

Unlocking a path dependency? The case of Brazilian ethanol implementation in Petrobras Oxford, UK Sept. 20th 2012

Msc Nelson Mojarro González
SPRU- Science and Technology Policy Research Unit
University of Sussex, UK
N.Mojarro@sussex.ac.uk

Oil firms and Biofuels ¿Transition from a path dependency system?

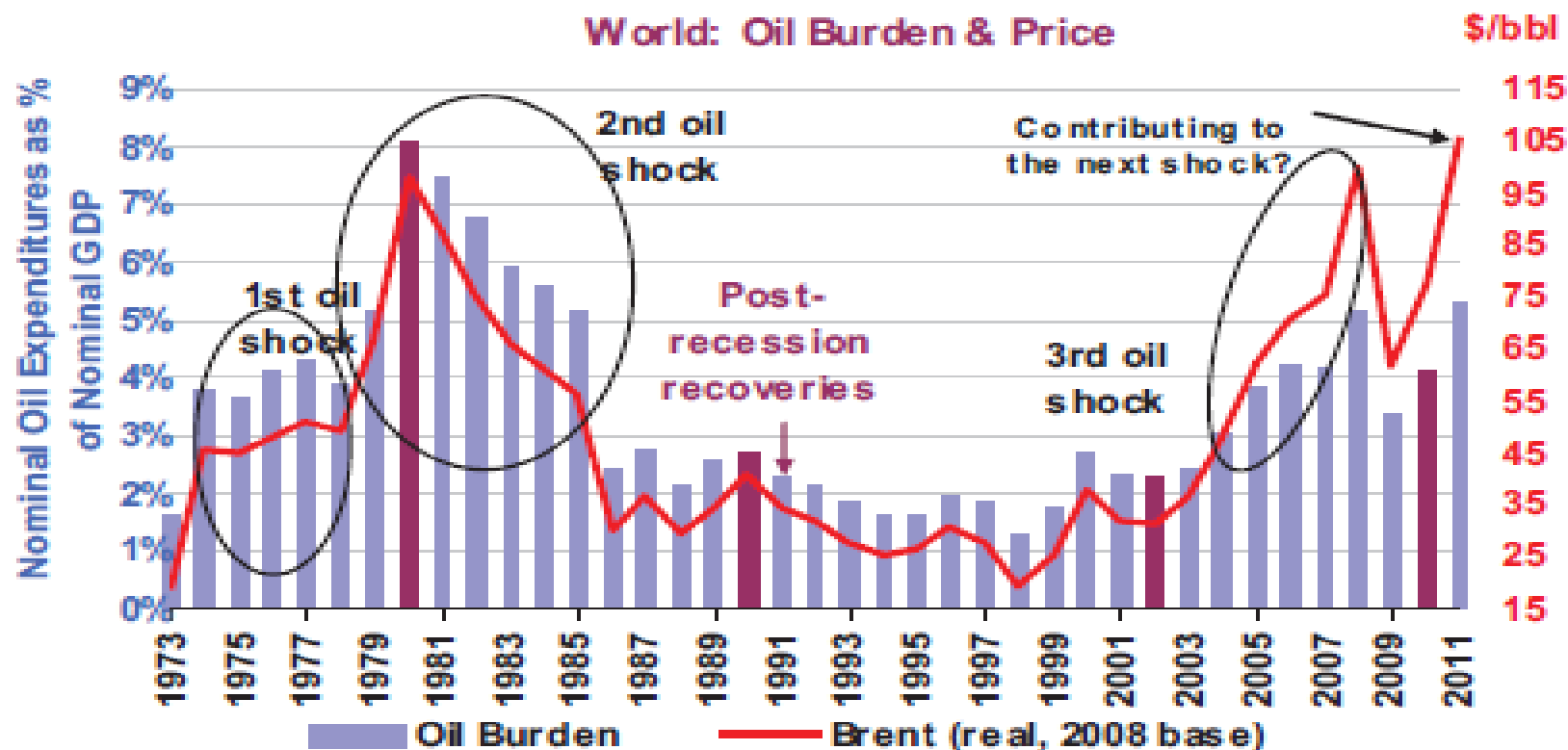
- Lock-in System based on oil products
- Fuel-Infrastructure-Subsidies-**Car/Engines**-Routines-Distribution-Petrol Stations-Safety/Norms-Oil income (certain countries)
- System Technological trajectory (incremental changes)
- Changes – Brazilian case Hydrous Alcohol and Anhydrous as additive (up to 25%) - Subsidies-Car/Engines-Routine-Consumer experience

- Lock-in System based on oil products plus **biofuels**:
- Changes:
- Flexfuel (Paradigm change)
- Climate change agenda Renewables Push
- Production costs reduction/increase in scale
- New technologies/New business opportunities
- ¿Shift in technological trajectory based on first and second generation biofuels?

Petroleum Companies and Biofuels (Evolution)

- Main factors 1970's
- High oil prices
- Need to develop ethanol run car engines
- Energy Security
- Policies:
- High subsidies for production and implementation
- Design specifically for development of biofuels
- Main factors 2012: **New conditions**
- High oil prices
- Car paradigm change in market. Hybrid cars/Flexfuel
- **Climate change/CO2 emissions**
- **New technologies**
- Policies:
- **Blending mandates** operating in several countries EU/Brazil/US

Peaks in Oil price; characteristic factor for Biofuels



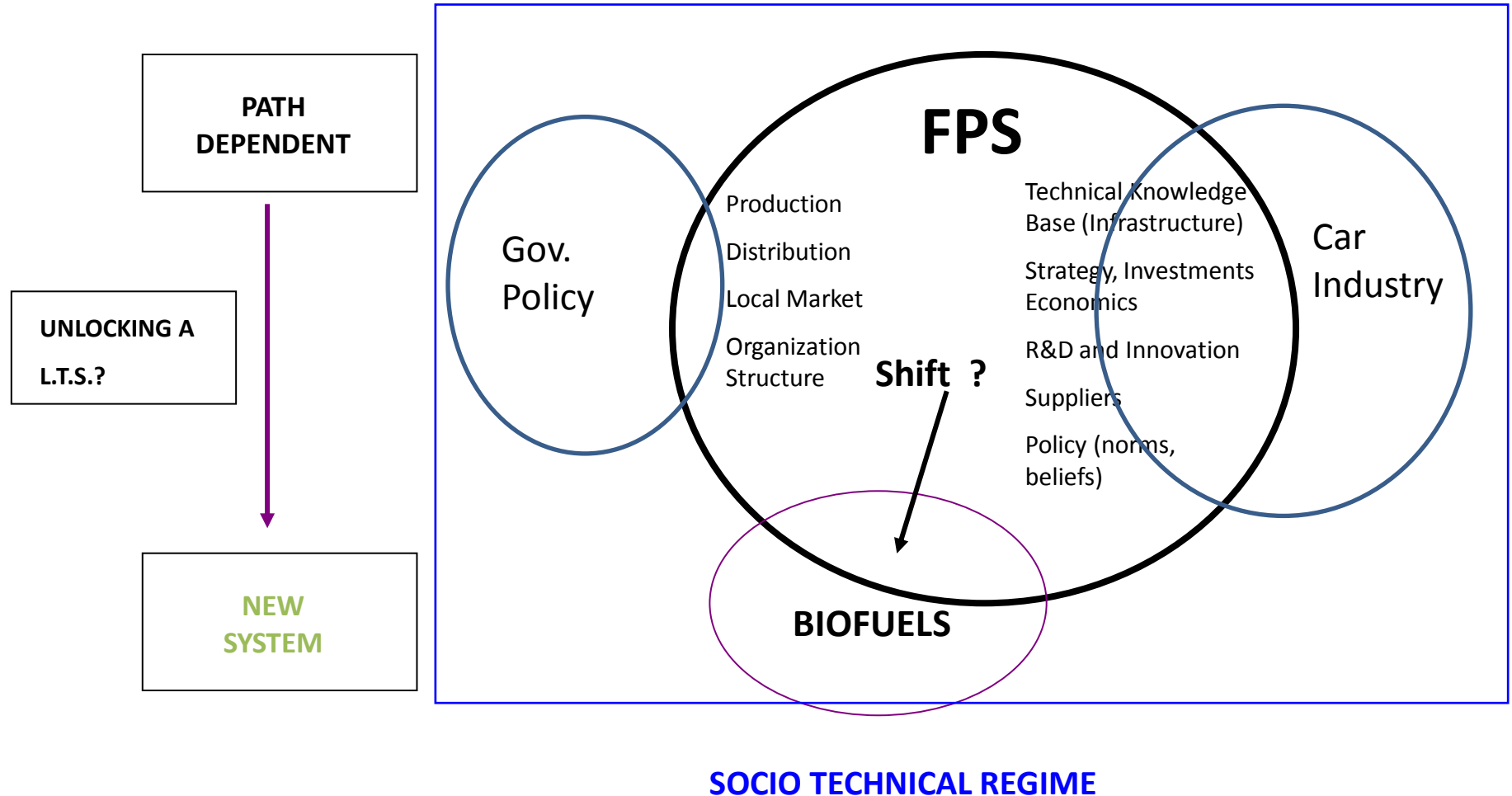
Source: International Energy Agency 2012

Main Focus of the Research

The study uses the approach of path dependency and argues that Oil firms have become locked in an oil dependent path that has recently been challenged by the increasing use of biofuels.

One of the questions that the study tries to answer is whether there is **a trajectory shift due to ethanol implementation of oil firms and the drivers behind the decision to implement biofuels.**

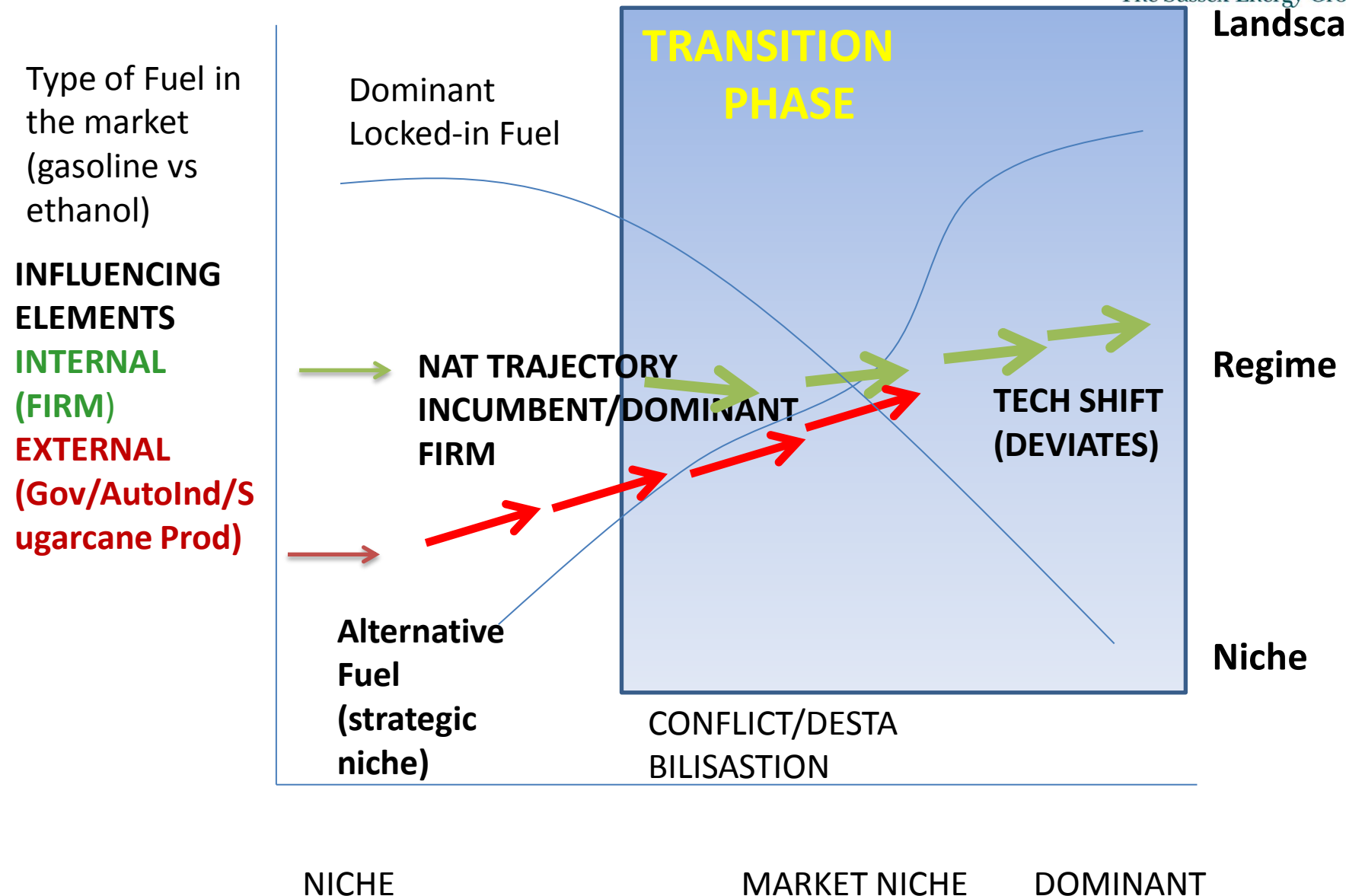
Motor fuel production system



Driving forces:

Internal vs External Forces (Oil Prices, Energy Policy, Agroindustry, etc.)

Motor Fuel Production System (MFPS)



THEORETICAL LITERATURE Path Dependence, Lock in and Lock out

- Zunsheng (1994) technological change is not a linear process. Arthur (1989), David (1985) and Roehrl and Riahi (2000) Initial conditions are crucial in technological choice that determines the **technological path** to be followed.
- Arthur (1989) when two technologies compete for adoption 'insignificant events' may give one of them a leading advantage and become dominant. Increasing returns favours the chances of adoption, once a course has been set **difficult to change**, that could have inferior long-run potential with respect to others.
- Hughes (1989) within LTS, **radical changes difficult** to occur.
- Geels (2004,2010,2011), Radical innovation come from niches and may produce a **REGIME to shift and INCUMBENT** firms into **reorientation**.

LARGE TECHNICAL SYSTEMS (LTS)

-Interdependence of technologies, sunk costs, components, and practices.

MOTOR FUEL PRODUCTION SYSTEM

- LTS with increasing returns, economies of scale and path dependent.
Many decades of incremental innovations.

- LOCKIN OIL PATH DEPENDENCY

Over a century, without major disruptions.

However,

NEW CONDITIONS FOR OIL FIRMS

-Stringent environmental quality specifications for their products (Szklo and Schaeffer 2007) Biofuel mandates, following regulations for CO2 reductions and other pollutants.

Modifying operations at various levels of the firms

METHODS

- Case study analysis.
- Qualitative Interviews.
Company/Government/Industry Experts for each case.
- Additional data (Patents/Investments for first and second gen.
- R&D data

PETROBRAS

- A Brazilian Oil Company/Leader in Brazil.
- Operates in 13 countries
- 2011 Revenue – 145,915 billion dollars
- Partly state/party private owned
- 81,918 Employees



ETHANOL IN BRAZIL

- SECOND PRODUCER IN THE WORLD
- SUGARCANE BASED/LOWEST PRICE
- PIONEER IN LARGE SCALE IMPLEMENTATION
- HUGE AVAILABILITY OF ARABLE LAND FOR ETHANOL (ONLY 1-2% OF ARABLE LAND USED FOR ETHANOL PRODUCTION)

MOTOR FUEL PRODUCTION SYSTEM HISTORY

1973 - - First “oil shock”

1975 - - PROALCOOL (ethanol program)

BRAZIL AN OIL IMPORTER

BALANCE OF PAYMENTS

PROBLEMS/SUGAR CANE

PRICE VERY LOW

1979 - - Second “oil shock”

1979 - - First Alcohol Powered Car T

ECONOMIC INCENTIVES

1982 - - Gasohol 78% Gasoline + 22% Ethanol

ETH 59% COST OF GASOLINE

1985 - - 96% of TOTAL CAR SALES WERE OF ALCOHOL ONLY CARS 4.5MILLION CARS

1989 - - Alcohol Supply Crisis

END OF PROALCOOL IN 1990.

1997 - - Alcohol Production Excess

1998 - - Ethanol Addition Increase (24%)

2000 - - Ethanol Addition Diminution (20%)

2001 - - Ethanol Addition From 20 to 26%

2003 - - Flex Fuel Car (2.6% of New car sales)

2005 - - Ethanol Addition 25%

PETROBRAS CHANGE OF STRATEGY

- Biodiesel addition to diesel (2% allowed in 2005, 5% obligatory by 2013)

2009 - - Flex fuel Car (NEARLY 90% OF NEW CAR SALES)

PETROBRAS (PB) ethanol implementation

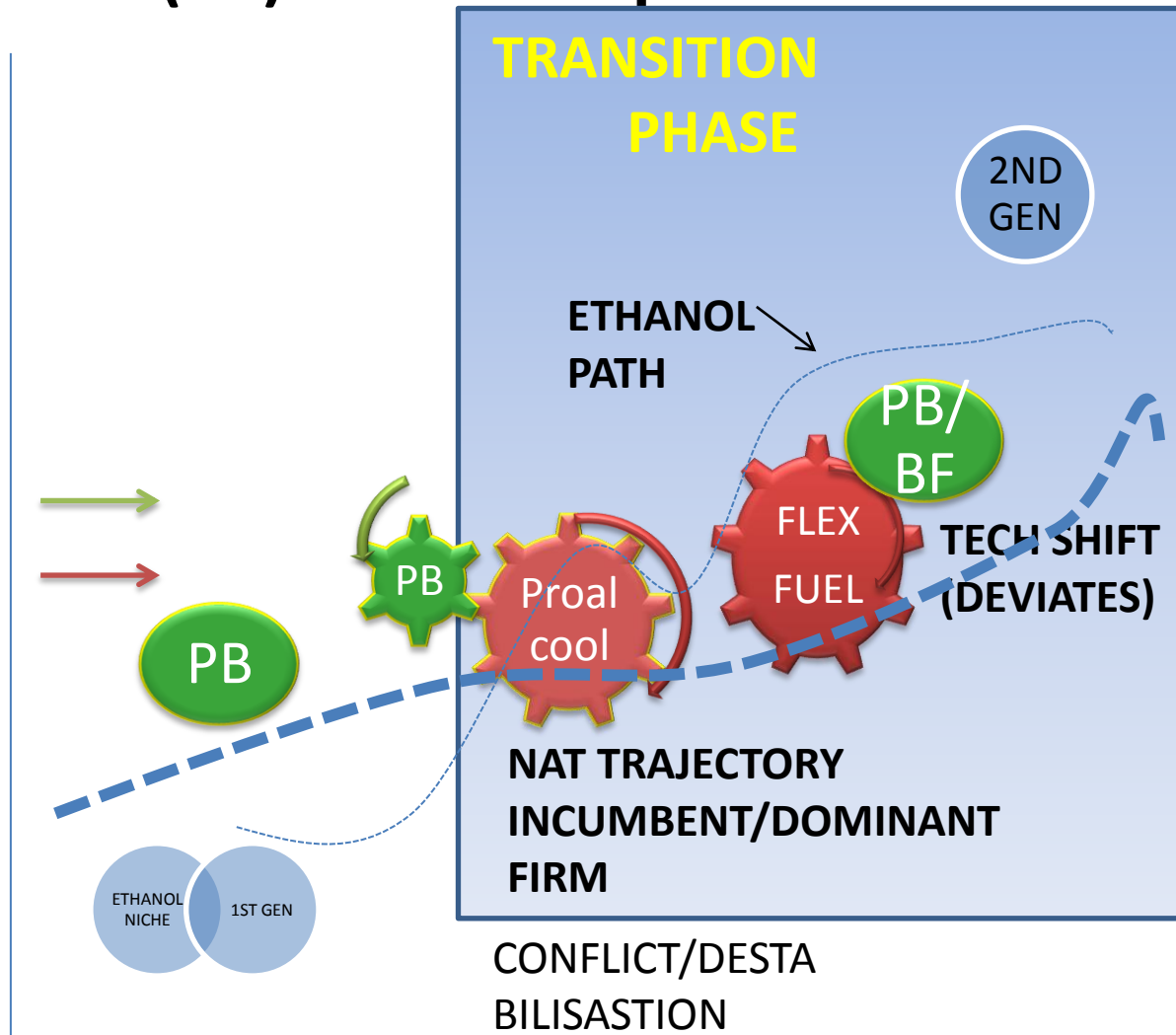
**Unlocked?
First
Generation**

**PATH
DEPENDENCY
/LOCK-IN
System**

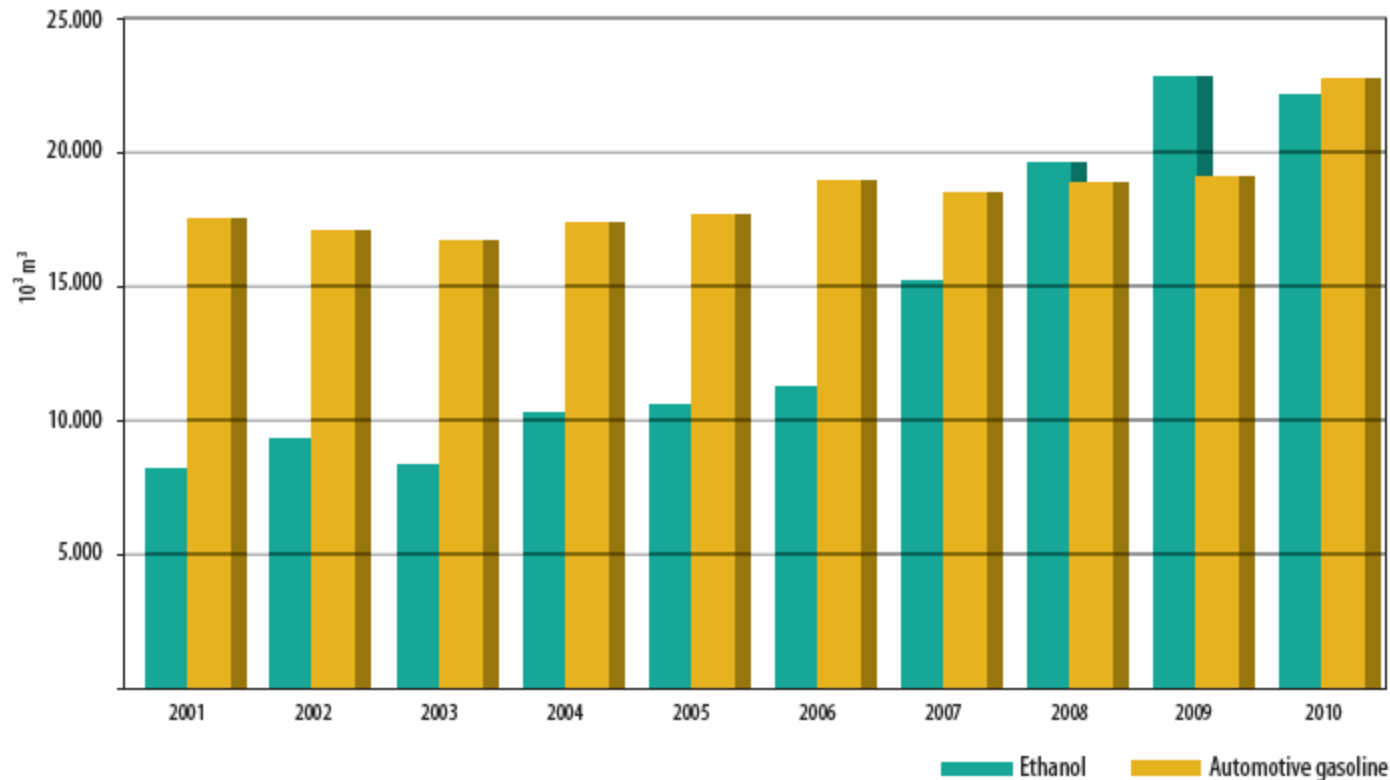
**INFLUENCING
ELEMENTS**

**INTERNAL
(FIRM)**

**EXTERNAL
(Gov/AutoInd/S
ugarcane Prod)**



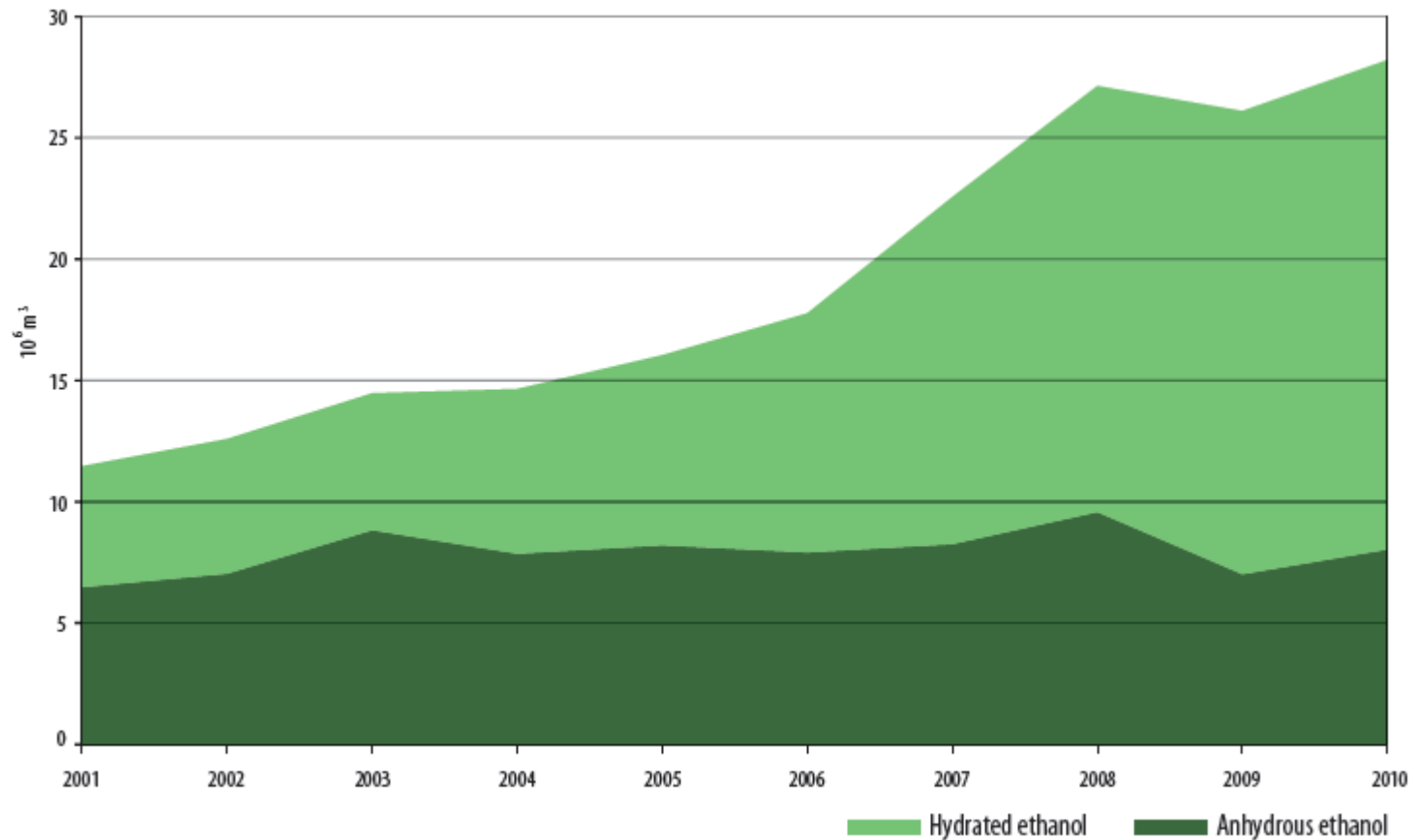
Domestic sales of ethanol and automotive gasoline 2001-2010



Source: ANP 2011 Report. Ethanol includes both hydrous and anhydrous. Gasoline does not include anhydrous, only Gasoline A.

**2007-2008 PETROBRAS
CHANGES STRATEGY,
EMBRACES ETHANOL AND
CREATES A NEW SUBSIDIARY:
PETROBRAS BIOCOMBUSTIVEL**

Hydrous and Anhydrous Production in Brazil



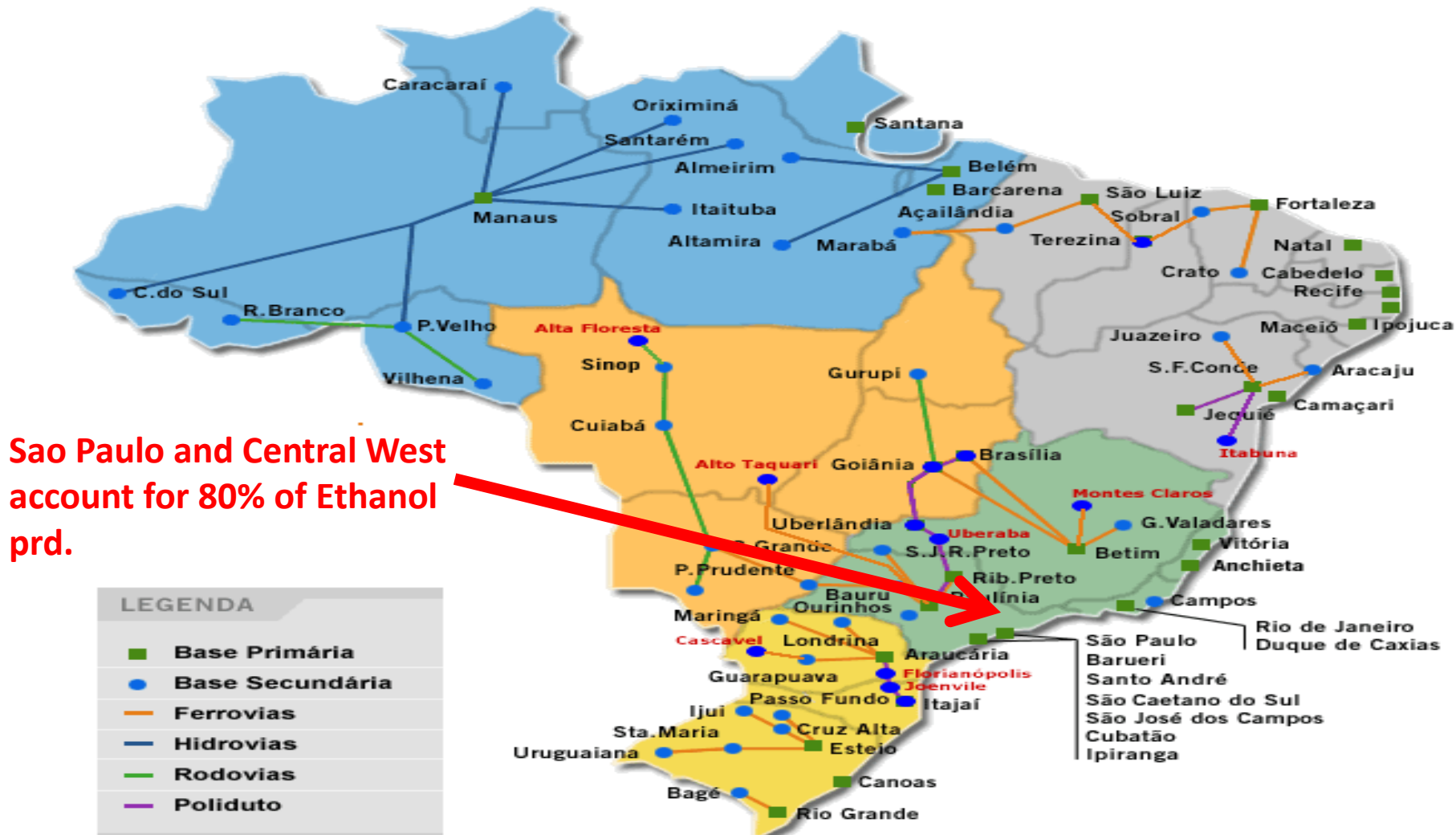
Source: ANP annual report
2011

Sugarcane production requires about 5% of Brazil's land devoted to primary food crops. IF sugar prod is taken into account it becomes 7.5%.

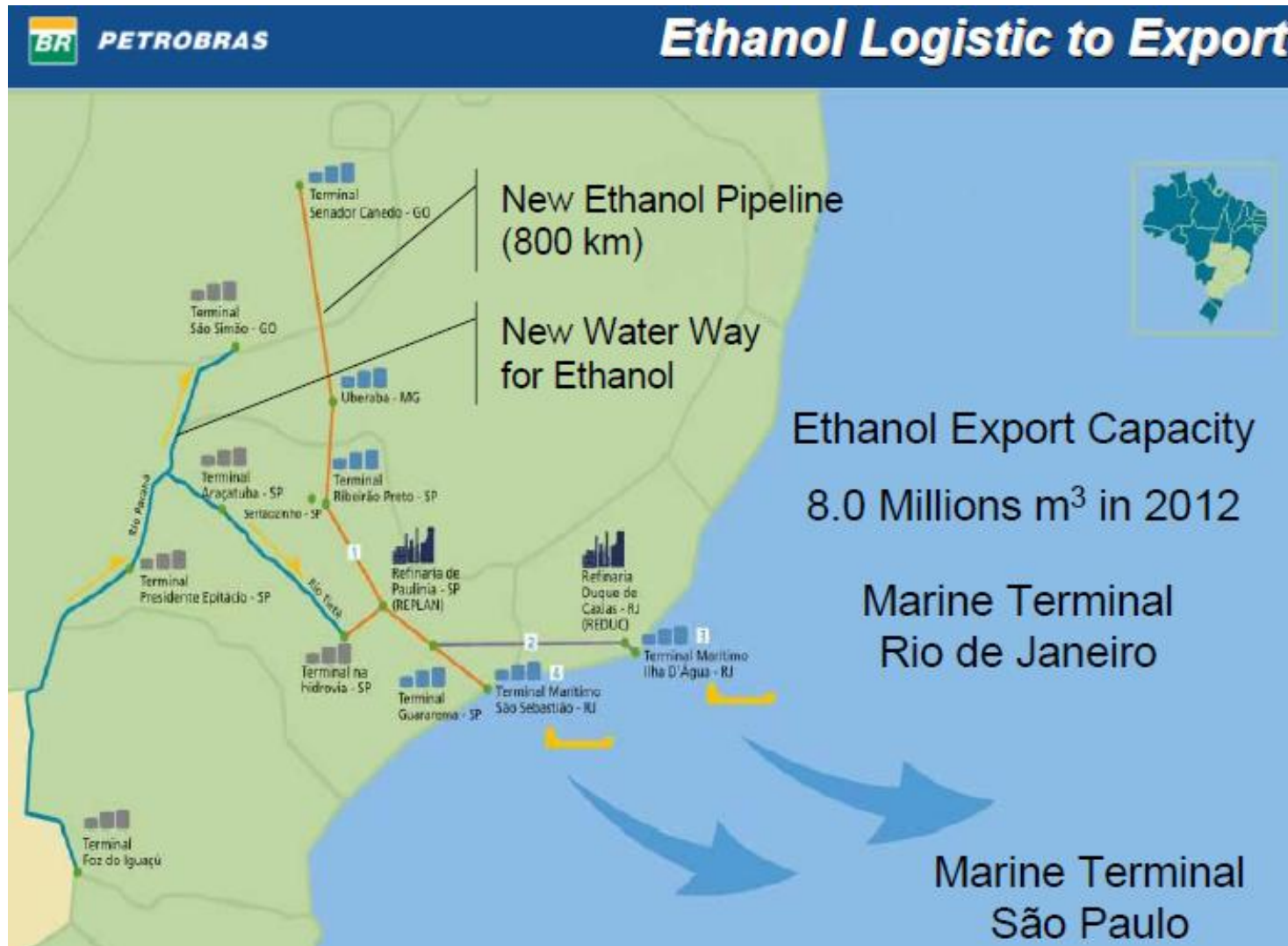
PETROBRAS STRATEGY

- Associated with Ethanol Producers from 2008!
- 1st Generation ethanol (Brasil)
- 2nd Generation biofuels (CENPES)
- From 2008 PB Biofuel Business Unit (Petrobras Biocombustiveis)
- Challenged by large ethanol market share (prox 50%)
- Based on 8 decades of ethanol blending and distributing in Brazil.
- Export infrastructured planned (ethanol specific pipelines)
- Planned in 2011-2014, 4.1 \$ US Billion for Biofuels (300Mill R&D)
- Announced that PB Business saved 1 million tons of CO₂ (Sust. Report 2010).

PETROBRAS Network Distribution



PETROBRAS Ethanol Export Strategy



Petrobras Ethanol Production Capacity and Market Share

Ethanol Production	Number of Plants	Production capacity (Million liters)	Market share in Brazil
Before 2006	0	0	0
2012	9	893	4%
2015	9	5600	12%

Extension capacity Planned
Increase of 627% from 2011

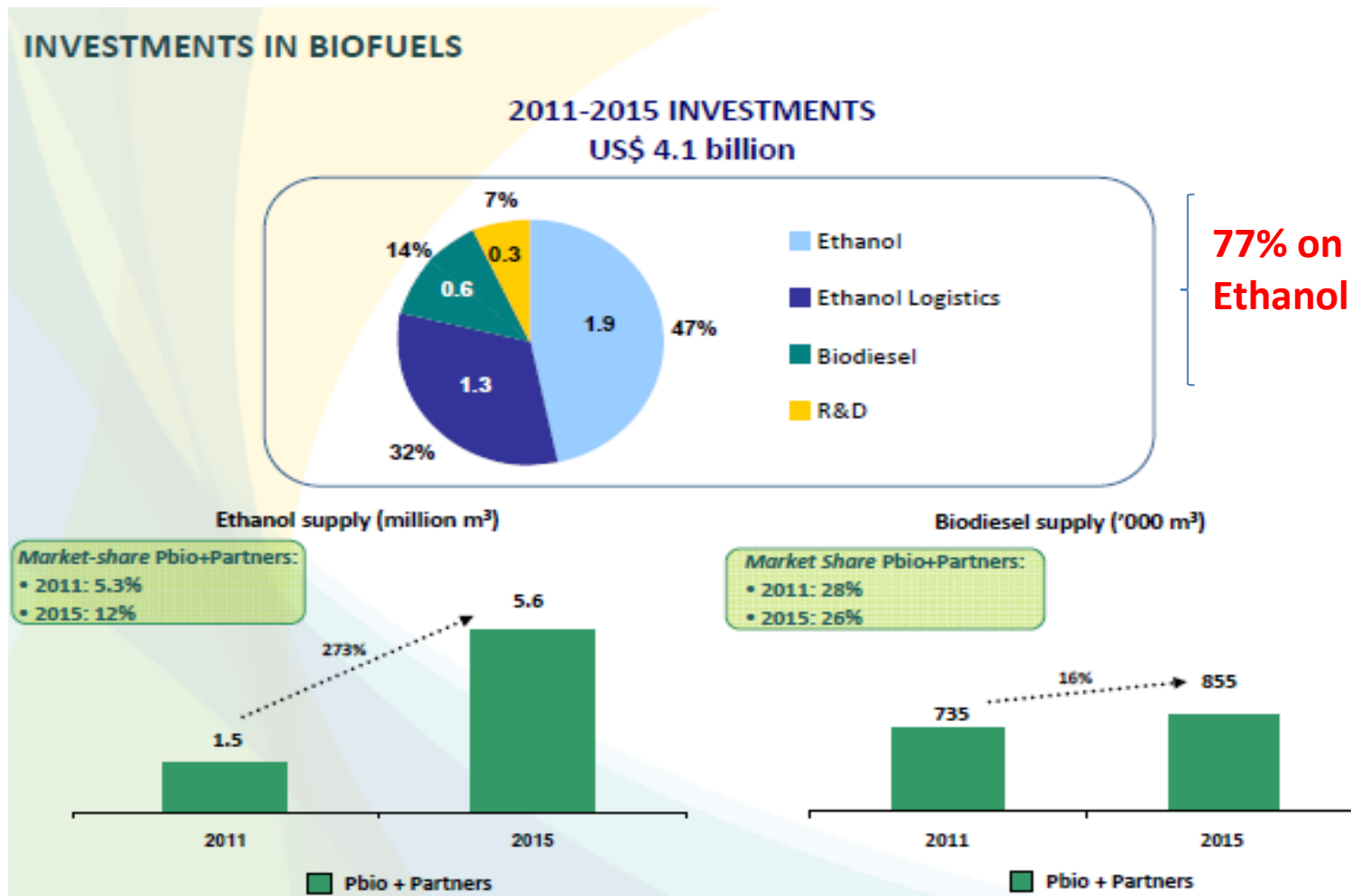
Source: Own elaboration with data from Petrobras Business Plan 2011-2015 and Petrobras Magazine

Petrobras Biofuel R&D

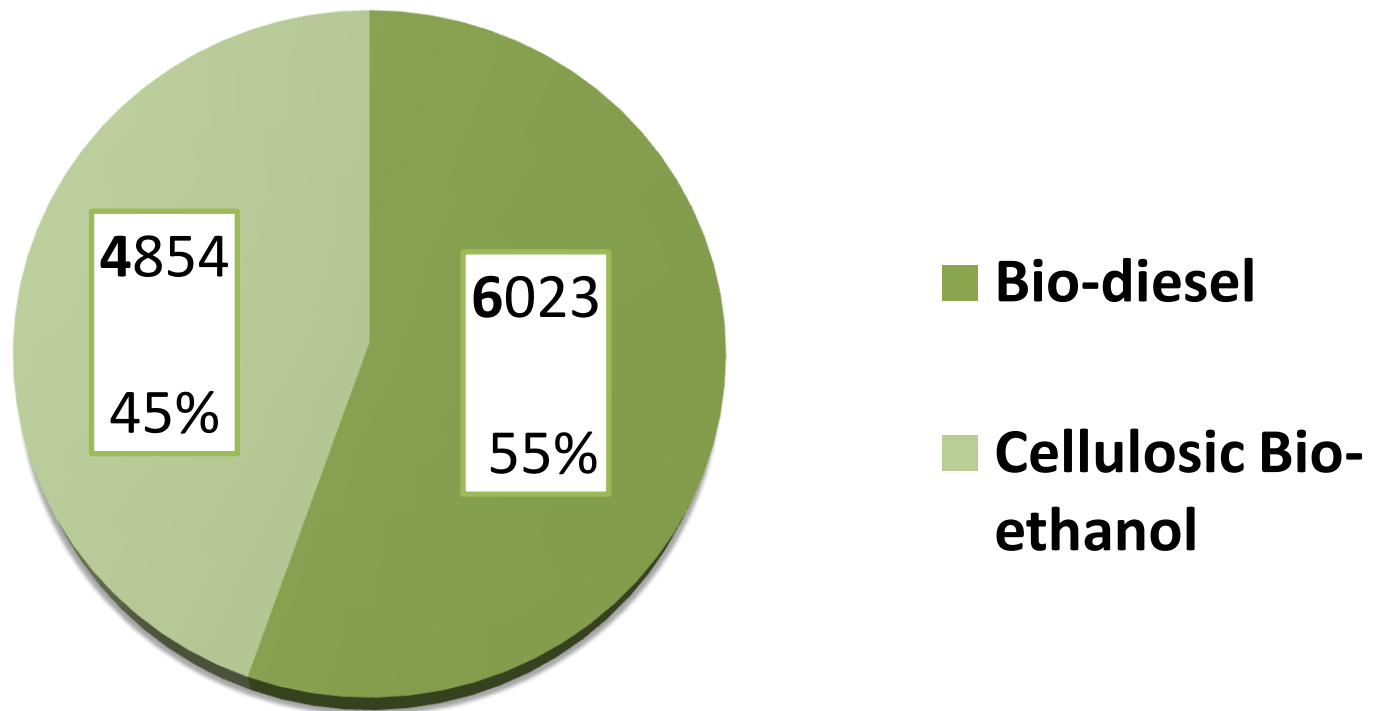
Petrobras R&D	2006-2010 US \$ millions	2011-2015 US \$ millions
Biofuels R&D	32	300
Average per year	8	75
Share of total R&D	5%	7%

Source: Own elaboration with data from Petrobras Business Plans

Petrobras Investments in Biofuels



Biofuel Patents



Source: Espacenet

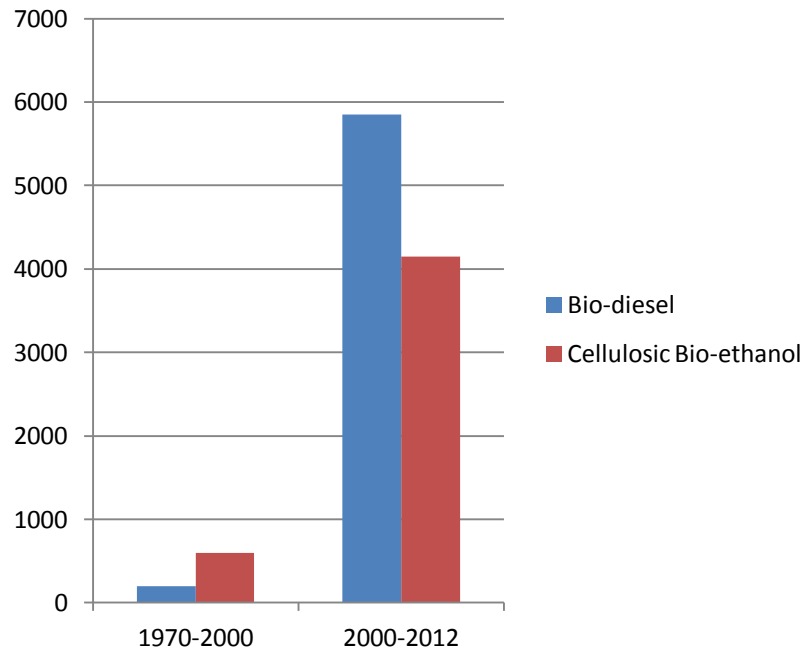
Ethanol patents

	Firms doing R&D	Patents	% of Total Patents
Input ethanol	Biotech (Novozymes, Genencor, etc)	400	89.8%
Ethanol Producers	Productoras, ej. Abengoa, ADM, Cargill	9	2%
Oil firms/Distributors	Petroleras, ej Chevron, Texaco, Shell	36	8%

Source: Karmarkar-Deshmukh and Pray (2008) data from USPTO

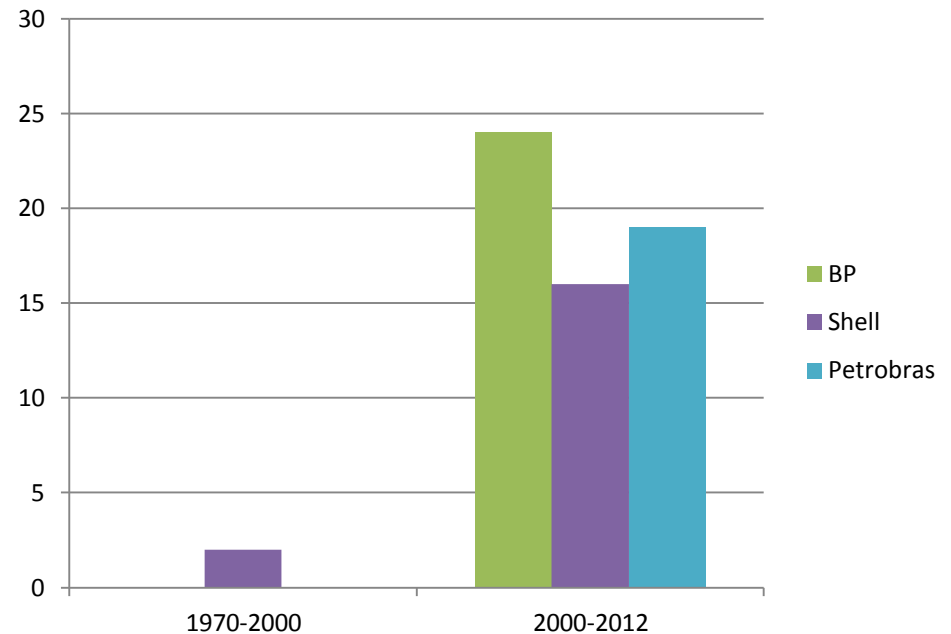
Patents in Biofuels

Biofuel Patents



30 years vs 12 years

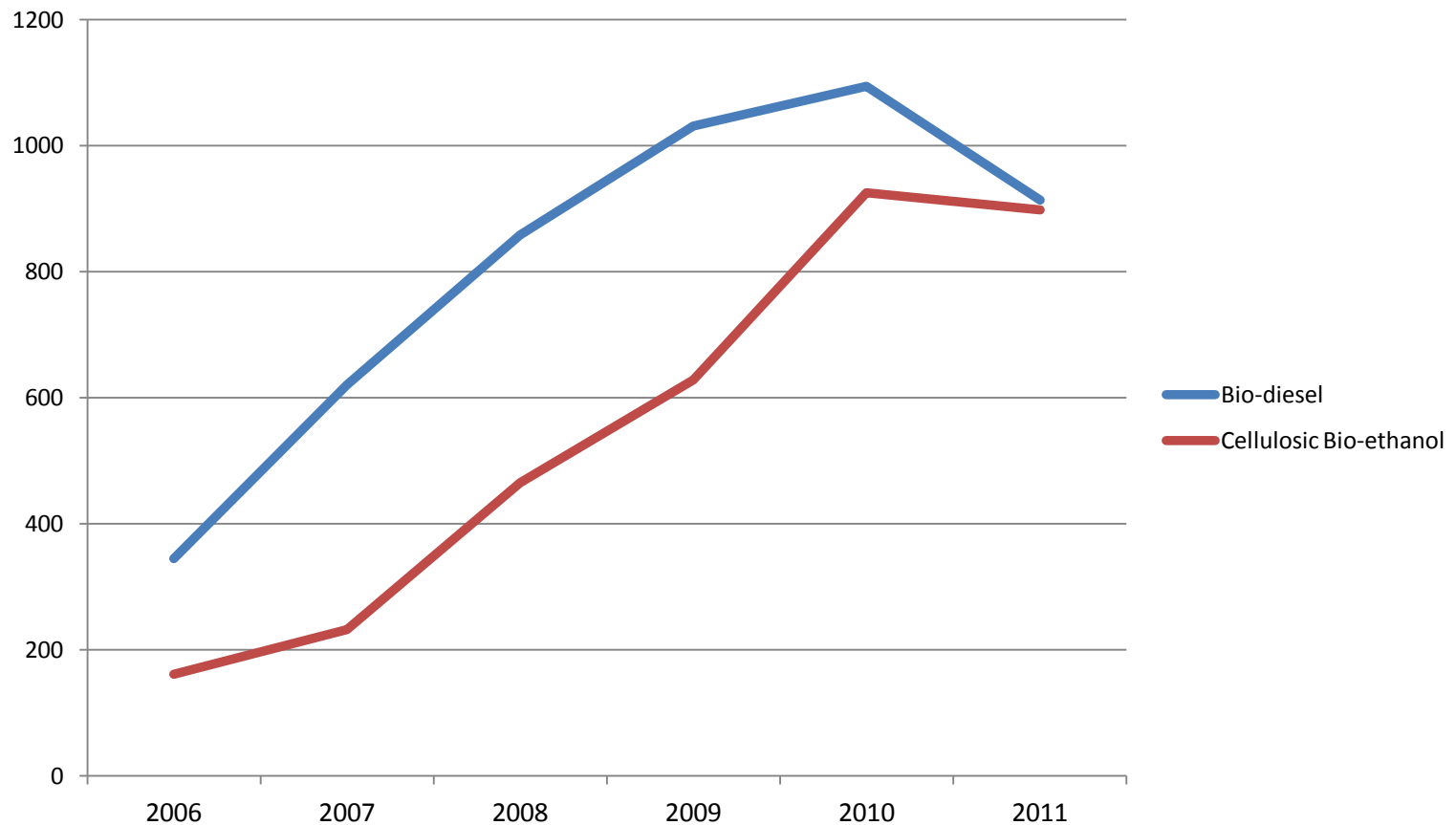
Patents by Oil Firms



30 years vs 12 years

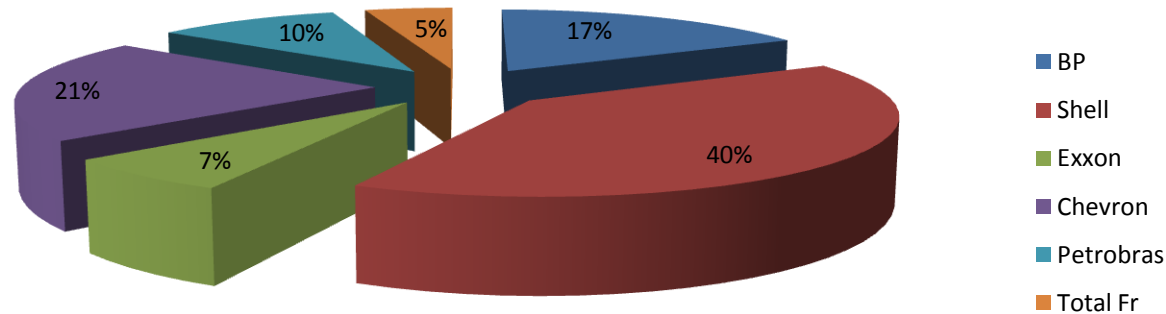
Fuente: Own elaboration with data from Espacenet

Biofuel Patents in last six years by type



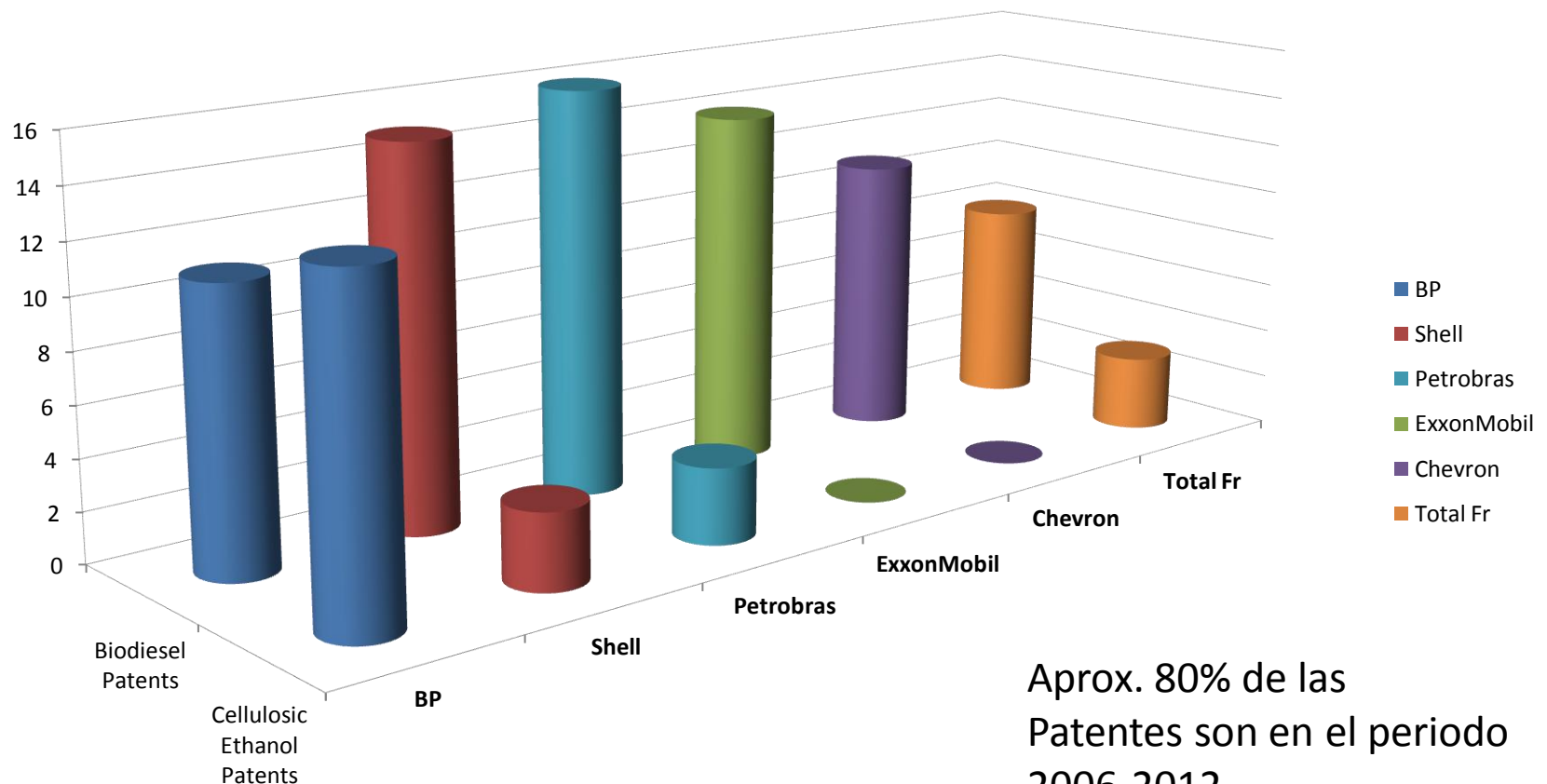
Source: Own elaboration with data from Espacenet

Patents in Alternative Fuels (non fossil) by Oil Firms



Source: Own elaboration with data from Espacenet (Historic)

Oil Firm Patents by type of fuel



Aprox. 80% de las
Patentes son en el periodo
2006-2012

Results

PETROBRAS	First Generation	Second Generation
Driver for implementation	External /Gov Mandate. Development of Flexfuel car	Internal . Environment/Business Opportunity
To what extent, rate and direction	Expansion in Downstream and Midstream. World leaders,	Demonstration stage/Behind peers
Technological Shift/Trajectory	“End of pipe” implementation	Two patents related to Renewable /one to Biofuels.
Technical Interrelatedness	Adjustments implemented until (Blend wall) for Anhydrous.	Similar
Economies of Scale	Started production in 2010	Potentially.
Irreversibility	Implementation seen as irreversible.	No

Results

PETROBRAS	First Generation	Second Generation
Organisational Change	Minimum until 2008. Major change creating a BF Business Unit.	Minimum until 2009. Ethanol R&D programme
Infrastructure	Major Changes throughout, Became the Largest Distributor of Ethanol and large exporter.	

- More substantial changes happen when oil firms enter the upstream business of biofuels.
- Downstream oil firms, technical adjustments, which although costly in the beginning it has not represented a substantial technological or logistical problem for a large oil firm.

Conclusions

- **TRANSITION IN PROCESS**
- **SUSTAINED BIOFUEL MANDATE SINCE 1931**
- CHANGE OF FIRM STRATEGY FROM 2008.
- LOCKED IN FIRST GENERATION ETHANOL.
- LARGE INVESTMENT IN 1ST AND 2ND GEN.
- INCREASING SHARE IN BIOFUEL PRODUCTION AND TECHNOLOGICAL DEVELOPMENT (ALLIANCES AND OWN R&D)

- POSSIBLE SHIFT IN TECHNOLOGICAL TRAJECTORY (R&D AND PATENTS)
- EXPANSION IN AREAS OF KNOWLEDGE AND CAPABILITIES (AGRIBUSINESS/BIOTECH)
- NEW MARKET OPPORTUNITIES

Thank you!

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University of Sussex, UK
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