

Clean Energy Sources for Future Northwest Transportation

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Hybrid Energy Systems - An Integrating Path Forward to Provide Cleaner Electricity and Fuels for Transportation

- Unlocking the vast energy resources within North America will require integrating, optimizing and stewarding a diverse set of domestic (and N. American) energy resources, interconnected by a dependable delivery infrastructure, and developed in an environmentally progressive manner.



Hybrid Energy Solutions

- Produce fuels, electricity & chemicals
- Revolutionize transportation
- Lower carbon footprint
- Utilize local, secure resources

**Today: High Carbon Intensity
Foreign Dependent**
Trillions \$ to foreign economies

**Low Carbon Intensity
Domestic Dependent**
Trillions \$ to U.S. economy



How are we doing...Energy & Environment S&T —Hybrid Energy Systems

**Electrical
Power,
Heat, H₂, O₂**



**Low Carbon
Energy Sources**



Renewable Biomass



Crude Oil



Coal



Oil Sands / Oil Shale

Carbon Donors

**Reduced
GHG
Fuels &
Petro-
chemical
products**



**Transportation
fuels, fertilizers,
and petrochemical
products**

Strategic Energy Islands

Renewable-Electric Integration

Electrolysis or co-electrolysis driver
Additional electricity to grid

Hydrogen Generation Plant

Upgrade of fossil and bio feedstocks
Catalytic feedstock for coal to liquids

Liquid Fuels & Chemicals Plant

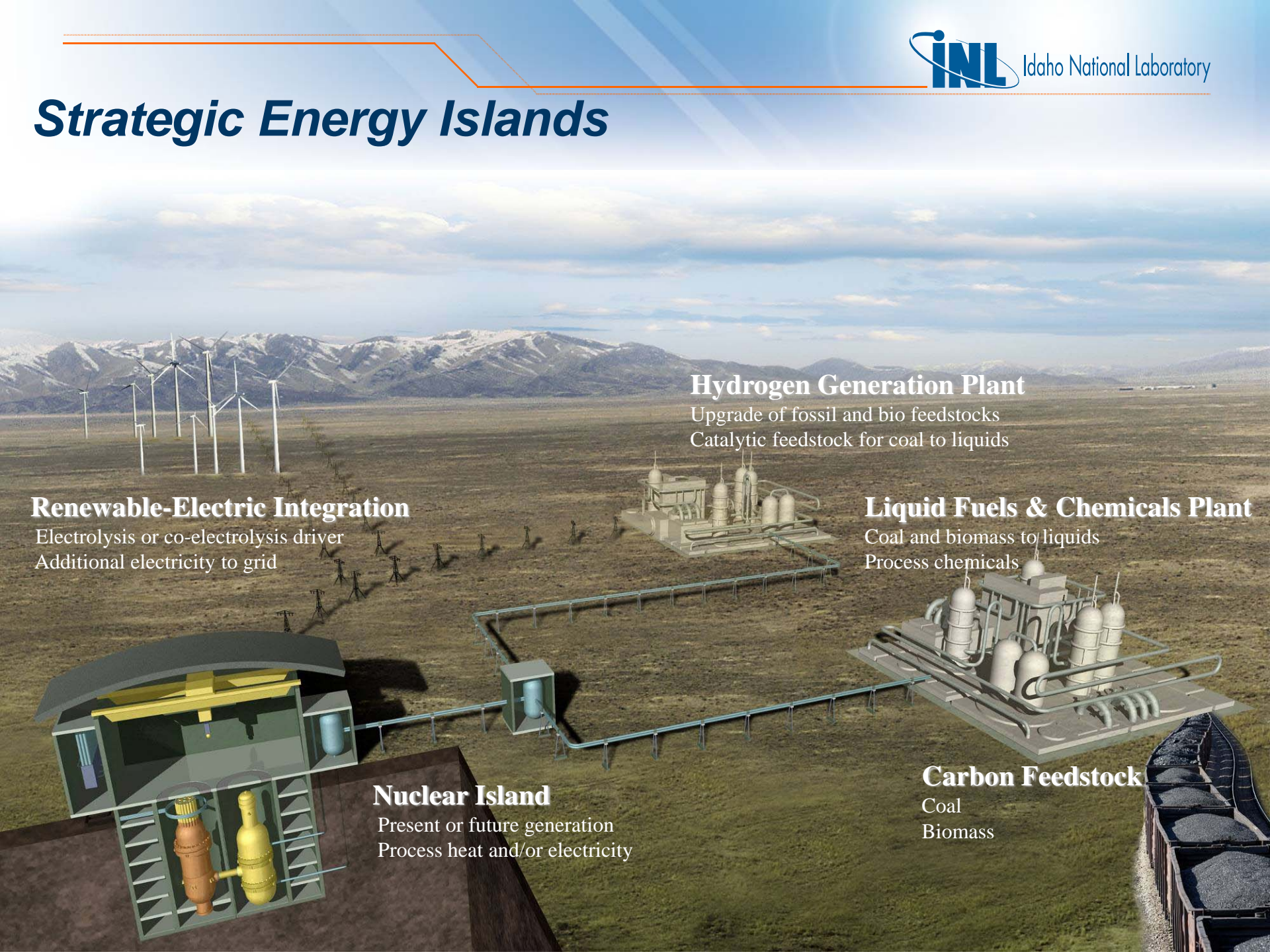
Coal and biomass to liquids
Process chemicals

Nuclear Island

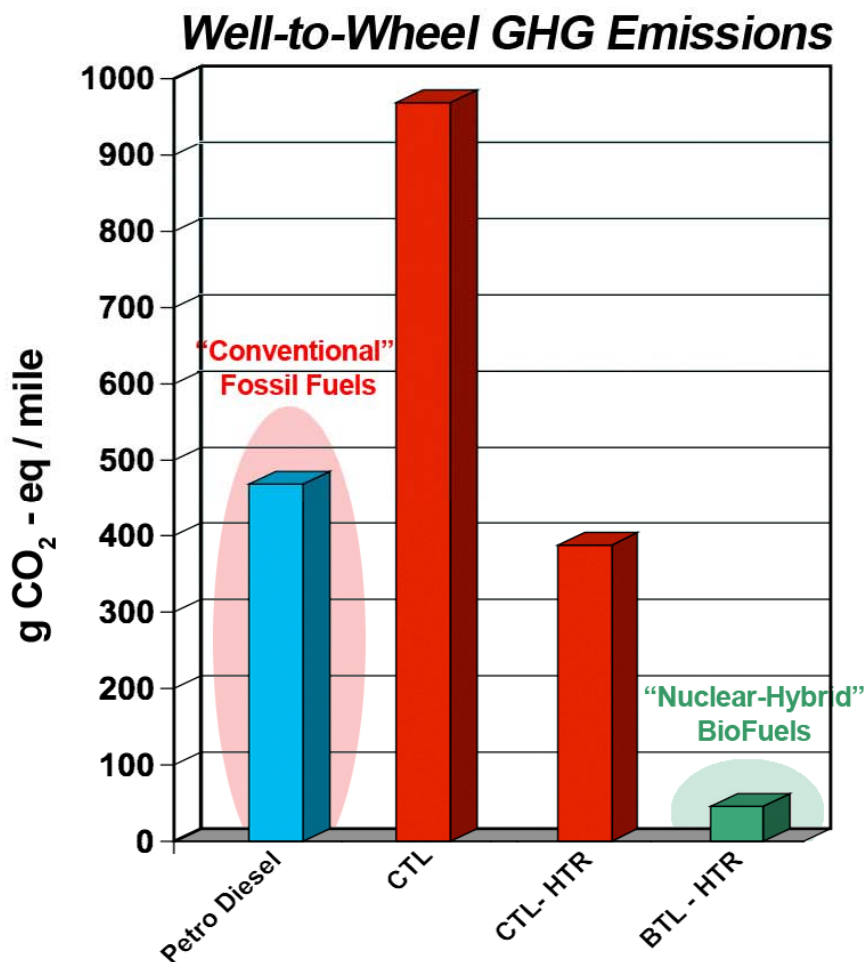
Present or future generation
Process heat and/or electricity

Carbon Feedstock

Coal
Biomass



Lifecycle Emissions of Liquid Fuels



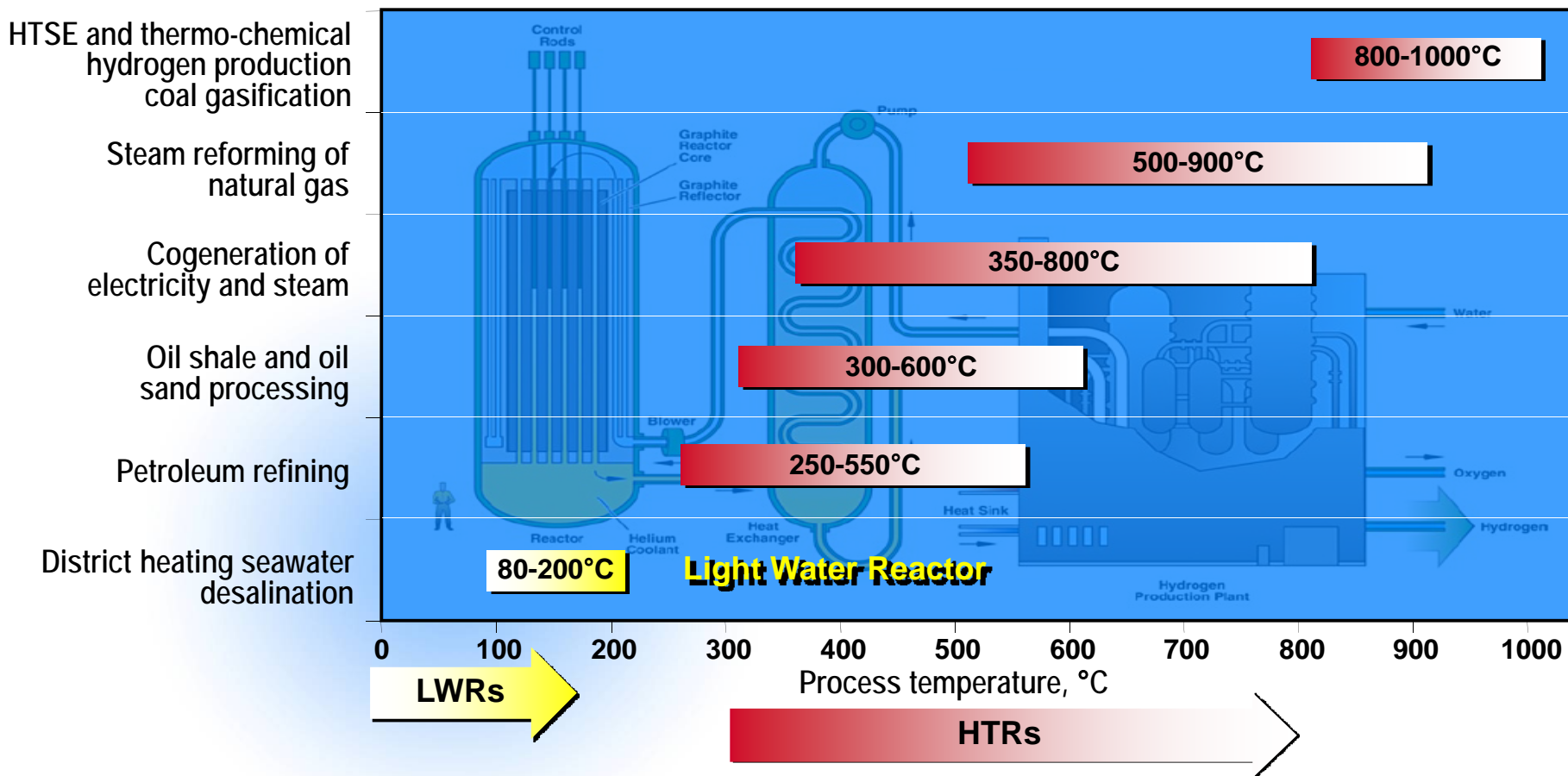
Fischer-Tropsch:



SMR:



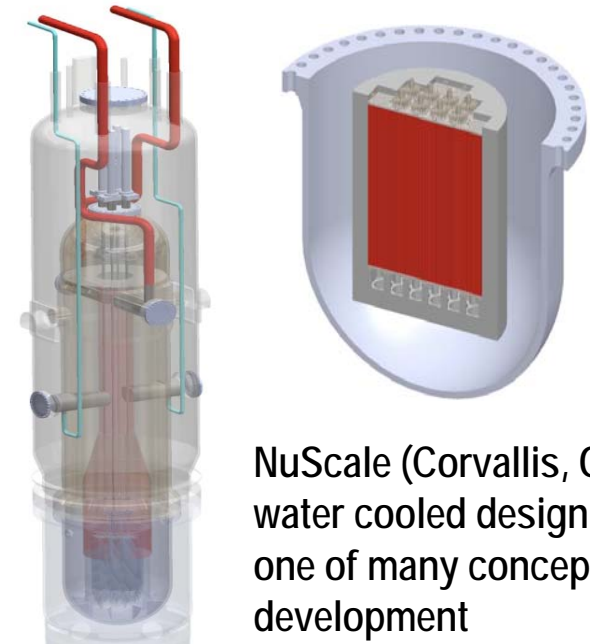
Efficiency gains could be possible in the future with high temperature reactors



There is a role for existing LWRs, advanced LWRs, and small reactors...

Growing interest in small reactor designs for non-electric applications in North American market

- US and international companies are pursuing LWR-based and novel designs that offer:
 - Simple, robust designs
 - Better water usage
 - Smaller components and footprint
 - Less cost, with less financial risk
 - Safety enhancements, such as inherently safe
 - Low carbon option for electricity and hydrogen production, coal to liquids, oil sands and shale, water desalination
- Design certification and licensing uncertainty and a bias toward large centralized LWRs must be addressed



NuScale (Corvallis, OR)
water cooled design, 45MWe,
one of many concepts under
development

Like larger reactors small reactors could provide a path to a low-carbon energy future.