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Offshore Heavy Oil Reservoirs Development in Trinidad and Tobago

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Outline

- Offshore Heavy Oil (OHO) - Context
- Challenges
- Heavy Oil in T&T – Historical perspective
- Offshore-T&T Heavy Oil Reservoir
- Scenarios for the Future
  - Framework
  - Scenario Context
  - Offshore Heavy Oil Scenarios
  - Conclusions

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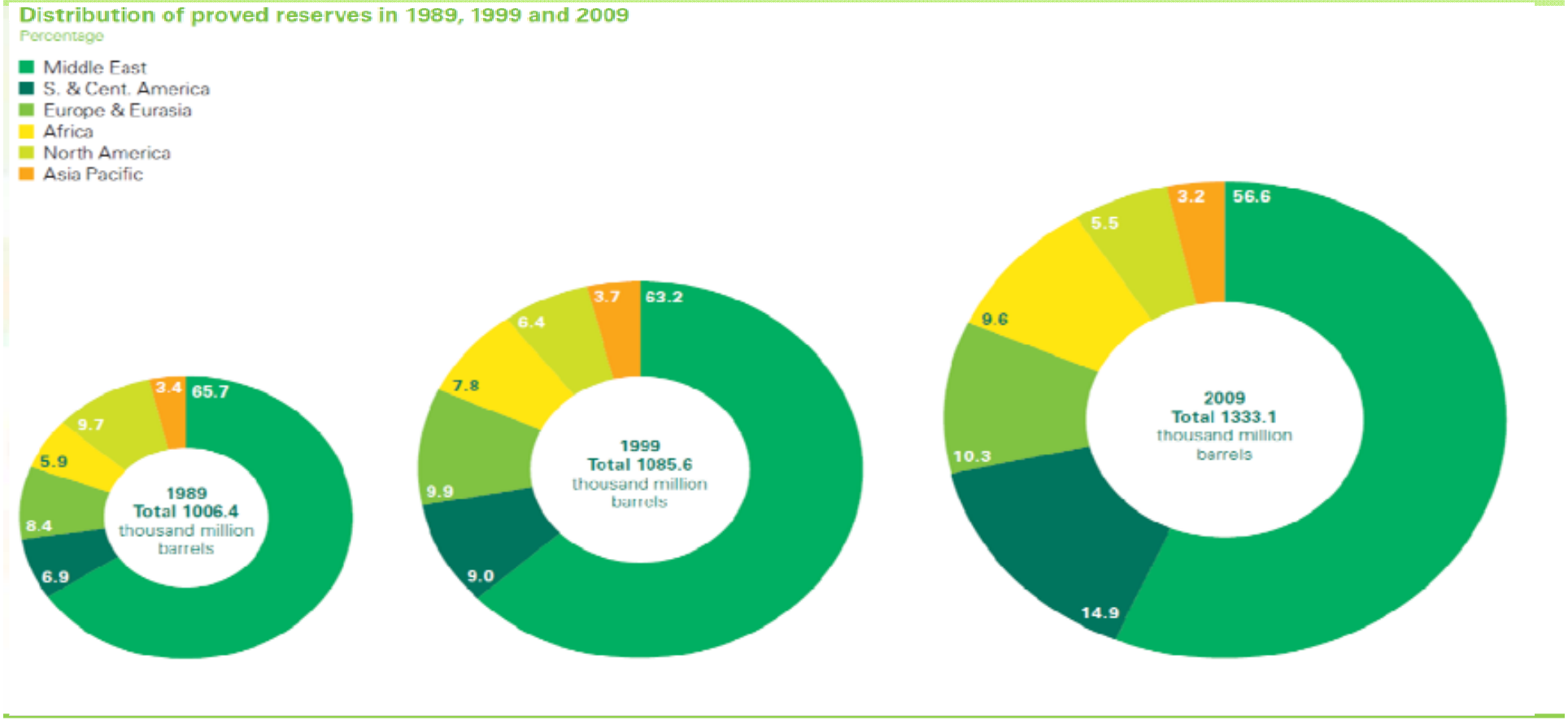
Worldwide Proved Oil Reserves



SOURCE: Bp Statistical Review of world Energy, 2010

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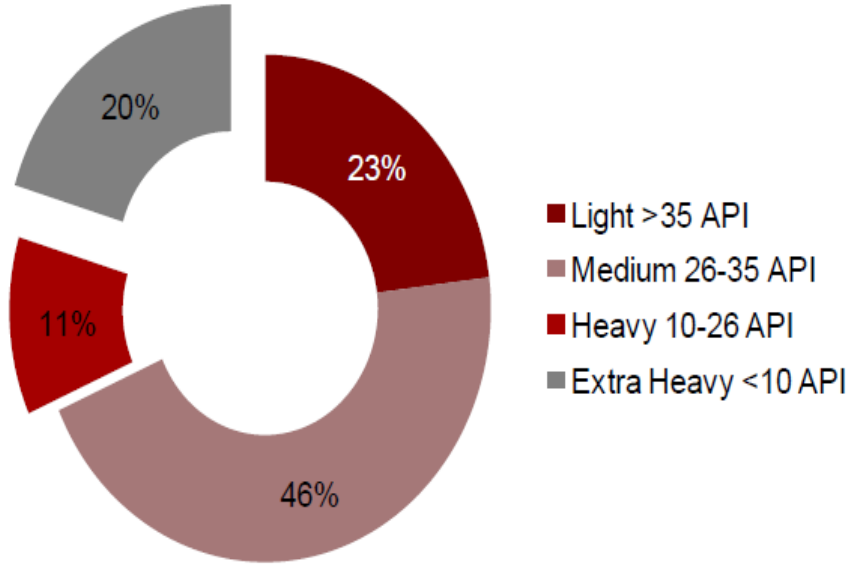
Heavy Oil Reserves

- Heavy Oil plays a significant role in world oil reserves
- 31% of world's proved reserves (1P)
- Heavy - 266 billion barrels
- Extra Heavy- 146 billion barrels



SOURCE: Douglas West Wood LTD, 2010

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Offshore Heavy Oil

- Approximately 8% of world production is from heavy oil
- Of this, only 10% is being produced offshore
- Some of the more prolific offshore heavy oil fields-
  - Captain Field located offshore United Kingdom - 956 million barrels in 340 ft. water depth (19 degree API)
  - Grane Field in Norway- 755 million barrels in 405 ft. water depth (19 degree API)
  - Jubarte Field offshore Brazil in Campos Basin more than 3500 ft. water depth- 600 million barrels (17 degree API)

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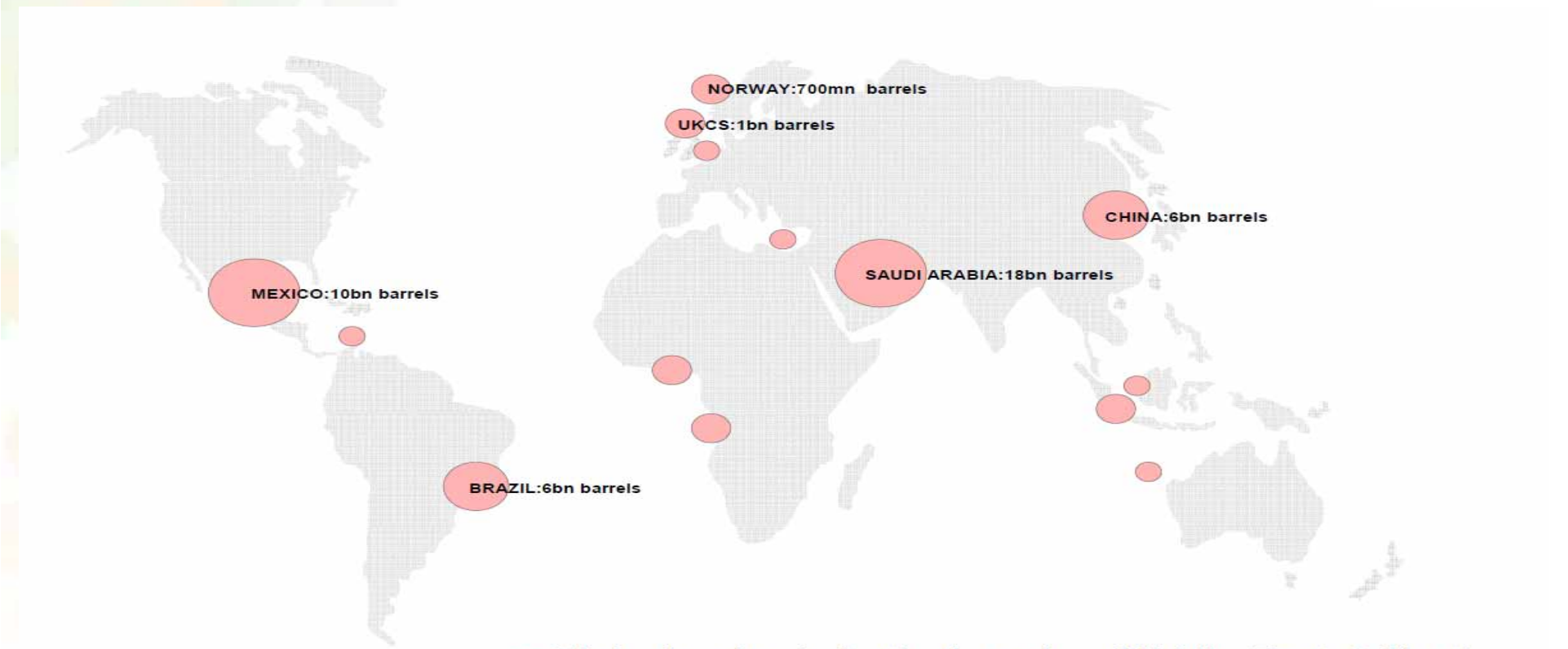
Offshore Heavy Oil Locations



- Major basins in Latin America, Middle East & North Sea.

SOURCE: Douglas West Wood , 2010

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Captain Field

United Kingdom.

Property	Measurement
Company	Texaco
Distance offshore	130km
API	19° 88cp@rt
Water depth	341ft
Recovery	20-35%
Reserves	956MM bbls
Porosity	30%
Permeability	3-7 Darcies
Production	85,000 bbl/d
Facilities	Specialized FPSOs

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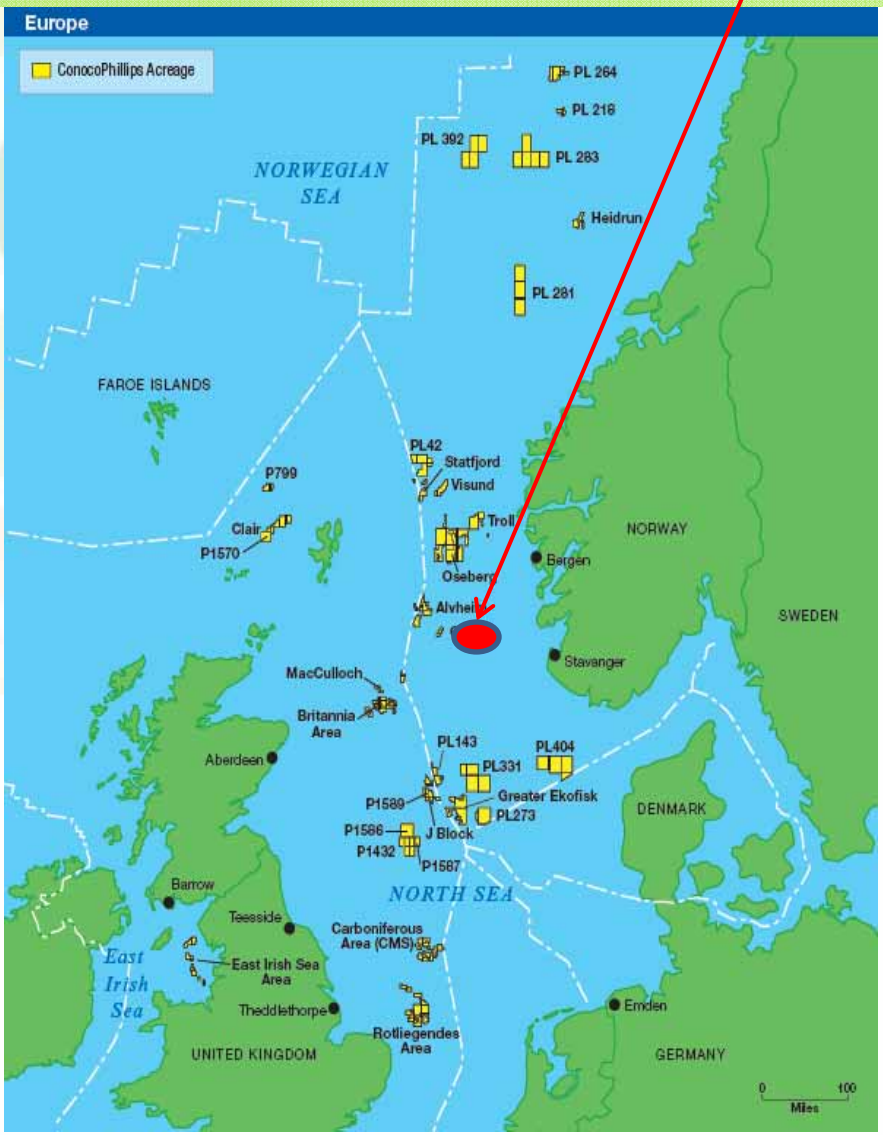
Grane Field Norway.



Property	Measurement
Company	Statoil
Distance offshore	185km
API	19°
Water depth	405ft
Reservoir pressure	2466psi
Recovery	35-40%
Reserves	755MM bbls
Porosity	33%
Permeability	5-10 Darcies
Pay thickness	120 ft
Reservoir area	10km^2
Production	200,000bbl/d
Facilities	29 inch Pipeline

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Jubarte Field Brazil.

Property	Measurement
Company	Petrobras
Distance offshore	77km
API	17°
Water depth	3,500 ft
Reservoir pressure	2,600 psi
Reserves	600 MM bbls
Production	18,000b/d
Facilities	FPSOs

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Offshore Heavy Oil Costs

- High Front-end costs due to intrinsic heavy oil qualities
  - High viscosity
  - Low API gravity
  - Low reservoir energy
  - High acidity content
- Market price of heavy oil can be as low as 65% of standard light oil such as Brent /WTI
- Profitability of production directly correlated to price of oil

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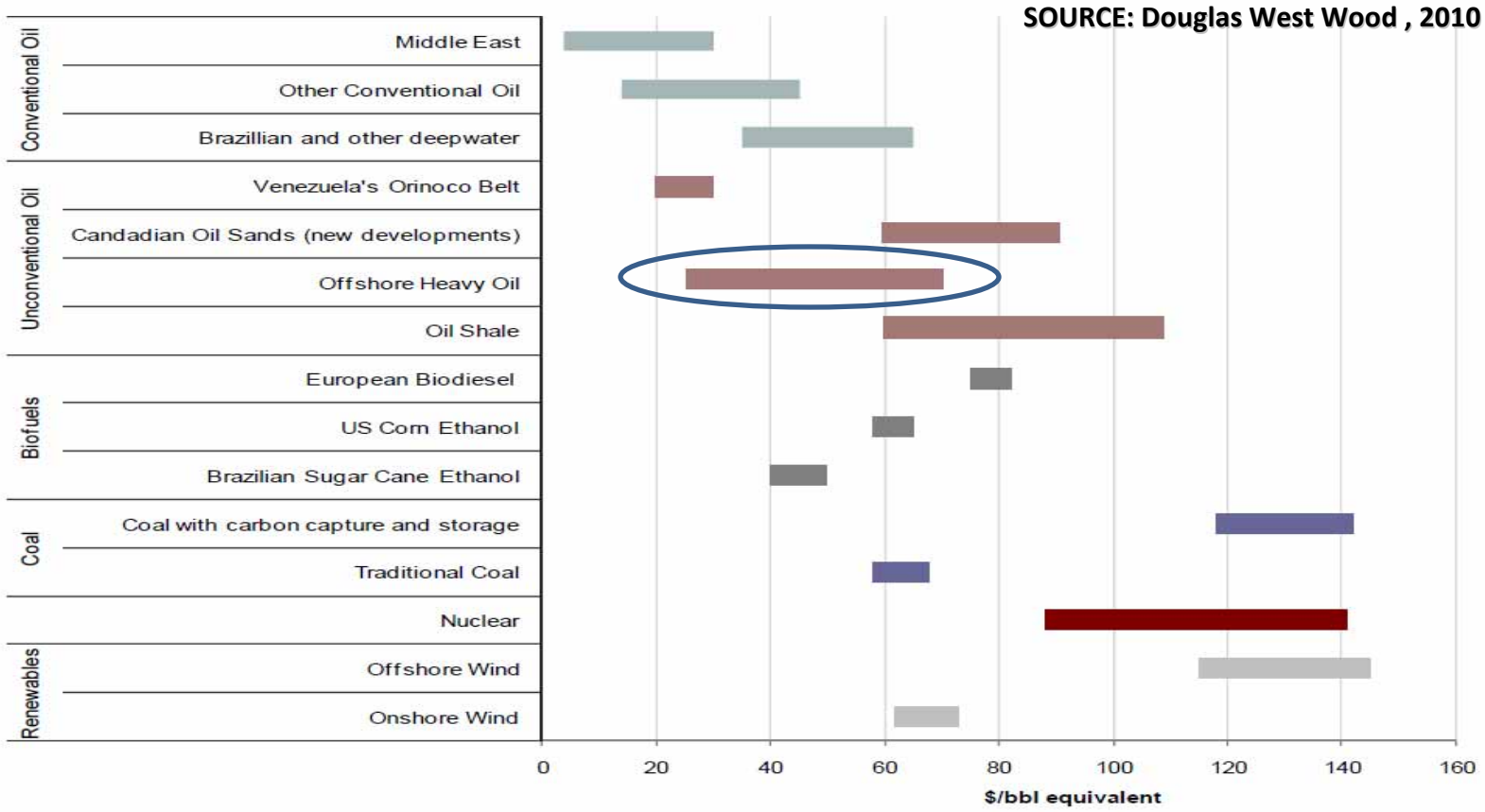
Energy Cost Comparison



However, offshore heavy oil is still competitive overall

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Heavy Oil Characteristics

Qualities of Heavy Oil -less desirable than light

	Light Sweet	Light Sour	Heavy Sweet	Heavy Sour	Extra Heavy
Gravity (deg API)	30-40	30-40	10-30	10-30	<=10
Sulfur %wt	<0.5	0.5-1.5	<0.5	1.0-3.0	>3.0
Metals (ppm)	low	low	low-high	low-high	high
Acidity	varies	varies	varies	varies	varies
Nitrogen (ppm)	varies20	varies	varies50	varies	high

SOURCE: Heavy Oil Recovery-A major Energy source for the 21st future.

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Technical Challenges

- Fluid Properties
  - Difficulty in measurement of fluid properties
  - High CAPEX for upgrading of Heavy Oils
- Reservoir Characterization
- Drilling and completion
  - High well productivity requirements
  - Well construction requirements

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Reservoir Performance

- Enhanced Oil recovery techniques cannot be applied offshore in the same way as onshore
- Weight and space considerations on platforms
- EOR techniques are sensitive to implementation timing- this may be a problem offshore
- However there are EOR projects offshore
  - Thermal Methods- Shallow environments like Lake Maracaibo
  - Water alternating Gas (WAG)- South Brae Field, UK

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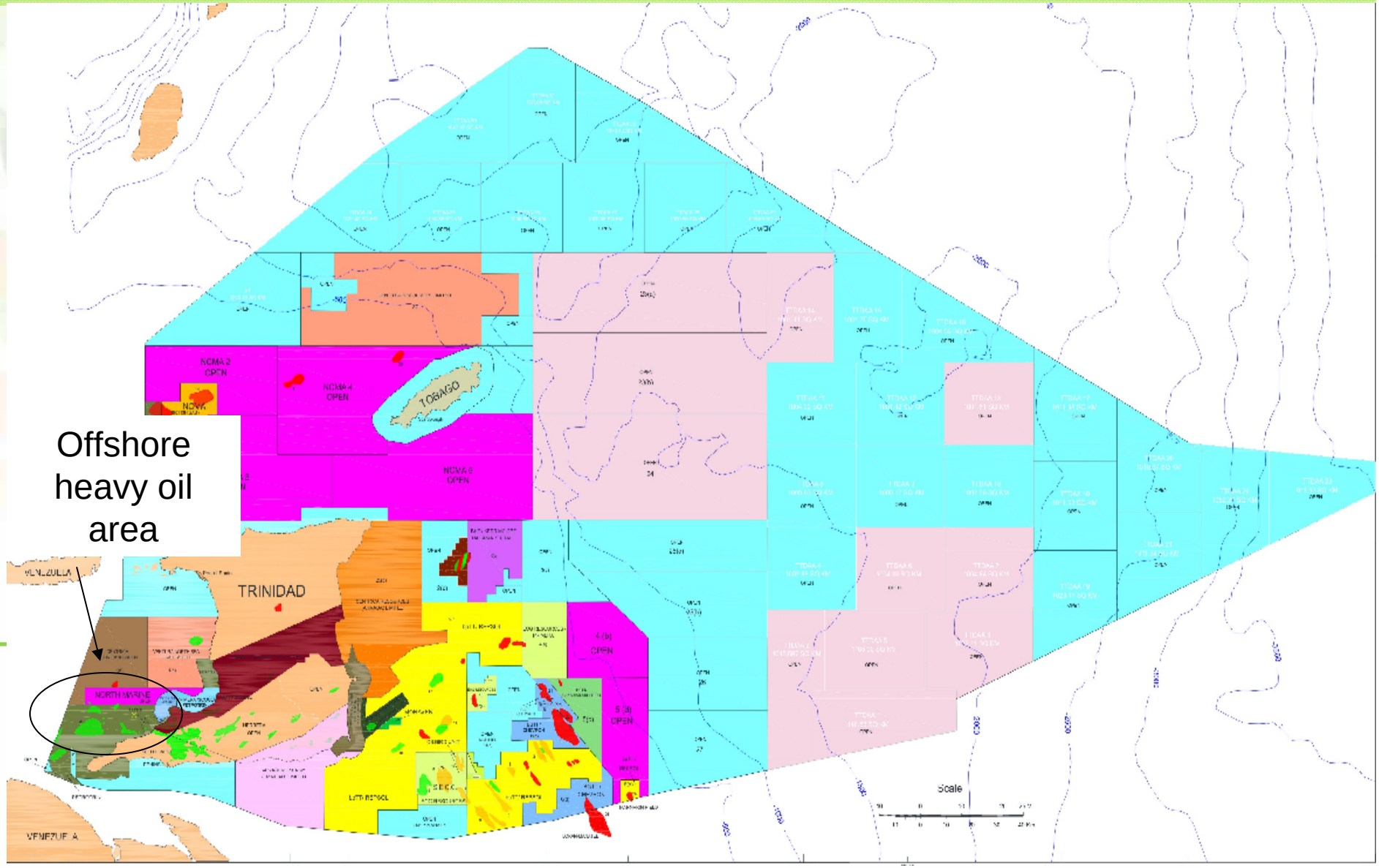
Trinidad and Tobago Offshore Heavy Oil Location



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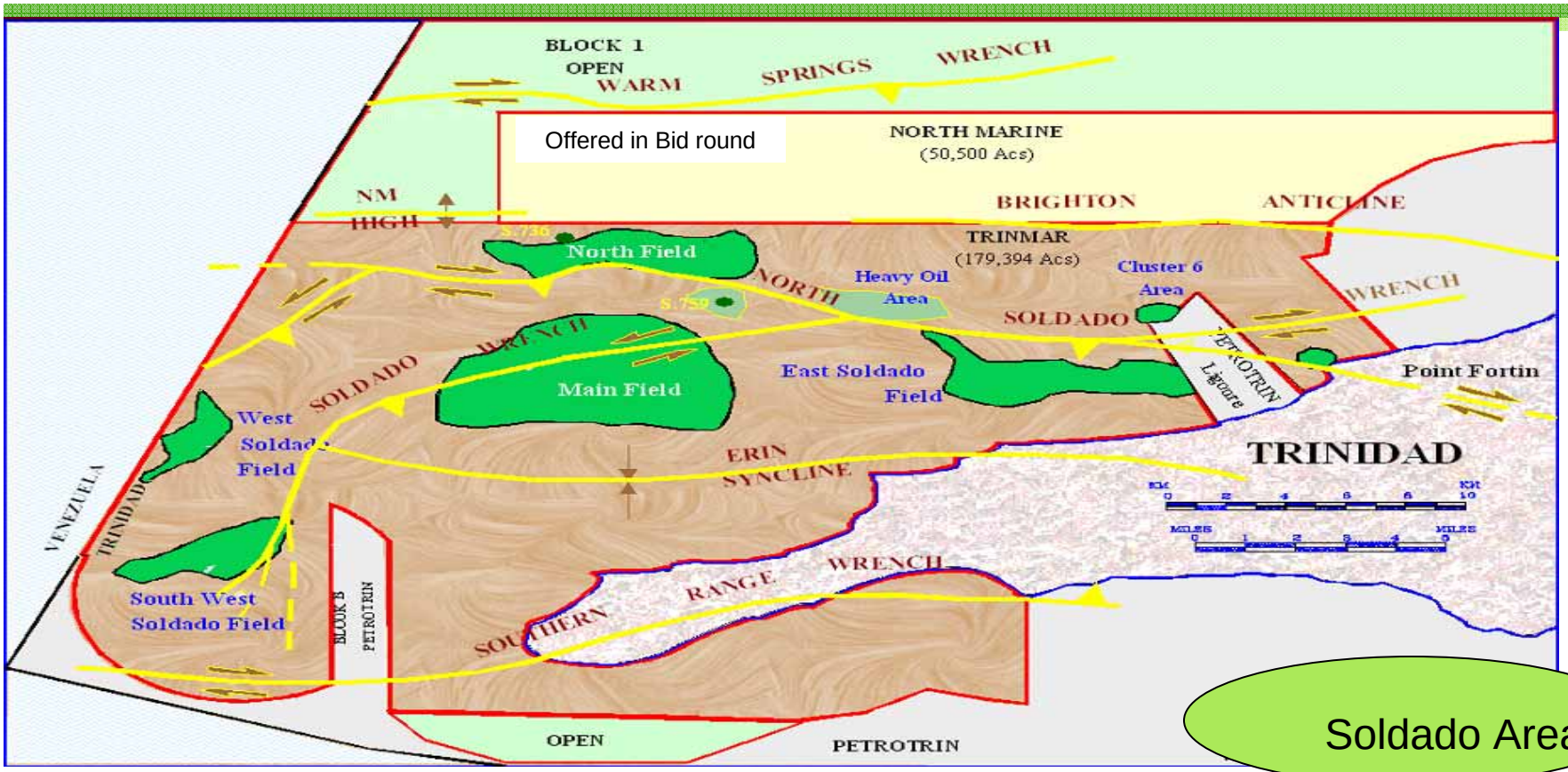
Offshore Heavy Oil -West Coast



Soldado Area

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T&T Offshore Heavy Oil

- Heavy oil offshore production approximately 15,000 bopd
- All via primary production
- Heavy oil from the West Coast primarily foamy oil- which has high Gas Oil Ratio and is mobile
- Heavy oil accumulations are associated with the Los Bajos fault system
- Occurs in the Forest, Cruse south of the Los Bajos and the Springvale and Manzanilla formations north of the Los Bajos
- Oil gravities range from 11 to 20 degree API

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Field comparisons

Country	UK	Norway	Brazil	Trinidad Tobago
Field	Captain	Grane	Jubarte	Soldado
Company	Texaco	Statoil 38%	Petrobras	Trinmar
Discovery	1996	Prod start 2003	2001	1962
Distance offshore	130km	185km	77km	35km
API	18-20°	19-20°	17-20°	16-20°
Water depth	341ft	405ft	3500ft	100ft
Reservoir pressure	-	2466psi	2600psi	1600psi
Recovery	20-35%	35-40%		16-20%
Reserves	956MM bbls	755MM bbls	600MM bbls	???MM bbls
Porosity	27-30%	27-33%	-	27-29%
Permeability	3-7 Darcies	5-10 Darcies	-	0.7-0.8 Darcies
Pay thickness	-	120 ft	-	-
Production	85,000bbl/d	200,000bbl/d	18,000bbl/d	24,028 bbl/d
Facilities	FPSOs	29 inch Pipeline	FPSOs	Leased FPSO

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T&T Offshore Heavy Oil Resource Size

- Significant heavy oil areas still to be exploited
- The jury is still out with respect to the size of the resources
- Complex geology
- Not the vast amounts of heavy oil structures as seen in Venezuela for example
- Solutions include using an upgrader
- What is the minimum size of resources needed
- What is the future outlook and how do we navigate from here?

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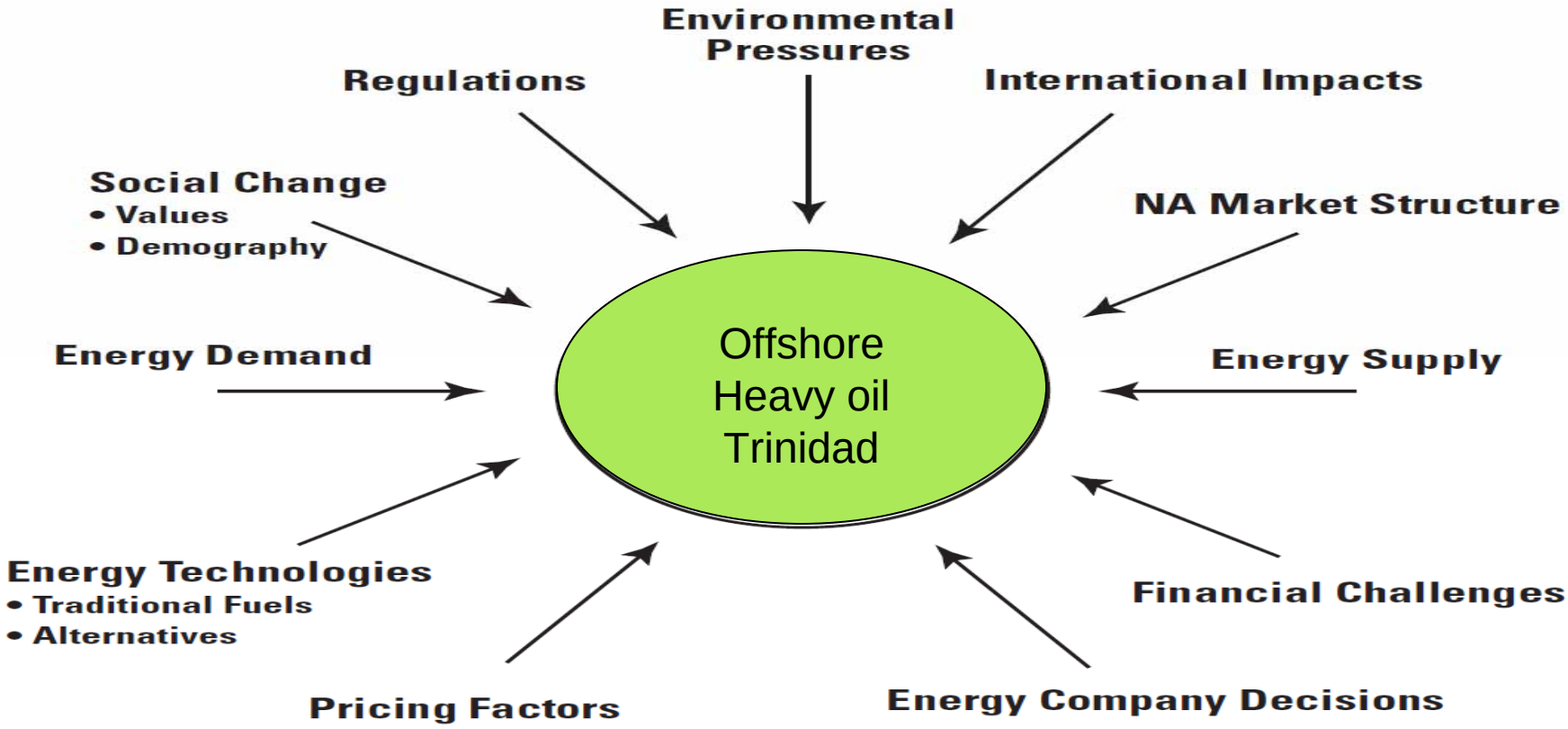
Driving Forces



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Scenario Analysis

- Scenarios are not forecasts
- Allows for issues, constraints and uncertainties to be identified
- Designed to challenge our thinking

Source:- Assoc. Now No2 F 2010

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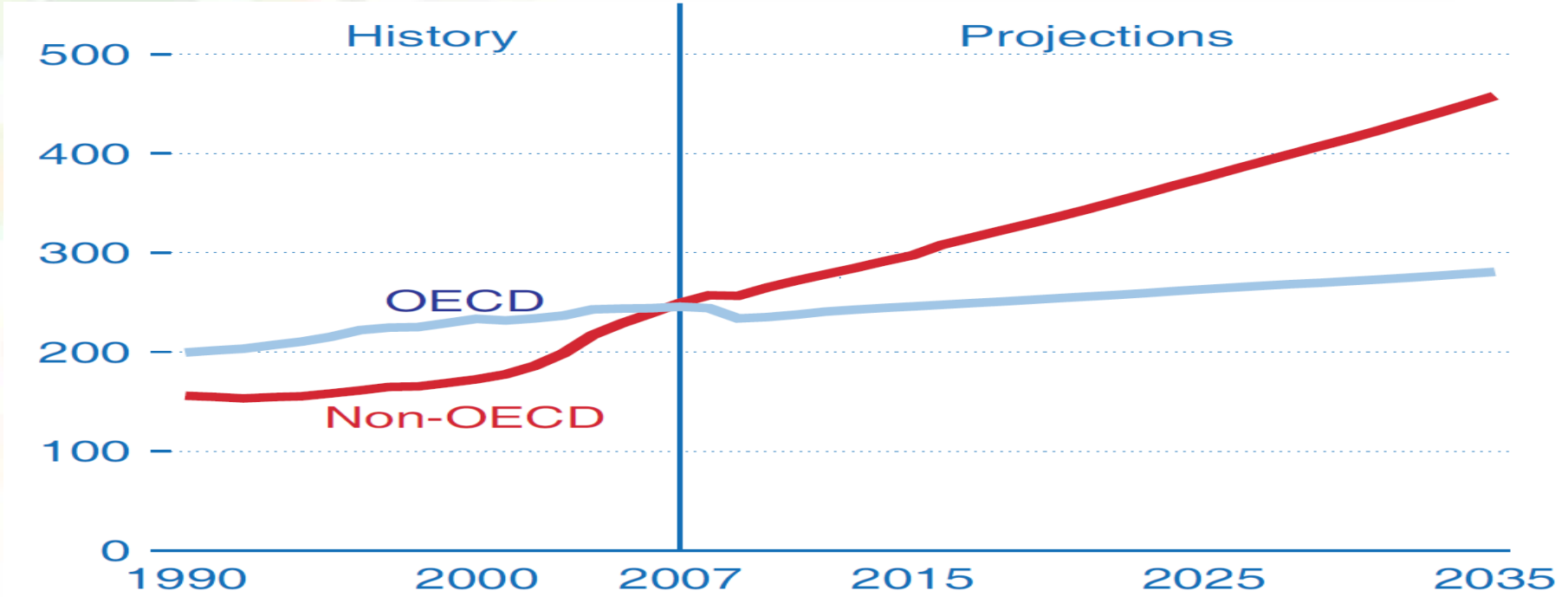
Scenario Context

World Marketed Energy Consumption:
1990-2035 (quadrillion BTU)



SOURCE: EIA 2010

Energy Consumption expected to increase

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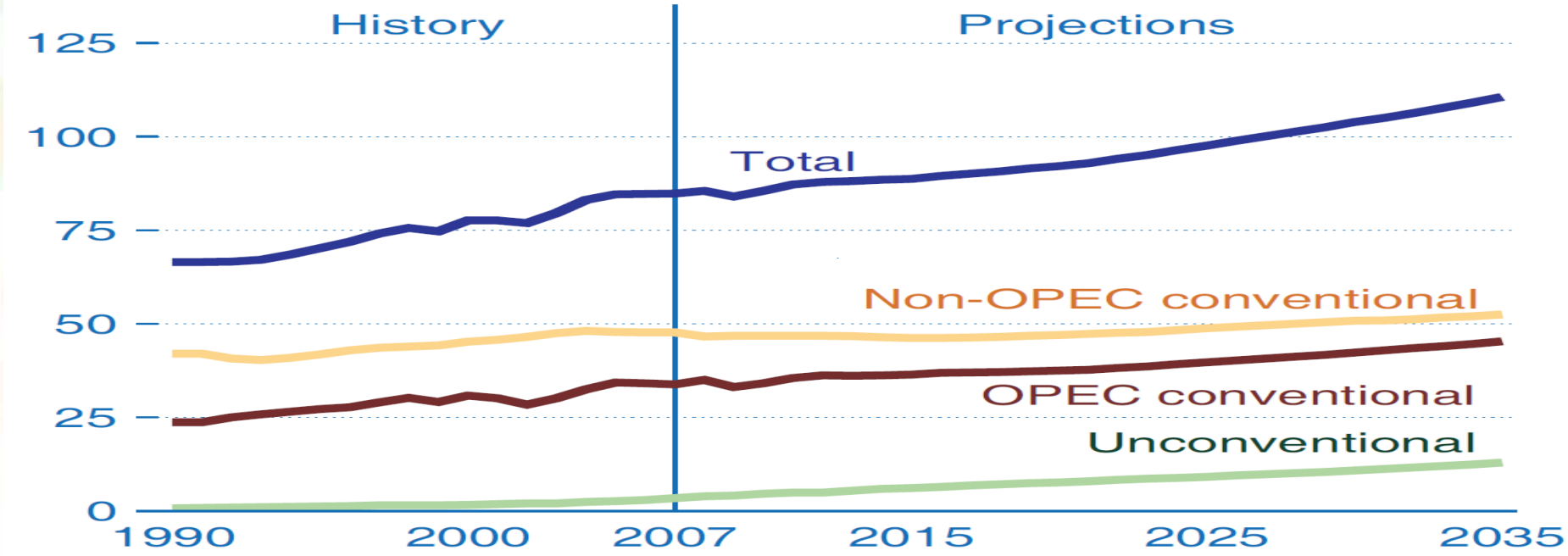
Scenario Context

Worlds Liquid Production, 1990-2035, millions barrels per day



SOURCE: EIA 2010

Continued increasing demand for unconventional oil

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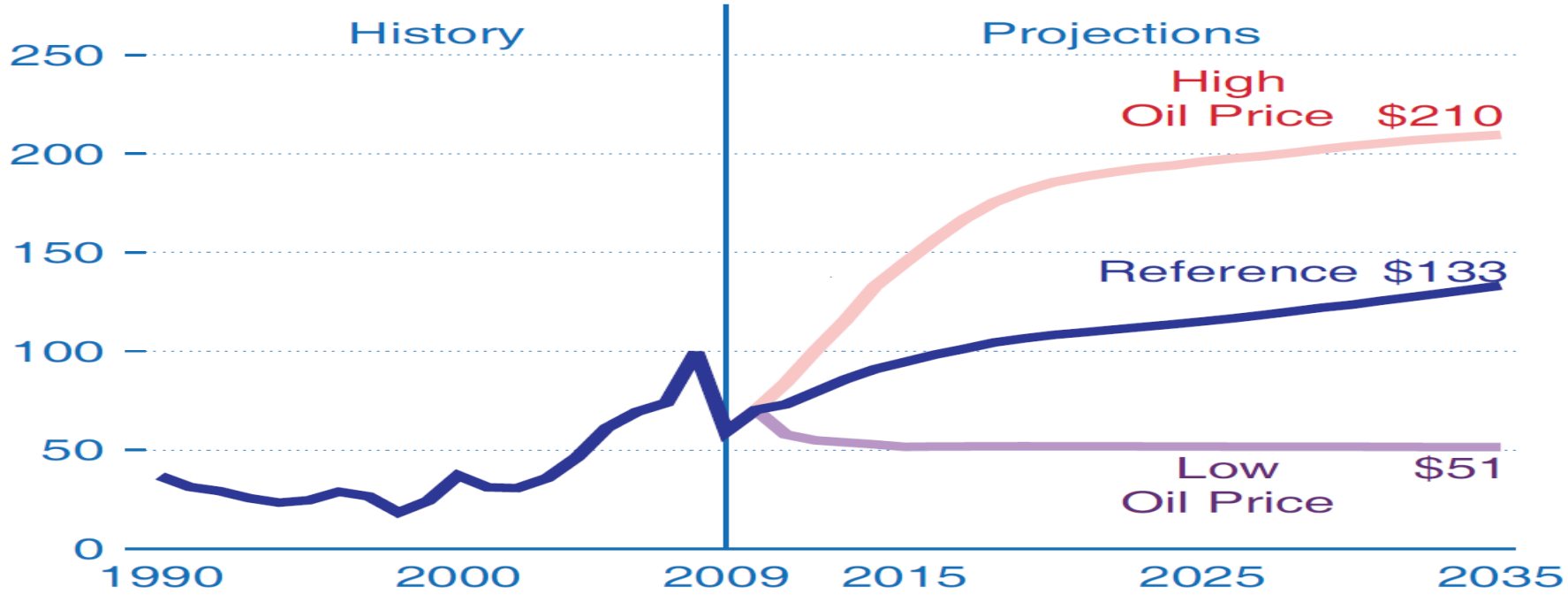
Energy Scenarios

World Oil Prices in three Oil Price Cases 1990-2035 (2007 barrels per day)



SOURCE: EIA 2010

EIA 2010 price scenarios used as basis

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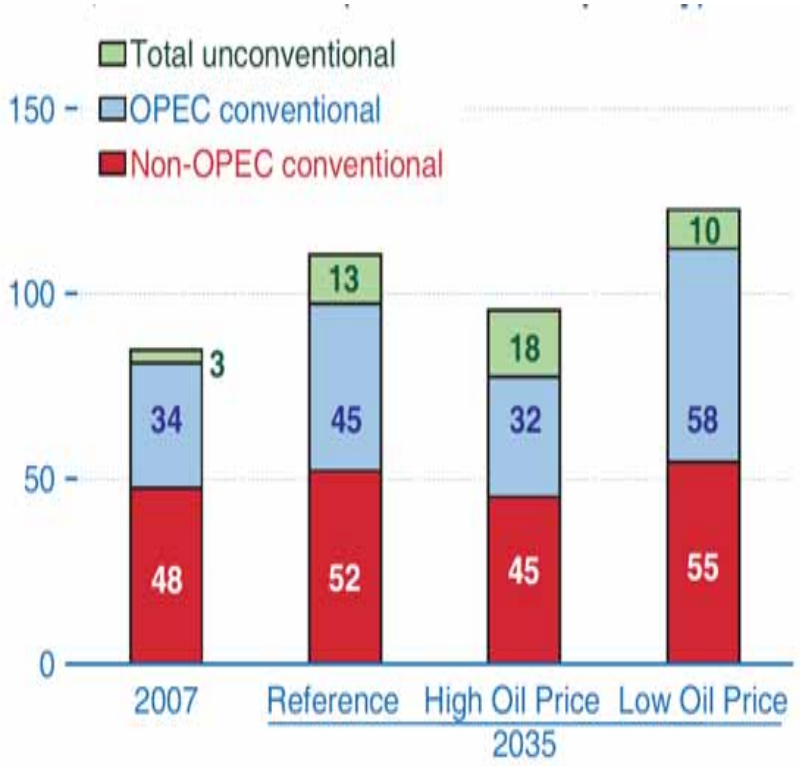
Energy Scenarios

- Highest liquids demand in low oil price case
- Unconventional fuel production is greatest in high oil price scenario

World liquids Fuel Production in three Cases
(million barrels per day)



SOURCE: EIA 2010

Unconventional demand is set to increase in every scenario

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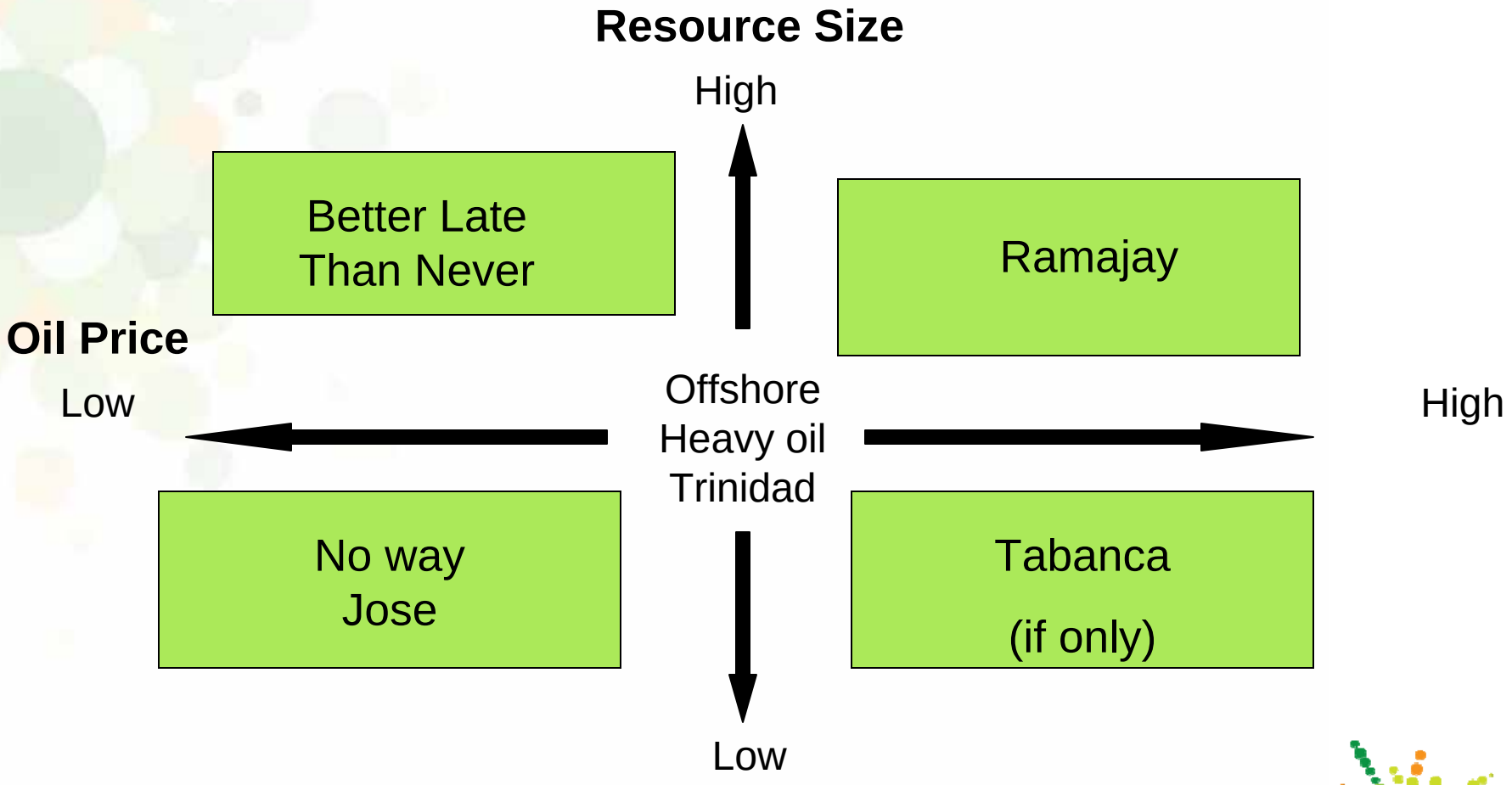
Trinidad OHO Scenarios



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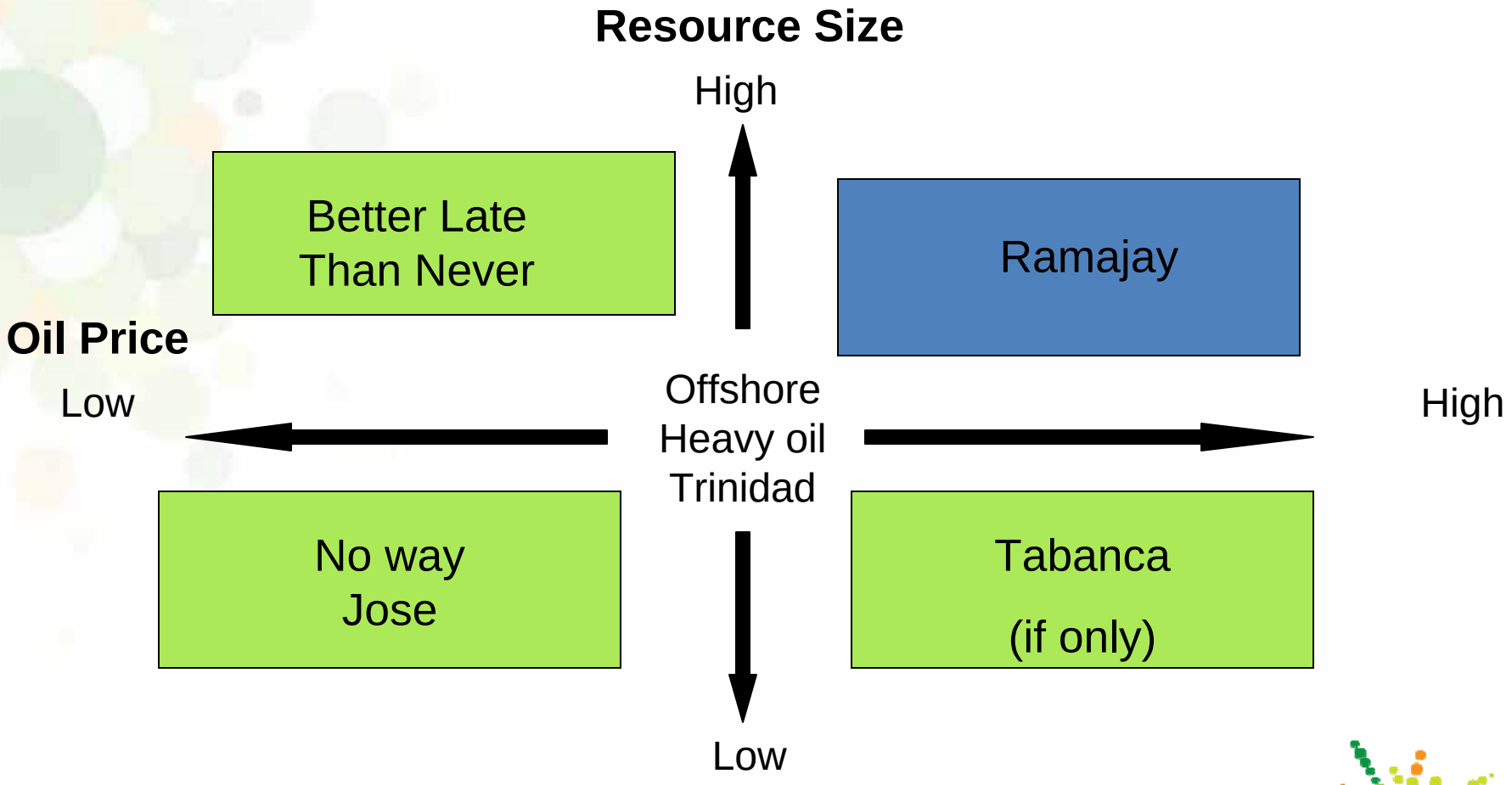
Trinidad OHO Scenarios



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Scenario Ramajay (Best Case)

High Oil Price, Large OHO Resource Size

- World Outlook
  - Development of difficult high risk expensive heavy oil accumulations
  - Development of EOR technologies
  - Increase in environmental concerns
  - Substitution to other forms of energy because of high oil prices like Biofuels and GTL

Scenario Ramaday (Best Case)

High Oil Price, Large OHO Resource Size

- T&T Outlook
  - Larger than expected offshore heavy oil accumulations off West Coast; maybe deepwater heavy oil discovery
  - Involvement of major deepwater players
  - Increased activity in heavy oil
  - Sharp increase in oil production - matching that of gas

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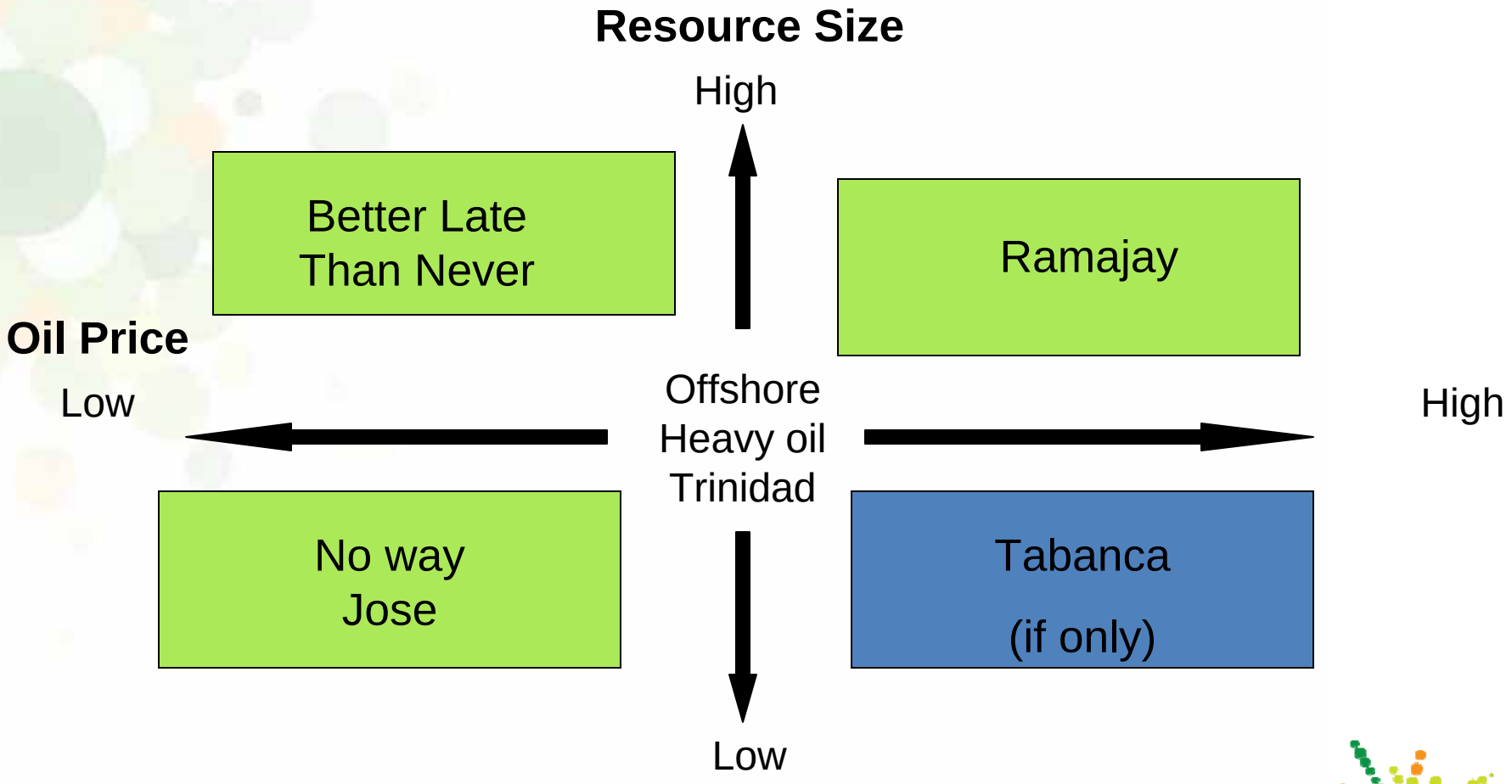
Trinidad OHO Scenarios



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Scenario Tabanca (if only)

High Oil Price, Marginal OHO Resource Size

- T&T Outlook
  - Less than expected offshore heavy oil resources- large gas/condensate finds in deepwater area
  - High oil price and new technologies make the small accumulations economic with high oil prices
  - Small independent operators from areas like North Sea and local companies seeking growth are interested
  - Increased production of heavy oil with focus on efficiency of operations
  - Focus and switch to other alternative sources of energy

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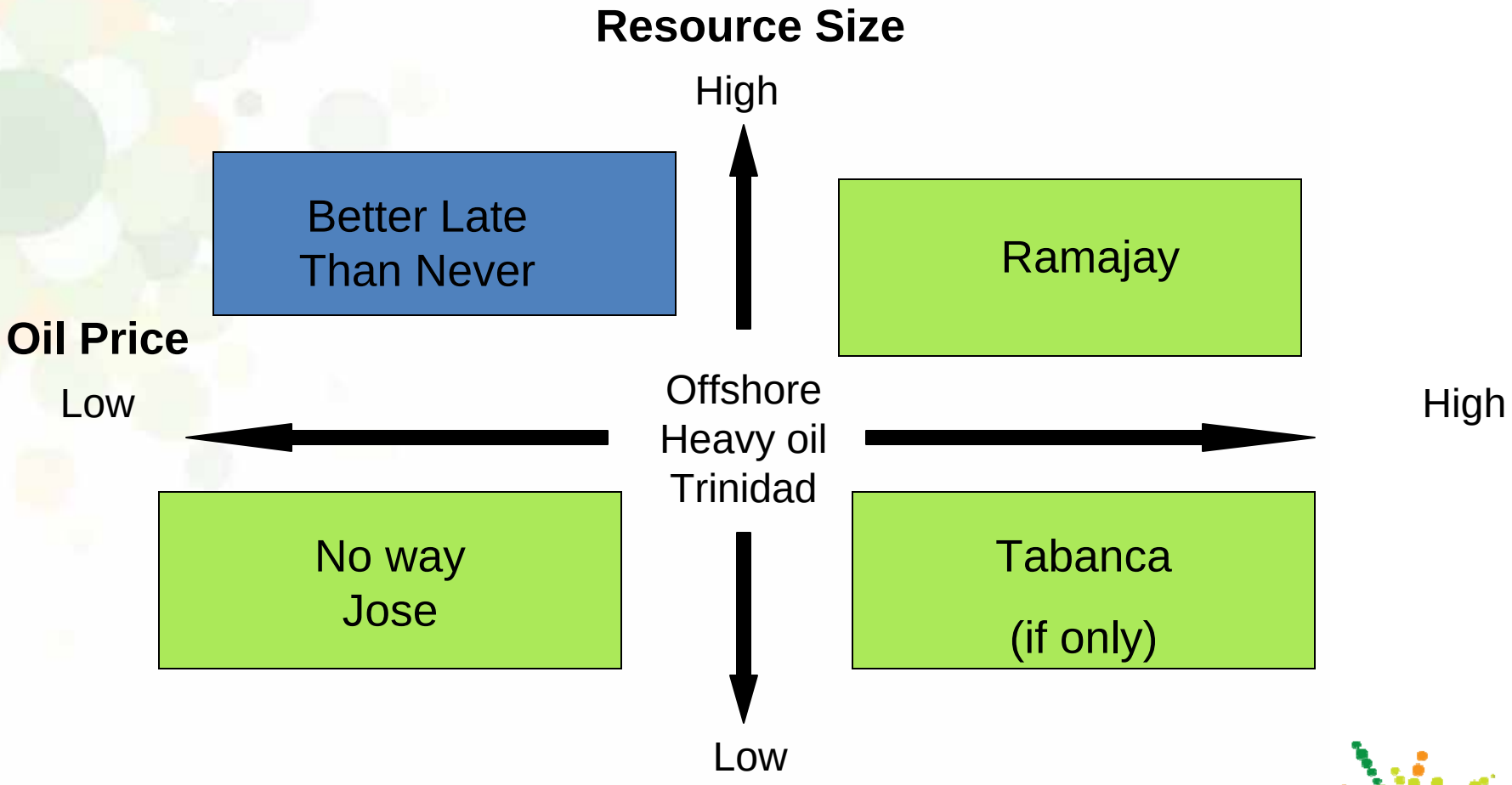
Trinidad OHO Scenarios



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Scenario Better late than Never

Low Oil Price, Large OHO Resource Size

- World Outlook
  - Increased production by OPEC
  - Dampened production of both conventional and unconventional oils
  - Fewer unconventional resources become economically competitive
  - Increase in environmental concerns

Scenario Better Late Than Never

Low Oil Price, Large OHO Resource Size

- T&T Outlook
  - Larger than expected offshore heavy oil accumulations off West Coast; maybe deepwater heavy oil discovery
  - Operators require fiscal incentives to develop OHO
  - Companies are risk averse to adopt technological innovation due to uncertainties in operational costs, market behavior and competition
  - Longer time to increased offshore heavy oil production

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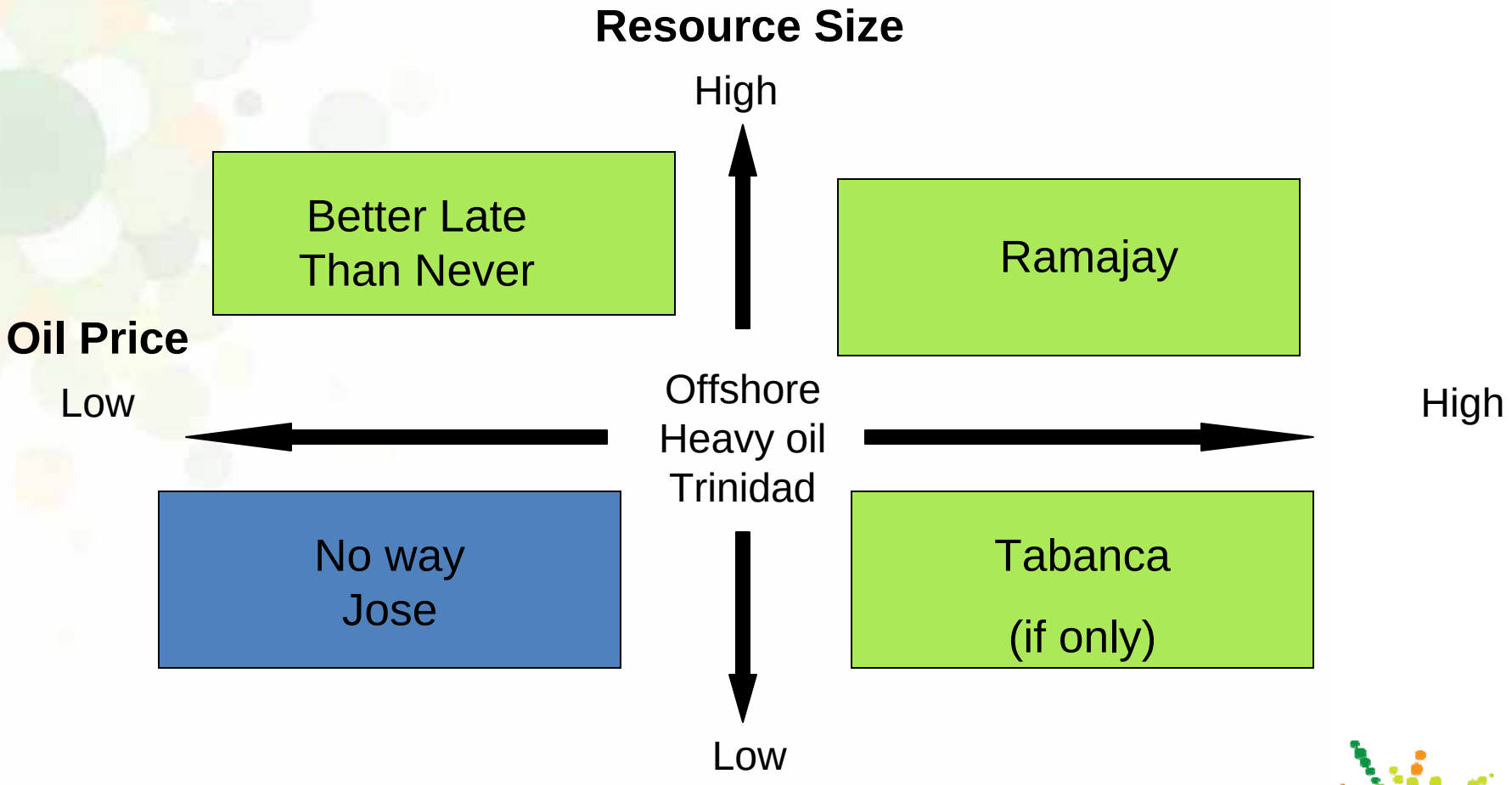
Trinidad OHO Scenarios



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Scenario No 5 Way Jose

Low Oil Price, Small OHO Resource Size

- T&T Outlook
  - Less than expected offshore heavy oil resources- large gas/condensate finds in deepwater area
  - Operators postpone investment for the future
  - Small independent operators from areas like North Sea and local companies seeking growth are interested
  - Continued focus on gas developments

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Conclusions

- The size of the resource accumulation and the price of oil are key uncertainties in development of offshore heavy oil in Trinidad and Tobago
- There is a need for detailed reservoir characterization of already known accumulations
- Fiscal incentives may be desired in low oil price environment regardless of the resource size
- Need to determine the price of oil necessary to trigger economically viable offshore heavy oil projects