The Abdus Salam
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United Nations
Educational, Scientific
and Cultural Organization

International Atomic
Energy Agency

Workshop on "Physics for Renewable Energy"
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"Process Heat Applications of Nuclear Energy: Hydrogen & Seawater Desalination"

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Process Heat Applications of Nuclear Energy:

Hydrogen & Seawater Desalination

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ICTP Workshop on Physics for Renewable Energy

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Department of Nuclear Energy
International Atomic Energy Agency

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  - Ex.: Nuclear hydrogen production
- Low-temperature process heat
  - Ex.: Seawater desalination
- IAEA role

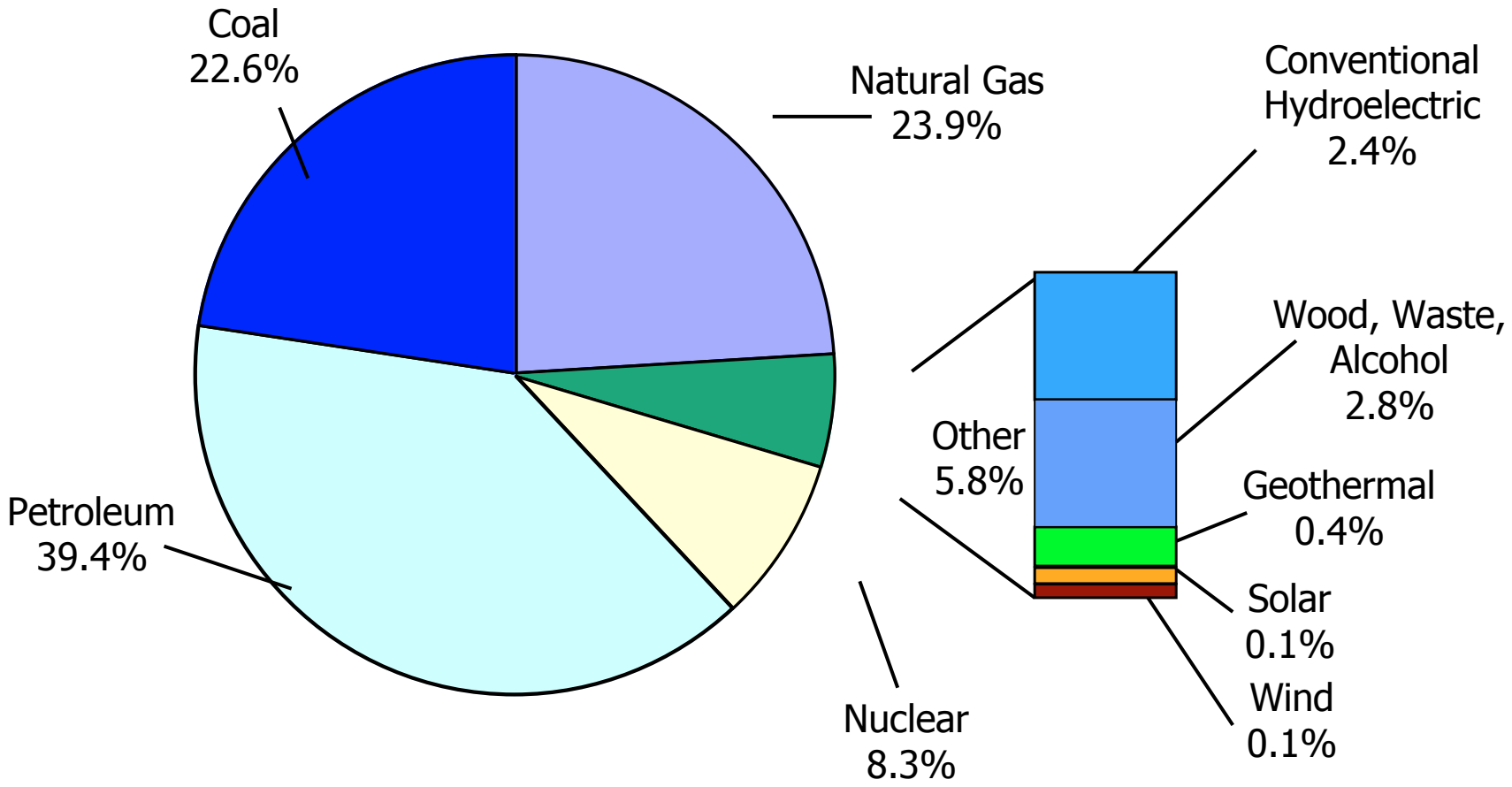
High-Temperature Process Heat

- **Hydrogen production**
- **Coal gasification**
- **Heavy oil recovery (Tar sands)**

Why hydrogen?

- **Possibly, a future alternative to fossil fuels.**
- **Arguments**
  - **Population growth**
  - **Limited fossil fuel resources**
  - **Concern over long-term emissions**

US Primary Energy Use (2001)



Source: Energy Information Administration

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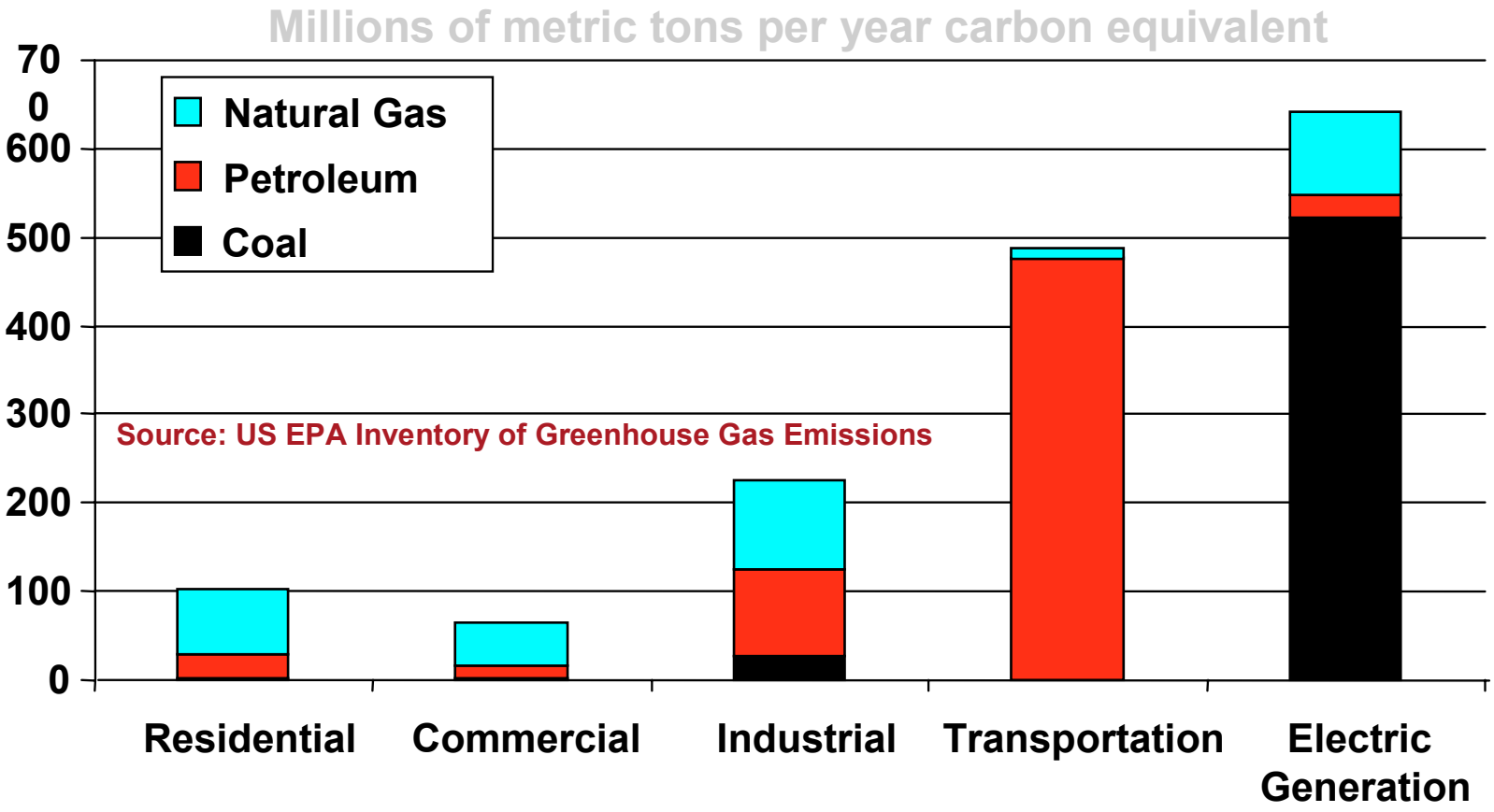
United States CO_2 Emissions by Sector and Fuels 2000



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Methods of Hydrogen Production

- **Steam Methane Reforming**
- **Thermo-chemical splitting**
- **Electrolysis**

Nuclear Role in Hydrogen Production

- **Nuclear power could provide high-temperature heat (850 – 950 C), which would increase H2 production efficiency up to 50%.**

Challenges

- **Technology**
- **Safety**
- **Economics**
- **Public acceptance**

Technology Challenges

- **Upscaling of production process**
- **Material challenges under higher temperatures**
- **Hydrogen storage:**
  - **(High pressures needed 5000-10000 psi) to account for H2 low energy density.**

Safety Challenges

- **Physical separation needed for H2 - NPP coupling:**
  - **Barriers against Tritium migration downstream and Hydrogen migration upstream**
  - **H2 flammability concern**

Economic Challenges

- **Efficiency needs to be demonstrated under process up scaling.**

Economic Challenges

- **To replace 50% of fossil fuel used for transportation in the US alone:**
  - **The generating capacity of ~1000 GWe needs to be doubled (~1000 large nuclear power plants)**

Public Perception Challenges

- **Anti-nuclear "ideolog" chatting with friend who is asking about the viability of the hydrogen economy:**
- **" The good news is that there is an efficient way to produce hydrogen. The bad news is that it is with nuclear power!"**

Low-Temperature Process Heat

- **Seawater desalination**
- **District heating**

Global water picture

- **Currently, 20 % of world population lack access to clean water.**
- **By 2025, 30% may be lacking access to clean water.**

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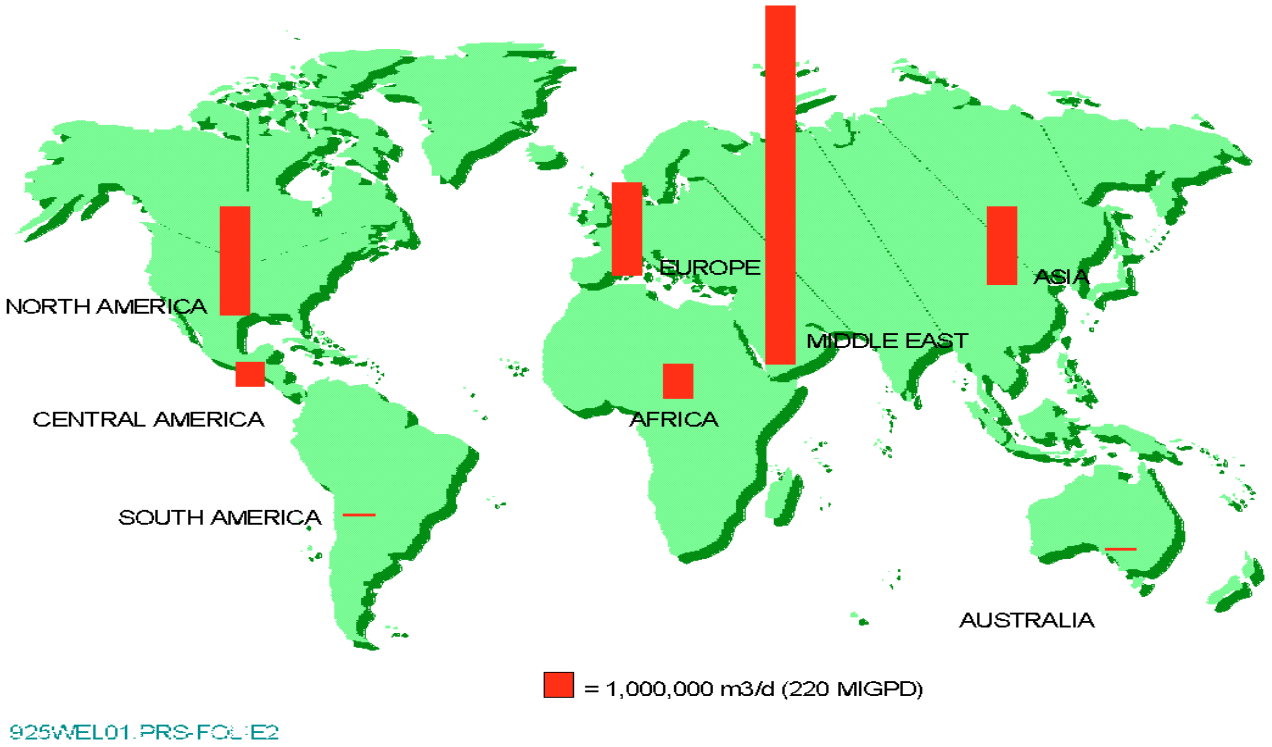
Distribution of contracted desalination capacity



Source: Wangnick Consulting GmbH

Nuclear desalination prospects

- **Addresses escalating global needs for fresh water, taking into consideration**
  1. **Population growth**
  2. **Limited fossil fuel resources**
  3. **Concern over long-term emissions**

Who is interested in nuclear desalination?

- **Pakistan (Demonstration Project)**
- **India (Demonstration Project)**
- **China**
- **Indonesia (SMART)**
- **North Africa**

Viability of nuclear desalination

- **High Temperature Gas Cooled Reactors offer cost-free waste heat at right temperature for desalination processes (120 C)**
- **Estimates for water costs are less US$ .5/m^3 (very competitive @ today's prices)**

Challenges

- Safety of the coupling
  - Intermediate loop
- Economics
  - Cost of steam & intermediate loop
- Public perception

Other Key Issues

- **Both for hydrogen as well as water production:**
  - **Distribution over long distances adds a significant cost.**

- **This may provide an argument for focusing on providing cheap nuclear electricity & opting for distributed**
  - **H2 production at gas stations using electrolysis**
  - **Stand-alone water production units using RO**

- **The flexibility to use off-peak load reserves in the production process is another incentive for distributed electricity-based systems.**

Potential Nuclear Non-electric Applications

- **High-Temperature steam for heavy oil recovery + hydrogen for heavy oil cracking**
- **Small & medium reactors for small grid areas in developing countries, producing electricity & water (SMART – PBMR)**

Useful Numbers

- **For hydrogen production:**
  - **Need 2 MWe to produce 1 tonne / day**
  - **1 tonne/day would fuel ~ 2000 cars.**
  - **Estimated H2 production costs > $2000/tonne**

Useful Numbers

- **For water production:**
  - **Need 3-20 MWe to produce 40,000 tonne / day (serving ~ 100,000 inhabitants)**
  - **Estimated production costs .5 – 1 US$/$m^3$**

IAEA Activities on Process Heat Applications

1. Support Member States with
    1. Information
    2. Tools (such as DEEP)
    3. Educational training

IAEA Activities on Process Heat Applications

2. **Support collaborative research projects & focused on process safety & economics.**

IAEA Activities on Process Heat Applications

3. Support selected demonstration projects focused on process safety & economics.

New IAEA Subprogram on "Non-electric Applications of Nuclear Power"

- **Will cover both nuclear desalination & nuclear hydrogen production activities**
- **Will be run under the nuclear power division.**

Concluding Remarks

- **Nuclear power plants have potential for both high-T and low-T process heat applications**
- **Examples include nuclear hydrogen & seawater desalination**
- **Challenges include**
  - **Technology & safety demonstration**
  - **Economics**
  - **Public acceptance**