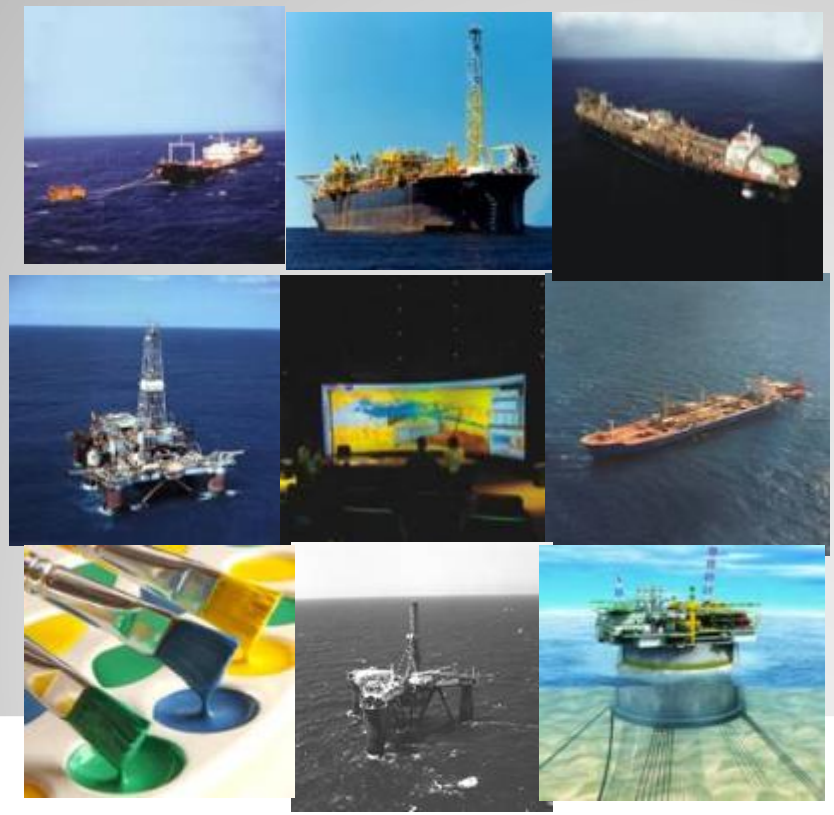
2015 GAS/ELECTRIC PARTNERSHIP

CONFERENCE XXIII SINCE 1994

February, 18-19, Houston, Texas,



Achieving The Most Cost and Schedule Effective Offshore Production of Oil and Gas

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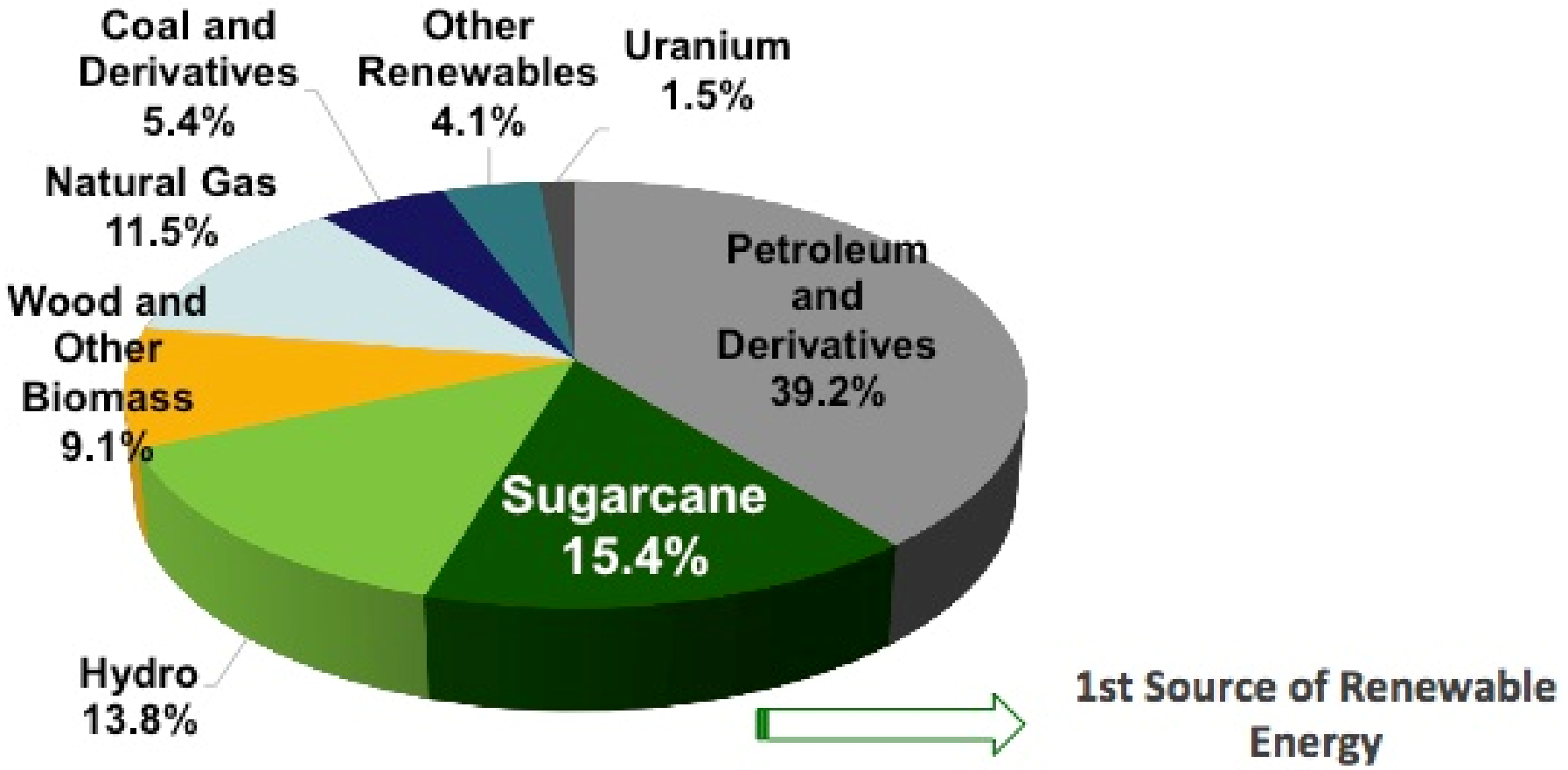
rcelo Accorsi Miranda

- Senior Turbomachinery Advisor
- 36 years of experience in the oil and gas business
- Member of the Turbomachinery Symposium Advisory Committee, sponsored by Texas A&M University.
- B.S. degree (Mechanical Engineering) from Universidade Federal do Rio de Janeiro
- M.S. degree (Industrial Engineering) from Universidade Federal Fluminense

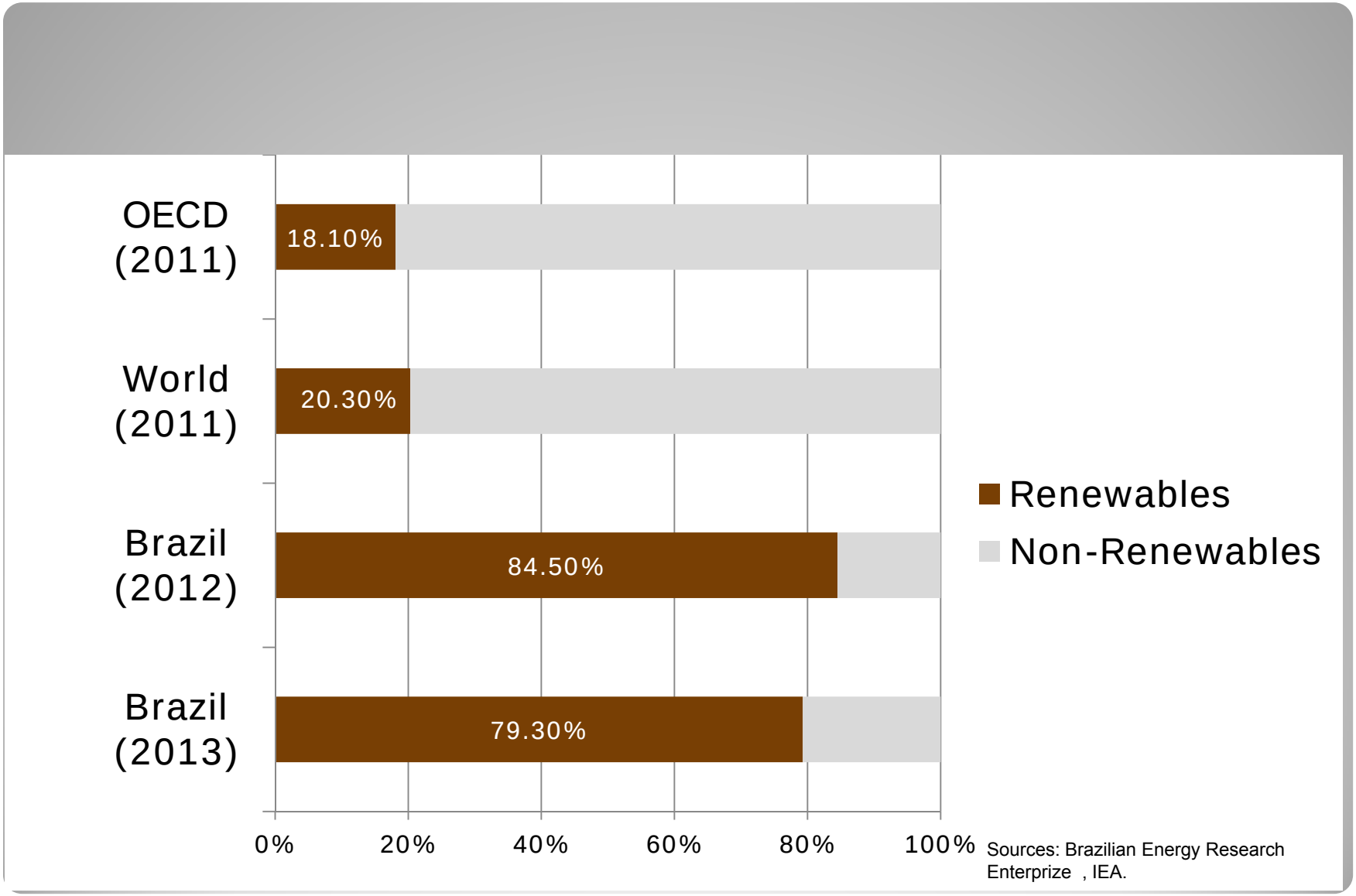
Agenda

- Brazilian Energy Market
- Pre-salt Province
- Machinery Configurations
- Life Cycle Costs
- Closing Remarks

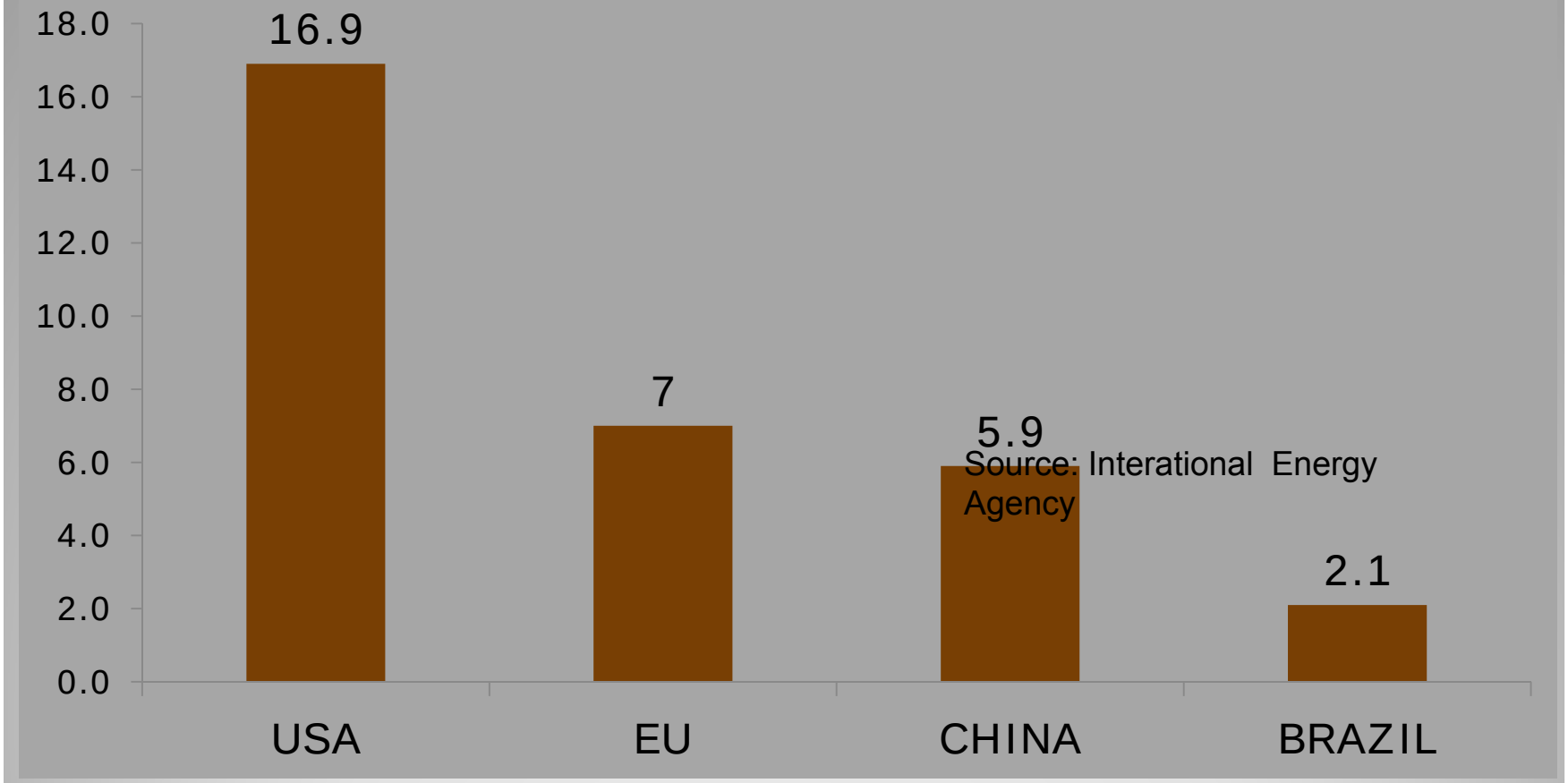
BRAZILIAN ENERGY MATRIX IN 2012



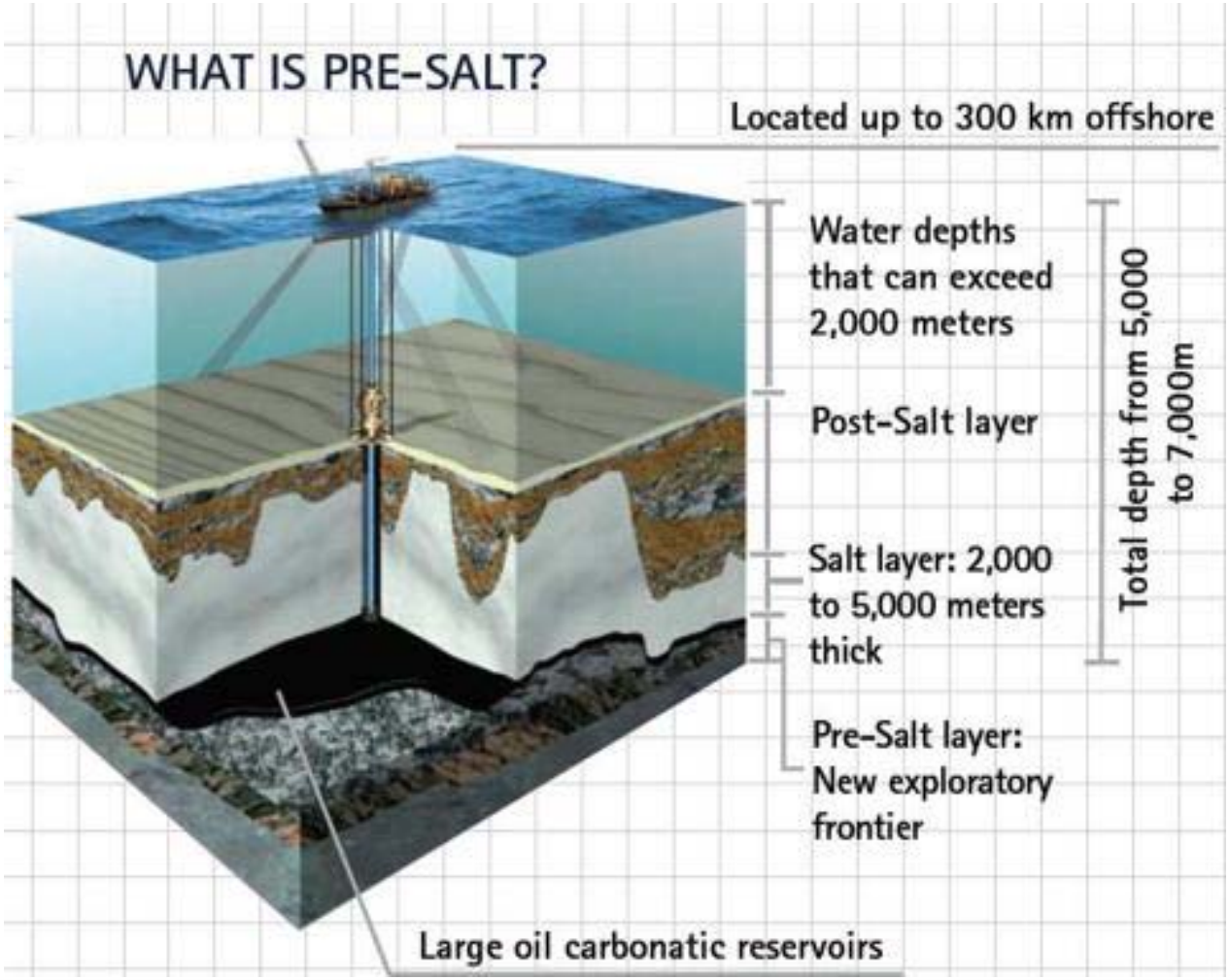
Sources: Balanço Energético Nacional BEN (2013) and International Energy Agency: World Energy Outlook 2012 and Key World Energy Statistics 2012 and Eurostat (2013). Compiled by UNICA

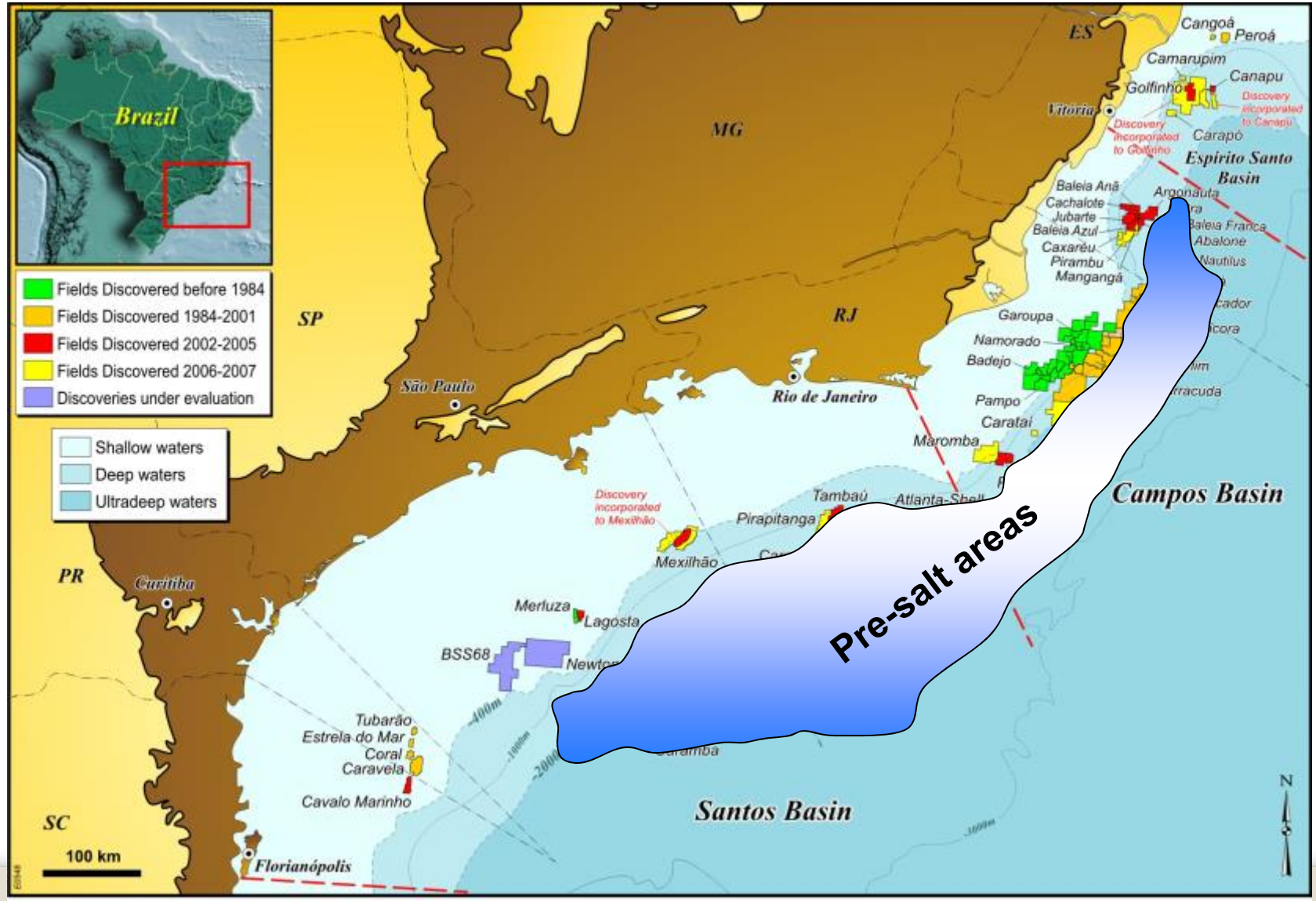

OECD (2011)
18.10%
World (2011)
20.30%
Brazil (2012)
84.50%
Brazil (2013)
79.30%
0%
20%
40%
60%
80%
100%
Renewables
Non-Renewables
Sources: Brazilian Energy Research Enterprize , IEA.

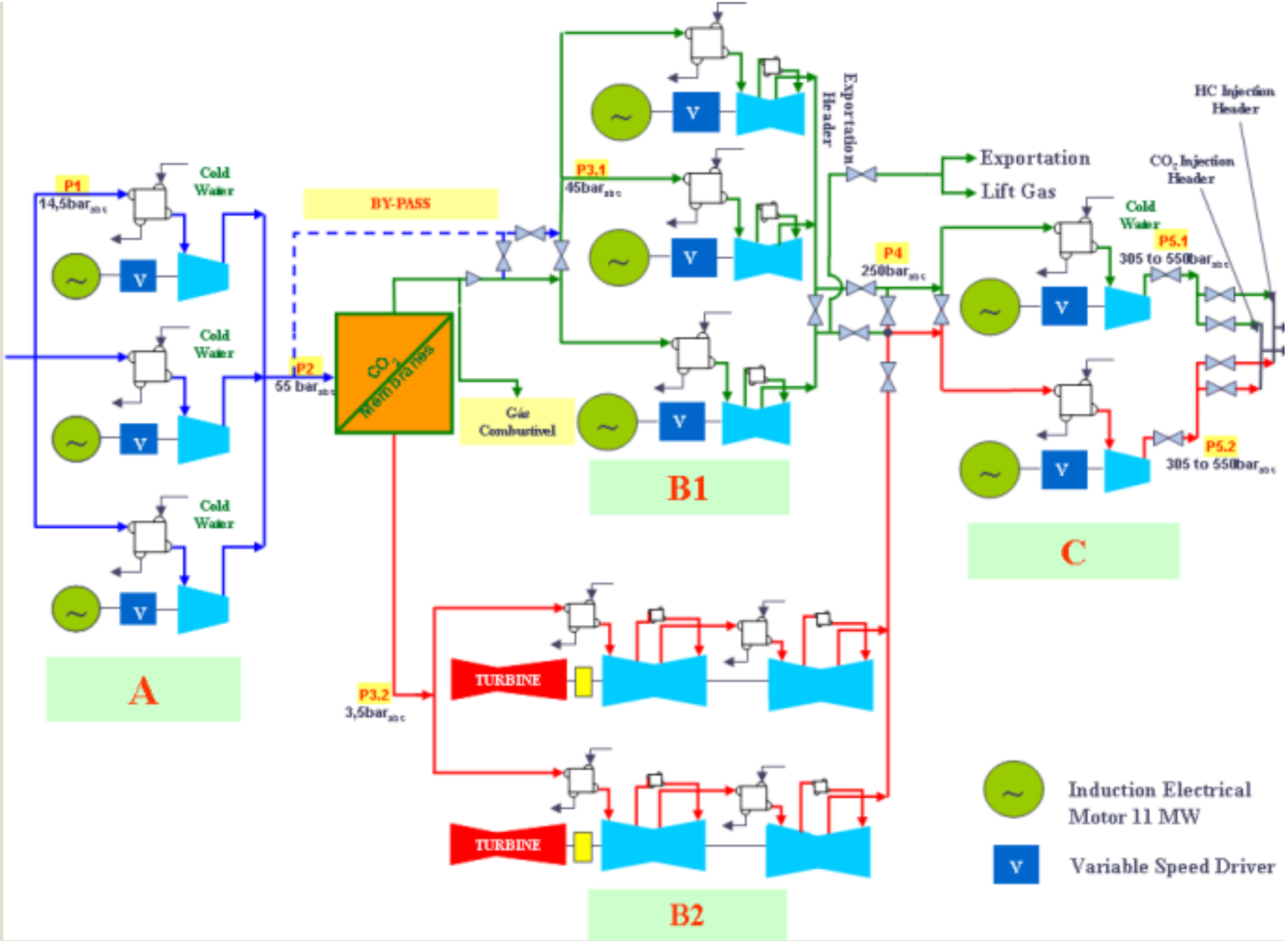
Per capita CO2 emissions



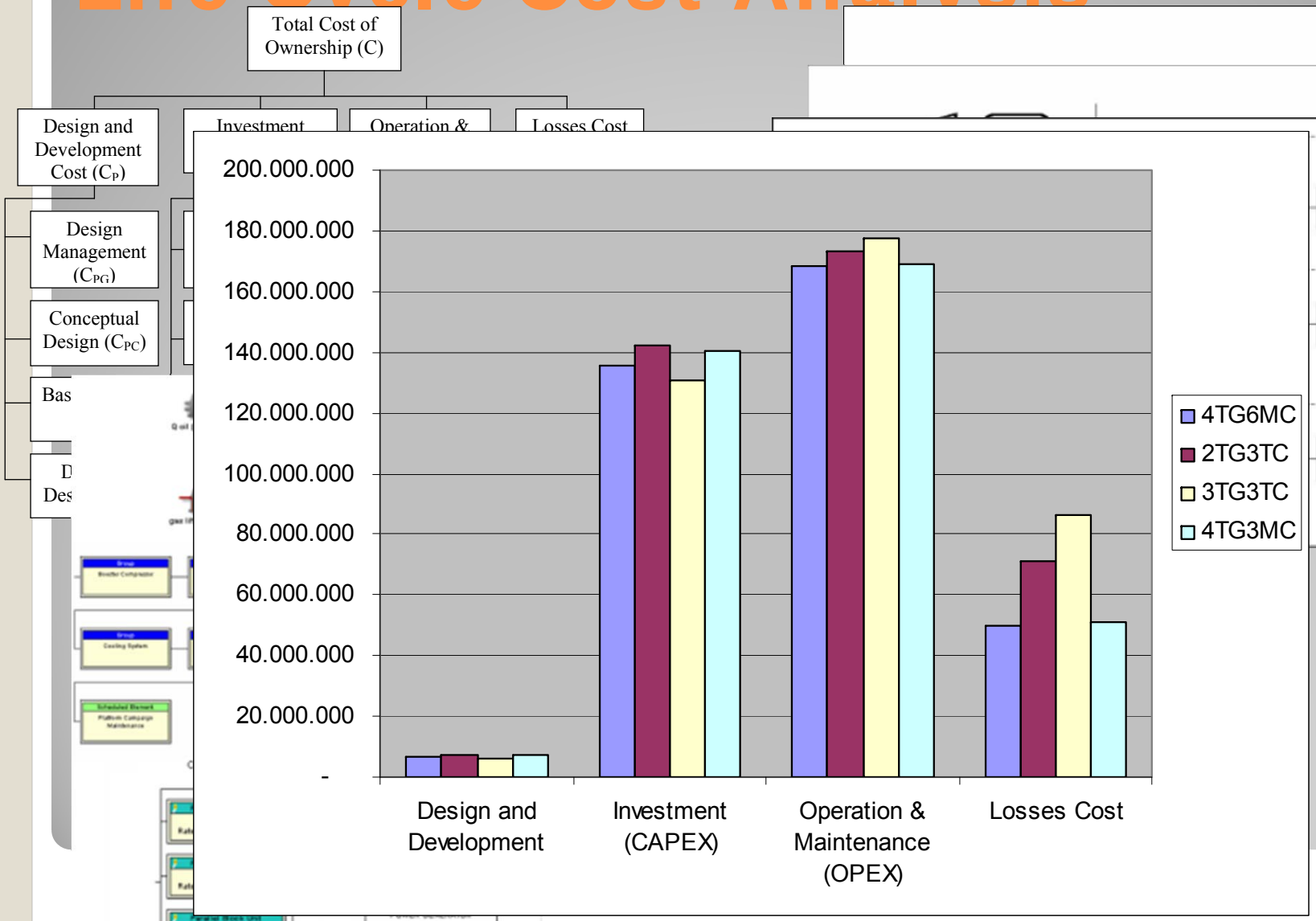
Source: Interational Energy Agency


WHAT IS PRE-SALT?
Located up to 300 km offshore
Water depths that can exceed 2,000 meters
Post-Salt layer
Salt layer: 2,000 to 5,000 meters thick
Pre-Salt layer: New exploratory frontier
Total depth from 5,000 to 7,000m
Large oil carbonatic reservoirs


Brazil
Fields Discovered before 1984
Fields Discovered 1984-2001
Fields Discovered 2002-2005
Fields Discovered 2006-2007
Discoveries under evaluation
Shallow waters
Deep waters
Ultradeep waters
ES
MG
SP
RJ
PR
SC
São Paulo
Rio de Janeiro
Curitiba
Florianópolis
Vitoria
Cangoá
Peroá
Camarupim
Canapu
Golfinho
Carapó
Espírito Santo Basin
Baleia Anã
Cachalote
Jubarte
Baleia Azul
Caxaréu
Pirambu
Mangangá
Argonauta
Baleia Franca
Abalone
Nautilus
Garoupa
Namorado
Badejo
Pampo
Caratai
Maromba
Tambaú
Pirapitanga
Atlanta-Shell
Campos Basin
Pre-salt areas
Discovery incorporated to Mexilhão
Mexilhão
Merluza
Lagosta
BSS68
Tubarão
Estrela do Mar
Coral
Caravela
Cavalo Marinho
Santos Basin
100 km
N


P1
14,5bar abs
Cold Water
Cold Water
Cold Water
A
BY-PASS
P2
55 bar abs
CO2 Membranes
Gáz Combustível
P3.1
45bar abs
B1
P3.2
3,5bar abs
TURBINE
TURBINE
B2
Exportation Header
P4
250bar abs
Exportation
Lift Gas
HC Injection Header
CO2 Injection Header
Cold Water
P5.1
305 to 550bar abs
P5.2
305 to 550bar abs
C
Induction Electrical Motor 11 MW
V
Variable Speed Driver

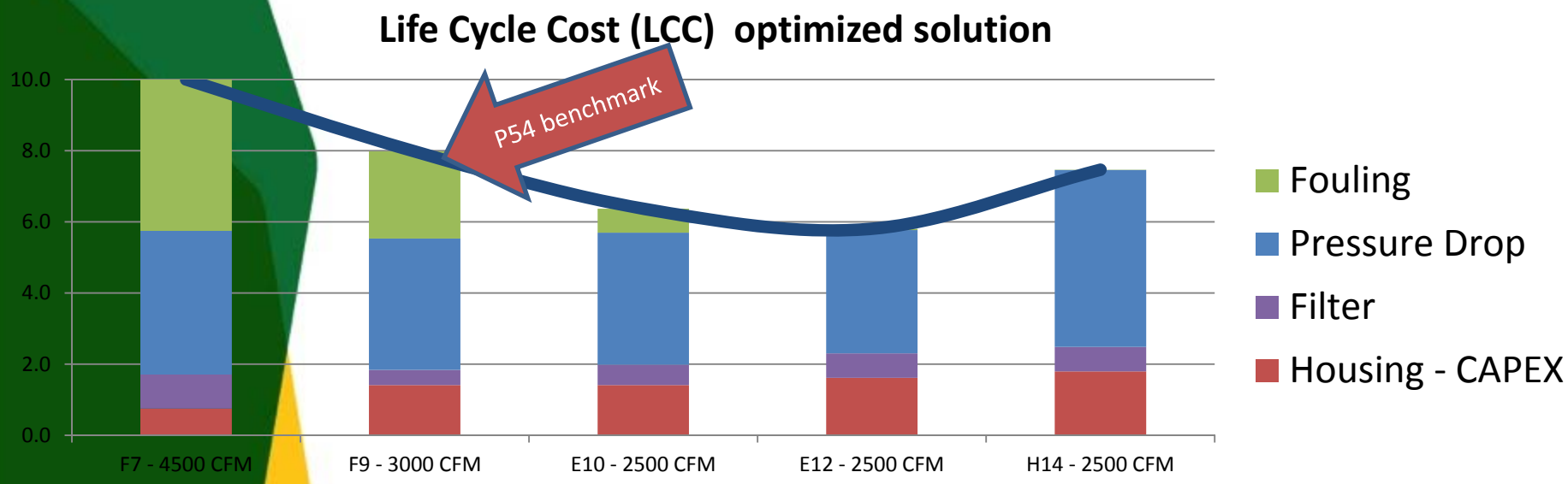
Life Cycle Cost Analysis

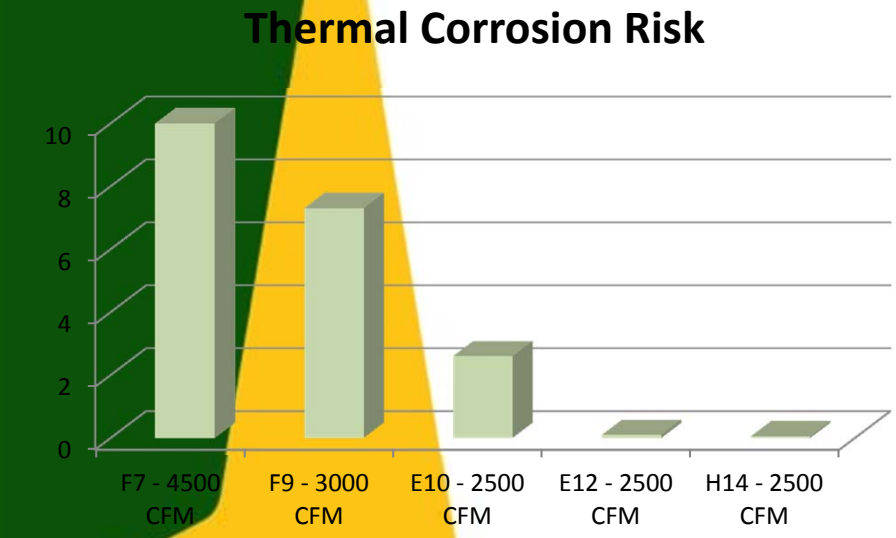


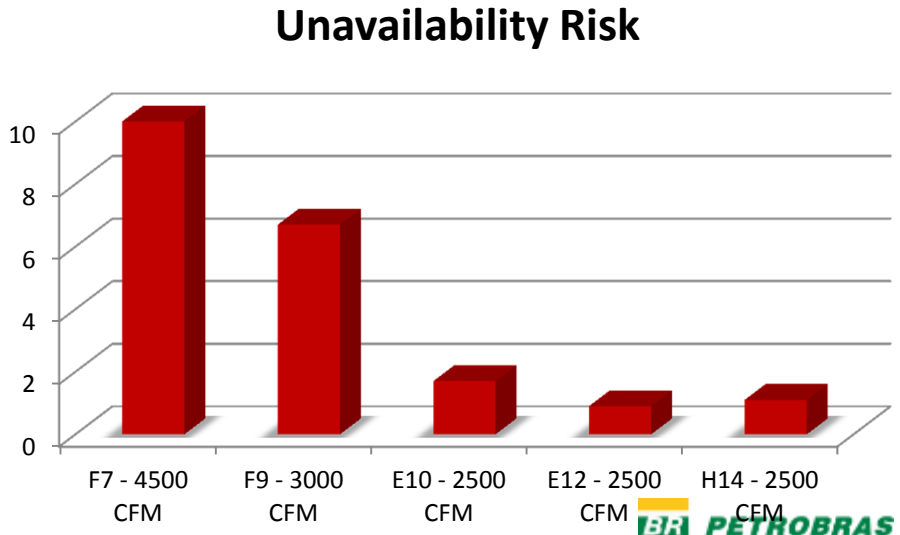
LCCA Conclusions

- Comparison among configurations: number of trains, redundancies, and types of drivers for the major equipment.
- The results of the case study demonstrated the potential cost reduction of up to 25 % of the overall life cycle costs.
- Cost reduction was obtained without significant impact on CAPEX.
- The case study also shows that the system average availability has strong influence in the total cost of ownership.

LCC Analysis for Air Filter System







PETROBRAS

Closing Remarks

- Delivered equipment conformity with order: Frame agreements; Standard solutions; Cooperation among operators, Plug and play solutions (Minimum interface configuration)
- Delivery delays: Poor vendor Planning; degraded quality control both for suppliers and manufacturing.
- EPC or buying directly: Regarding schedule it might be an advantage to use EPC, however the user will have less control over the whole process. Scope and quality issues may impact the following phases, either during commissioning, start up and even operation.

EPC sourcing

- EPC sourcing consequences:
  - ✓ Design mismatch between major equipment x process x controls. Buy a system not a puzzle.
  - ✓ Schedule advantage just for initial delivery. Schedule often compromised during commissioning and start up
  - ✓ Project value undermined during Life Cycle due to poor reliability.
  - ✓ It prevents good standardization policies.
- User shall have complete control of the purchasing process of major equipment.

Buyer and Supplier Relationship

- Best Practices
- ✓ Regular technical meetings between User and Supplier,
- ✓ Frame Agreements,
- ✓ Clear and transparent communication plan;
- ✓ Specs and standards discussions out of the heat of a bid process;
- Buying cooperatives
- ✓ cooperation among operators would be of great value, by sharing requirements, practices, standardization policies. For the Supplier it means less uncertainty/risks, predictability, cost reduction and schedule improvements.

Maintenance Policy

- Maintenance cost for operator-maintained versus 3rd party contractors
  - ✓ Maintenance costs are lower in general for the self maintained equipment, with some outsourcing. The best balance between self and 3rd party depend on the type of equipment, the technology transfer, and logistics related to plant site.
- Remote monitoring/operation mandatory.
- Impacts of a declining skills set in operating personnel
  - ✓ Knowledge Management Process, Mentoring, Lessons Learning,
- "Generation gap" mitigation: it shall combine training with some outsourcing, even if temporary.

THANK YOU!