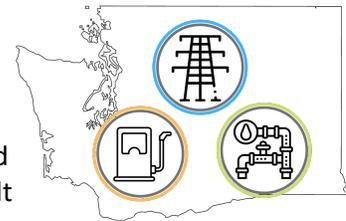


# The Consortium for Hydrogen And Renewably Generated E-Fuels (CHARGE) *Making Washington State a Global Hub for Commercializing Alternative Fuels*

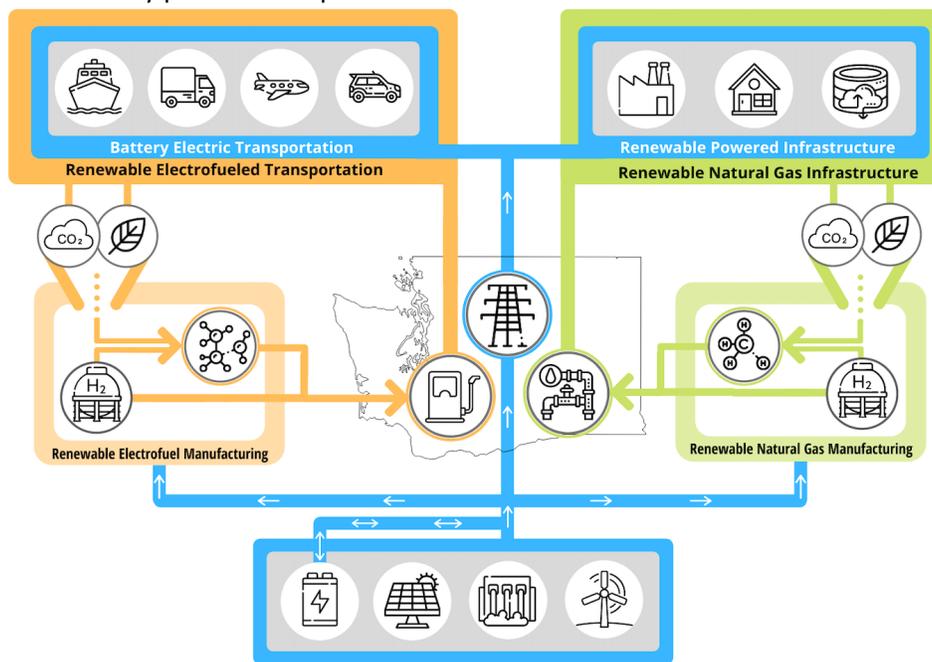
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**The Challenge:** From transportation to energy infrastructure to cloud computing, our global economy relies heavily on carbon-emitting fossil fuels and critical materials. Critical materials are imported from only a few places, are rare within the earth’s crust or mined using practices that harm humans and the environment, but these materials underpin the technology that is needed to support our energy economy. These issues with critical material sourcing weaken our supply chains and increase economic dependency. We must avoid critical materials for a sustainable clean energy built on earth abundant alternatives. Furthermore, the current focus for decarbonizing our energy sector is heavily reliant on electrification and battery-based energy storage. While electrification is an important next step towards reducing CO<sub>2</sub>, the limitations of this technology will prevent us from reaching our deep decarbonization goals. The next step must include a hybrid solution that merges electric energy infrastructure with hydrogen and other alternative renewable electricity-derived fuels (e-fuels).

As in most of the world, Washington State’s economy is powered by three sources of energy: electricity, liquid fuels for transportation, and natural gas fuels for heat and power. Over 40% of Washington State’s CO<sub>2</sub> emissions are derived from transportation related emissions alone. We need to decarbonize these energy sources with technology and supply chains built on recycling and earth abundant materials.



**The Solution:** In the proposed future ecosystem illustrated below, **electricity**, **liquid fuel**, and **gas fuel** all play major parts. Abundant renewable electricity is the foundation, and it feeds the power grid where electricity can also be stored in batteries or other energy storage systems to supply power when renewables are unavailable. In most cases, renewable electricity can power transportation, buildings, agriculture, and industry as shown by the **blue** lines, but in certain instances fuel is needed and will produce CO<sub>2</sub> emissions. However, in this new model, CO<sub>2</sub> doesn’t remain in the atmosphere. It is either captured or consumed by plants which provide bio-sources of carbon to e-fuel manufacturing.



Certain parts of our transportation network (e.g., aviation, freight, or long-haul trucks) depend on **liquid fuels** (currently fossil fuels), and existing natural **gas fuel** infrastructure provides seasonal stability and backup power but both sectors emit unacceptable levels of CO<sub>2</sub>. Instead of abandoning these parts of our economy, they can be decarbonized. Hydrogen produced from renewables can be used directly as fuel, mixed with natural gas, or reacted with recycled carbon containing feedstocks like CO<sub>2</sub> or bio-derived hydrocarbons in electro-fuel plants shown in **orange** and **green** boxes. Powered by renewable electricity, these electro-fuel plants need clean hydrogen and recycled carbon (CO<sub>2</sub> or bio-carbon sources like ethanol or methanol) to produce low carbon electro-fuels which function just like jet fuel, diesel, or natural gas in existing infrastructure. High value low-carbon electro-fuels may even be exported.

**We Start in Washington State:** Washington State is the ideal place to launch the pilot programs that will propel us into this new economy. Because the state's energy grid is already powered by clean, abundant, and low-cost electricity from hydro-electric and renewable sources with very little reliance on fossil fuels, our state is one of the best places in the world to produce green hydrogen. Launching this proposed new solution will require a broad combination of expertise involving, chemical catalysis, systems integration, cryogenic hydrogen, hydrogen safety, grid management and sustainable materials development. Washington State University (WSU), having world leading expertise in all of these areas, is uniquely positioned to lead the CHARGE consortium.

Given the combination of regional infrastructure, expertise, and engaged industries, the Pacific Northwest is an ideal launchpad for this burgeoning new economy. Our local aerospace, truck, and ship manufacturers along with our regional power industry are all ideal partners for pilot programs in the development of new electro-fuels for existing technology or deployment of green hydrogen-powered transportation options. As the cloud computing capital of the world, local tech companies will ensure that the thriving data economy is built on clean energy and earth abundant supply chains free from the challenges of critical materials. Washington State utilities are progressive innovators that are already active in this space. Between local ports and e-commerce, our state is poised to decarbonize global shipping and logistics operations. Our research institutions are second to none in their ability to deliver innovative earth abundant solutions, and the entrepreneurial spirit of local investors and startups is vibrant and ready to bring these new technologies to manufacturing scale.

**CHARGE- A new consortium for research and pilot demonstration projects:** WSU has the intellectual capital and state-wide reach necessary to advance cutting edge research towards the high technology readiness levels (TRL) needed for adoption. Bringing together the private sector in collaboration with PNNL, utilities, Public Utility Districts, and others across the state, we aim to develop and deploy new technologies in the emerging hydrogen and e-fuels economy.

The consortium starts with dedicated faculty participants in key technology areas including:

- Chemical Engineering: earth abundant catalysts, reaction engineering, and process innovations
- Materials Science Engineering: earth abundant materials and electrochemical conversion
- Mechanical Engineering: hardware design, hydrogen and e-fuel management
- Civil Engineering: site planning, construction management
- Power Systems Engineering: grid reliability, optimization, and transportation platform integration

Faculty will commit their own intellectual and physical assets to a consortium database that can be leveraged across members. We encourage membership from other universities and Pacific Northwest National Lab (PNNL). We will seek private sector partnerships from the outset to match company resources with academic and national lab assets focused on achieving objectives in pilot scale demonstration projects. WSU will simplify and standardize intellectual property agreements within the consortium to support and accelerate commercialization objectives.



The consortium seeks commercialization partners in the following sectors:

- Transportation: marine, aviation, shipping, trucking, and personal transport OEMs with a focus on long term deep decarbonization
- Harvesting: agriculture, fishing, logging, and mining with the goal of long-term sustainability and circular carbon economies
- Cloud Computing: companies interested in alternate fuels for decarbonizing the cloud
- Utilities: focus on deploying and managing low cost or excess clean energy assets towards hydrogen or fuel production which is sold or used for long term energy storage and reintroduced to the grid
- Process Engineering: firms dedicated to innovative chemical engineering and process scaleup
- Chemical and Materials Manufacturing: companies that will commercialize new processes for hydrogen or fuel/chemical production and materials needed to enable efficient processing

After identifying potential partners for pilot programs, we will organize a series of launch meeting to collect feedback, develop project ideas, and form collaborations to address future funding opportunities.

**Our Immediate Focus:** The priorities as we move forward include:

- **Producing low-cost clean hydrogen** is the starting point. Hydrogen can directly power transportation, act as an energy storage medium for power balancing on the grid, and also serve as a feedstock for sustainable fertilizer and low carbon e-fuels.
- **Scaling e-fuel technology** by combining CO<sub>2</sub> or bio-feedstocks with hydrogen (from splitting water with clean electricity) to power parts of the economy that are not easily run on batteries including:
  - Aviation fuel where medium and long-haul flights are very unlikely to be battery powered
  - Diesel fuel substitutes for trucking when long-haul truck routes make EV solutions impractical
  - Non-fossil derived fertilizers to eliminate natural-gas-based hydrogen in ammonia production
  - Fuel for ships such as liquid hydrogen, liquid natural gas, or hydrocarbon electro-fuels
- **Reducing the cost of e-fuel** technology to add seasonal stability to renewables with existing infrastructure e.g., clean hydrogen and zero-carbon methane in current natural gas pipelines
- **Scaling renewable generation capacity** in an economical and operationally reliable way to meet increased customer demands from electric vehicles and from proposed hydrogen and e-fuel systems
- **Utilizing renewable generation capacity** to power electro-fuel-based transportation and non-electric sectors and enable Washington to become an exporter of zero-carbon electro-fuels
- **Offering Hands-on Hydrogen safety training and certification** during course offerings at WSU
- **Developing earth-abundant technology** to ensure sustainable supply chains for all of the above

**Join the Partnership:** WSU has already made substantial progress and we want you involved.

1. **We want your thoughts and your time:** We are making connections in the transportation, energy, and technology sectors. We aim to form the teams, ideas, and project plans that result in winning proposals. Industry, researchers, government agencies, and startups are welcome. The following WSU centers will act as founding members and their network will catalyze the CHARGE Consortium:
  - JCDREAM – Joint Center for Deployment and Research in Earth Abundant Materials
  - HYPER – Hydrogen Properties for Energy Research
  - ESIC – Energy Systems Innovation Center
  - ASCENT – Aviation Sustainability Center
2. **We will help match your funds to win proposals:** CHARGE will rely on a consortium funding model for matching grants. By building and aligning partnerships, we aim to leverage existing WSU funding, member capital, and intellectual assets to grow our scope and help bridge the gaps in hydrogen and electro-fuels. The CHARGE consortium will host a launch event in April to develop consensus on our focal points, identify consortium funding, and align collaborators for pilot projects aimed toward future funding opportunities.

