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Center on Global Energy Policy

New Energy Technologies and National Security Applications

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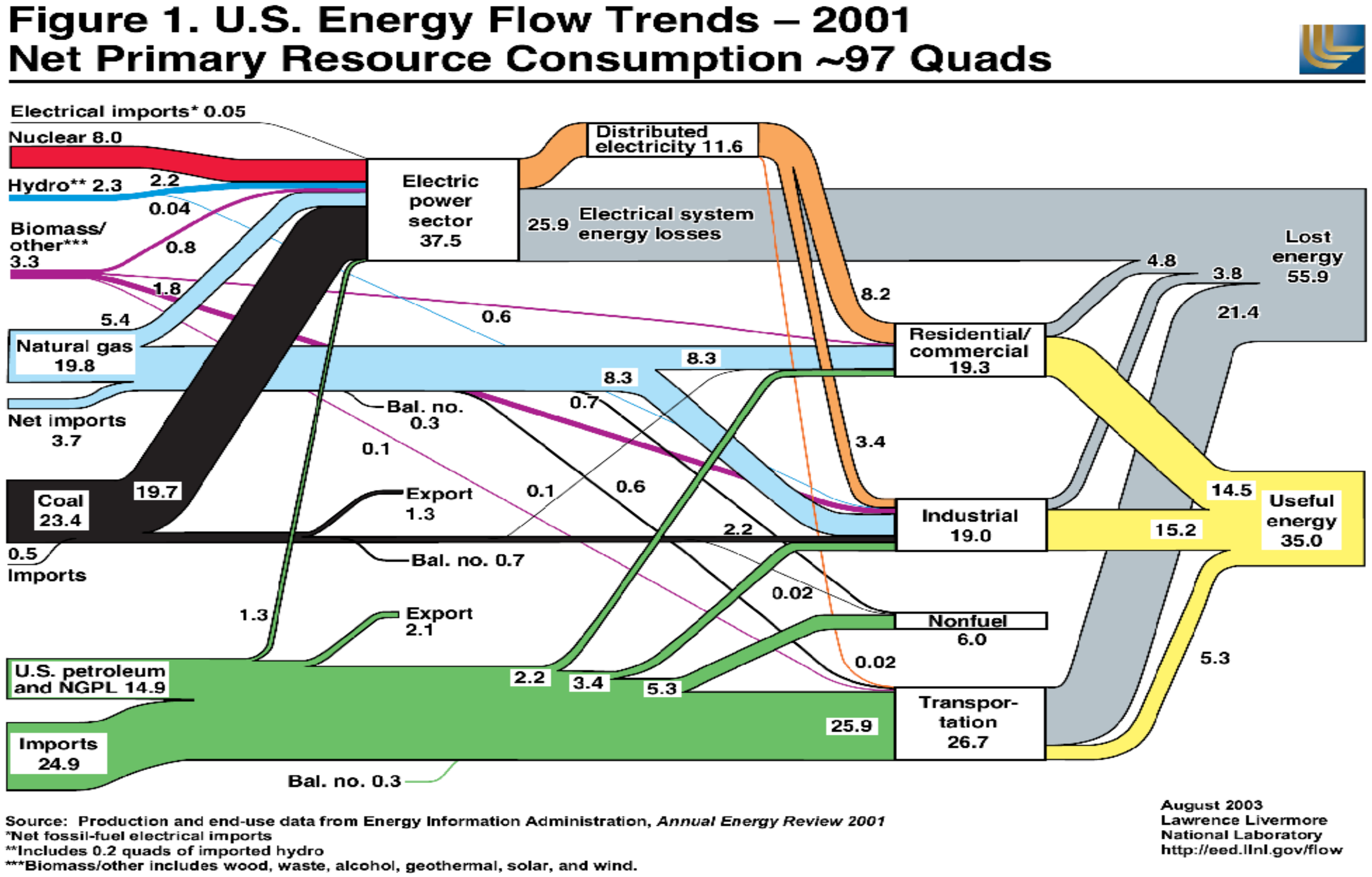
Most new energy technologies we are using today were not economically viable or available 15-20 years ago

A series of technologies are now available as competitive costs and supporting lower emissions:

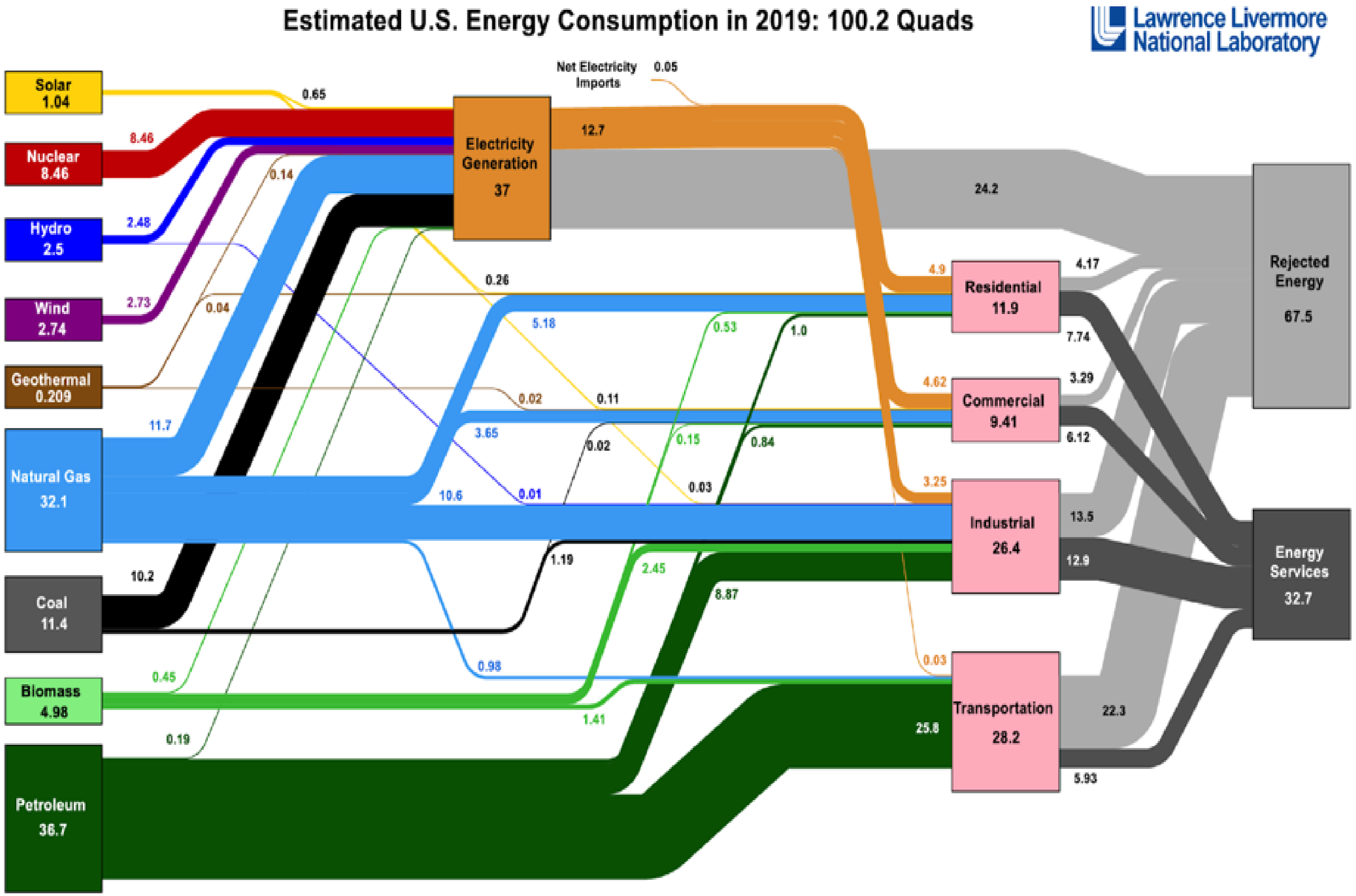
- Solar PV: ~70% lower $/mwh costs
- Wind: capacity factors ~ 100% improvement
- Lithium Ion batteries: went from basic chemistry discovery to wide scale adoption and a Nobel prize
- Electric vehicles
- Unconventional oil & gas production costs dropped ~70%
- Gas turbine heat rates (i.e. efficiency) dropped about 30%

Conclusion: Innovation in energy has made a significant impact

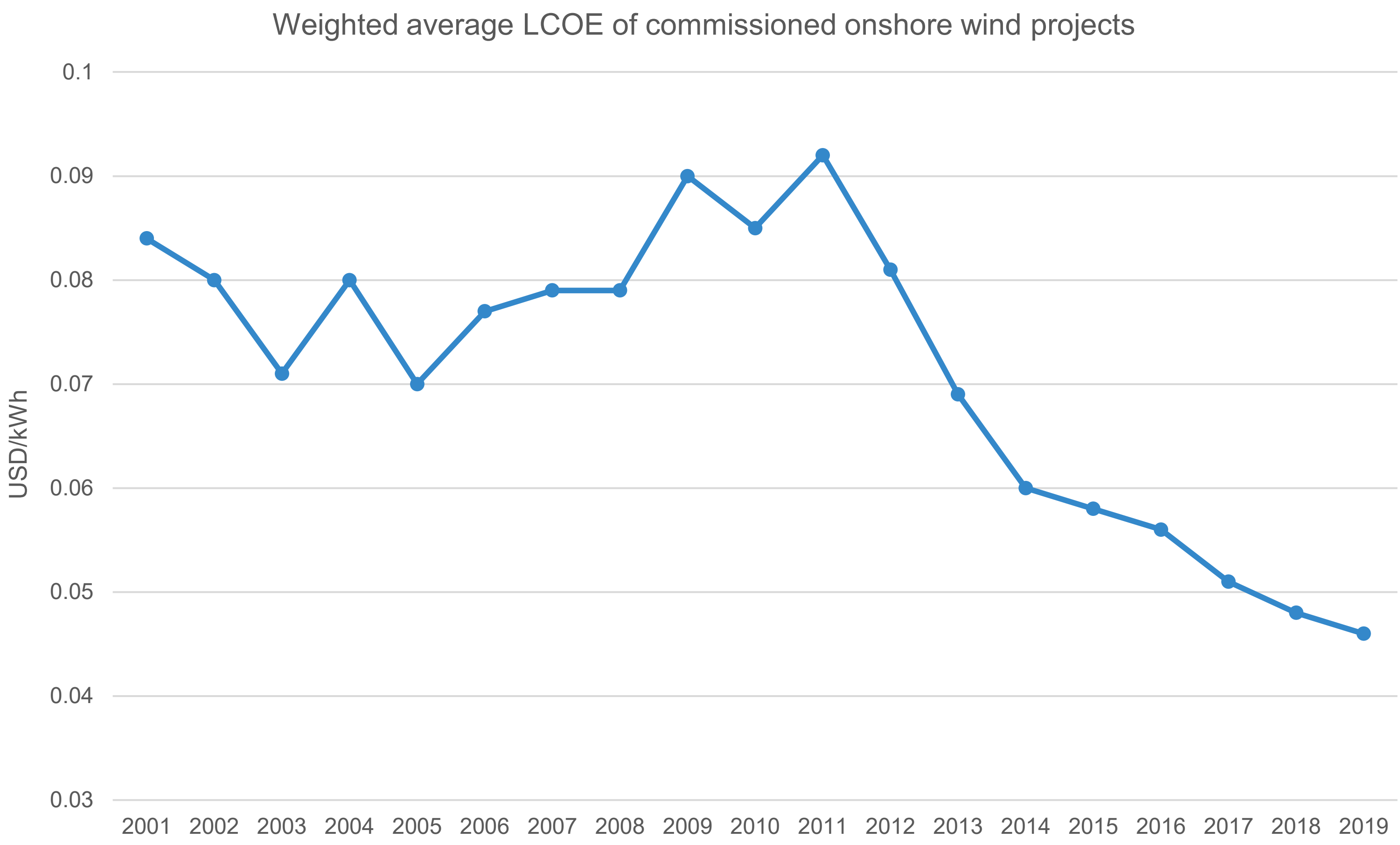
In 2001, Most U.S. Energy was from Imported Oil and Domestic Gas and Coal



By 2019, U.S. Energy had shifted Towards Gas, With Additions of Wind and Solar

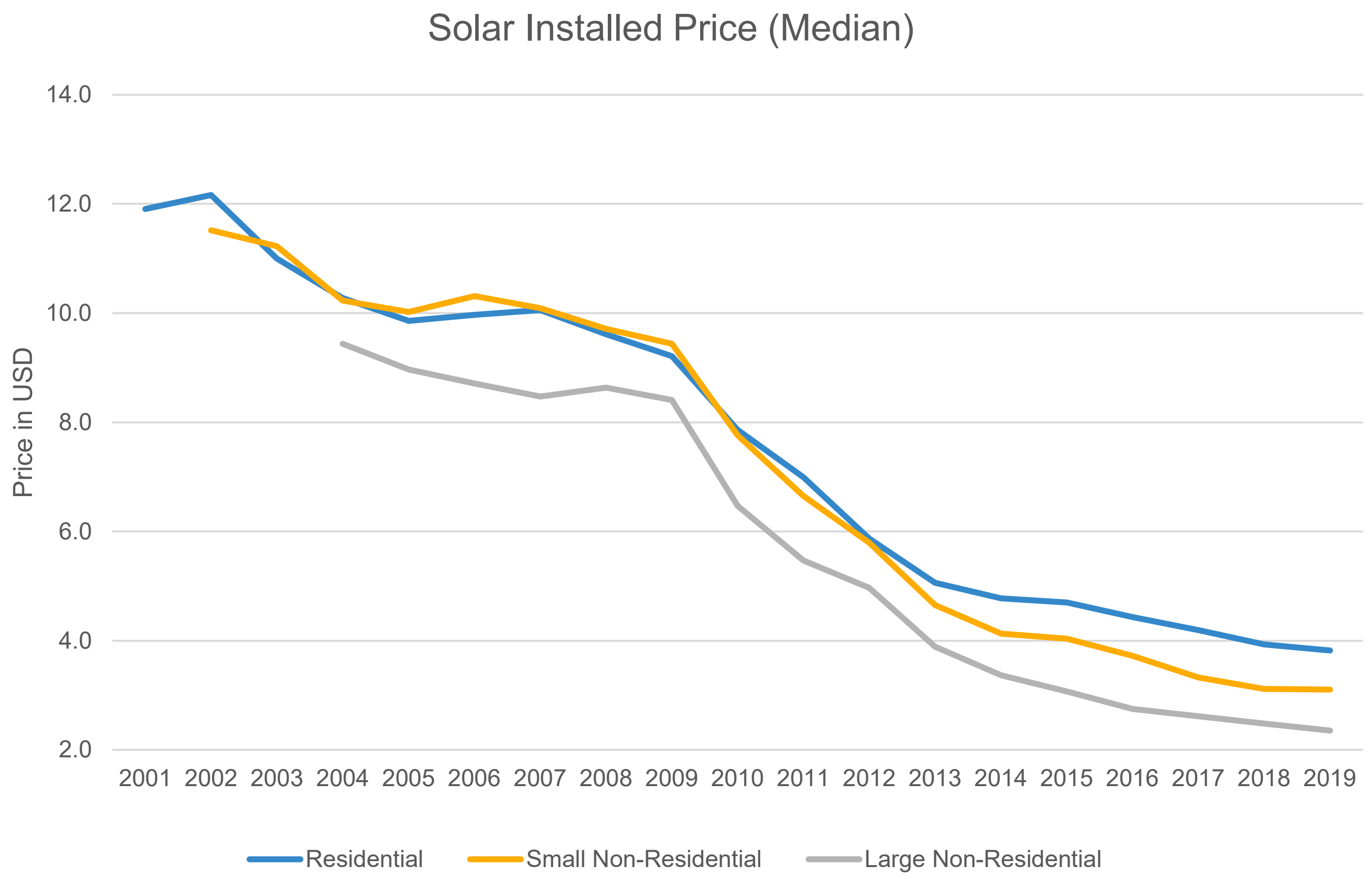


Levelized cost of wind has dropped by half



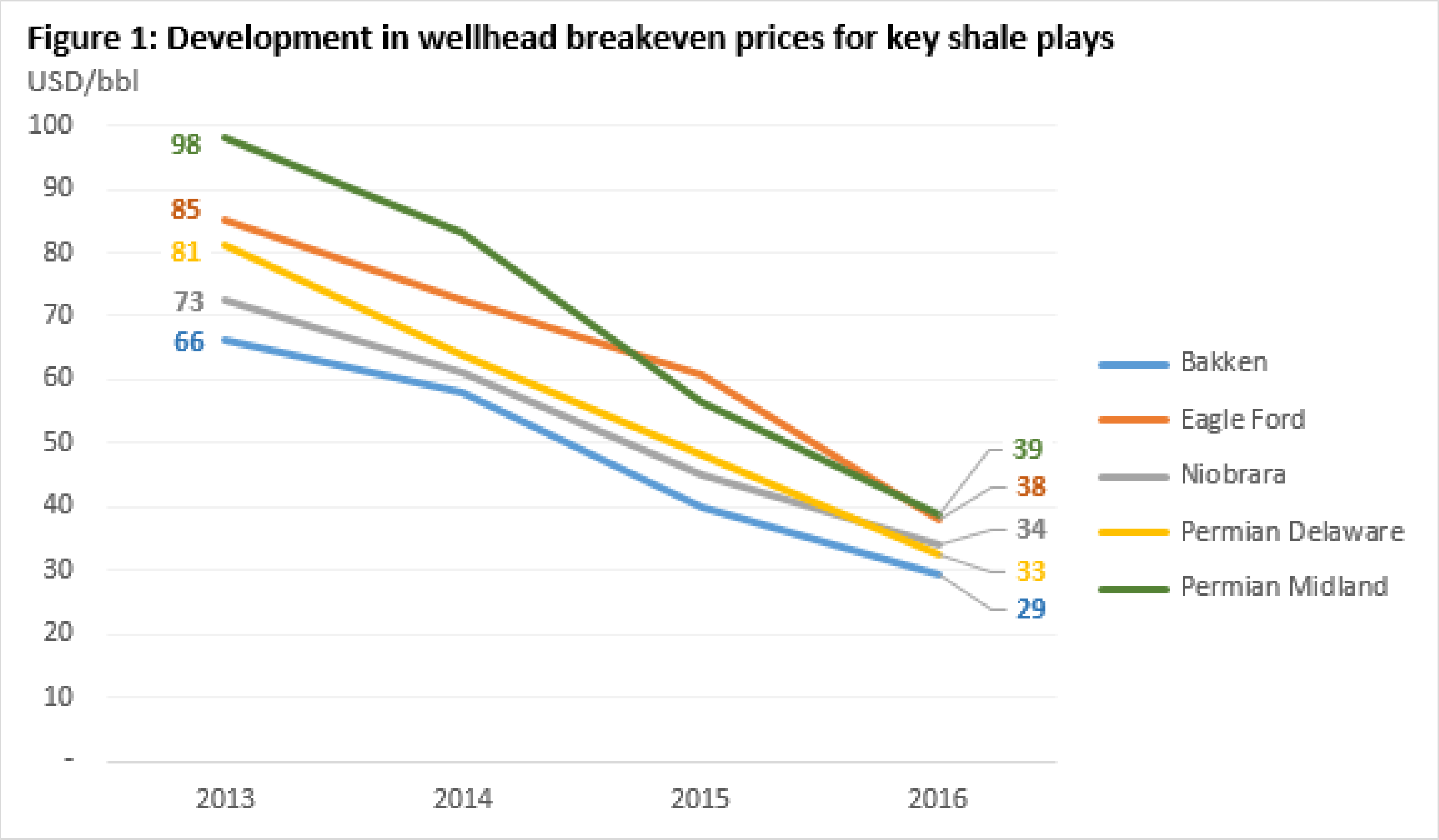
Source IRENA

$/Watt Solar PV Costs have dropped by 60-70%



Source IRENA

In only three years, U.S. Oil & Gas production costs dropped by over 50%



Source: Rystad Energy NASWellCube




And there are a series of potential new technologies that could make additional impact

- Hydrogen
- Fusion
- Advanced nuclear reactors
- Beyond lithium-ion battery chemistries
- Offshore wind
- Grid management
- Renewable natural gas
- Bio energy
- Carbon capture

Fusion

- Achieving usable Fusion has been perennially “40-years-out”
- After the Cold War in 2001, an international consortium of EU, UK, Russia, China, S. Korea Japan and the U.S. designed and started building the first “net-out” fusion plant in southern France: ITER
- Significant issues in construction has delayed ITER
- In the last few years, significant advances in containment look to technology jump ITER, driven by the private sector, mostly startup companies, including:
  - Commonwealth Fusion
  - Tokamak Energy
  - TAE (Tri Alpha Energy)
  - General Fusion
  - Helion
  - Zap Energy

Advanced Nuclear and Small Modular Reactors

- Light water reactors require significant high pressure systems, adding to cost of the overall system
- Also commercial reactors have always had poor construction project schedule and cost performance, primarily due to scale challenges
- They also have inherent safety challenges that need to be managed through engineered systems
- Advanced nuclear addresses these challenges through different fuel and primary fluid changes:
    - Molten sodium and U-238/Pu-238 (TerraPower)
    - Gas cooled reactors and HALEU (X-energy)
    - Fluoride sale and HALEU
- Note: U.S. and Soviet navies have not had great experience with molten salt
- Commercial SMR efforts is partially as a result of navy nuclear experience

Naval Services Implications

Navy Policy topics for new energy adoption:

- Existing infrastructure for logistics
- Existing platforms designed for current energy types
- Reduce costs/logistics efforts
- Reduce overall environmental footprint
- Longer term desire to reduce emissions




Naval Services Implications (cont'd)

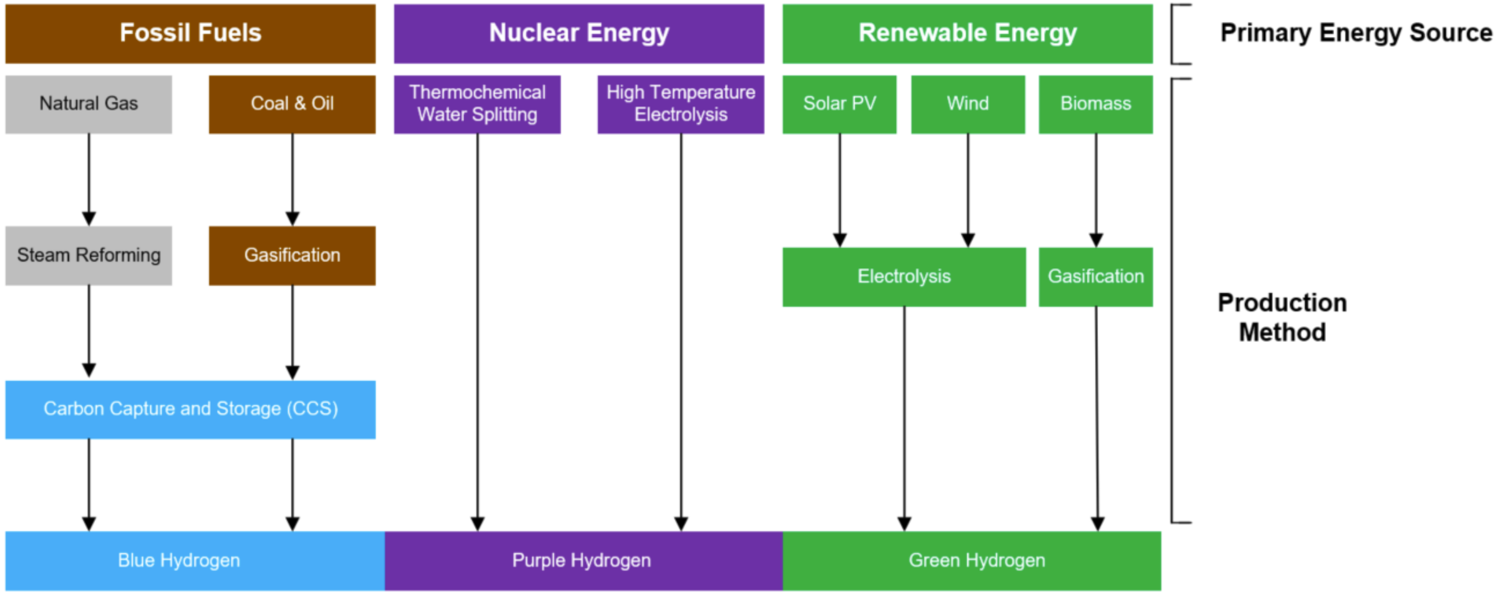
More likely Naval Service deployable new energy technologies:

- Beyond Lithium-Ion Batteries
  - Batteries will likely be focused on light-duty applications: light duty vehicles, power back up,
  - Li-Ion has many strengths, it has poor duration characteristics vs other energy sources, has fire risks, and other performance limitations
  - Likely several different type of chemistries could be part of new battery types, each useful for specific use cases:
    - Fe-based: long duration and cheaper
    - Sodium-ion: charge speed, cost
    - Lithium sulfur: energy density, weight
    - Solid state: lighter, fire risk/cooling needs
- Renewable liquid fuels
  - Traditional efforts have been biofuels
    - Solid biomass, sugars, cooking fats, etc
    - Cost is still significant
  - New renewable chemistry chains could create new opportunities
    - Electricity (nuclear, fusion, wind, solar, etc.) → hydrogen → negative carbon liquids or gas → zero net carbon post combustion
    - Can also be used for negative carbon polymers
    - Could lead to some interesting in situ refining of liquids

Naval Services Implications (cont'd)

More likely Naval Service deployable new energy technologies:

- Hydrogen
  - The alternative with best characteristics for heavy duty use
    - Shipping
    - Heavy vehicle
    - Aero-nautical and-space



Naval Services Implications (cont'd)

More likely Naval Service deployable new energy technologies:

- Hydrogen (cont'd)
  - Production technologies
    - Steam Methane Reforming
    - Electrolysis (alkaline & PEM)
    - Solid Oxide
    - Pyrolysis
  - Transportation, storage, and firing
    - Materials embrittlement
    - Fire safety
    - Co-firing/blending