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Véhicules électriques et hybrides rechargeables 28 au 30 septembre, 2009 – Montréal

Session: Renewable and Zero GHG Energy Opportunities

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EMC MEC
Electric Mobility Canada
Mobilité électrique Canada

Uranium Fueled Futures

- All of our potential energy arises from nuclear processes:
  - Solar, fission terrestrial radioactive decay (U, Th, K)
- We are depleting some of these sources too fast
  - **We now burn oil at about 1000 barrels per second**
- **We must find new energy currencies**
  - **Electricity and hydrogen**

Fission Chain Reactors

- Natural – Oklo, Gabon, 1.7 billion years ago
  - 15 reactors operated, each for about 50,000 years
- Reinvented – Chicago, Illinois, 1942
- **The "trick" is to exploit natural fission by arranging the right materials so that each fission reaction causes one more** -- a "chain"
  - 31 billion fissions → 1 watt-second (1 Joule) of heat
  - **Boil some water, spin a turbine, drive a generator**

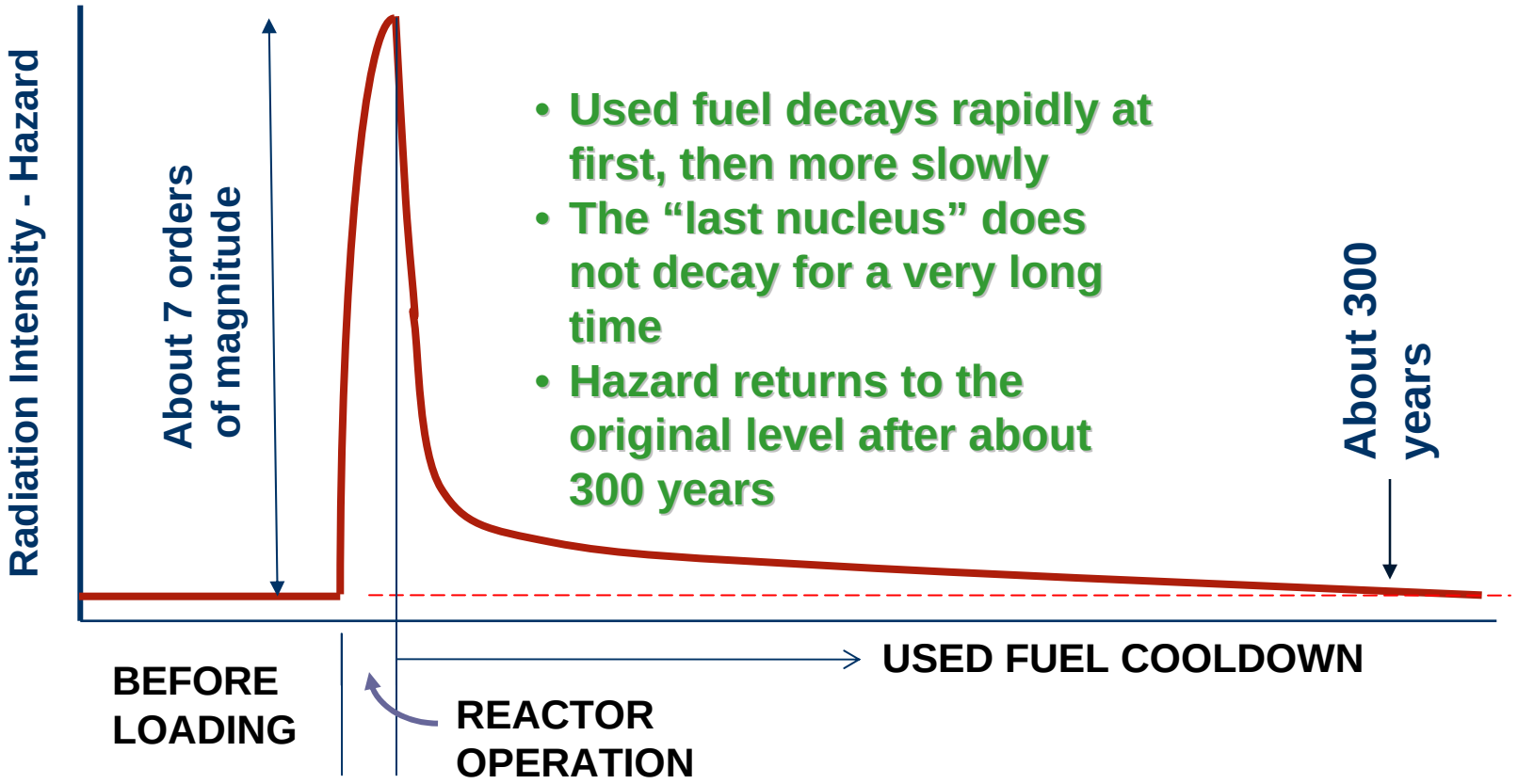
Risk

- The fission rate (neutron density) determines the rate of thermal energy production
  - One Darlington reactor produces about 3 billion watts of heat -- about 880 megawatts of electricity
  - Fissions occur at a rate of 3×10^{18} per second
- The "fission chain" is always controlled
  - **Measure the neutron density, then adjust neutron absorption so that the density remains constant**
  - If things go wrong, shut off the chain reaction

How about the ashes?

- They are "hot" when newly out of the reactor
- They cool off fast; in about 300 years they are back to the level of the original uranium ore
  - **Cheap to contain because their volume is small**
  - BUT the ashes still contain 99% of the original uranium potential energy – save them? recycle?
  - Won't the stuff be dangerous for a long time?

The Risk Varies



- Used fuel decays rapidly at first, then more slowly
- The "last nucleus" does not decay for a very long time
- Hazard returns to the original level after about 300 years

Do We Have Enough Uranium?*

- Today, the uranium price is about $100 per kilogram
  - **At this price we have enough to fuel about 6000 thermal reactors for more than 40 years**
  - If the uranium price were half the price of gold:
    - the price of electricity from thermal reactors would double
    - it would be very profitable to extract uranium from seawater
  - Seawater is known to contain enough uranium to supply 100% of the world energy demand today, for about
    - four thousand years using thermal reactors
    - **at least five hundred thousand years using fast reactors**

* Douglas Lightfoot et al, "Nuclear Fission Energy is Inexhaustible", Proc. Climate Change Technology Conference, EIC, Ottawa, May 2006

Nuclear Energy Promise

Fission fuel is inexhaustible

↓

Nuclear fission energy supply is sustainable

↓

On the time scale of human existence,

↓

Nuclear fission energy is renewable

What Does it Cost?

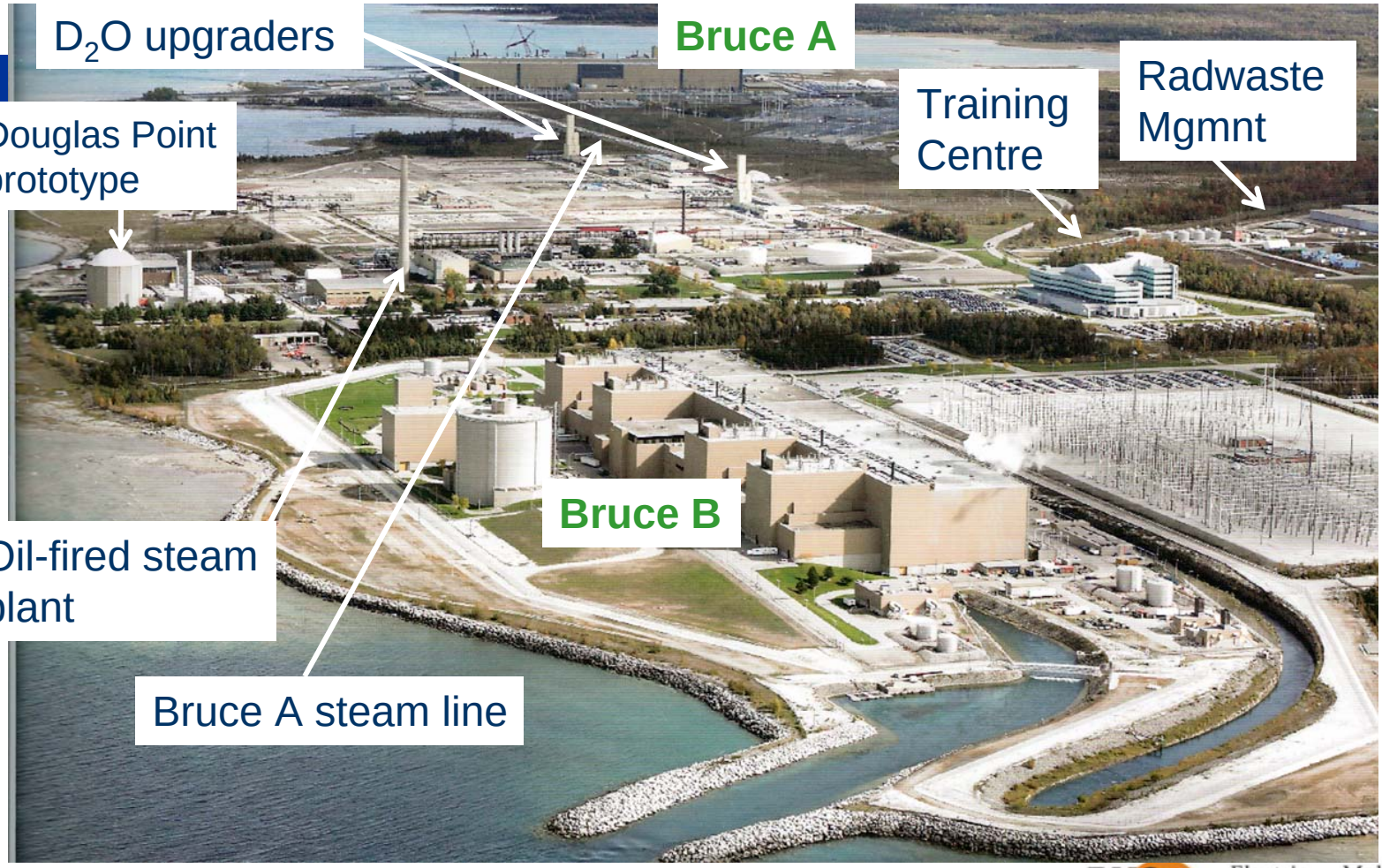
- Canada already owns all of the essential elements
  - Material, knowledge, skill, industry, operation, regulation
  - Expenditures for installation, operation, and decommissioning can be made almost 100% internal to Canada's economy
- Further R&D is possible -- but not essential
  - **The technology is "shovel ready"**
- Near-zero environmental impact
  - Nearly zero emission of GHGs
  - **Small ecological 'footprint'**

Nuclear Weapons?

- Existence of uranium-fired power plants in Canada does not change the chances of nuclear weapons production
  - This is a political/sociological issue that must be solved through diplomacy
- **Nuclear weapons are strictly controlled**
  - **Effective treaties – not used in war since 1945**
  - **Other modern weapons are now more effective in battle – nuclear is only a 'fear' weapon**

Bruce Site – 2008 (a prototype for future)

6000 Mwe Electricity Production Capacity



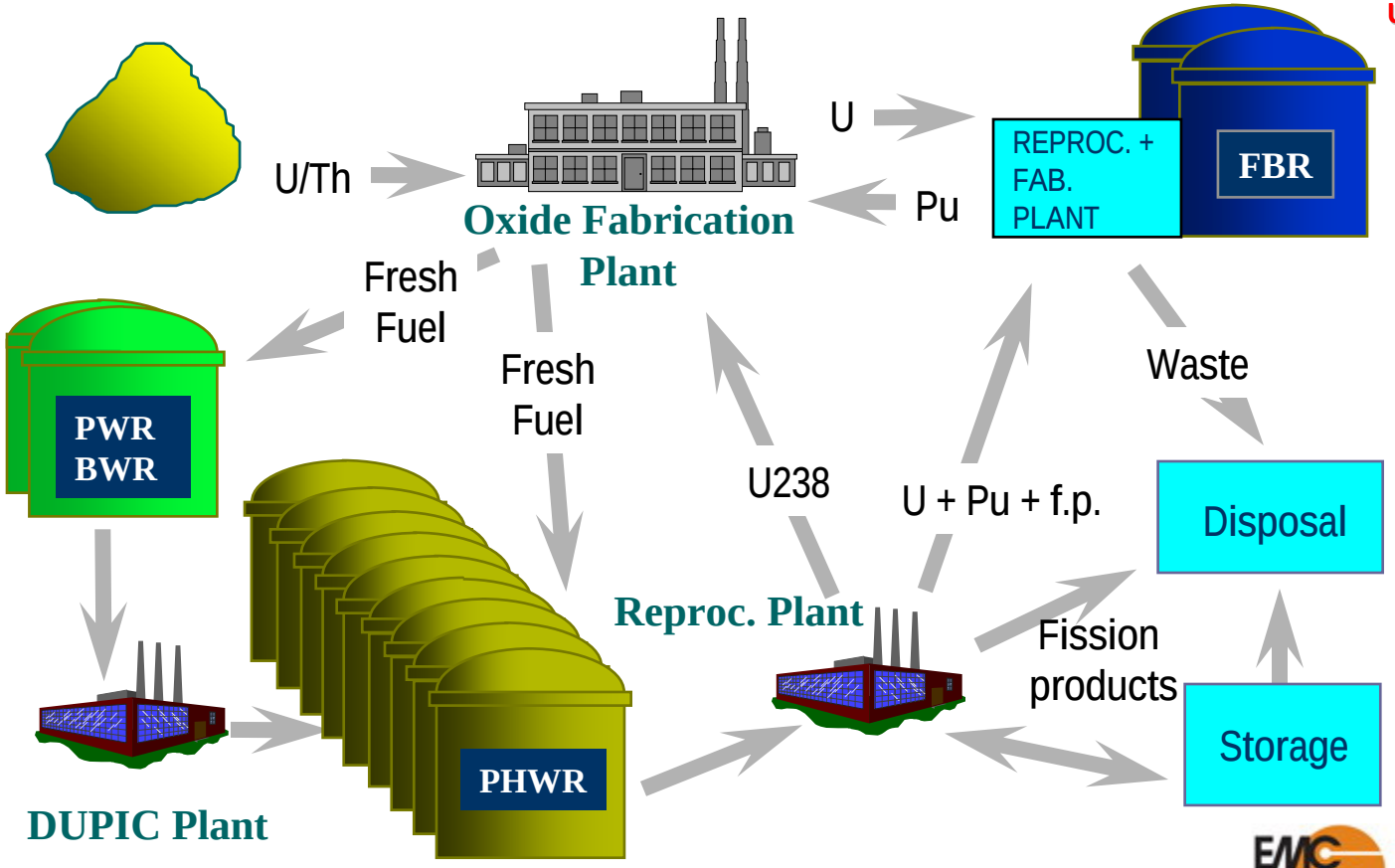
Bruce Site - 2100?

ELECTRICITY PRODUCTION

FUEL FABRICATION

FUEL REPROCESSING

USED FUEL STORAGE & RADWASTE DISPOSAL



Site Extension – 2100?

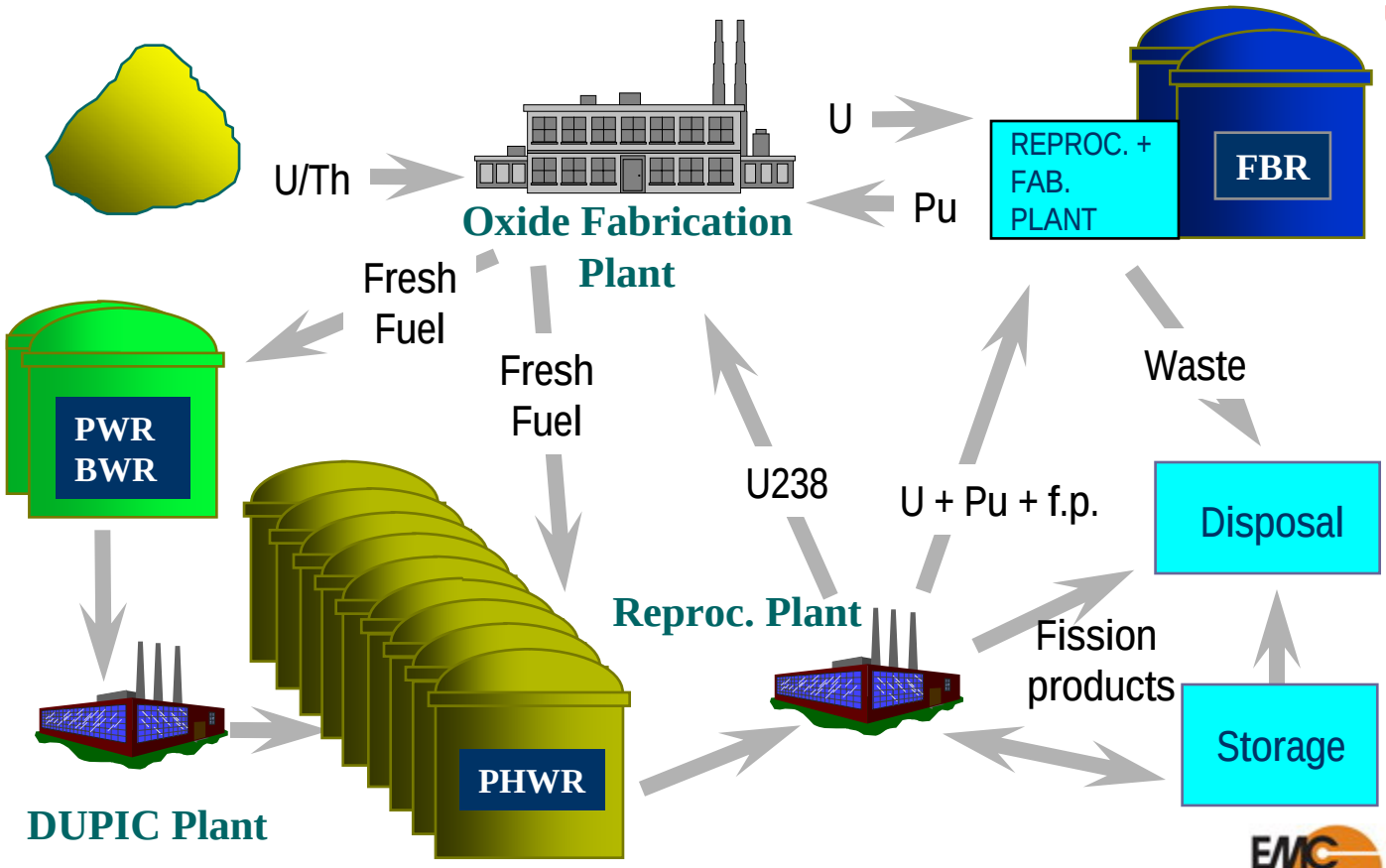
ELECTRICITY PRODUCTION

FUEL FABRICATION

FUEL REPROCESSING

USED FUEL STORAGE & RADWASTE DISPOSAL

ELECTROLYTIC OR THERMO-CHEMICAL HYDROGEN PLANT
- Peak electricity
- Fuel cell feed
- Industrial gasses



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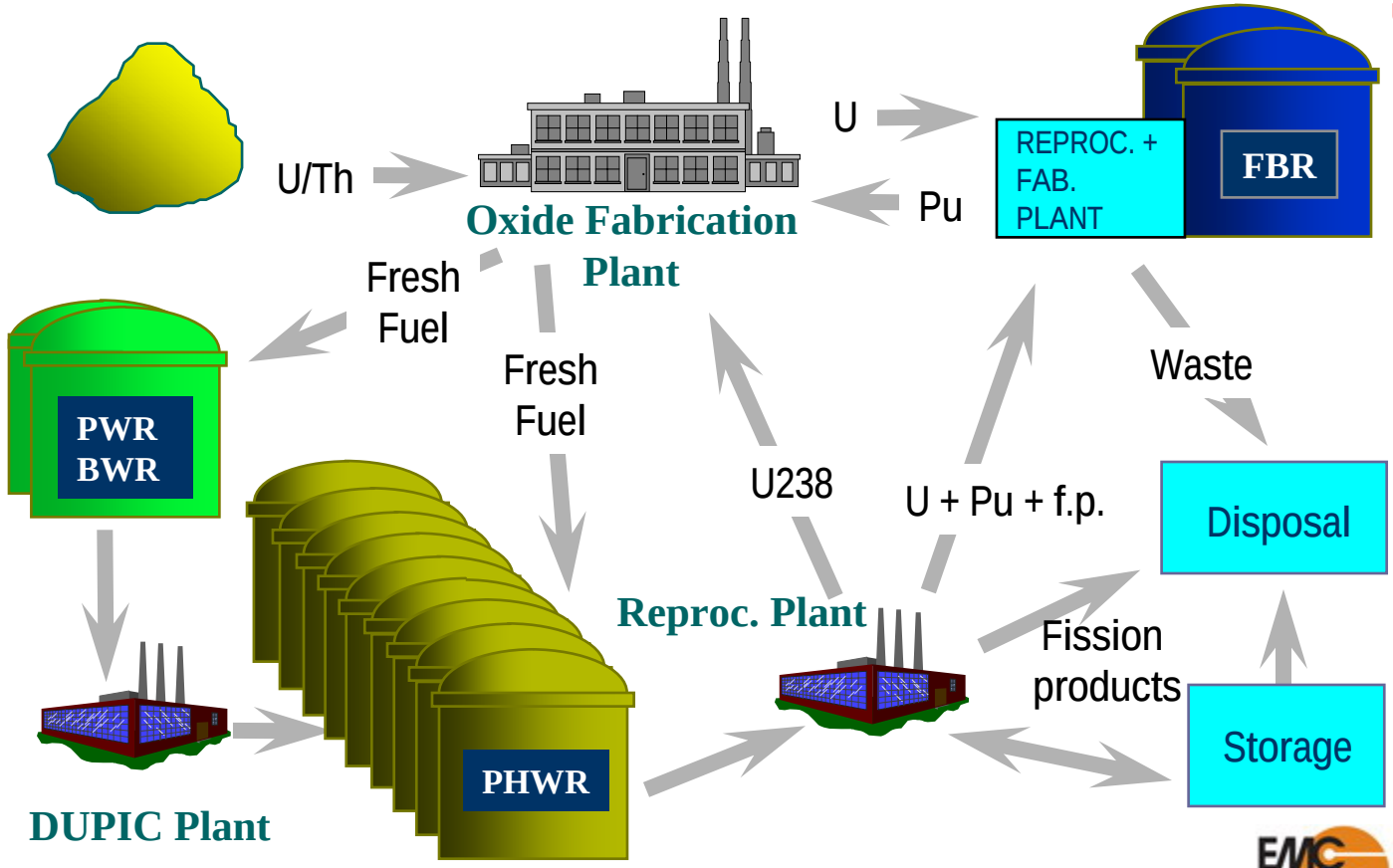
Site Extension – 2100?



ELECTRICITY PRODUCTION

FUEL FABRICATION

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USED FUEL STORAGE & RADWASTE DISPOSAL

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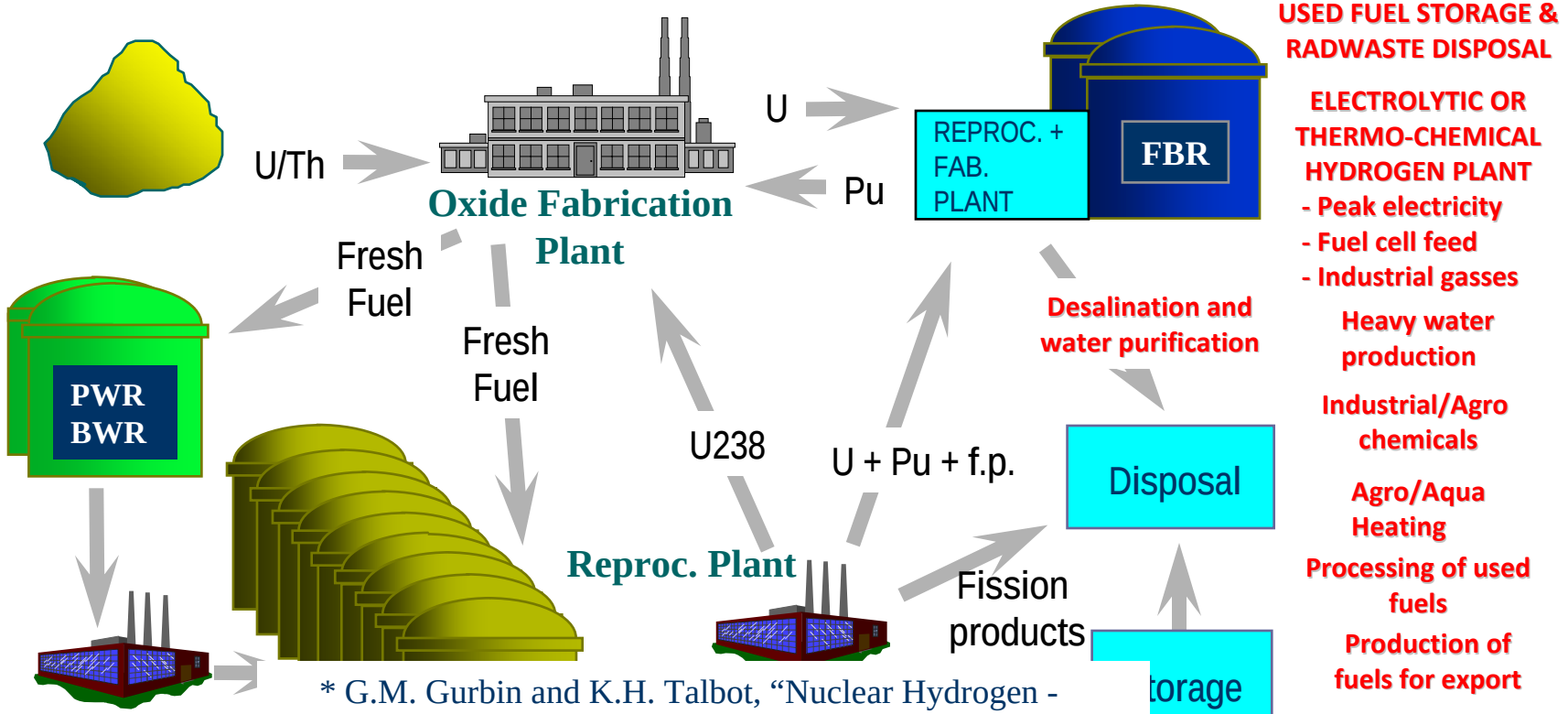
- Peak electricity
- Fuel cell feed
- Industrial gasses

Heavy water production

Industrial/Agro chemicals

Site Extension – 2100?*



* G.M. Gurbin and K.H. Talbot, "Nuclear Hydrogen - Cogeneration and the Transitional Pathway of Sustainable Development", 9th Pacific Basin Nuclear Conference, Sydney, Australia, May 1994

Conclusions

- **We now have everything we need** to provide later generations with energy as and when they need it
- Plug-in hybrid technology can put nuclear energy "on wheels" to help solve our transportation fuel supply needs, now and forever
- All energy sources should be exploited up to their economic optimum. **Nuclear energy can and will supply a solid large-scale "supply foundation" for alternative developments**