

Hydrogen Economy

A Presentation and Discussion

for

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Topics to be covered

1. The history of human energy use

- Change of energy regimes
- History of fossil-fuel regime
- The global oil production

2. Envisioned hydrogen economy

- Hydrogen, carbon and decarbonization
- Hydrogen as a fuel
- Fuel cell and its applications

3. Discussions

- Source of hydrogen
- Energy infrastructure of the future

1. Energy and the fossil-fuel era

‘The degree of civilization can be measured by its ability to utilize energy for human advancement or needs’

Change of energy regimes

- Wood
- Coal, steam engine and industrialization
- Oil, combustion engine and automobile

1. Energy and the fossil-fuel era

- **Coal**

- England started to use coal in 1700
- Steam engine and train
- Industrial revolution

- **Oil**

- 1859, Pennsylvania
- 1868, Rockefeller and Standard Oil Company
- 1885, Invention of internal combustion engine
- 1911, Mass production of automobiles by Ford
- 1930, Oil industry was the biggest industry in the world

1. Energy and the fossil-fuel era

The importance of oil

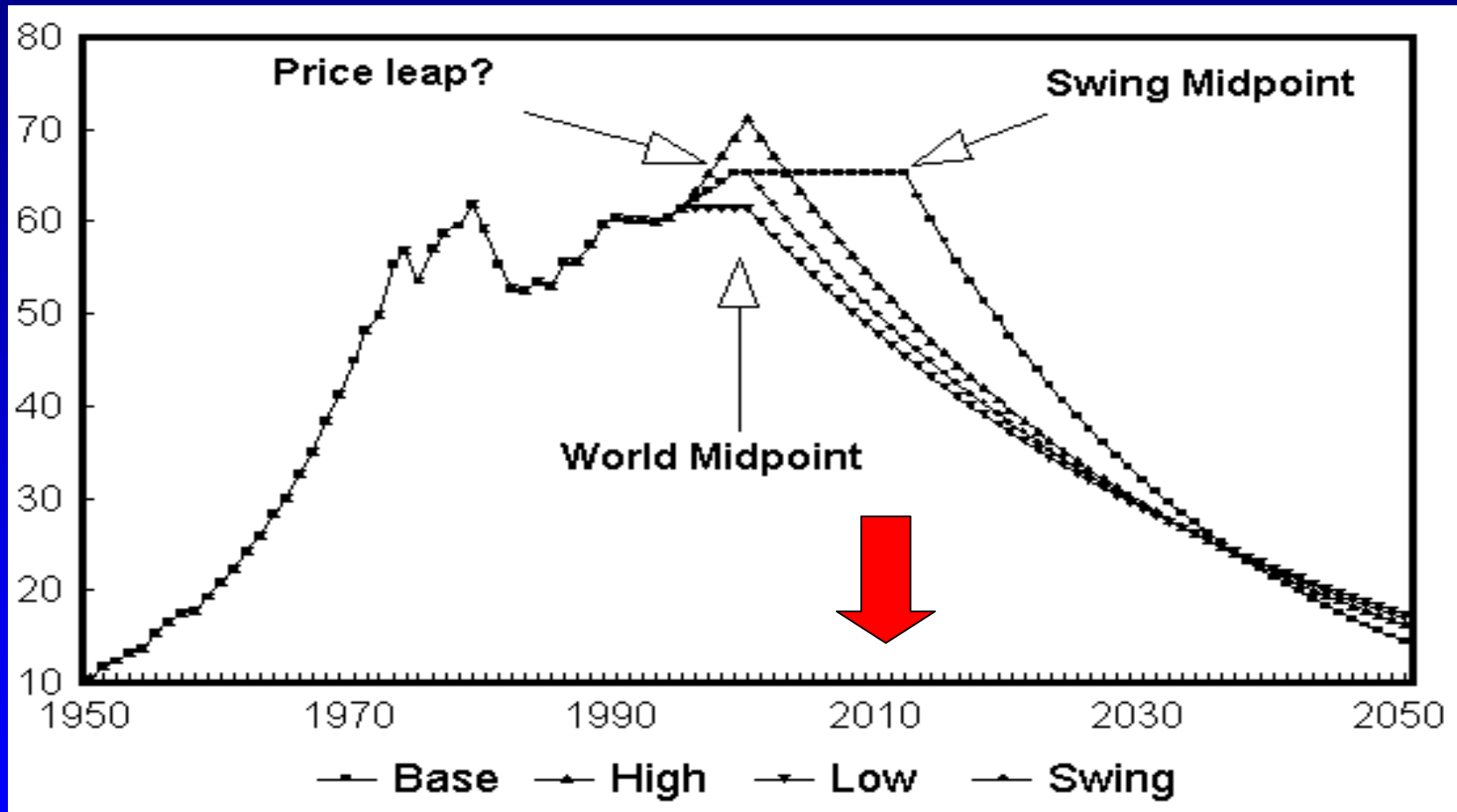
- WWI: Oil-powered ships, tanks, airplanes
- WWII: German invasion of Soviet Union, Pearl harbor
- Oil empire
 - Still the largest industry in the world
 - 3 of the 7 largest companies in the world are oil companies

Oil use in USA

- USA has 5% of world's population but consumes about 26% of oil
- USA produces 11% of oil and has only 2% reserve left
- USA has 190BB reserves, produced 169BB and has only 20B left.
- Its production peaked in 1970.

1. Energy and the fossil-fuel era

Peak of global oil production

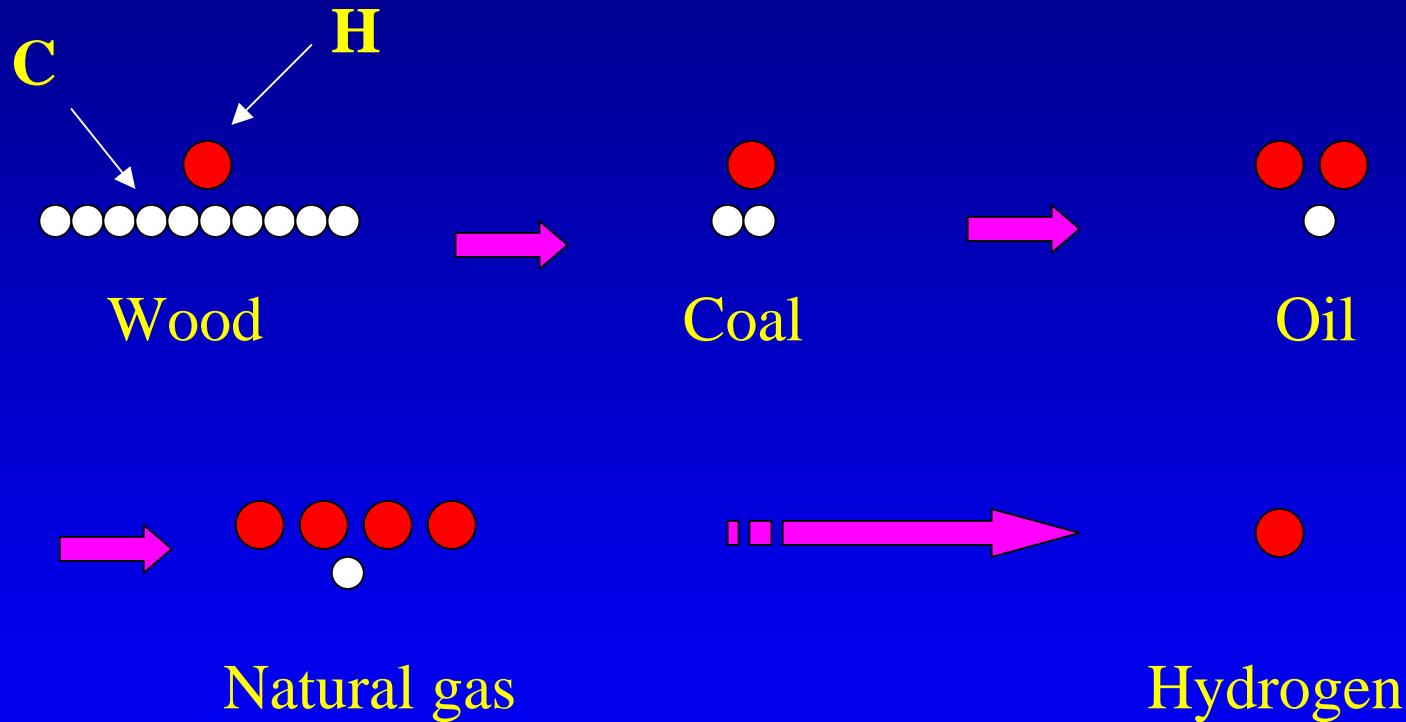


2. The hydrogen economy

**Refers to a society that relies
on hydrogen as its fuel**

2. The hydrogen economy

Decarbonization



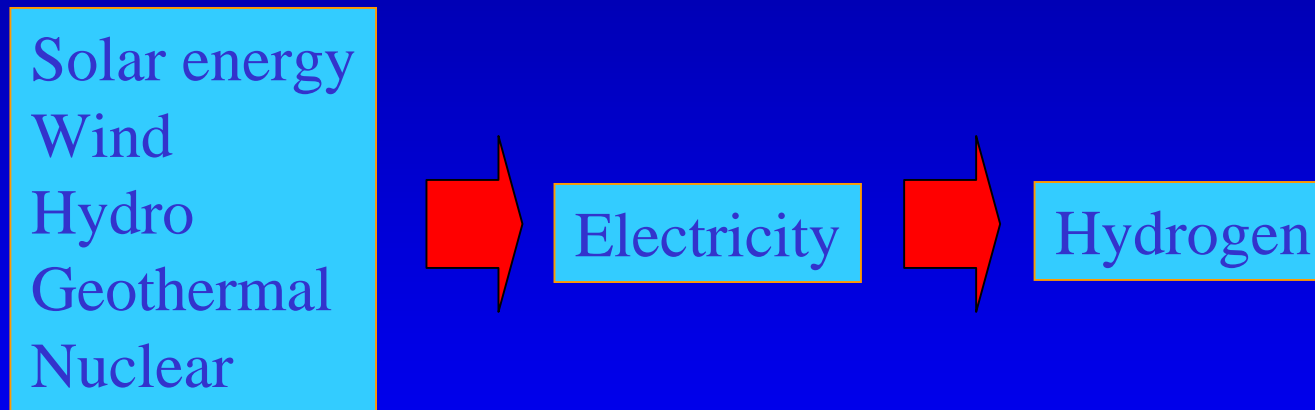
- Hydrogen is the most efficient media to store energy on per weight basis
- Pollution free
- Relatively easy to transport

2. The hydrogen economy

Where to get hydrogen?

Near term: from natural gas using steam-reforming process

Future: from water using electrolysis



Hydrogen is an energy storage media

2. The hydrogen economy

History of using hydrogen as a fuel source

1920: Germany

1930-40: experimental fuel for automobile

1973: oil crisis renewed interest in hydrogen

1990: global warming concerns

Soviet – a passenger jet in 1988

US – a personal airplane 1988

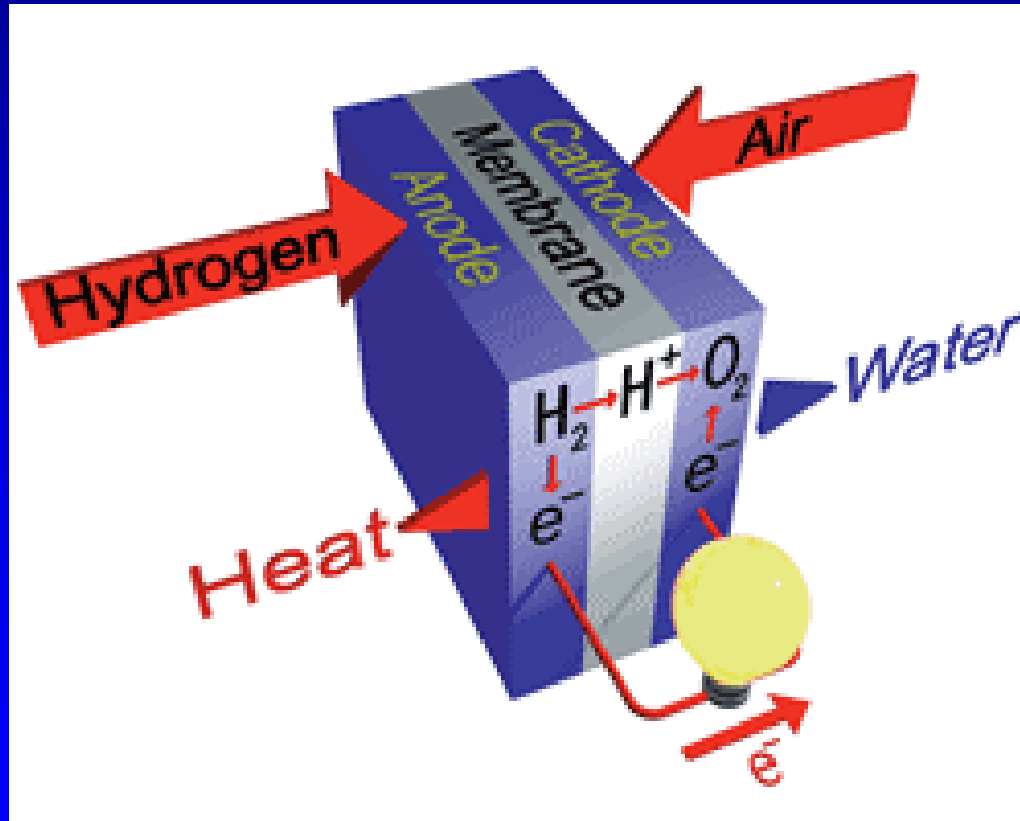
Germany – solar home using hydrogen to store energy 1992

Belgium – first hydrogen powered bus 1994

2. The hydrogen economy

Modern method of using hydrogen

Fuel Cell



2. The hydrogen economy

Fuel Cell Powered Devices



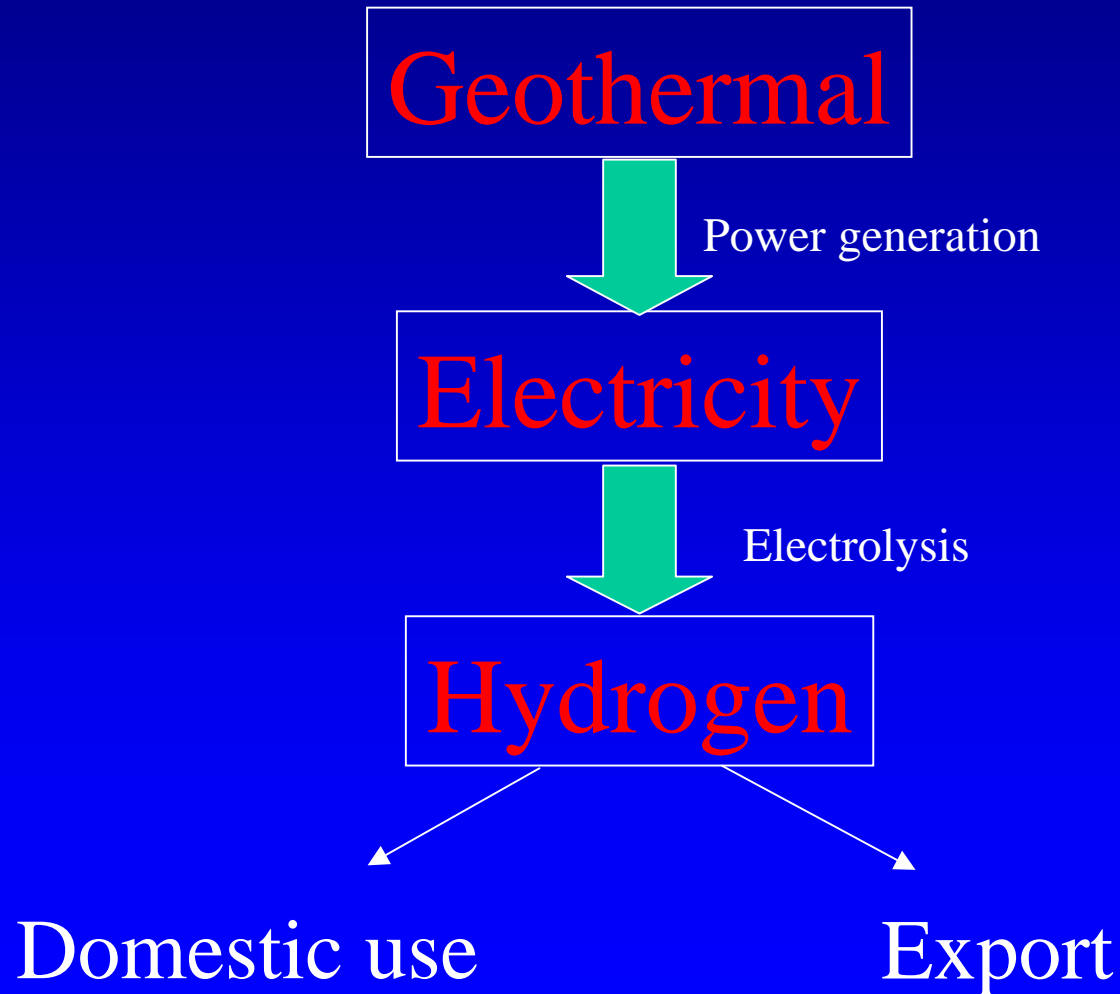
2. The hydrogen economy

Fuel Cell Power Generator



2. The hydrogen economy

The model of Iceland (1996 and possibly Hawaii)



3. Questions and Discussions

- It is certain that oil will run out in near future
- In addition, global warming concern will discourage the use of coal and other fossil fuels
- Hydrogen is just an energy carrier. It needs to be produced
- We still need to find other energy sources

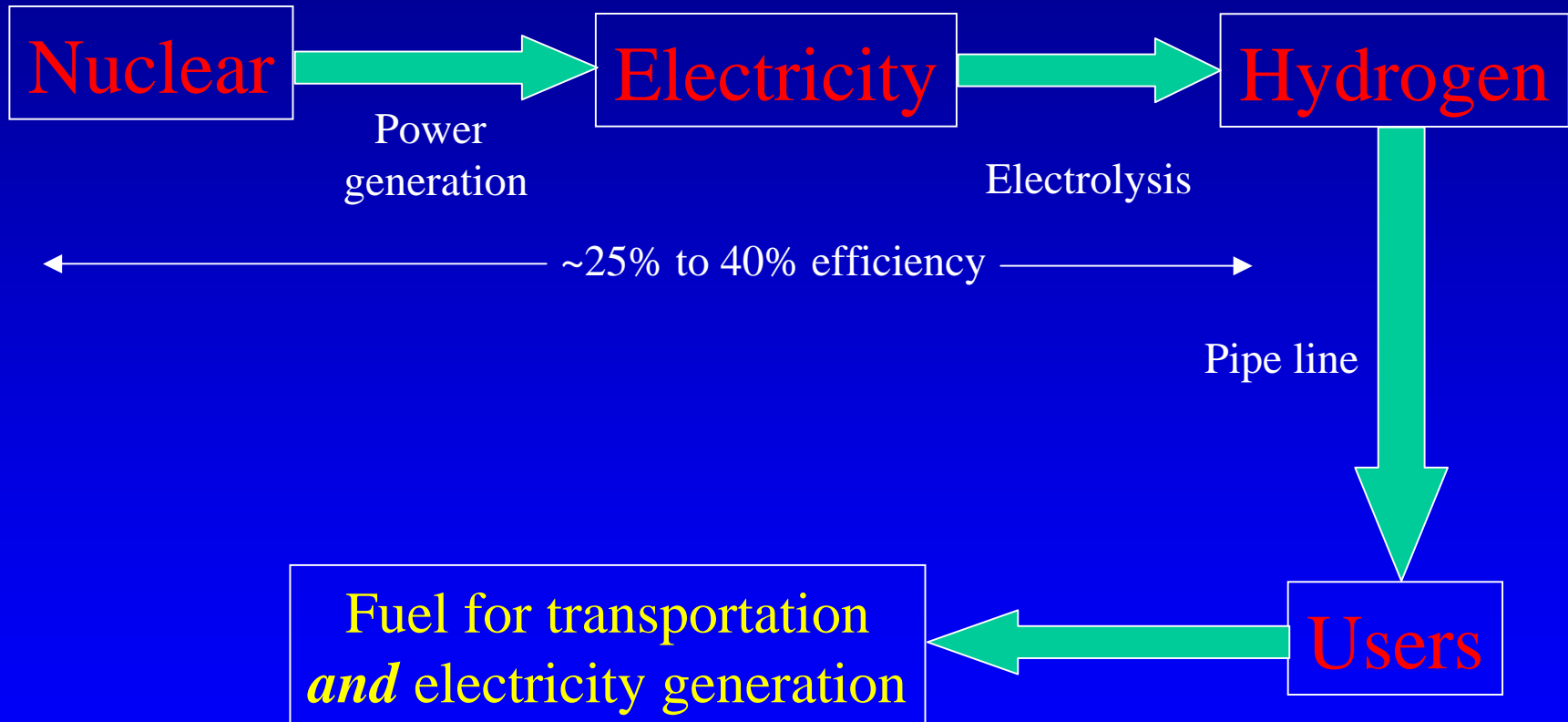
3. Questions and Discussions

Sources of energy

- Renewable (solar, wind, hydro, etc.)
 - Distributed, intermittent, location dependent
 - It seems more attractive to convert them to electricity than to hydrogen
 - Amount available is not sufficient
- Nuclear
 - Non-carbon source and GHG free

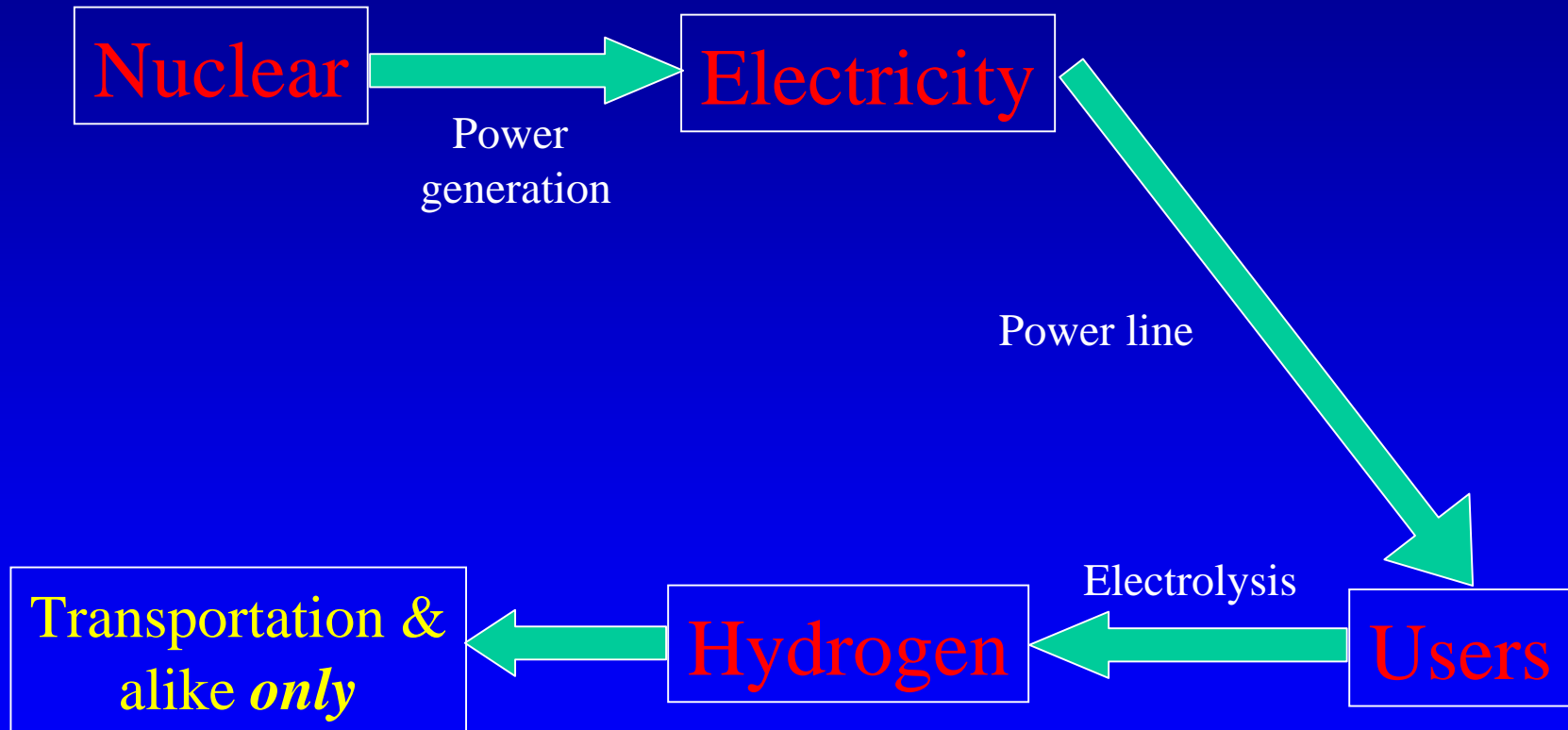
3. Questions and Discussions

Model 1 (popular hydrogen economy model)



3. Questions and Discussions

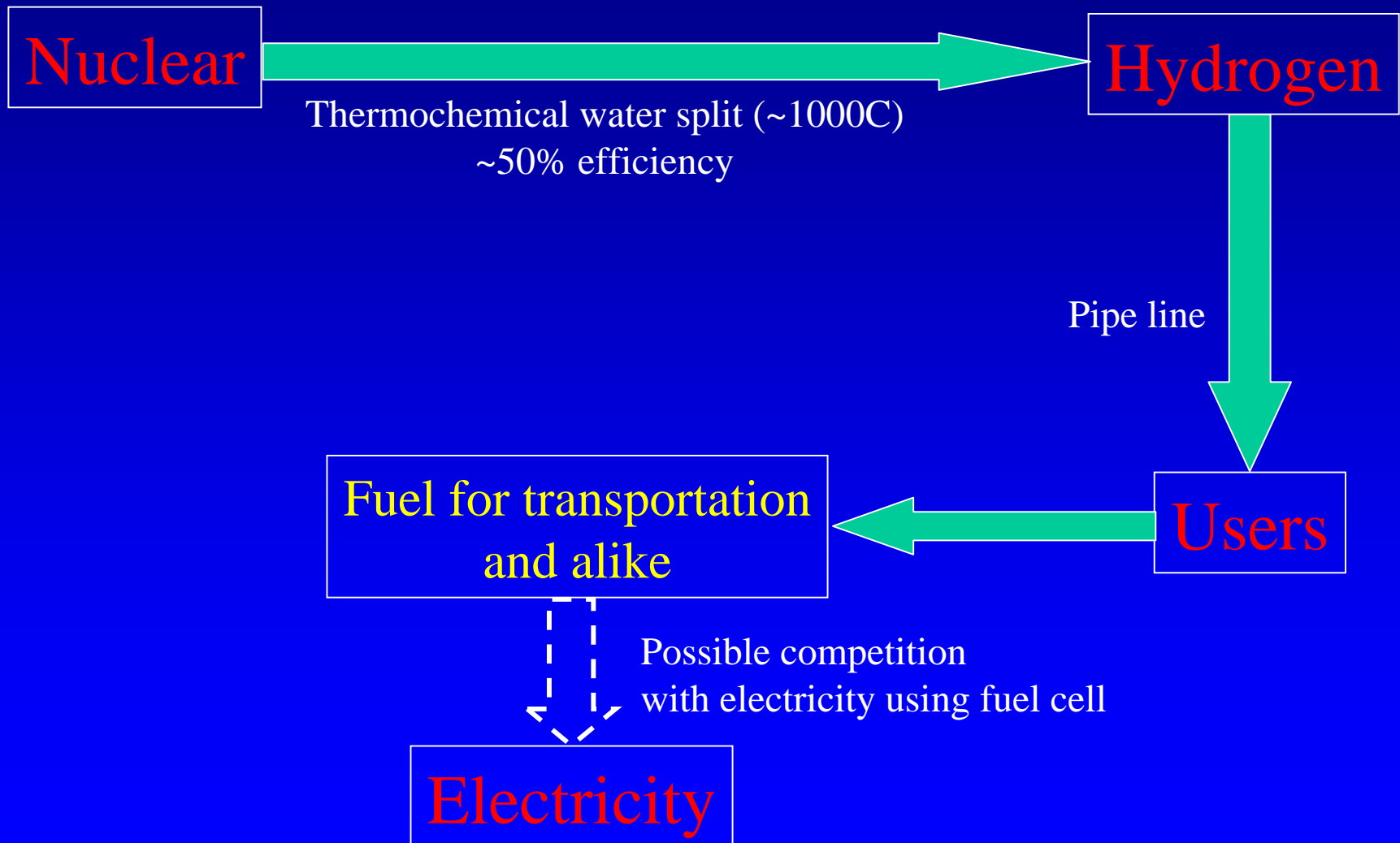
Model 2 (“electric” economy model)



20 CANDU (690MW each) => 13M Vehicles

3. Questions and Discussions

Model 3 (alternative hydrogen economy model)



3. Questions and Discussions **Impact on electric power industry**

- Model 2 (“electric” economy)
 - Offer major opportunities to power industry
 - double current capacity
- Model 3 (direct nuclear to hydrogen conversion)
 1. Co-existence of hydrogen and electric power
 2. Hydrogen will produce power locally, resulting in major structure change in power industry