



Idaho National Laboratory Nuclear Fuel Cycle Separations Capabilities

November 2023

Changing the World's Energy Future

Michael Anthony Norato



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Idaho Falls, Idaho 83415**

<http://www.inl.gov>

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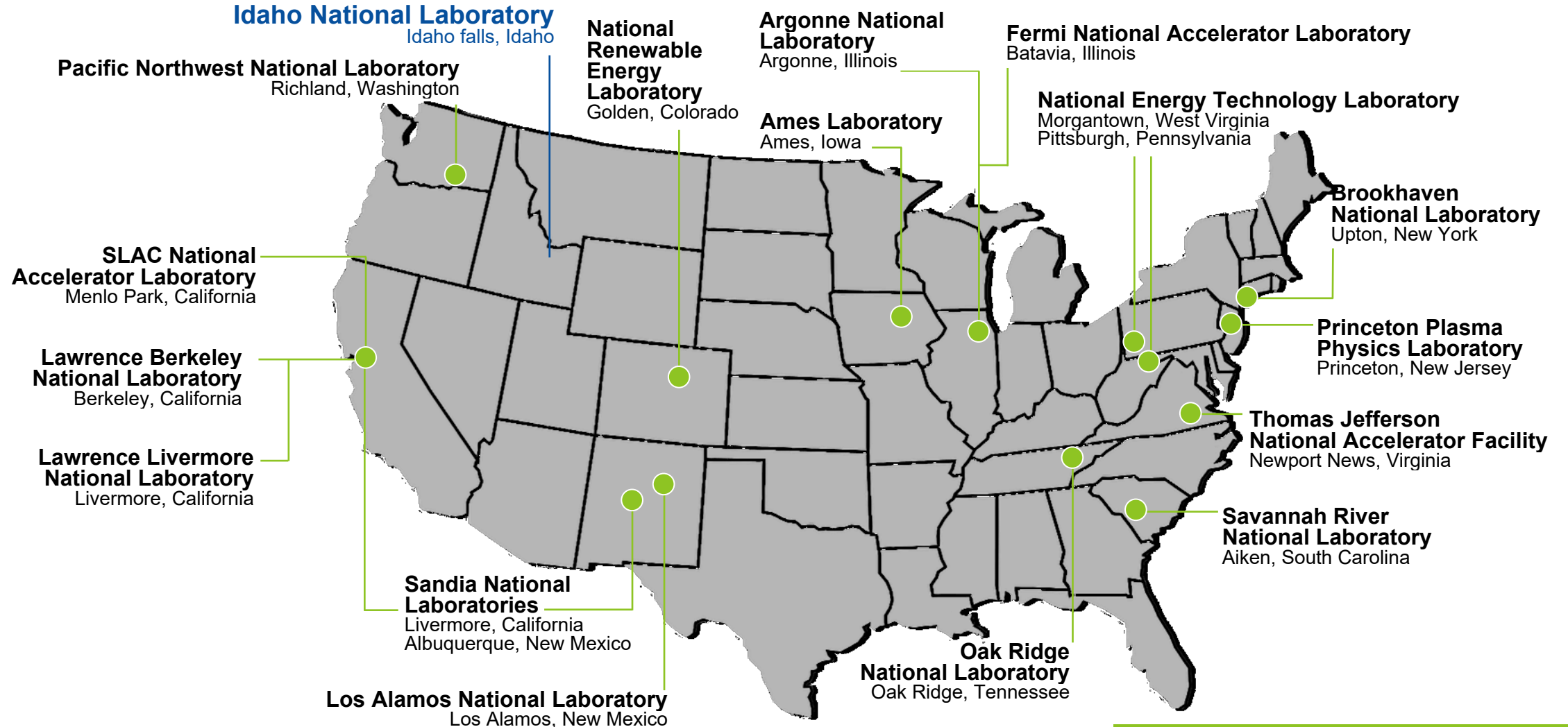


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DOE National Laboratories

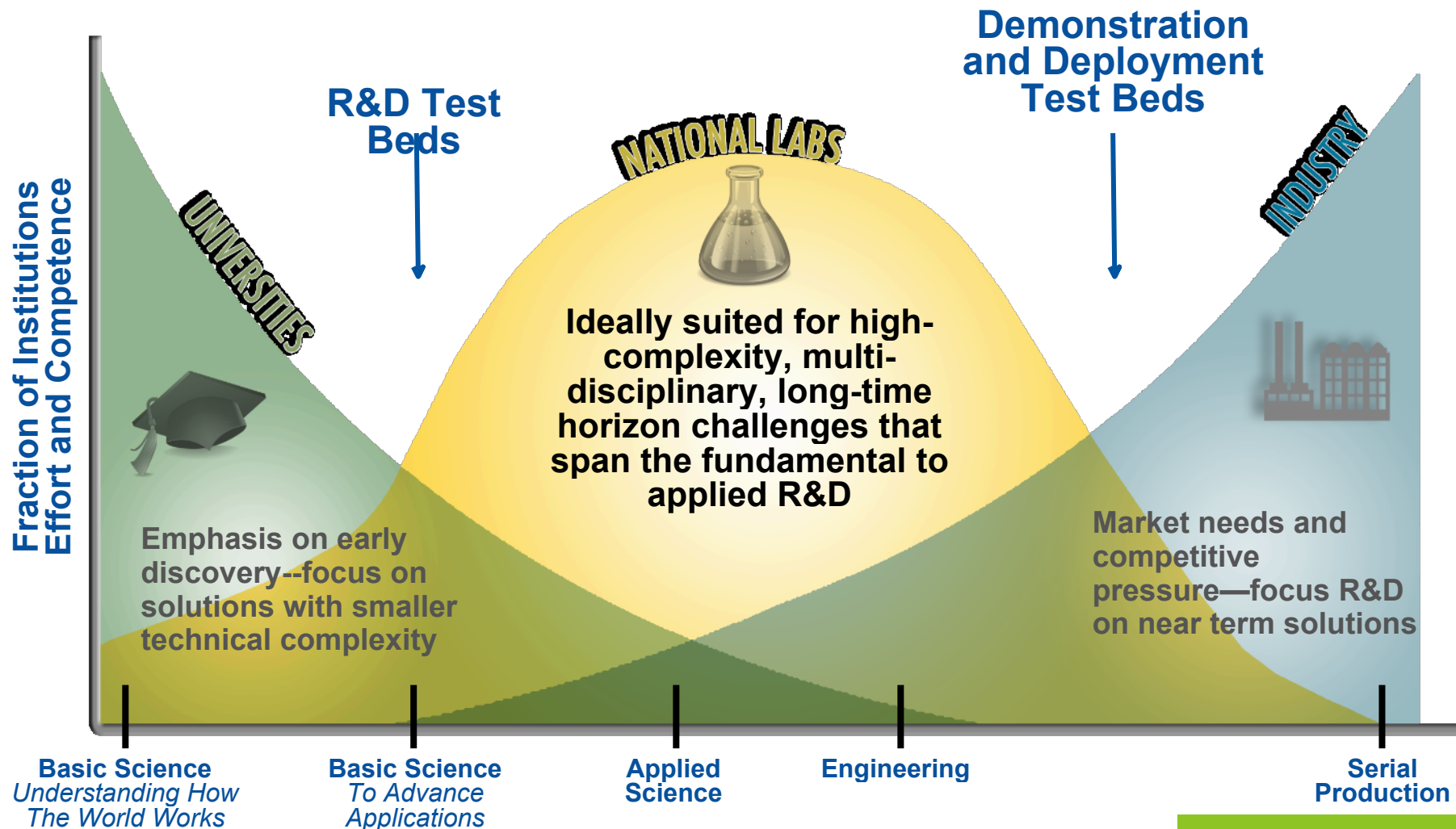


“Spectrum” of DOE Laboratories



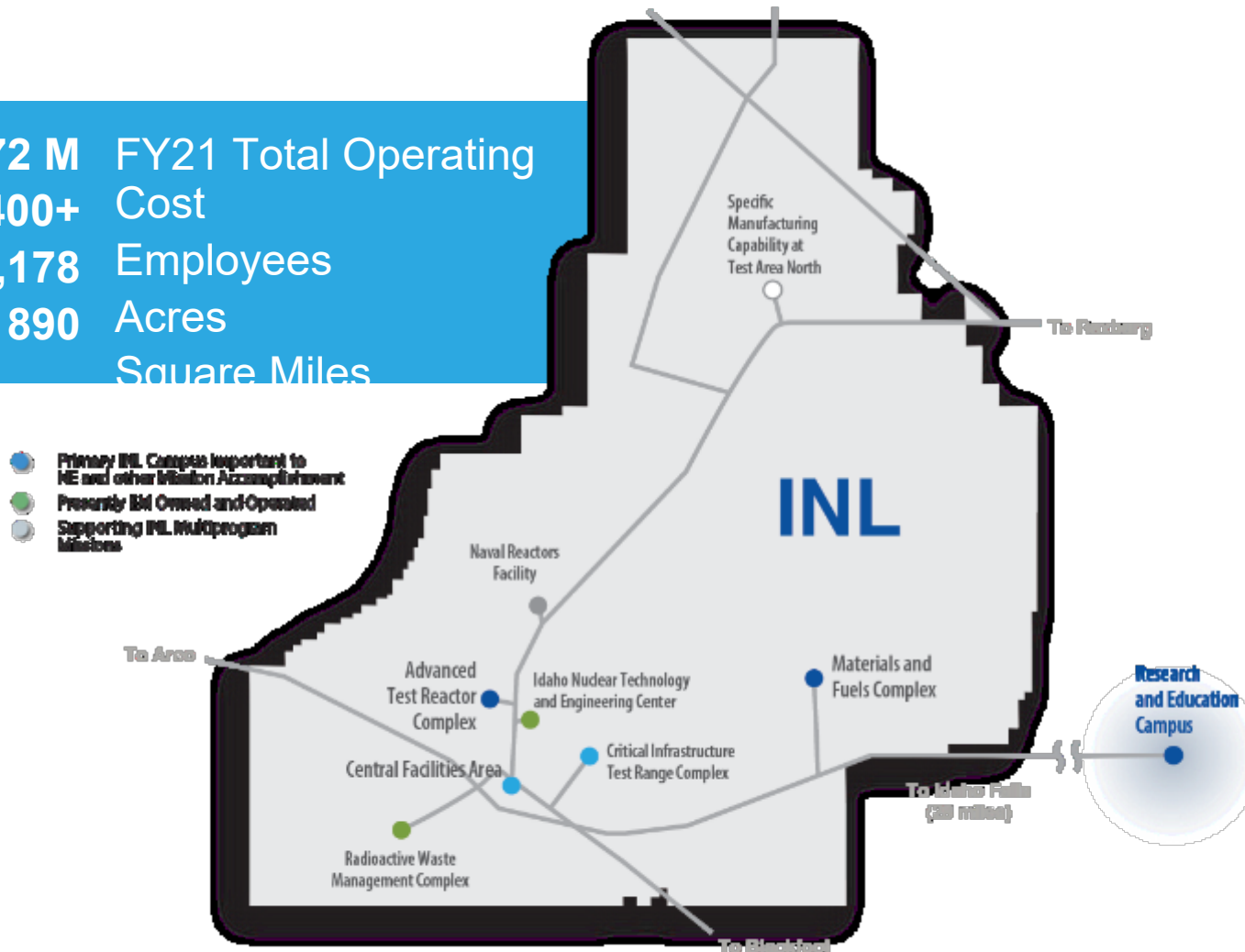
Advancing Technologies: Role of DOE Labs

Supporting the entire technology lifecycle



Unique site, infrastructure, and facilities that enable energy and security R&D at scale

\$1,572 M FY21 Total Operating Cost
5,400+ Employees
569,178 Acres
890 Square Miles



12 Miles high-voltage transmission lines

17.8 Miles railroad for shipping nuclear fuel

5 Operating reactors

12 Hazard Category II & III non-reactor facilities/activities

50 Radiological facilities/activities

3 Fire Stations

INL is addressing the world's most challenging problems

Nuclear Science & Technology

- Nuclear fuels and materials
- Reactor systems design and analysis
- Fuel cycle science and technology
- Nuclear safety and regulatory research
- Advanced scientific computing

Advanced Test Reactor Complex

- Steady-state neutron irradiation of materials and fuels
 - Naval Nuclear Propulsion Program
 - Industry
 - National laboratories and universities

Materials and Fuels Complex

- Transient testing
- Analytical laboratories
- Post-irradiation examination
- Advanced characterization
- Fuel fabrication
- Space nuclear power and isotope technologies

Energy & Environment Science & Technology

- Advanced transportation
- Environmental sustainability
- Clean energy
- Advanced manufacturing
- Biomass

National & Homeland Security Science & Technology

- Critical infrastructure protection and resiliency
- Nuclear nonproliferation
- Physical defense systems

Increased urgency as imports from Russia are no longer viable to support advanced reactors initial cores

**U.S. Rethinks Uranium Supply for Nuclear Plants
After Russia's Invasion of Ukraine**

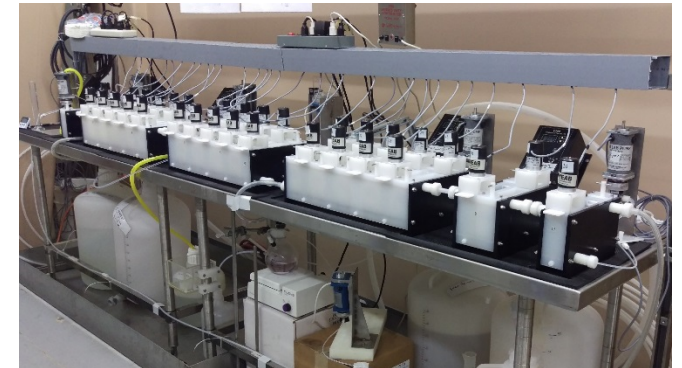
**Over a Barrel: Energy Exports
as a Political Weapon**

**Russian Uranium Dominance
Leaves U.S. Scrambling to Catch Up**

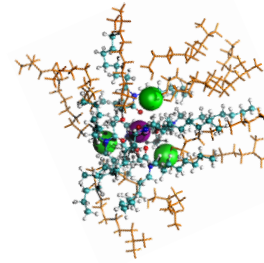
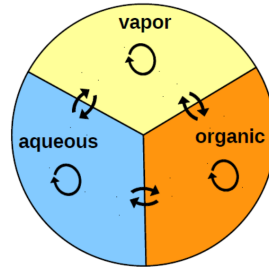
**Nixed Russian fuel supply
complicates Sodium schedule**

INL Solvent Extraction Capabilities

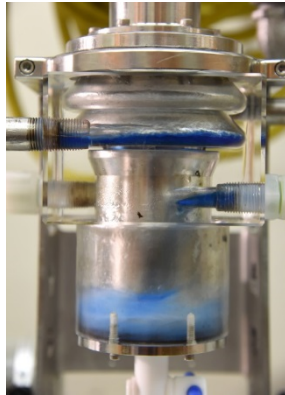
- MEAB Mixer-settlers: 32 stages
- CINC V2 centrifugal contactors: 30 stages
- Glass mixer-settler systems: 30 and 20 stages
- Stainless steel 20 L mixer-settlers: 20 stages
- Rousselet-Robatel mixer-settlers: 16 and 32 stages
- DOE design mixer-settlers: 16 stages
- Miscellaneous: pulse columns, single and dual stage systems
- Over 200 stages of SX equipment in total



Flowsheet Development Approach

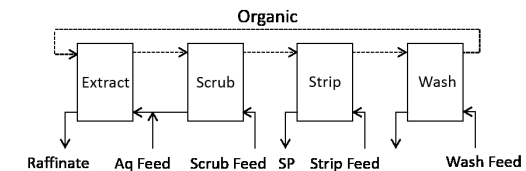


$$\frac{d(V_O \bar{C}_N + V_A \bar{C}_N)}{dt} = v_O \bar{C}_{N-1} + v_A \bar{C}_{N+1} - v_O \bar{C}_N - v_A \bar{C}_N$$



**Governing SX
Mass Balance
Model**

Chemistry Modules

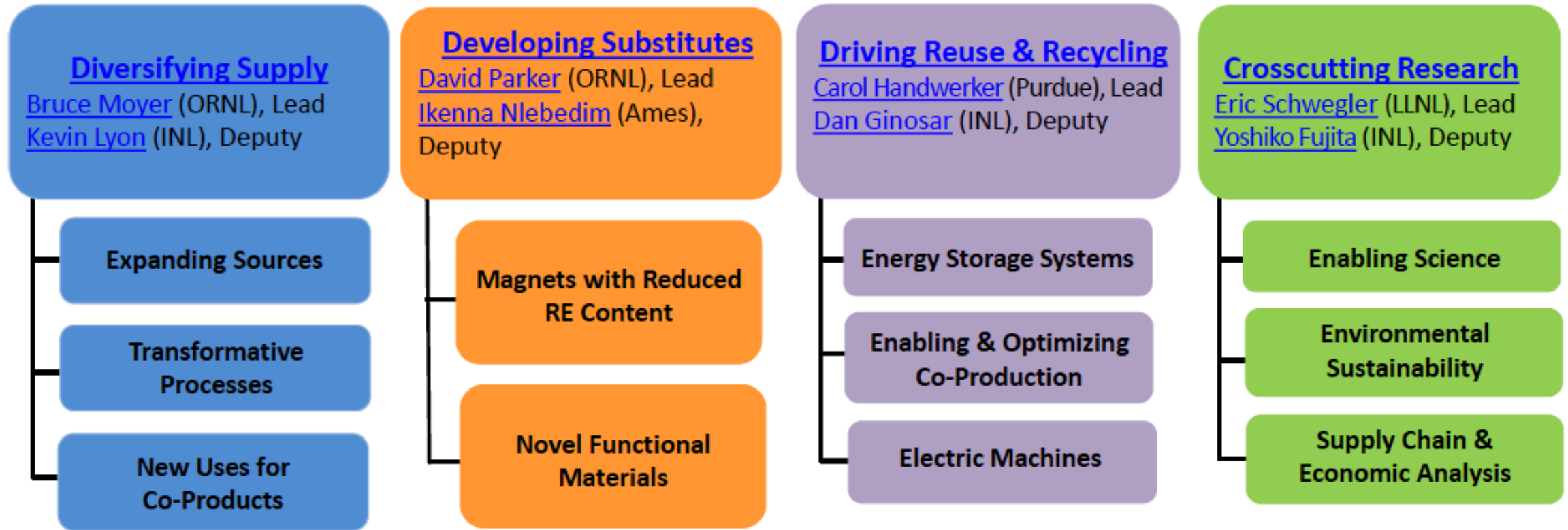


Flowsheet Design



Testing and Validation

CMI Organization (Phase II, 2018-2023)



Industry, Academia, and National Laboratory Partnerships

- Adjacent Rare Earth Element Separations
 - MP Materials, Mountain Pass
 - Cytec Solvay Group
 - Energy Fuels
 - Marshallton Research Laboratories
 - Oak Ridge National Laboratory
 - Colorado School of Mines
- Lithium extraction and recovery
 - Rio Tinto Borates
 - All American Lithium
 - Oak Ridge National Laboratory
- Rare Earth Recovery from Phosphate Ore Processing
 - Florida Industrial & Phosphate Research Institute
 - J.R. Simplot Company
 - The Mosaic Company
 - Oak Ridge National Laboratory
 - UT Knoxville



Idaho National Laboratory

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