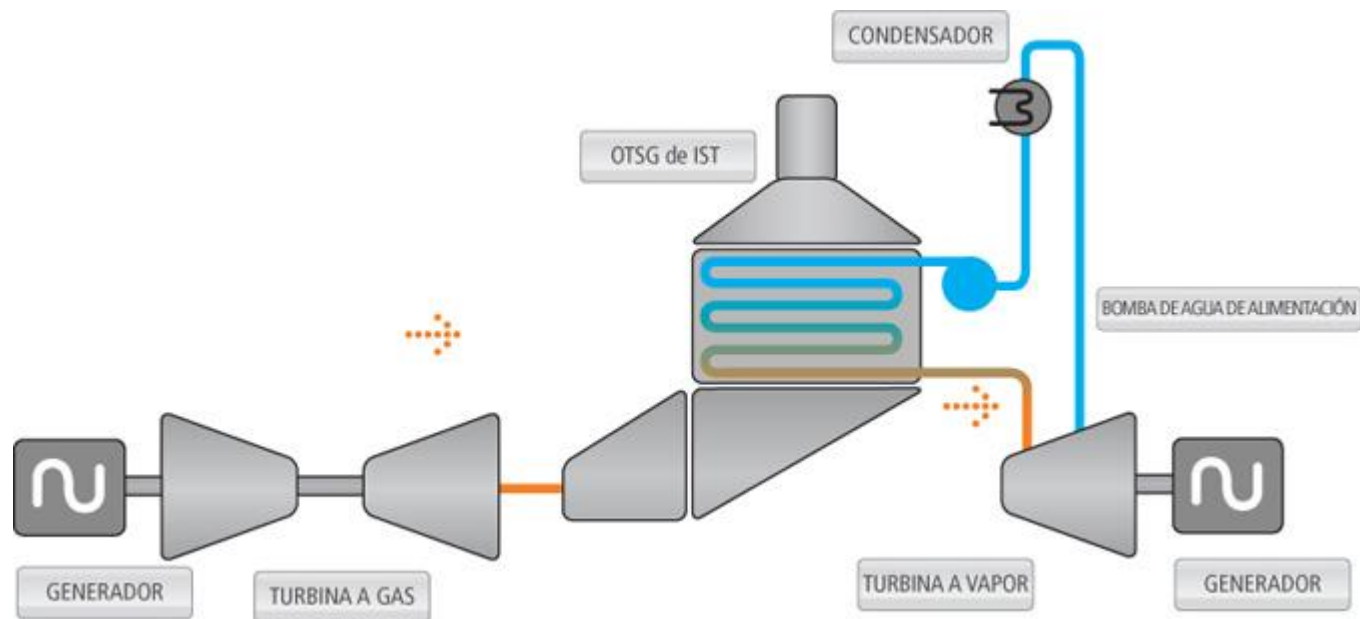
- Petróleo



- Gás natural



- Gás natural

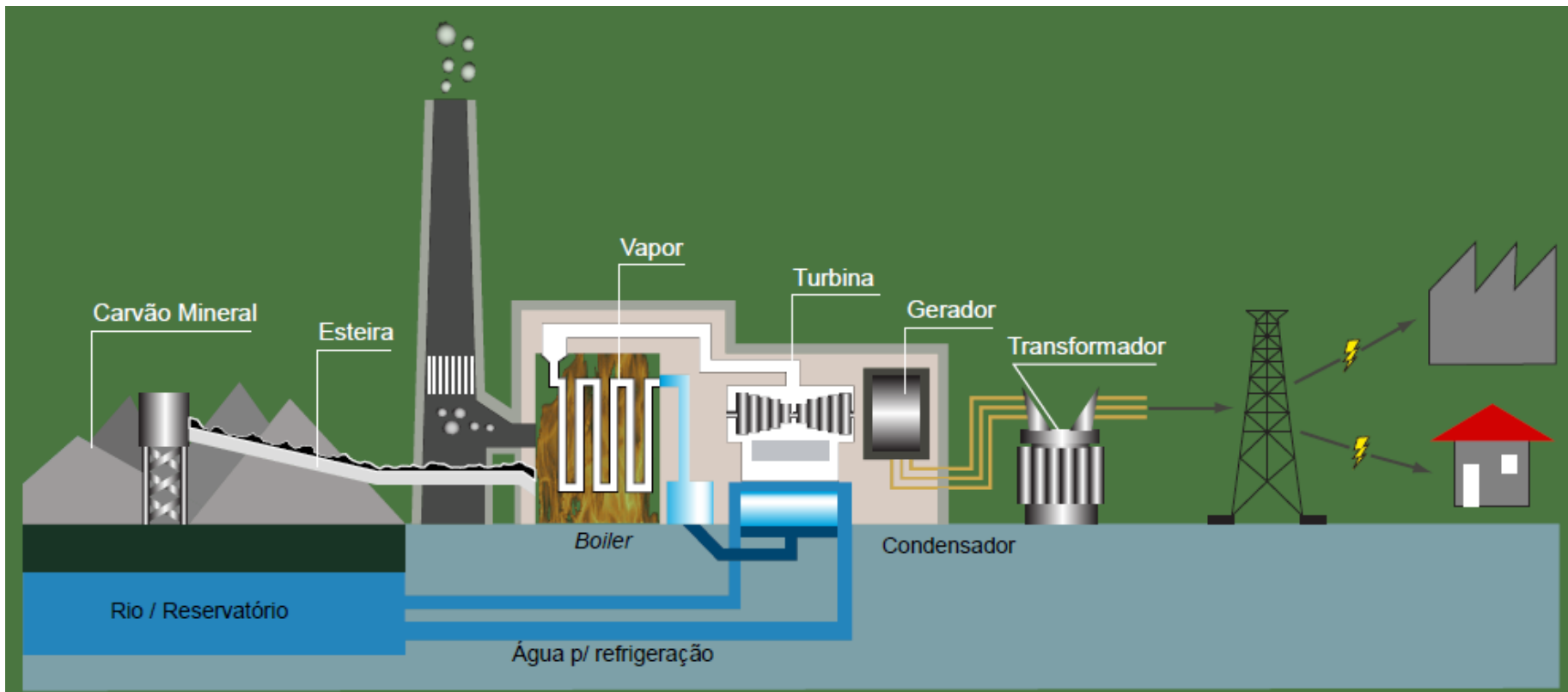


- Gás natural



TERMOPE: 530 MW; FC=0,81

- Carvão mineral



- Carvão mineral



Jorge Lacerda, Unidade C, Santa Catarina

363 MW

170 bar; 538 C

- Carvão mineral

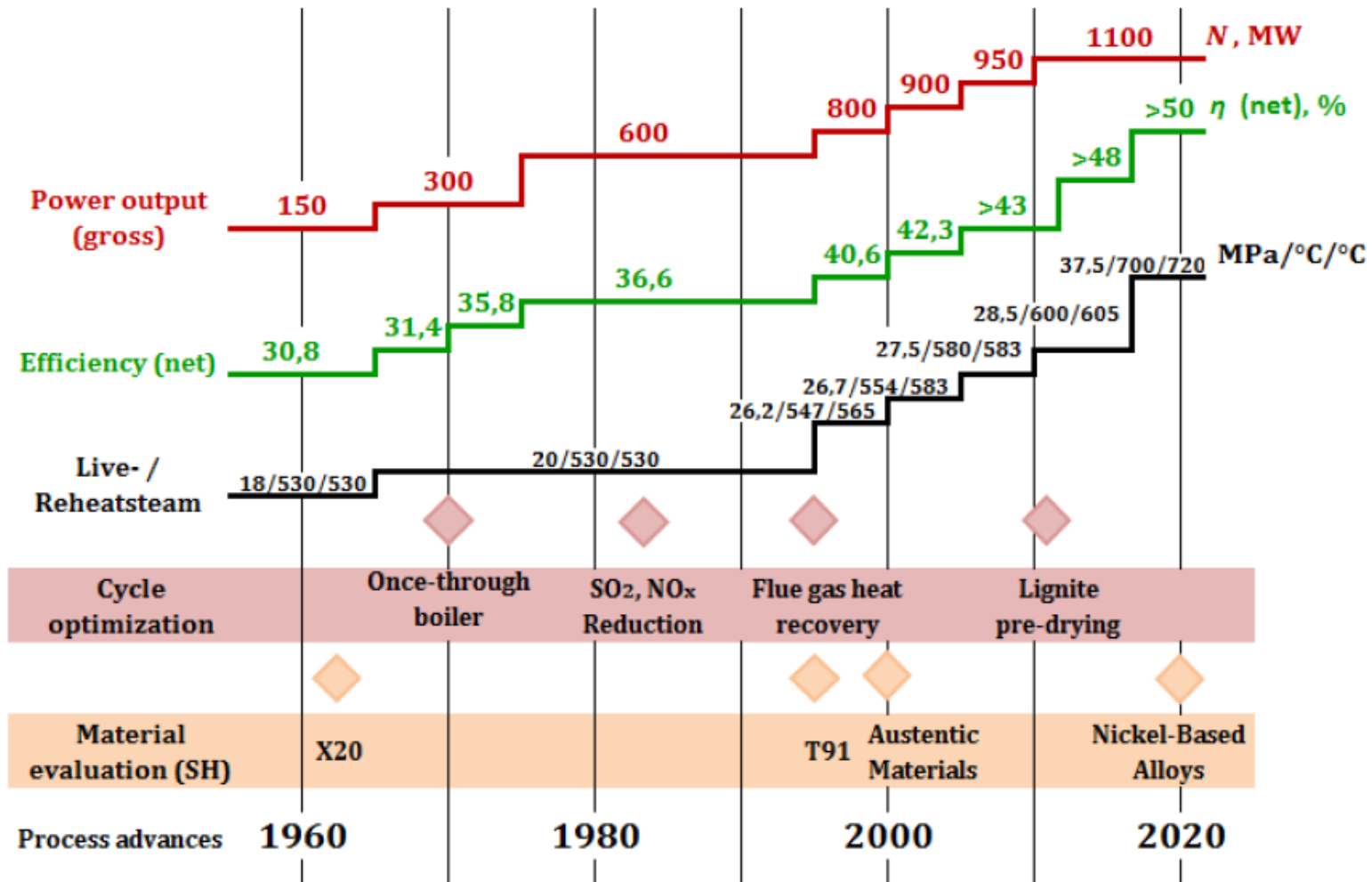


Boa 2 e 3; Nordrhein-Westfalen, Alemanha

1.060 MW + 1.060 MW; 280 bar / 600 C

Uso final

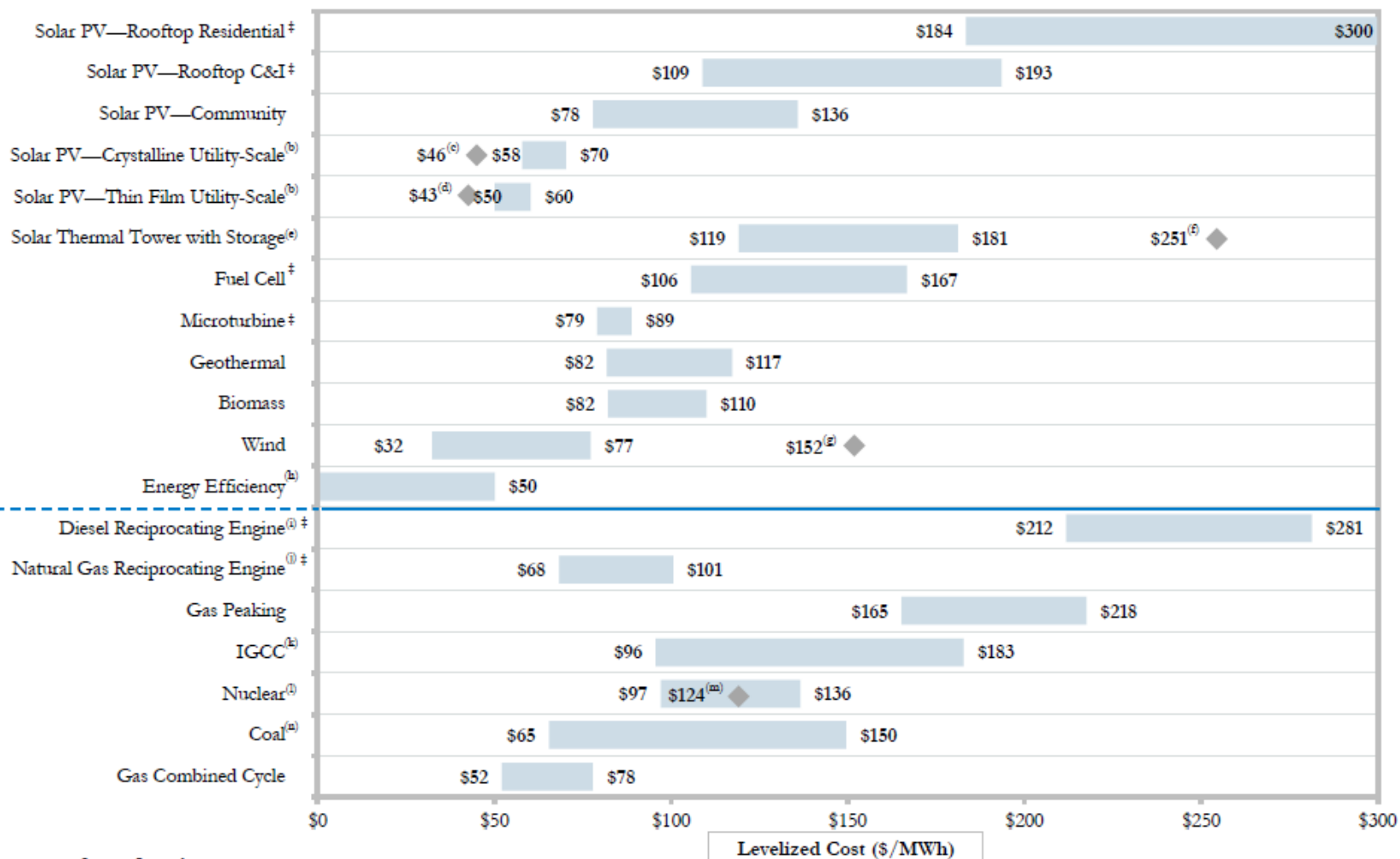
Carvão mineral



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

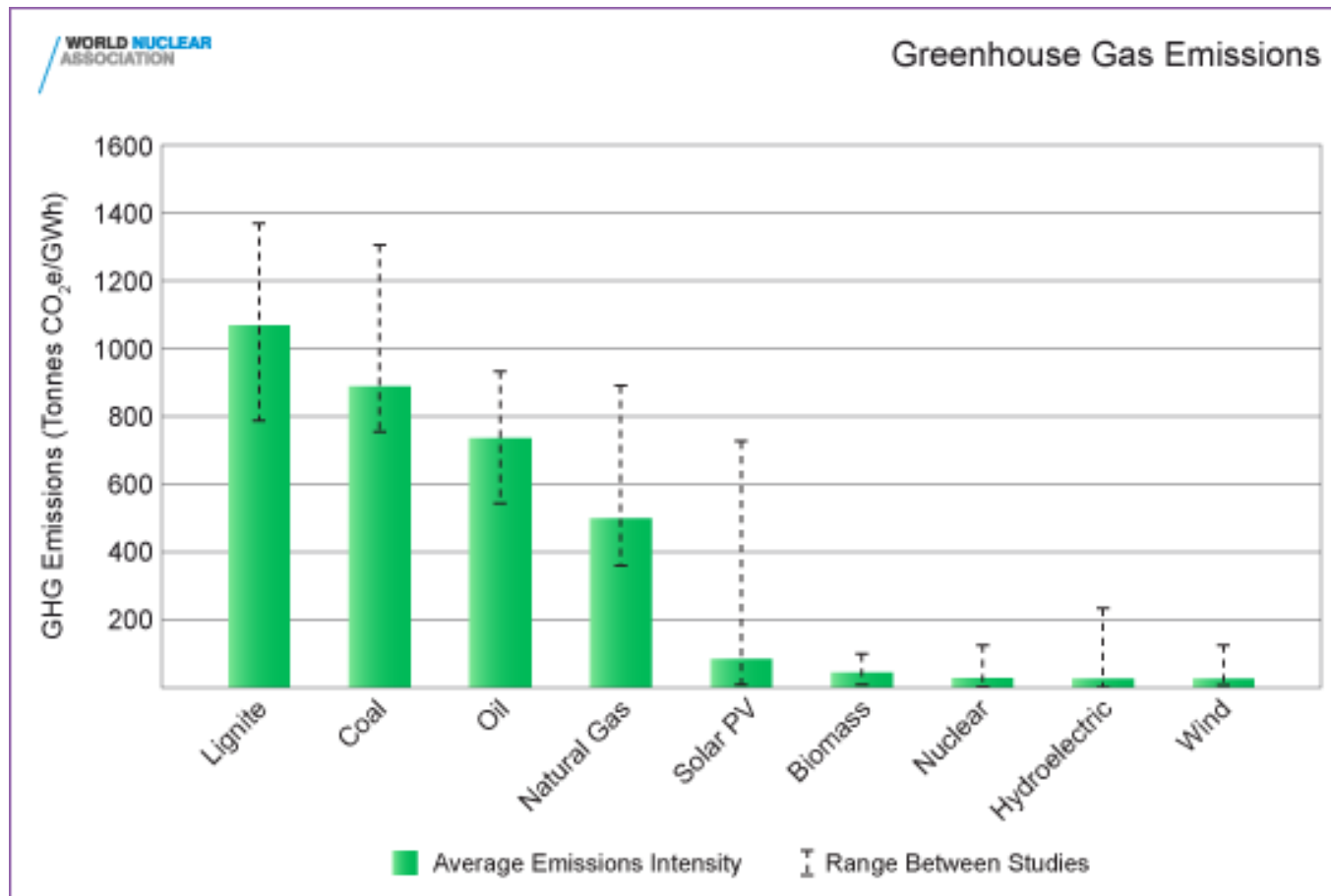
ALTERNATIVE ENERGY^(*)

CONVENTIONAL



Source: Lazard estimates.

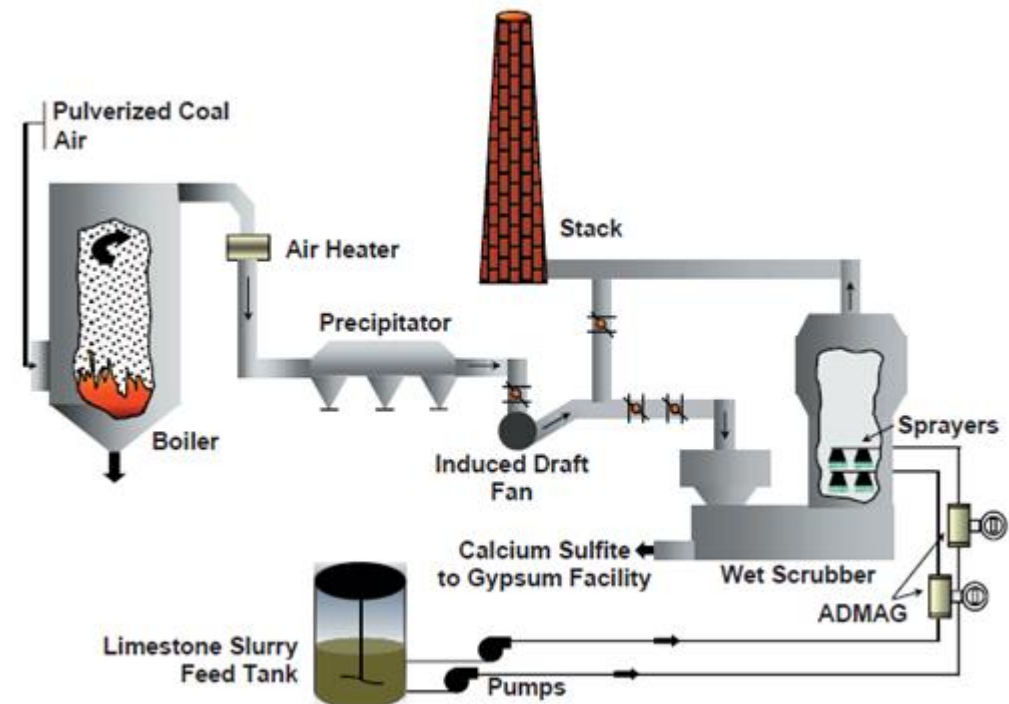
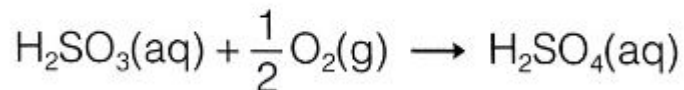
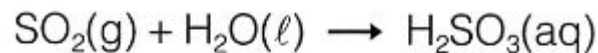
- Emissão de gases do efeito estufa



■ Emissões de SO_x

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

Formação de chuva ácida

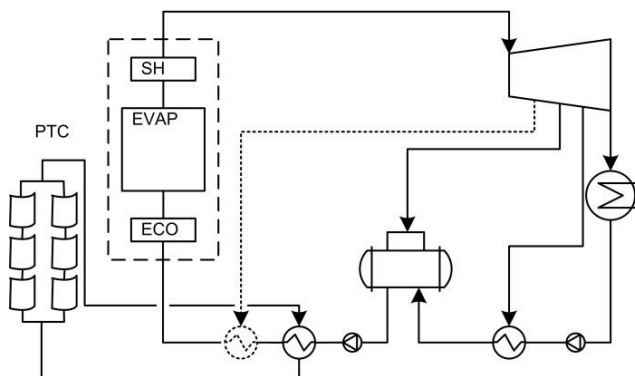


- Emissões de NOx
 - NOx combustível
 - NOx térmico (>1400 C)

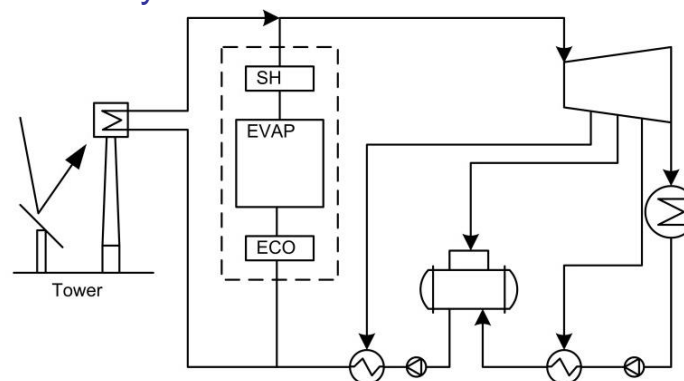
- Desafios
 - Aumentar a eficiência dos sistemas de geração termelétrica
 - Desenvolvimento de combustíveis com baixo teor de S
 - Encontrar substitutos para os fósseis

■ Geração Solar+Fossil

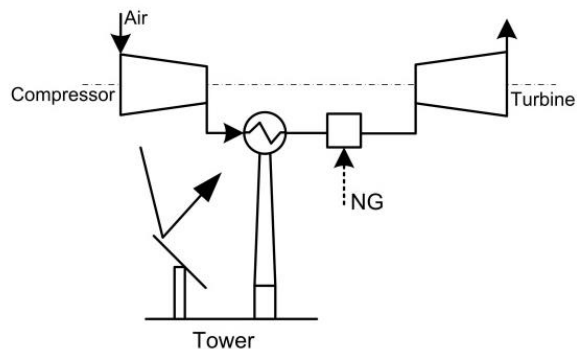
SAFWH: Solar-Aided Feedwater Heating



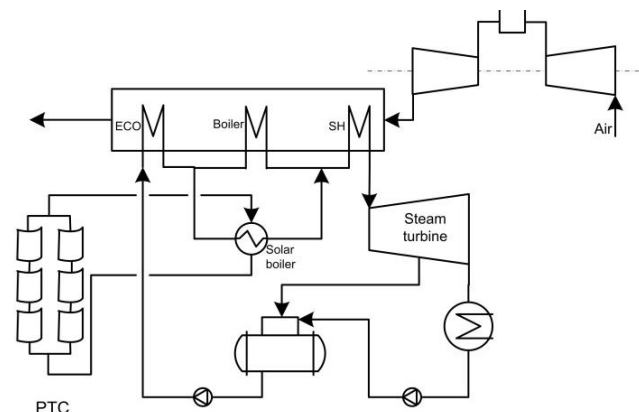
HSG: Hybridized Steam Generators



SGT: Solar-Gas Turbines



ISCC: Integrated Solar Combined Cycles



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