CURRENT STATUS OF HYDROGEN ENERGY DEVELOPMENT IN BRAZIL

IPHE – Steering Committee Meeting

Ministry of Mines and Energy

Secretary of Oil, Natural Gas and Renewable Fuels

Kyoto, Japan

September, 2005

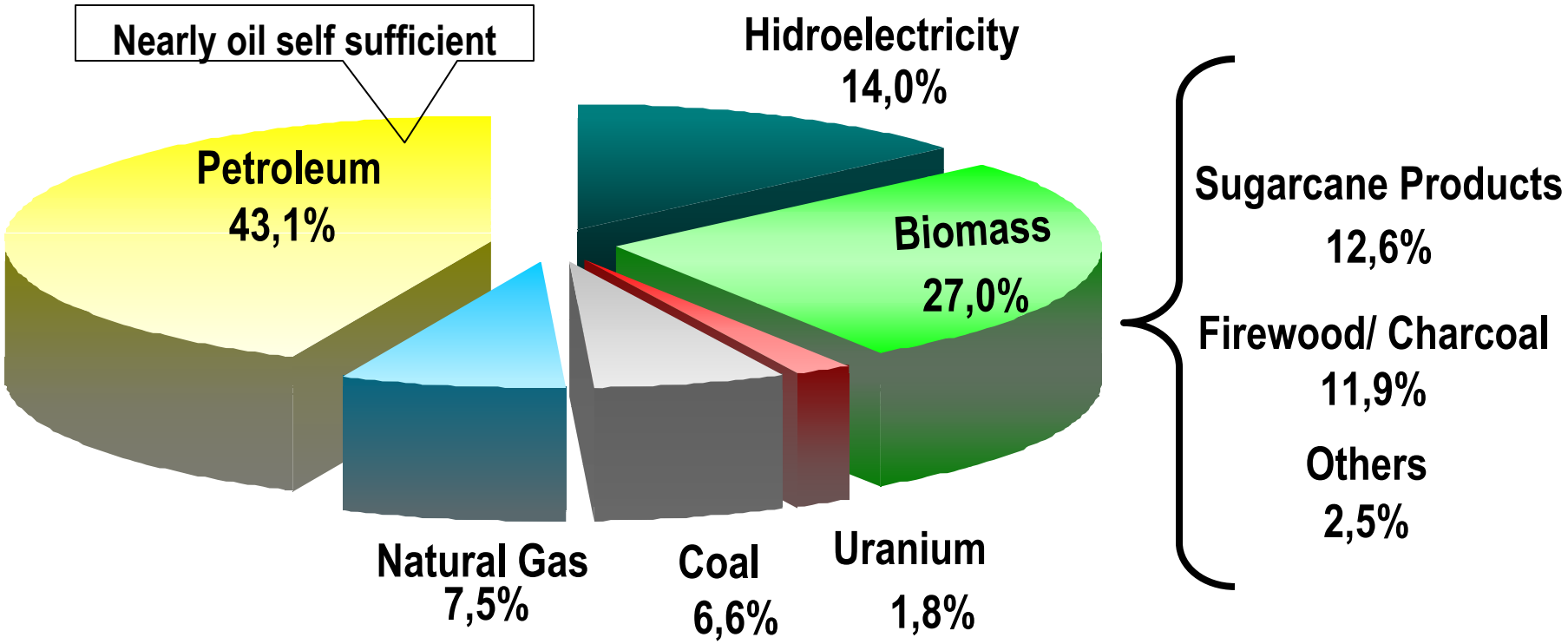
Executive Summary

- **Key points**
  - **Brazilian energy mix: Policy and courses of action**
  - **Energetic hydrogen use in Brazil**
  - **Brazilian Hydrogen Economy Development**
    - Steps to Brazilian Hydrogen Economy development
  - **Phase 1: Brazilian Roadmap (beta_version), 2005**
    - Priorities
  - **Phase 2: Organization of Structuring Projects (2005 to 2006)**
    - Four programs
    - Milestones
  - **Efforts toward hydrogen economy: Production**
  - **Efforts toward hydrogen economy: Delivery Insfrastructure**

Energy Mix: Policy and Courses of Action

- SOCIAL INCLUSION
- CONCERN WITH ENVIRONMENT
- REDUCING FOSSIL FUELS CONSUMPTION – MAJOR USE OF RENEWABLE FUELS
- STRENGTHENING TECHNOLOGICAL BASIS
- DEVELOPMENT OF NATIONAL INDUSTRY (SERVICES AND GOODS)

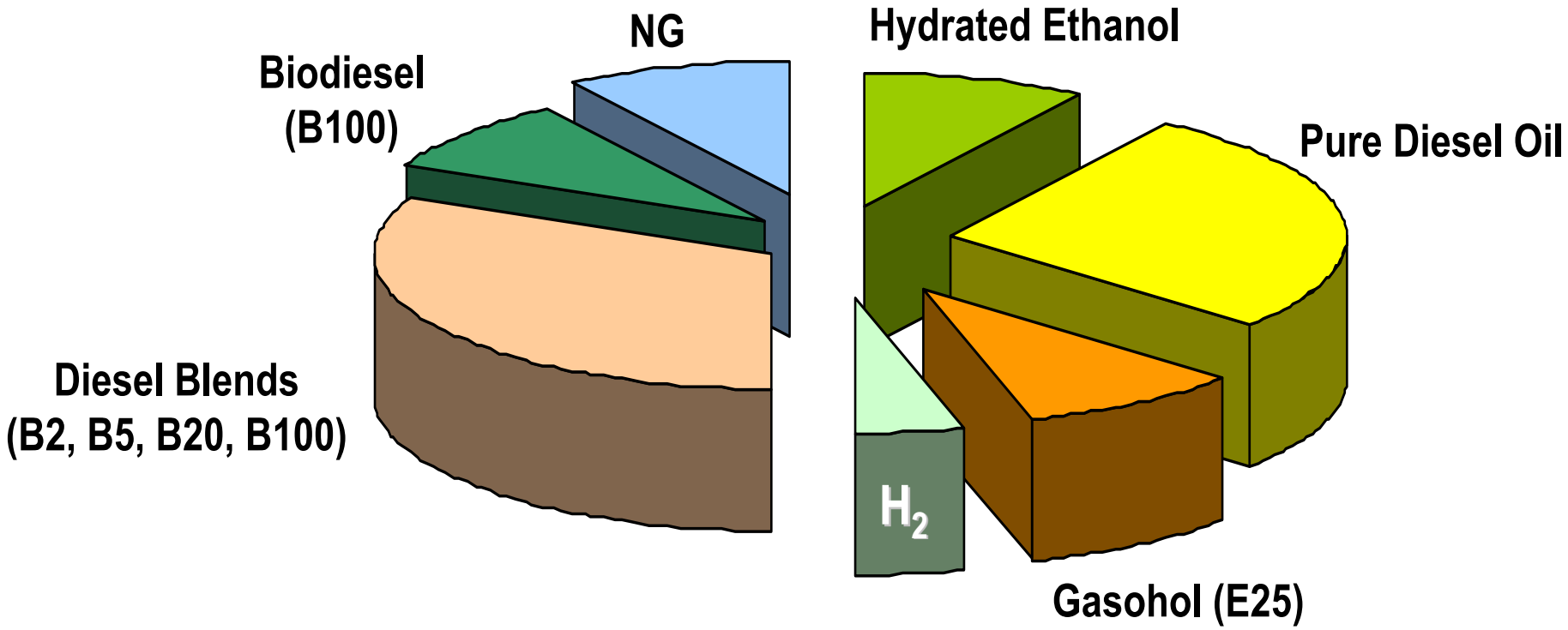
Brazilian Primary Energy Mix



Source: MME/2004

Energetic Hydrogen Use in Brazil

H2 TO COMPLEMENT PRIMARILY RENEWABLE BRAZILIAN ENERGY MIX BY 2020



Energetic Hydrogen Use in Brazil

OBJECTIVE

HYDROGEN AS A COMPLEMENT BY 2020 TO PRIMARILY RENEWABLE BRAZILIAN ENERGY MIX

PERMANENT ACTIVITY

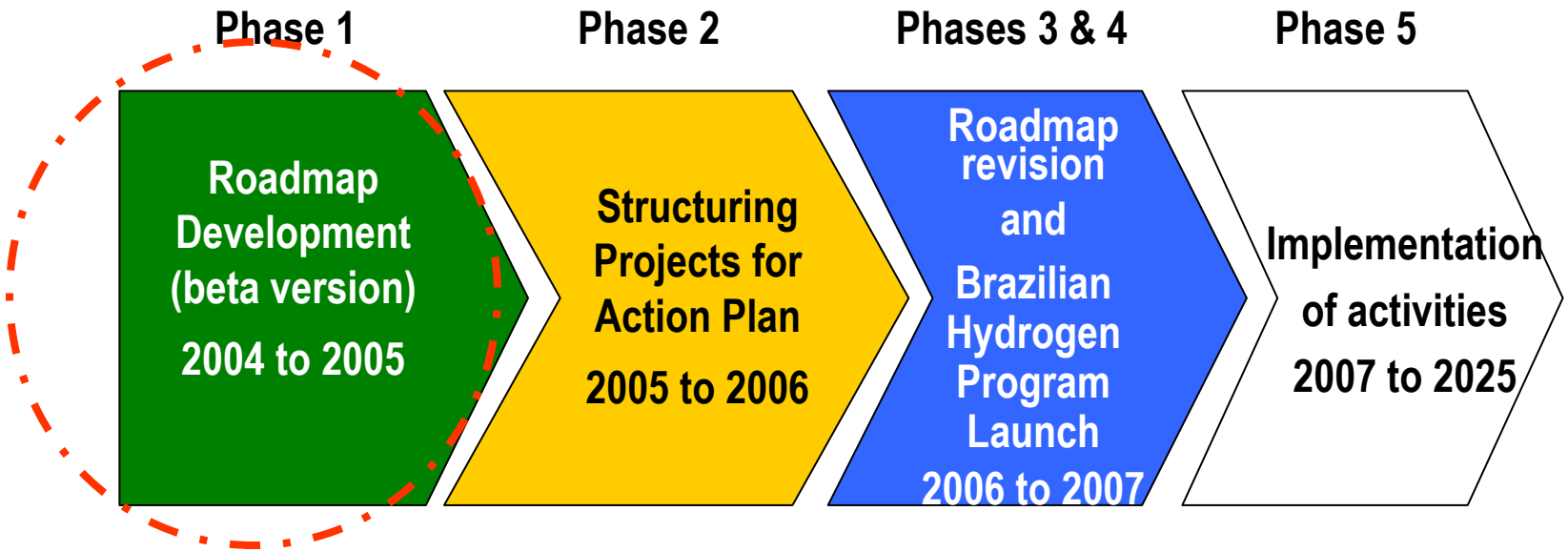
DESIGN BRAZILIAN POLICY DIRECTIVES FOR THE USE OF HYDROGEN

PRESENT STAGE

BRAZILIAN HYDROGEN ROADMAP – beta version _ 2005

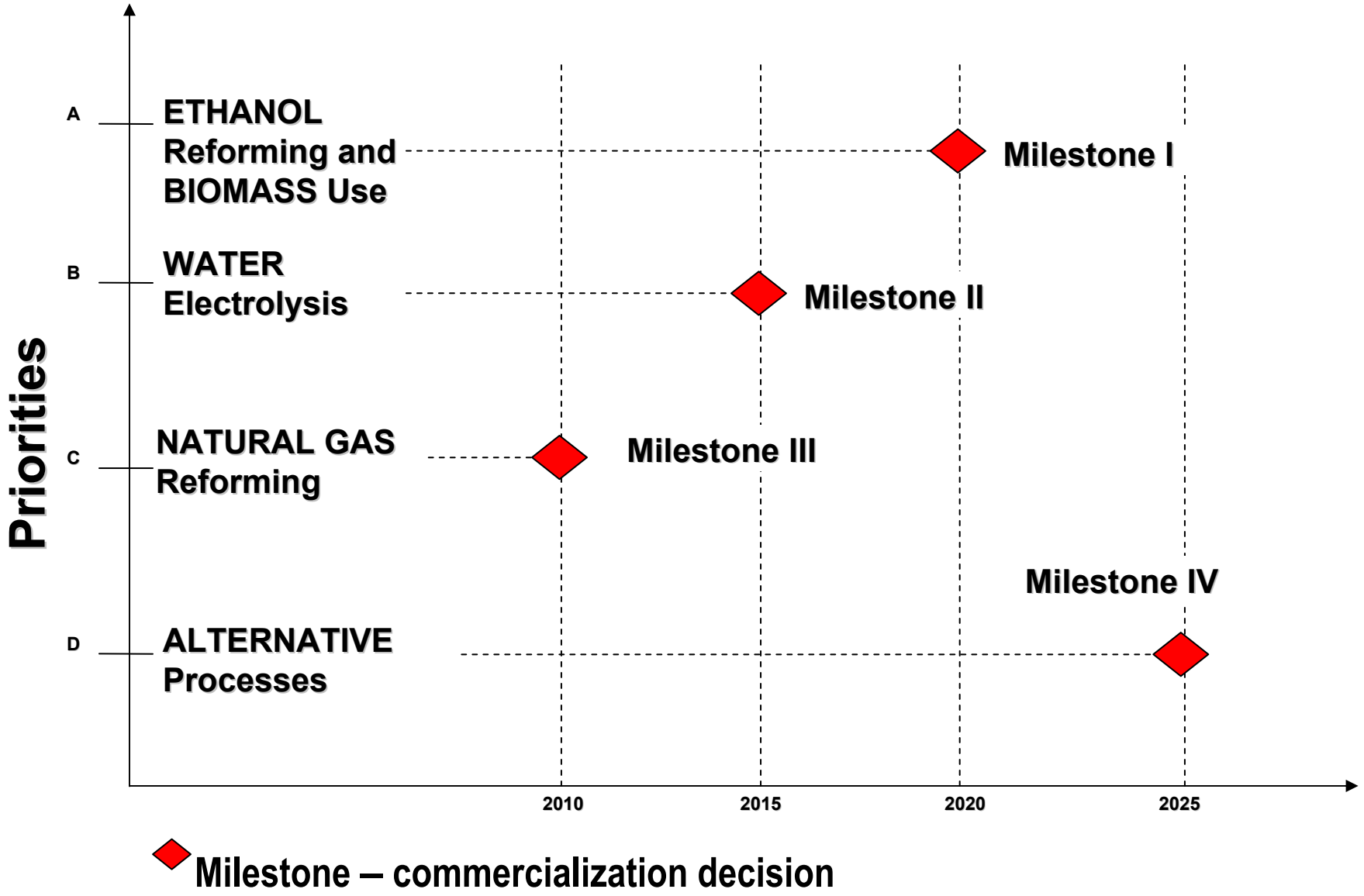
Brazilian Hydrogen Economy Development

STEPS TO BRAZILIAN HYDROGEN ECONOMY DEVELOPMENT



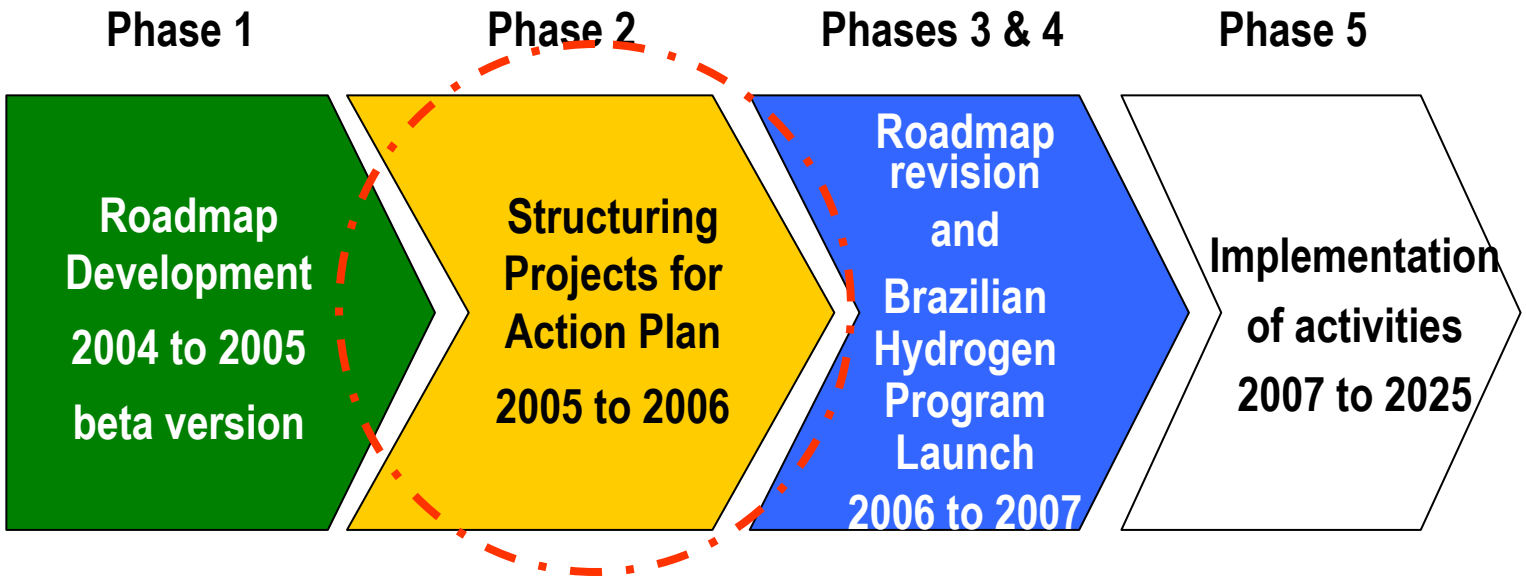
Source: Brazilian Roadmap (beta_version) - 2005

Priorities – Brazilian Roadmap



Brazilian Hydrogen Economy Development

STEPS TO BRAZILIAN HYDROGEN ECONOMY DEVELOPMENT



Source: Brazilian Roadmap (beta_version), 2005

Organization and Development of Structuring Projects

- Technological Development
- Assembling of Pilot Plants
- Market Mapping and Quantification
- Goods and Services Industry Development
  - Development of Systems for Hydrogen Prodution
  - Development of Infrastructure for Comercialization
  - Development of Systems for Energy Conversion
- Implementing Regulatory Legislation
- Implementing Credit Lines
- Tax and Price Formation
- Environmental Studies

DECISION POINTS

Structuring Projects

- **FOUR PROGRAMS:**
  - Ethanol reforming and Direct Ethanol Fuel Cells (DEFC)
  - Water electrolysis
  - Natural gas reforming
  - Alternative processes

Structuring Projects: Ethanol Program

- Ethanol will the main source of hydrogen production in Brazil, considering the Brazilian expertise and technology on sugarcane growing, alcohol fuel production, distribution and utilization

- Ethanol reforming to hydrogen and its direct use on fuel cell are presented as technologies that must be developed with highest priority

Priority A: Ethanol Reforming - Milestones

COMMERCIALIZATION DECISION
HYDROGEN PRODUCTION FROM ETHANOL

Intermediate Goals

	2010	2012	2015	2020
Production	· Catalysts	· Reactors for 10 KW	· Reactors for 10 to 50 KW	· Reactors for 10 to 500 KW
Logistic Infrastructure	· Pressurized Vessels · Hydrogen Fueling Stations		· Solid Structures	· Storage in huge amounts
Conversion Systems	· Proton Exchange Fuel Cell - 5 kW	· Proton Exchange Fuel Cell - 200 kW · Solid Oxide Fuel Cell - 10 kW	· Proton Exchange Fuel Cell – 250 kW · Solid Oxide Fuel Cell - 50 kW	·Direct Ethanol Fuel Cell · Solid Oxide Fuel Cell - 500 kW
Applications			· Buses and Heavy Duty Transportation	· Stationary Generation – Polymeric Fuel Cells up to 10Kw

Source: Brazilian Roadmap (*beta_version*), 2005

Structuring Projects: Water Electrolysis Program

- More than 70% of installed capacity of electric generation comes from hydroelectricity. In this way water electrolysis will be highly used as hydrogen source.

- In order to make the electrolytic hydrogen competitive, a strong effort on developing systems of conventional and advanced electrolysis is necessary.

Priority B: Water Electrolysis - Milestones

COMMERCIALIZATION DECISION
HYDROGEN PRODUCTION FROM WATER ELECTROLYSIS

Intermediate Goals

	2005	2006	2010	2015	2020
Production		Conventional electrolyzers, 10m^3/h	Conventional (50 m^3/h) and advanced (10 m^3/h) electrolyzers	Conventional (150 m^3/h) and advanced (50 m^3/h) electrolyzers	Advanced electrolyzers, 150 m^3/h
Logistics and Infrastrutura			- Pressurized vessels - Hydrogen Fueling Stations	- Pipelines - Solid structures	Huge ammounts storage
Conversion Systems	- PEMFC 5 kW		- PEMFC, 200 kW - SOFC, 10 kW	- PEMFC, 250 kW - SOFC, 50 kW	-Reversible Fuel Cells - SOFC, 500 kW
Applications			- DG for isolated villages: PV electrolysis, 10 m^3/h - Wind energy storage, 10 m^3/h	Small hydro power plants combined with electrolyzers, 150 m^3/h	Hydro power plants combined with electrolyzers, +1.000 m^3/h

Source: Brazilian Roadmap (*beta_version*), 2005

Structuring Projects: Natural Gas Program

- Natural gas will be the mostly used source in the first 15 years for hydrogen production.

- Natural gas reforming systems will be optimized in order to create initial hydrogen market.

Priority C: Natural Gas Reforming - Milestones

COMMERCIALIZATION DECISION
HYDROGEN PRODUCTION FROM NATURAL GAS

Intermediate Goals

	2005	2010	2014	2015
Production		0,06% of total NG to Hydrogen (10 MW)		0,24% of total NG to Hydrogen (50 MW)
Logistic and Infrastructure		- Pressurized vessels - H2 fueling stations - Shared pipelines (NG+H2)		- Hydrogen pipelines - Solid structures
Conversion Systems	PEMFC, 5 kW	- PEMFC, 200 kW - SOFC, 10 kW	- PEMFC, 250 kW - SOFC, 50 kW	
Applications		Stationary power using PEMFC, 200 kW and SOFC, 10 kW	Buses and heavy duty transportation	Stationary power using PEMFC, 250 kW and SOFC, 50 kW

Source: Brazilian Roadmap (*beta_version*), 2005

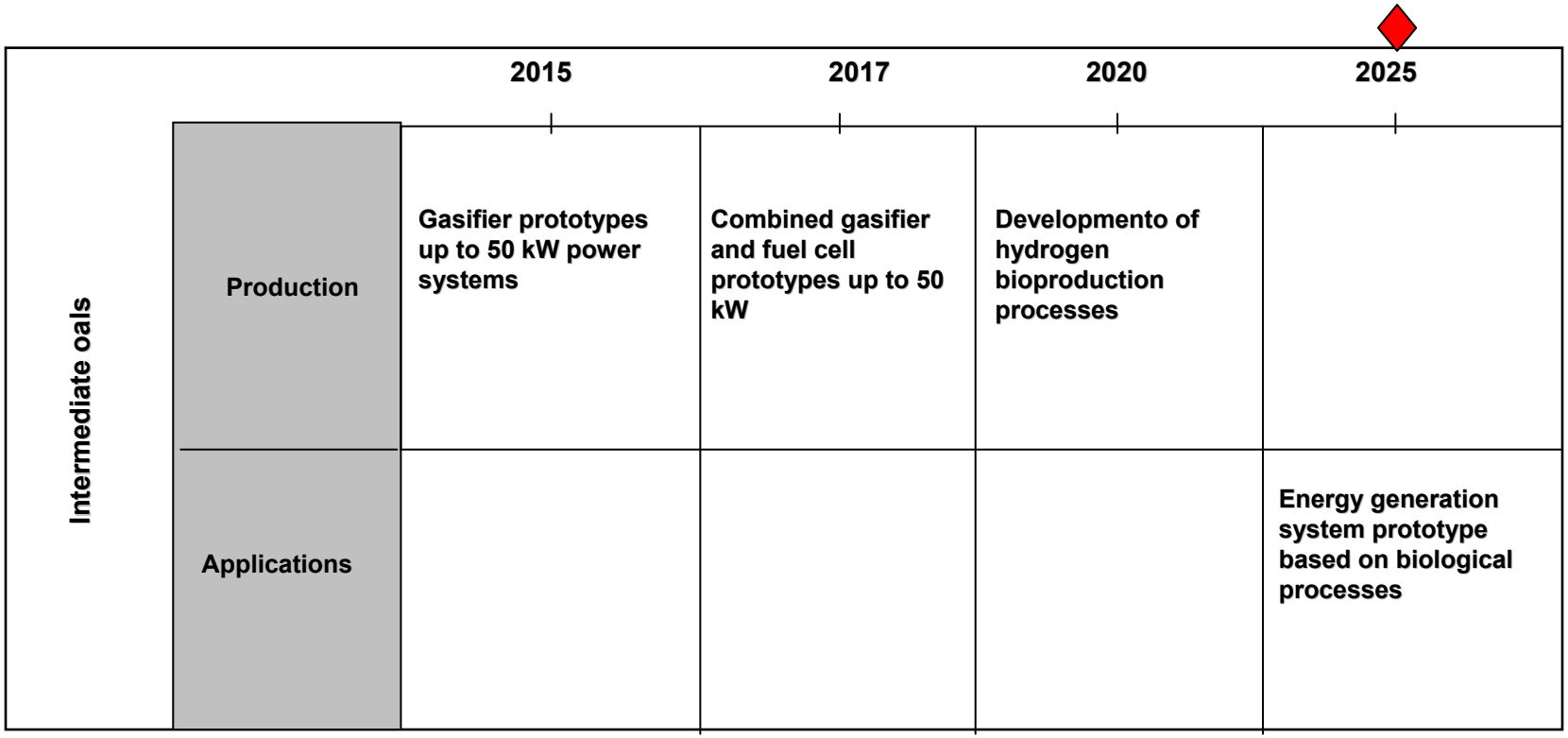
Structuring Projects: Alternative Processes Program

- Biomass gasification is a very important option for hydrogen production in Brazil.

- Biological and photoelectrochemical processes are being studied on basic science level.

Priority D: Alternative Processes - Milestones

COMMERCIALIZATION DECISION
HYDROGEN PRODUCTION FROM ALTERNATIVE PROCESSES



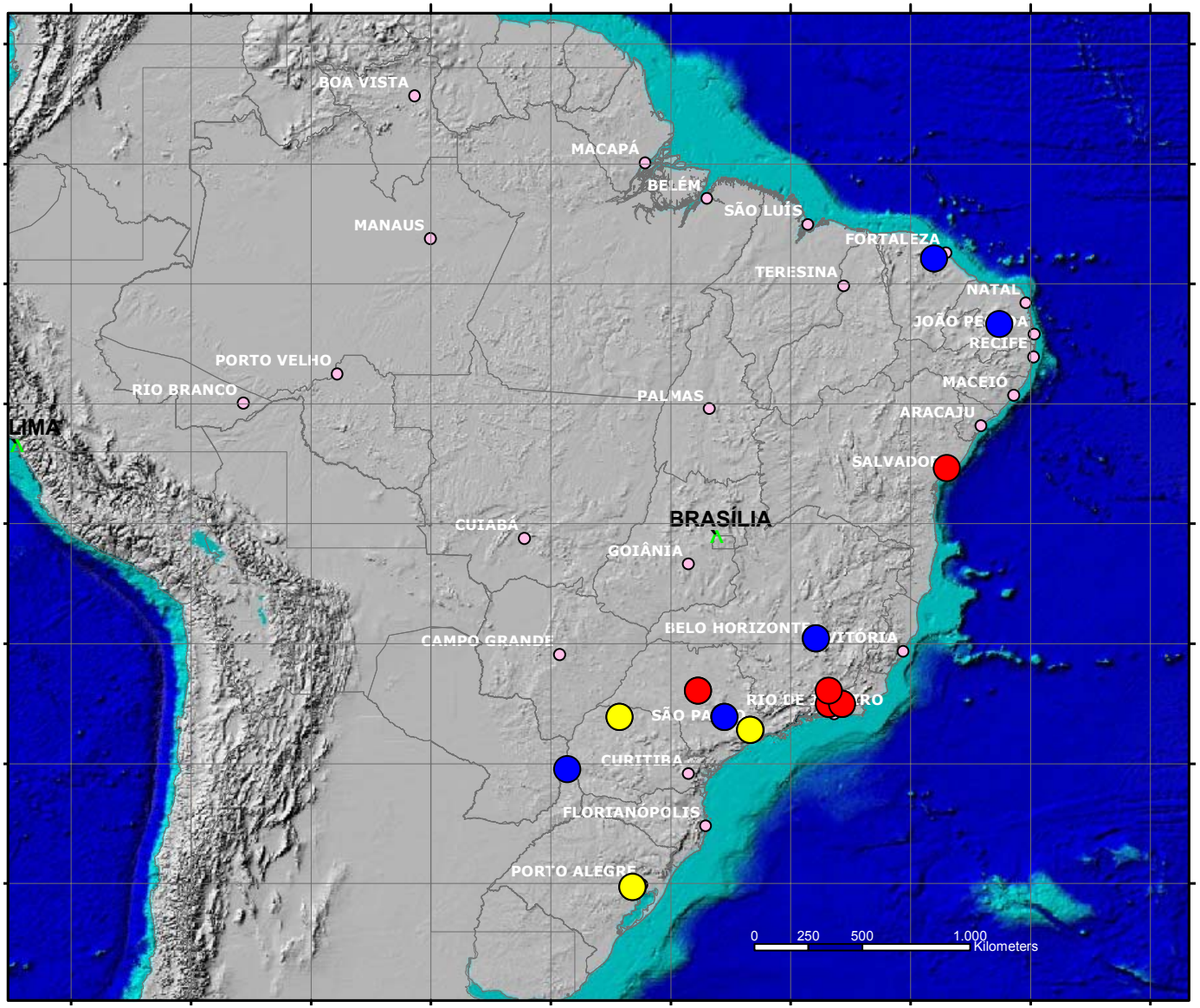
Source: Brazilian Roadmap (*beta_version*), 2005

Structuring Projects Main Results

- Biomass, biogas and ethanol will put Brazil in a condition of the biggest producer of renewable hydrogen.

- Brazil must seek world leadership on technologies of renewable hydrogen production.

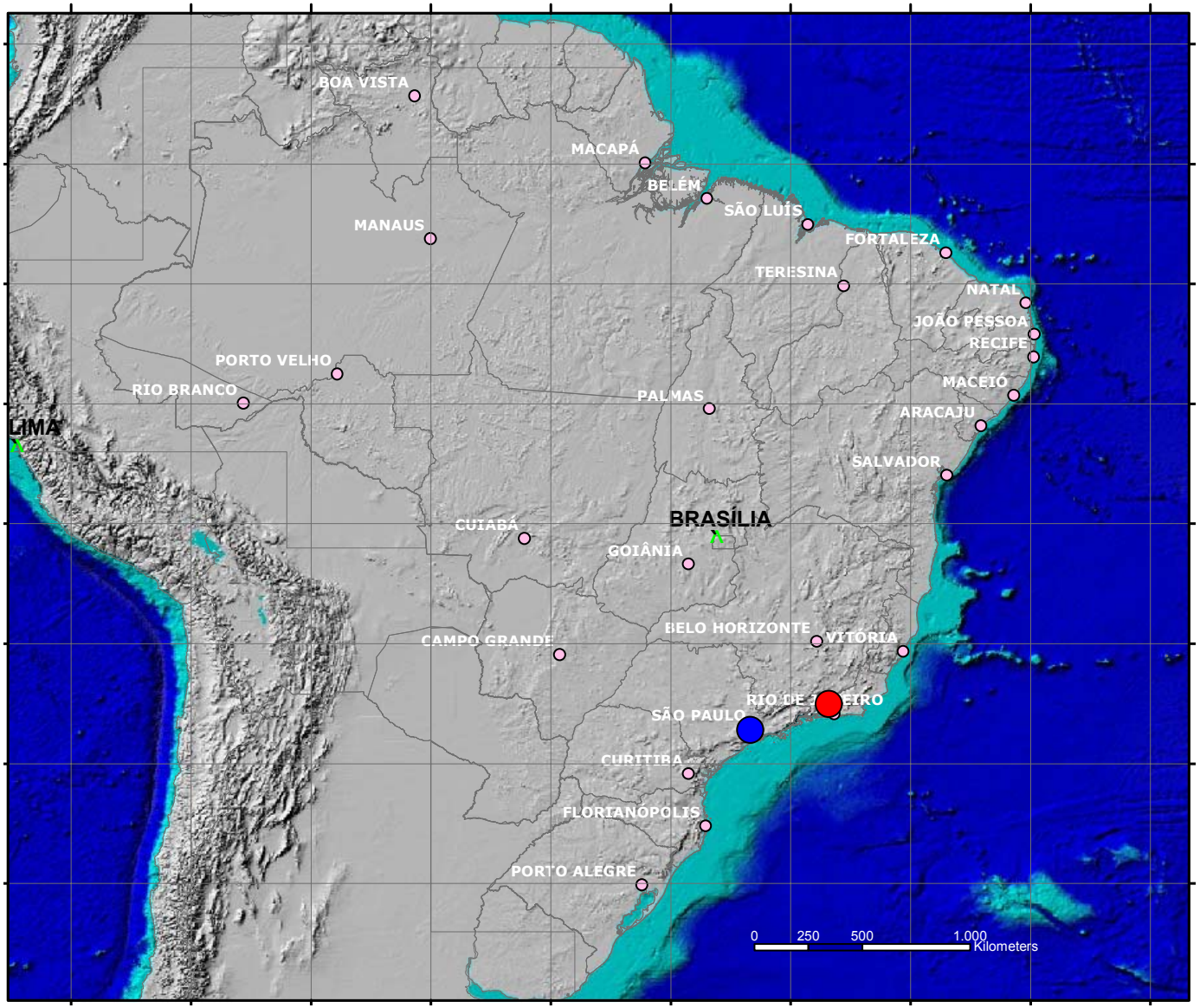
Efforts Toward Hydrogen Economy: Production



R&D Groups

- Ethanol reforming
- Water electrolysis
- NG reforming
- Alternative processes

Efforts Toward Hydrogen Economy: Delivery Infrastructure



Demonstration Projects (Hydrogen fueling stations)

- Water electrolysis
- NG reforming

THANK YOU!