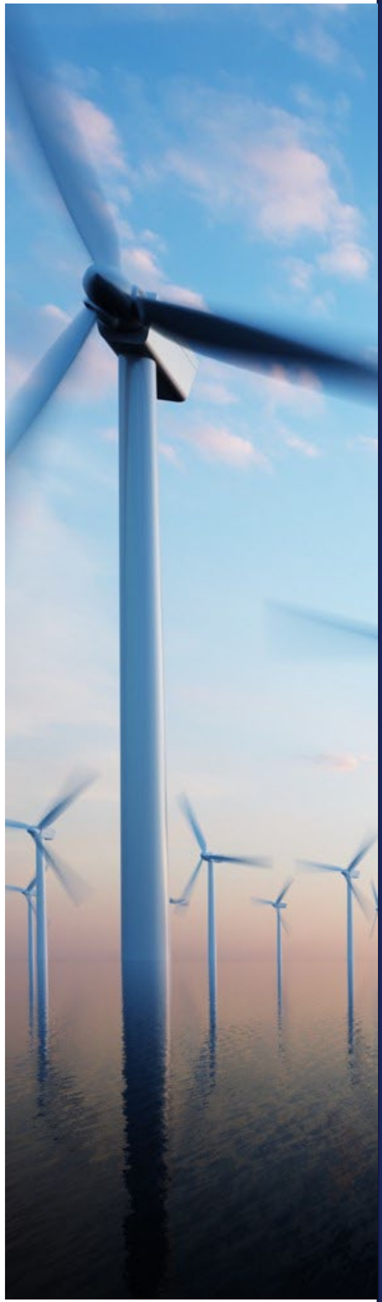

LOW-CARBON FUELS POLICY DESIGN

Dan Esposito
Fuels & Chemicals Policy Lead

Prepared for Oregon Department of Energy

April 30, 2025

ENERGY INNOVATION
POLICY & TECHNOLOGY LLC

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- Non-partisan energy and climate policy think tank
- Our work is based on scientific assessments of climate change
- We provide customized research and policy analysis to support policy design that reduces emissions at the speed and scale required for a safe climate future
- We are working towards a climate safe future where people and the planet thrive
- Our technology-neutral policy recommendations are grounded in data, driven by our open-source and peer-reviewed Energy Policy Simulator model and our climate policy book, *Designing Climate Solutions*
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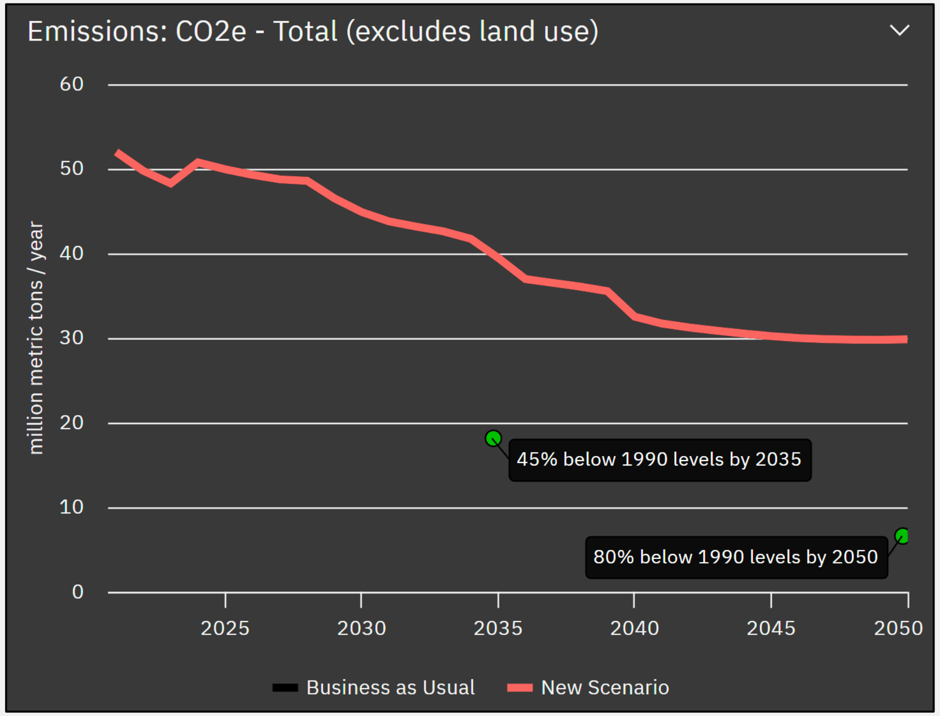
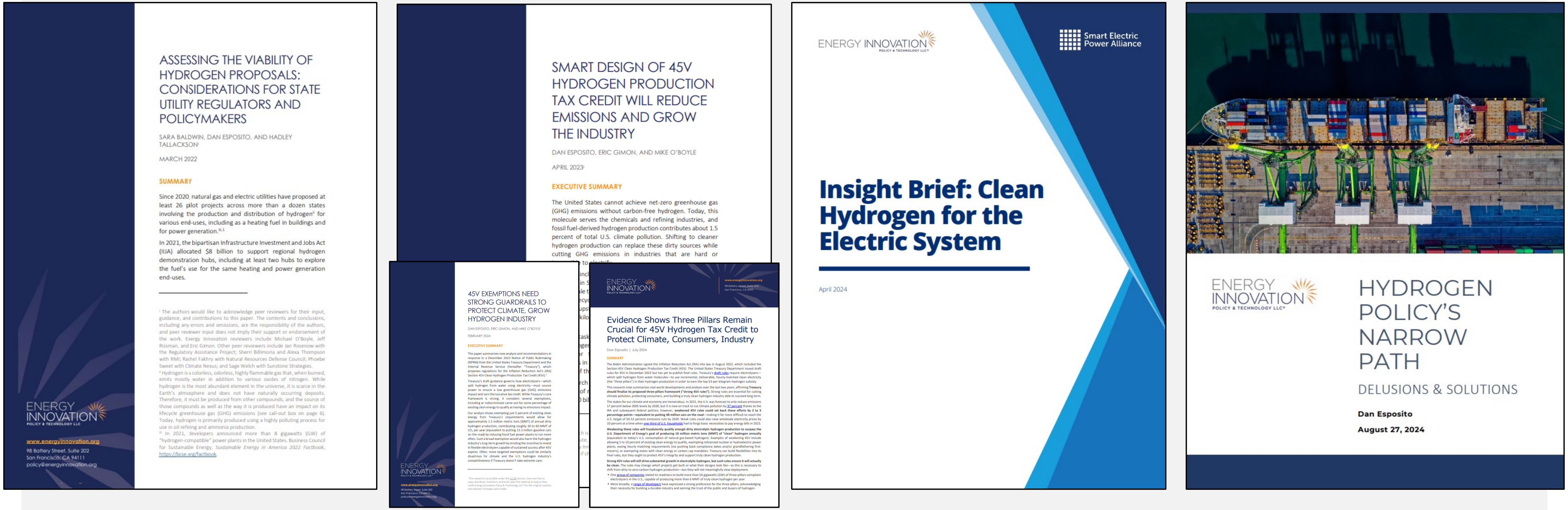


https://energypolicy.solutions/home/oregon/en

Energy Innovation's Key Hydrogen Papers



Disclaimer

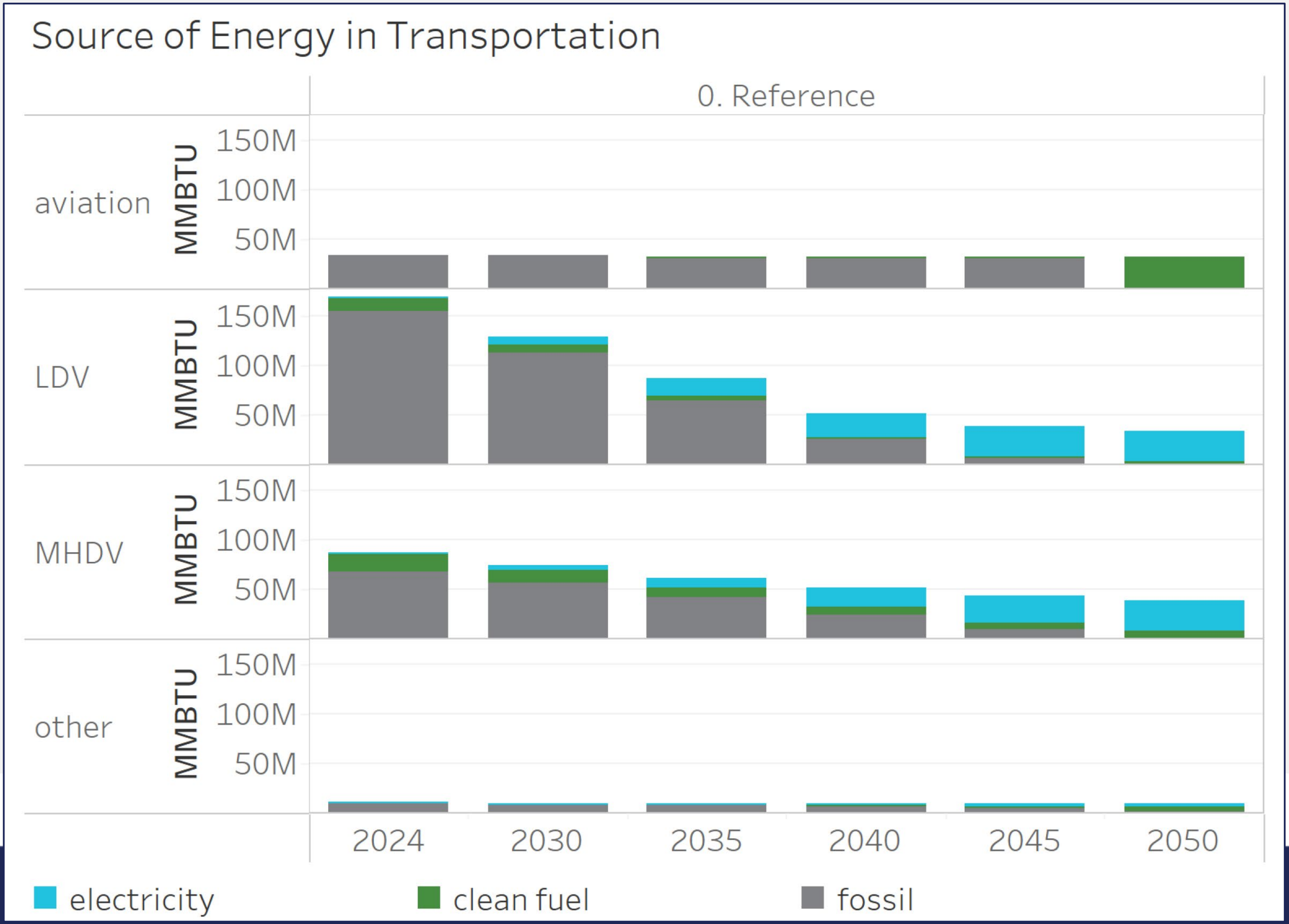
- This slide deck represents a non-exhaustive review of relevant low-carbon fuels (LCFs) research, questions, and example policies
- The inclusion of any given example policy does not imply an endorsement or recommendation from Energy Innovation, unless otherwise stated

Agenda

- Guiding principles for smart low-carbon fuels policy design
- Example LCF policies
  - *LCF Growth*
  - *Electric Sector*
  - *Electrification*
  - *Gas Transition*
- Discussion

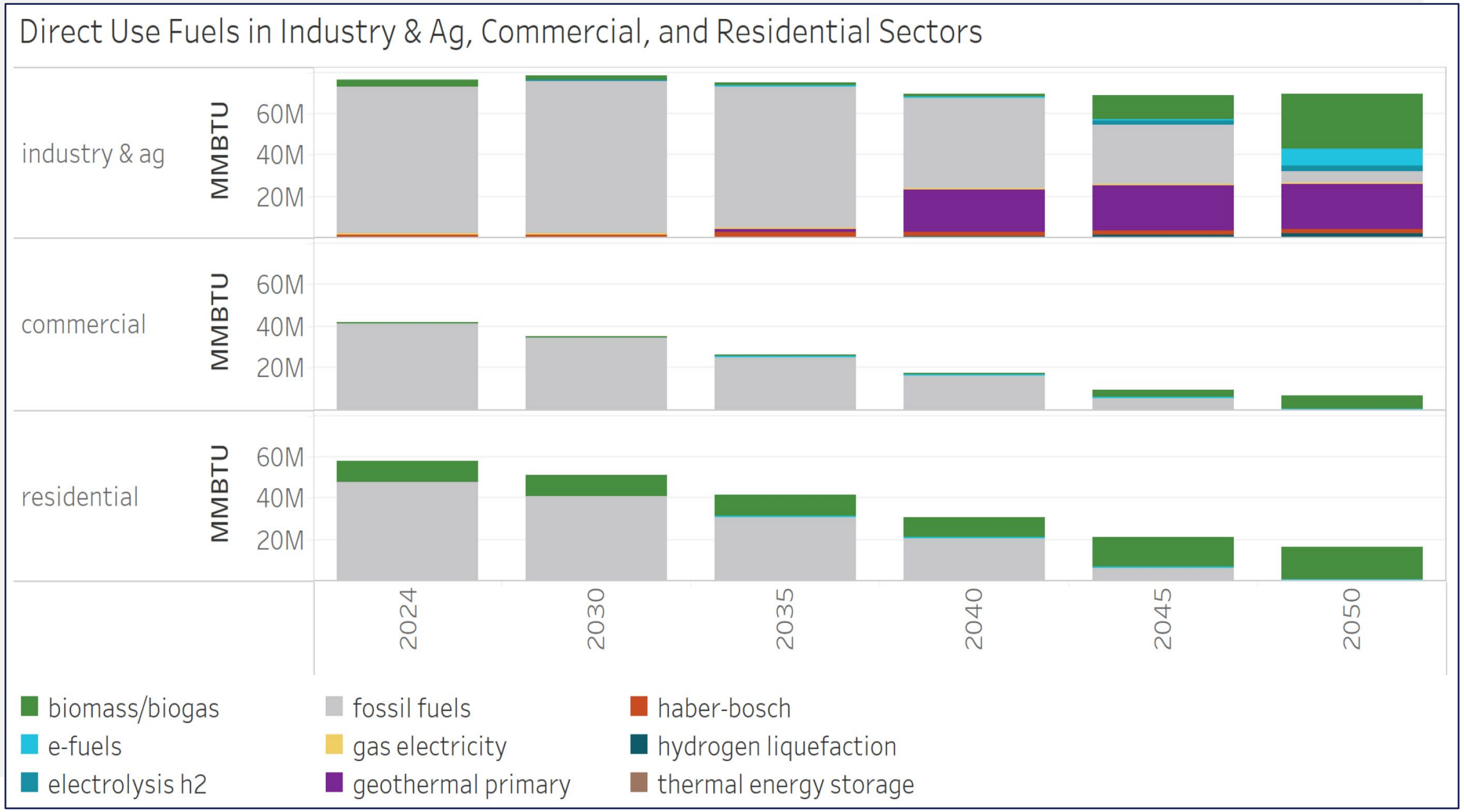
Modeling Refresher (Evolved Energy Research)

- Ground vehicles are overwhelmingly electrified



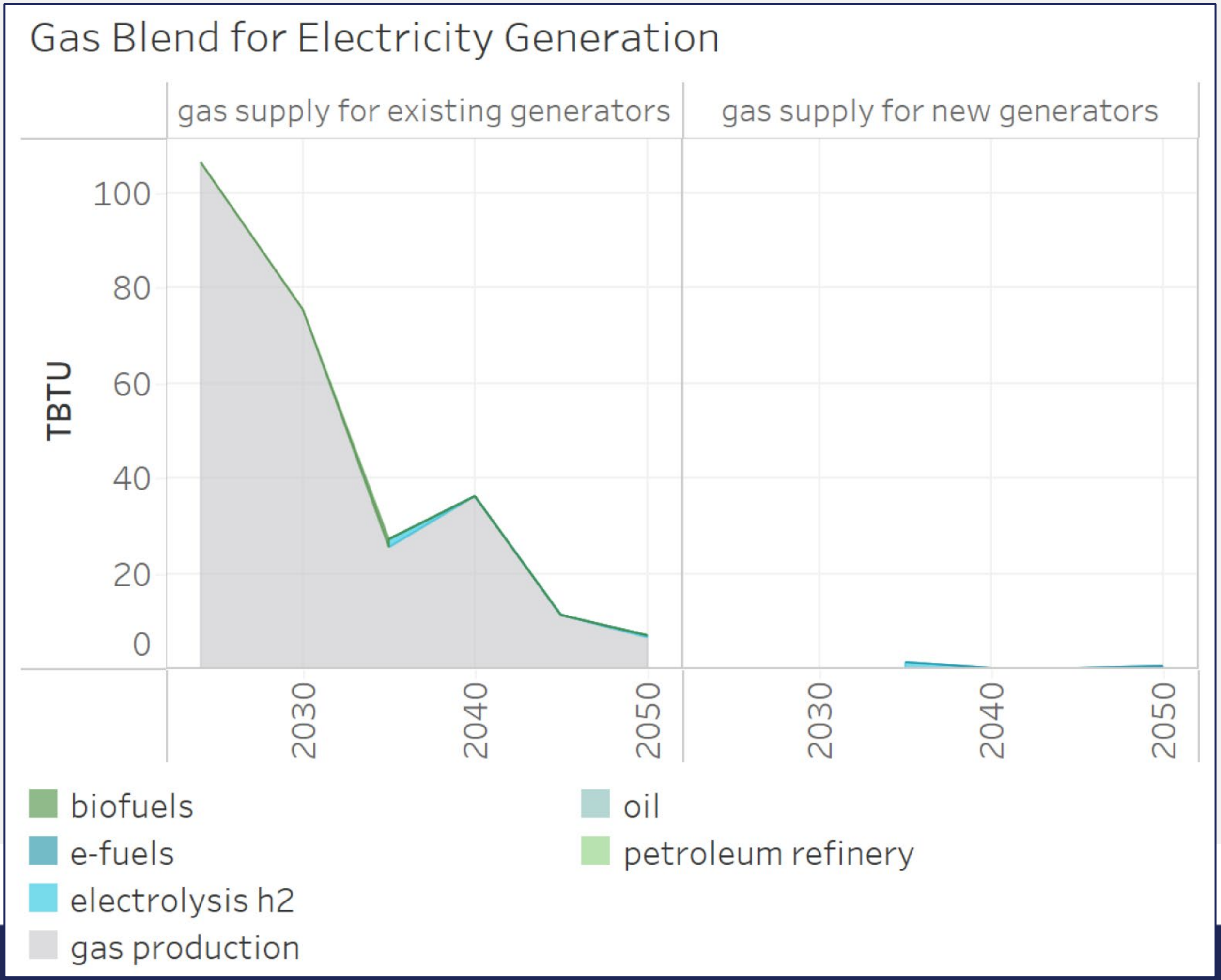
Modeling Refresher (Evolved Energy Research)

- Ground vehicles are overwhelmingly electrified
- Gas distribution volumes (for buildings) fall substantially and don't use hydrogen
- Industry uses a wide range of LCF options



Modeling Refresher (Evolved Energy Research)

- Ground vehicles are overwhelmingly electrified
- Gas distribution volumes (for buildings) fall substantially and don't use hydrogen
- Industry uses a wide range of LCF options
- Electric sector LCFs are all about capacity / timing, not volume



Guiding Principles: Landscape Analysis Lessons

- It's very easy to design LCF policies that have little-to-harmful climate impact, are difficult to unwind (i.e., have strong political inertia and infrastructure lock-in), and otherwise do not set jurisdictions up for long-term success
- Policymakers should aim to implement policies in the near term that will develop the needed LCFs and LCF-using technologies, where and when they are needed
  - But, in the grand scheme of climate policy, LCFs should take a back seat to efficiency and clean electrification given the latter's cost-effectiveness across all domains where they are applicable (e.g., buildings, ground transport)
  - It should be a red flag if a policy promotes LCFs over efficiency and/or clean electrification, even if ostensibly on a technology-neutral "level playing field"
- In lieu of shining examples to follow, it will be important to judge policy designs against a set of principles, making adjustments as needed

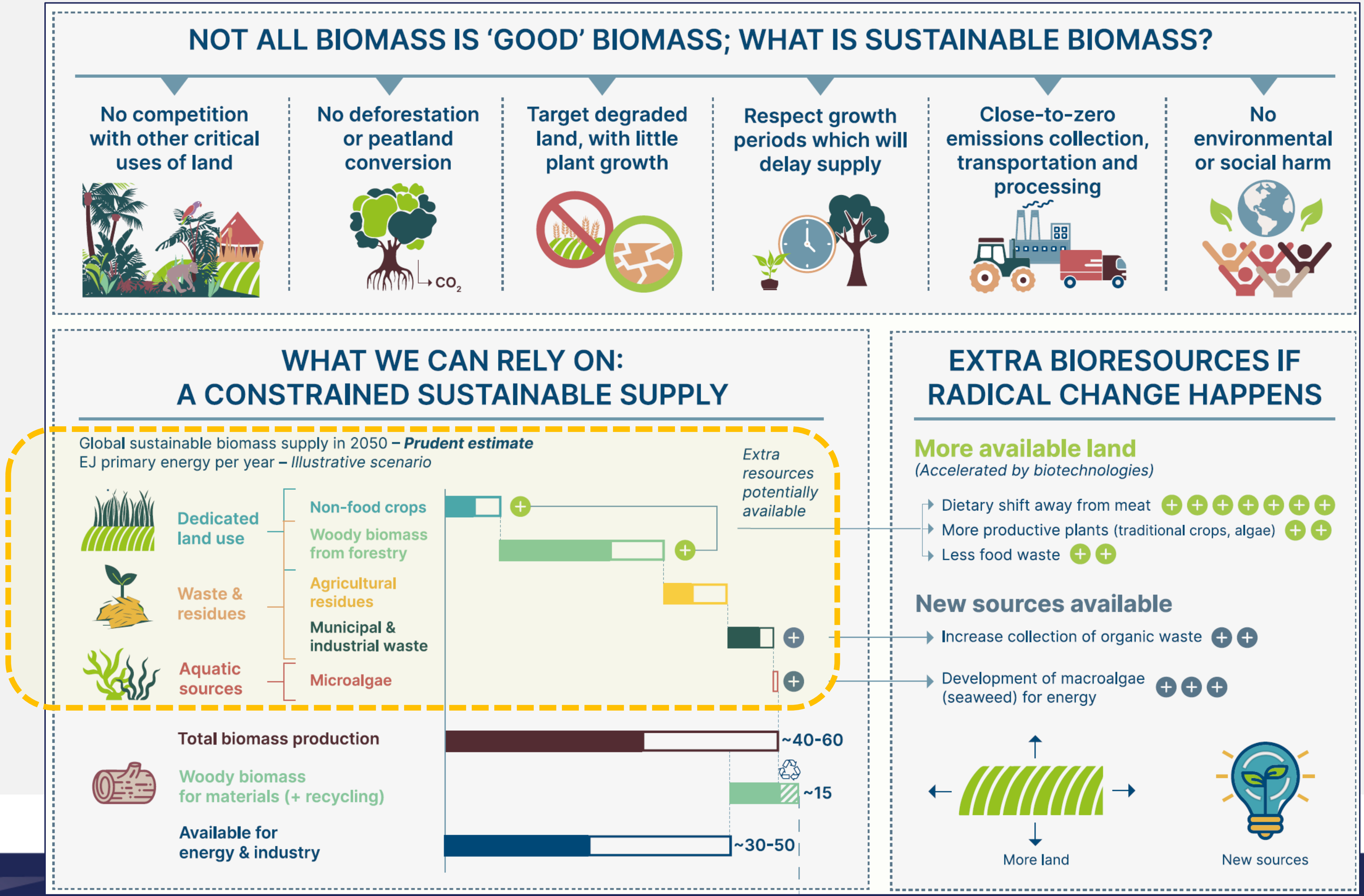
Guiding Principles: Overview

Policy should support truly clean and sustainable LCF production:

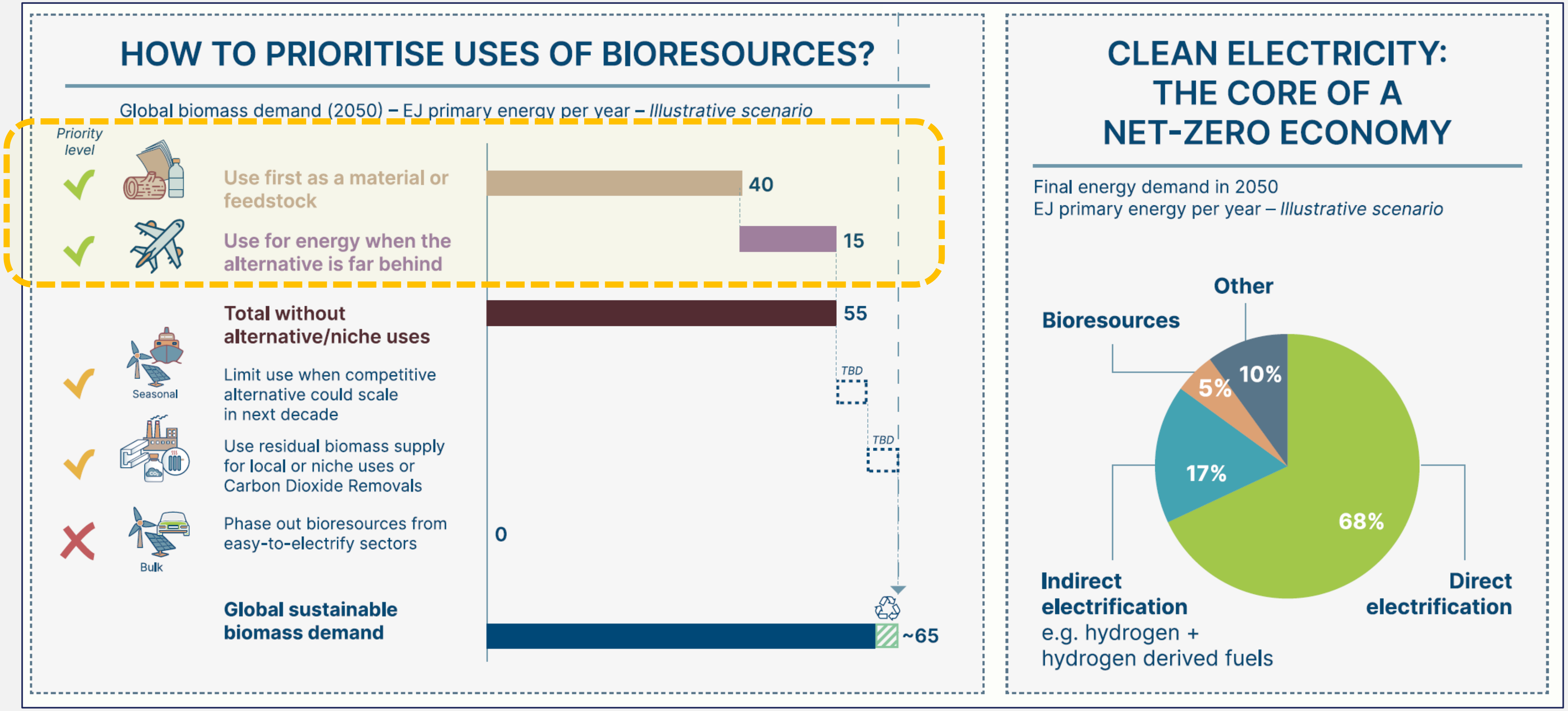
- Support sustainable biofeedstocks (e.g., waste biomass, cellulosic biomass) with conservative carbon intensity assumptions—while ensuring incentives do not motivate the generation of extra waste
- Cap or gradually phase out support for first-generation biofeedstocks (e.g., food crops, oils, trees)
- Prioritize truly clean hydrogen production (i.e., three-pillars electrolysis)

Policy should support LCF uptake in high-value applications and protect against its use in low-value applications:

- Bioresources should largely be limited to materials, chemicals, and aviation fuel
- Hydrogen should largely be limited to refining, chemicals, steel, aviation fuel, and marine shipping fuel (ammonia or methanol)
- Bioresources and hydrogen may have niche applications elsewhere, such as dispatchable power generation (very low capacity factors) and some instances of high-temperature industrial heat

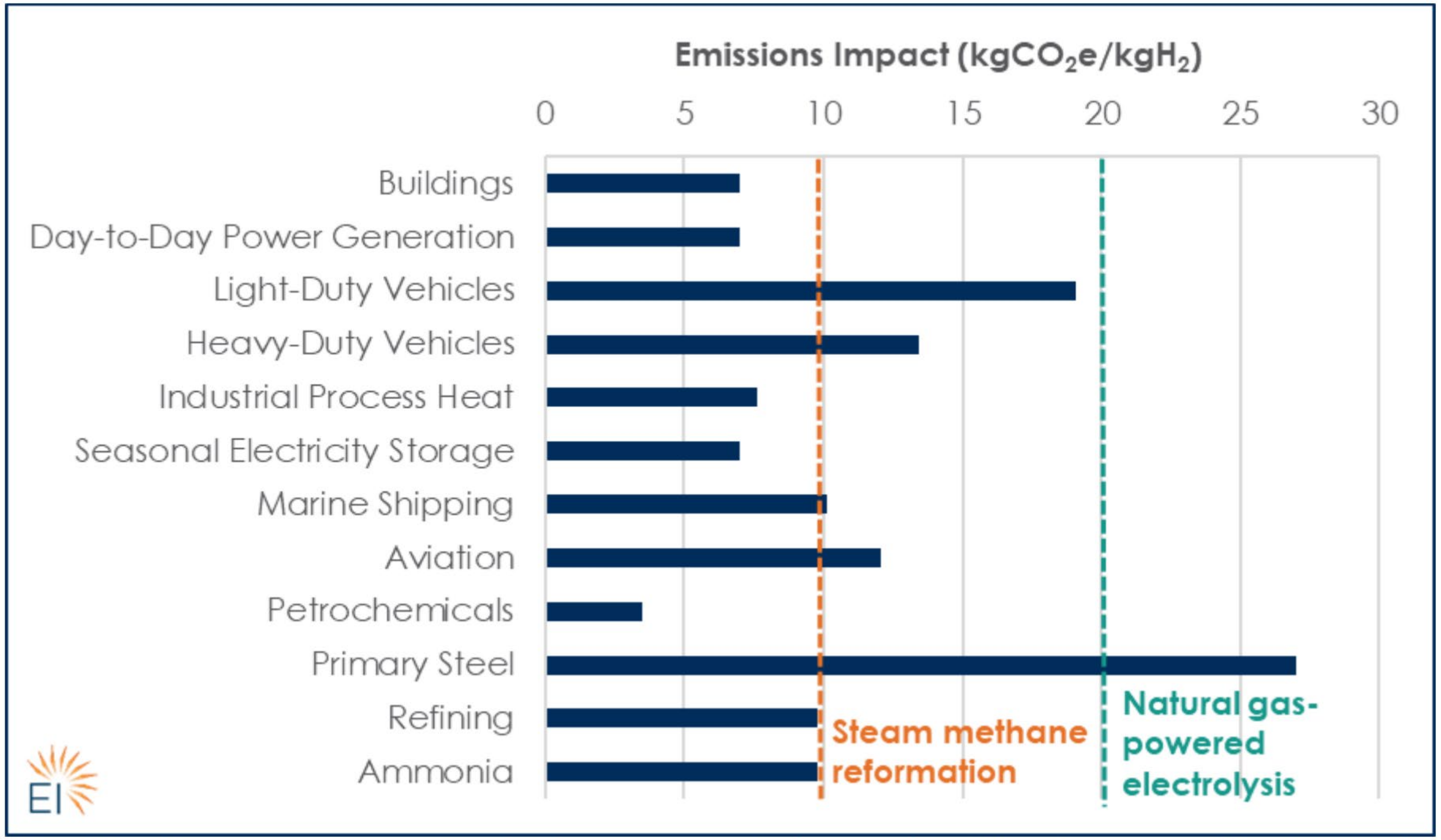


https://www.energy-transitions.org/wp-content/uploads/2021/07/ETC-bio-Report-v2.5-lo-res.pdf



https://www.energy-transitions.org/wp-content/uploads/2021/07/ETC-bio-Report-v2.5-lo-res.pdf

***Figure 4. Net climate pollution impact from hydrogen production and use*[vii]**



The blue bars represent the GHGs that would be avoided by the use of hydrogen in place of the incumbent fossil fuel for each application. The dashed lines represent the GHGs that would be emitted by today's hydrogen production (orange) and by electrolysis if not using new, deliverable, hourly matched clean power (turquoise).

Hydrogen's competitive prospects for decarbonization by end-use sector

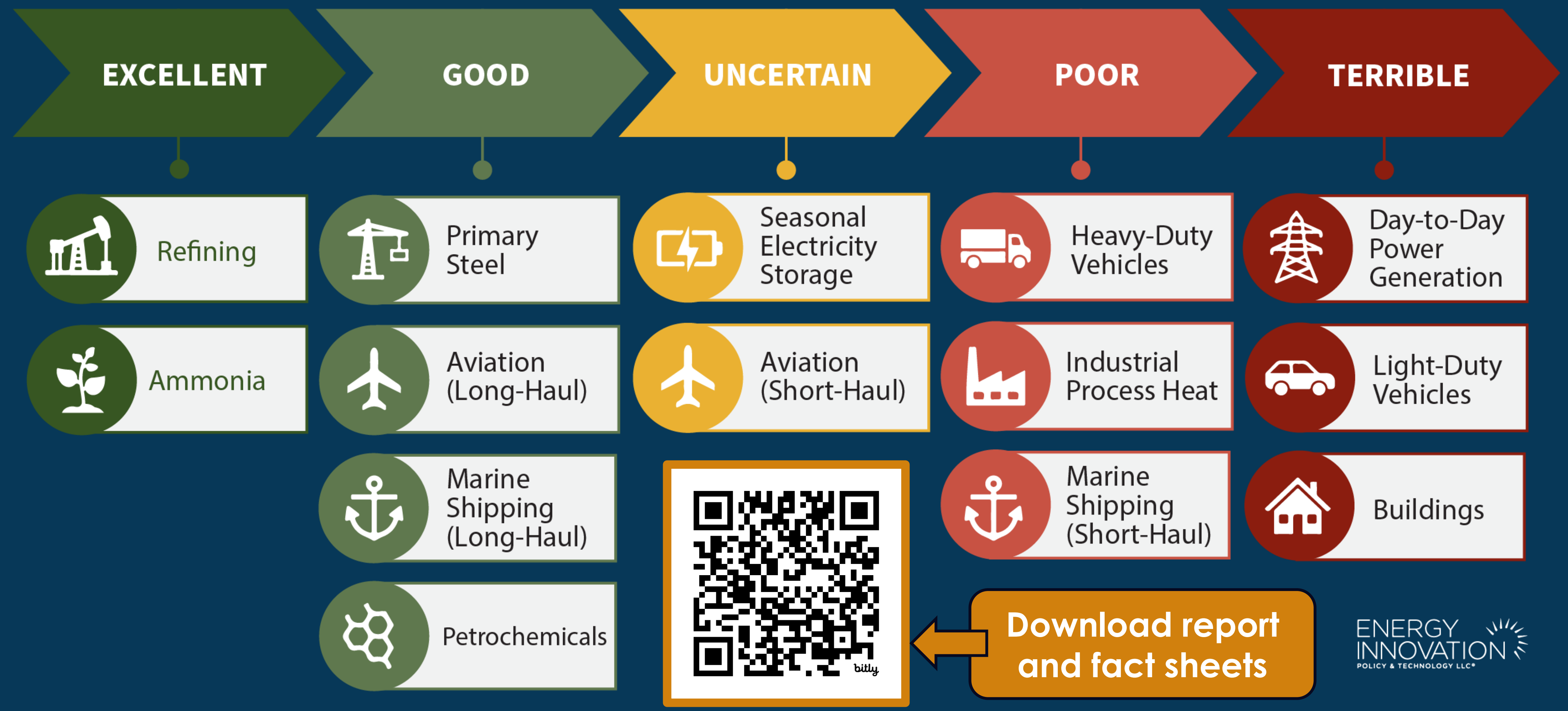
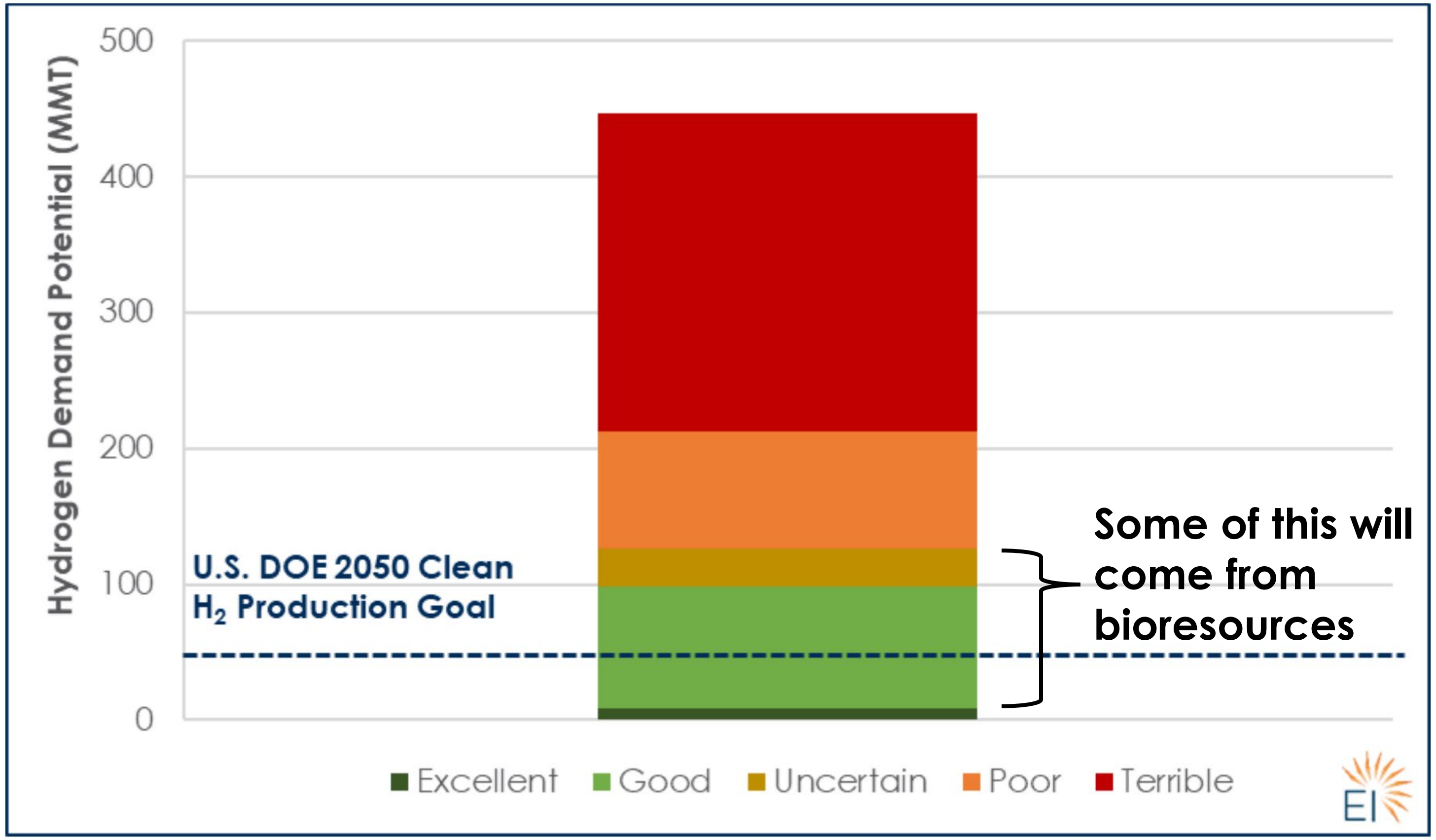


Figure 6. U.S. hydrogen demand potential by prospect category



The hydrogen demand potential for high-value uses ("excellent" and "good") is approximately double the DOE's 2050 clean hydrogen production goal—meaning achieving a net-zero economy by 2050 will likely require directing hydrogen to these high-value uses while also relying on alternatives (e.g., efficiency, biofuels).

https://energyinnovation.org/report/hydrogen-policys-narrow-path-delusions-and-solutions/

H2 Analysis Qualitative Takeaways

Hydrogen's low-value uses are all when used for energy, while its high-value uses are all when used as a feedstock

Hydrogen's low-value uses are much more dependent on the development of sprawling hydrogen pipelines and end-use equipment than its high-value uses

Hydrogen's low-value uses often increase the risk of social harms and inequitable outcomes, while its high-value uses generally do the opposite

Hydrogen's uptake in high-value uses will require targeted demand-side policies—supply-side subsidies alone will not ensure this outcome (and may make better alternatives for low-value uses look worse)

H2 Policy Recs: Boosting H2's High-Value Uses

- Advance market commitments (AMCs)
- Contracts for difference (CfDs)
- Reverse auctions
- Subsidies for end-use equipment or utilization
- Research and development (R&D) support for emerging technologies
- Performance standards

H2 Policy Recs: Minimizing H2's Low-Value Uses

- Focus midstream infrastructure on tight industrial clusters
- Require a high burden of proof of value and community benefits agreements
- Hedge bets on hydrogen infrastructure investments
- Set rigorous health and safety standards

Example Policies Overview

[1] Targeted Low-Carbon Fuels Development and Use

[2] Dispatchable Capacity for the Electric Sector

[3] Coordinating Electrification and LCFs

[4] Decreasing Fuels Demand and Pivoting Business Models

[1] Clean Fuels Standards – Problems

Evidence suggests California's LCFS (as an example):

- Favors biofuels over electrification (e.g., ~80% of credits have gone to biofuels)
- Causes environmental harm by:
  - Primarily supporting crop-based fuels (driving land use change)
  - Crediting biofuels that would have been produced regardless
  - Awarding deeply negative CI scores to dairy biogas instead of regulating in-state methane emitters – encouraging larger herd sizes and poor practices
  - Incentivizing the shipping of waste lipids from across the world
- Raises retail fuel prices for consumers and businesses

[1] Clean Fuels Standards – Recommendations

Make adjustments as to what can qualify for the CFS (and to CI accounting):

- Cap crop-based biofuel, lipid, and biogas credits, disallow palm oil, and require biogas to be delivered in state
- Update CI scores with latest best evidence (incl. for biogas counterfactual)
- Increase funding for electric vehicle charging infrastructure (incl. heavy-duty)

Make adjustments that help direct biofuels to sectors that will need it long term:

- "Designate intrastate aviation fuel as a mandatory reporting fuel and explore stricter regulation options," especially for intrastate flights (RMI)
- "Designate maritime fuel as an opt-in fuel with a defined ramp-up" (RMI)

Ideally bioresources would go ~exclusively to materials, feedstocks, and aviation

[1] Production of Sustainable Bioresources

COLORADO: Wood to Energy Program

- Provides technical assistance and education on wood-to-energy opportunities in Colorado
- Related programs (e.g., Wildfire Risk Mitigation Loan Fund) provide funding for select projects
- **Good** to collect wood waste, and worth exploring uses in wood products, composting or mulching, biochar, and conversion to chemicals
- **But**, need to guard against overharvesting or poor forest management, and wood for energy can drive substantial local air pollution

MINNESOTA: Bioincentive Program

- Uses incentive payments to boost the production of "advanced biofuels, renewable chemicals, and biomass thermal energy"
- Requires that agricultural and forestry biomass is harvested in "ways that do not harm the environment"

[1] Industrial Fuel-Switching (Priority)

Priority policies to promote industrial fuel-switching (to electricity or LCFs)

Option	Examples
Carbon price and/or standards limiting GHG emissions from industrial processes	• EU Emissions Trading System + CBAM • EU Renewable Energy Directive (RED) III • South Coast Air Quality Management District (SCAQMD) Rule 1146.2
Policies to lower the cost of clean electricity	• Feed-in tariffs, clean electricity standards, government auctions for renewables, green banks, …
Production tax credit / subsidy for cleanly manufactured products	• Carbon contracts for differences (CCfDs) in EU/Germany • Stimulation of sustainable energy production and climate transition (SDE++) in the Netherlands

[1] Industrial Fuel-Switching (Ancillary)

Ancillary policies to promote industrial fuel-switching (to electricity or LCFs)

Option	Examples
Grants for pilot and demonstration projects	• U.S. Industrial Demonstrations Program (IDP) • Japan Green Innovation Fund • Pilot and demonstration projects in China
Investment tax credit for industrial decarbonization projects	• U.S. 48C Advanced Energy Project Credit
Loans and loan guarantees for early deployments	• U.S. Loan Programs Office (LPO) Title 17 Clean Energy Financing Program (CEFP)
Standard on the GHG-intensity of fuel production	• Germany GHG Reduction Quota (THG Quota) • Canada Clean Fuel Regulations (CFRs)
Tax credit / subsidy for the production of LCFs	• U.S. 45V Clean Hydrogen Production Tax Credit
Workforce training and development programs	• U.S. Industrial Training and Assessment Centers (ITAC) • Australia Vocational Education and Training (VET) Program • Germany industrial apprenticeships

[1] Aviation and Marine Shipping Fuel-Switching

Challenging to decarbonize without federal support (e.g., Federal Aviation Administration has regulatory power over aviation fuel requirements) – but states can still make progress

Aviation (UC Berkeley, April 2025)

- Extend LCFS to all fuel sold in state, with carbon content reduction rate designed to not require modification to jet engines
- Use indirect source rule authority under Clean Air Act to set requirements on airports in state implementation plans
- Set and increase taxes and/or landing fees on high-carbon jet fuel, using revenue to fund SAF incentives

Marine Shipping (RMI, July 2024)

- Adjust LCFS to include fuels used by ocean-going vessels (if only for generating credits) and cap conventional biofuels
- Use targeted incentive to close cost gap, such as via tax credits for marine fuel offtakers, a sales and use tax incentive, or a contract-for-difference mechanism
- Invest in port transition planning and implementation

[2] Dispatchable Capacity for the Electric Sector

A clean electricity system in Oregon will likely rely on high shares of variable renewable energy (solar and wind) as well as hydropower. It will need resources that can provide flexibility over daily, seasonal, and multi-annual timeframes.

Dispatchable Resources

- Explore the option set with Requests for Information, Requests for Proposals, and procurement targets (see NYSERDA's efforts on long-duration storage, hydrogen, and advanced nuclear)
- Oregon's geology suggests a role for enhanced geothermal systems (ESG)

Proactive Transmission

- Explore transmission development and upgrading existing lines to bring energy from areas of high resource quality to load centers (see Texas' Competitive Renewable Energy Zone projects, research on reconductoring)

Flexible Demand

- Tariffs giving large loads access to wholesale electricity rates can promote price-responsive behavior (see controllable load resources in Texas, EDFR's Project Arete RFP)
- Energy parks can co-optimize variable generation and flexible demand (see Colorado's Comanche replacement discussion)

[2] Very Low Capacity Factor Power Plants

Policies or market frameworks to shift utility business models to support building and running gas- and clean gas-fired power plants at very low volumes as a reliability resource.

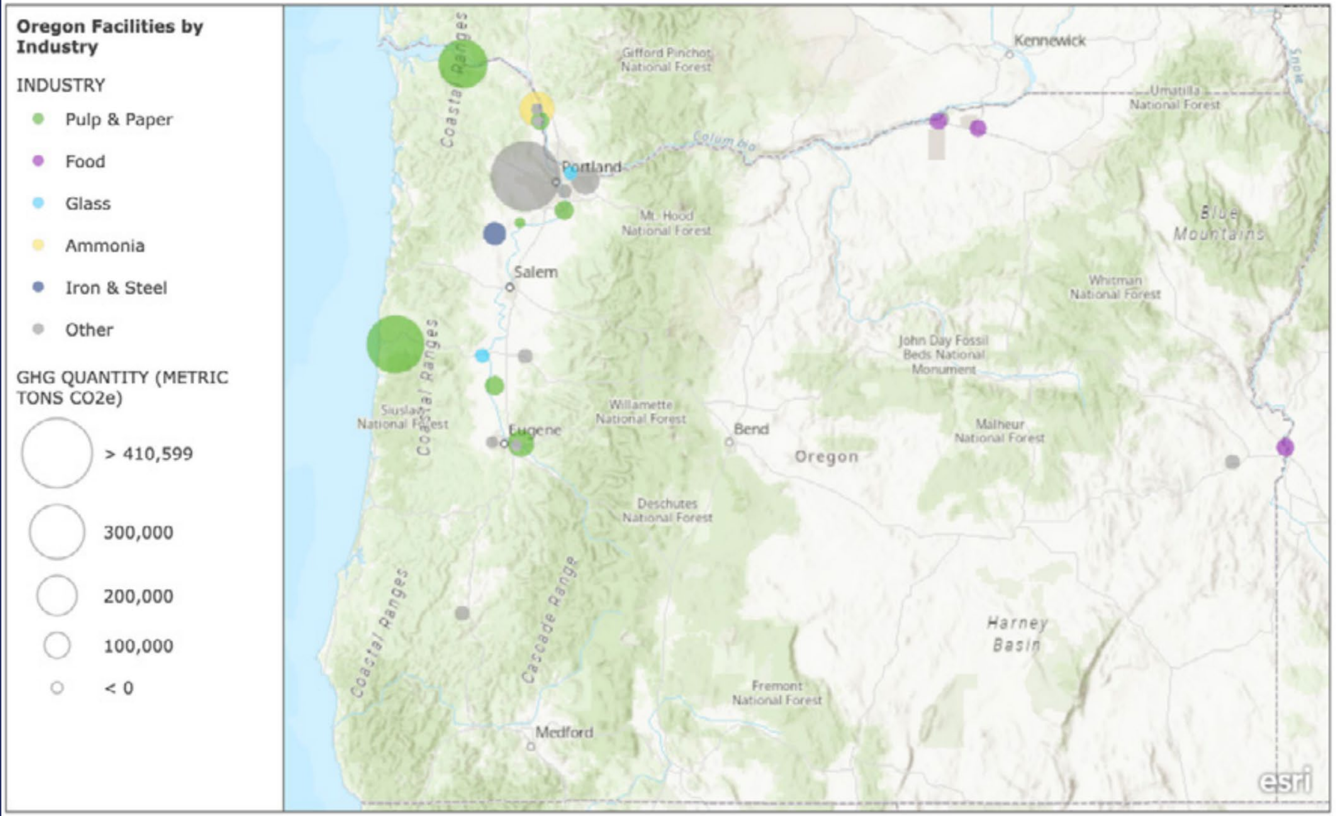
- **Strategic reserve:** compensates capacity to supply power during emergencies, but otherwise, these resources do not participate in the market **(see: Australia, Germany – p.12)**
- **Capacity investment scheme:** helps underwrite investment in clean dispatchable capacity via a long-term revenue safety net (using competitive tender bids) **(see: Australia + analysis)**
- **Coordinated gas/electric system planning:** joint planning helps arrive at the right investments (e.g., which pipelines need attention as parts of the system electrify) **(see: PJM, RAP/LBL)**
- **Resource adequacy planning:** for PNW, such planning can help navigate hydroelectric variability and drought risk, extreme weather risk (e.g., heat waves), demand growth (e.g., electrification, data centers) and opportunities for demand flexibility, and climate and carbon policy **(see: GridLab, ESIG, LBL)**

[3] Opportunities to Electrify Industry

A resource from Global Efficiency Intelligence, Renewable Thermal Collaborative, and David Gardiner and Associates assesses industrial electrification opportunities in Oregon. Key insights:

- Electrifying ammonia and pulp and paper production "can significantly reduce emissions"
- Electrifying recycled plastic, milk powder, container glass, soybean oil, cast aluminum, or beer production may "reduce energy costs per unit of production"

Includes discussion of technologies and policy recommendations.

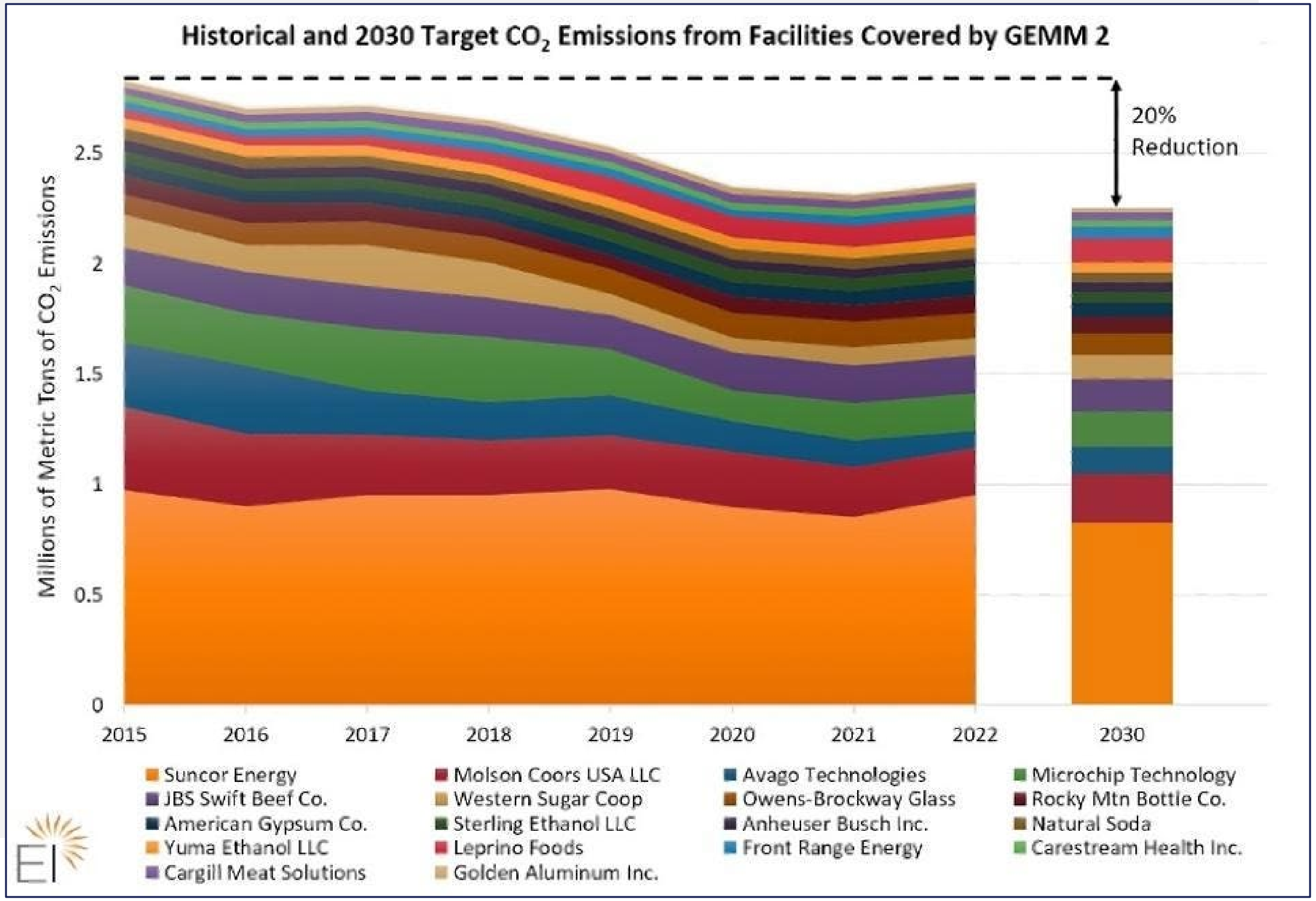


Esri, USGS | County of Crook, State of Oregon GEO, Esri, HERE, Garmin, FAO, NOAA, USGS, Bureau of Land Management, EPA, NPS

[3] Policies Driving Industrial Electrification

COLORADO: **Greenhouse Gas Emissions and Energy Management for Manufacturing (GEMM) 1 and GEMM 2 rulings**

- GEMM 2 targets 20% emissions reductions by 2030 from 2015 levels from 18 individual facilities
- Each facility has its own tailored target, but facilities must meet the goal as a group (i.e., via credit-trading)
- Facilities must prioritize on-site measures; off-site options only available if the former prove insufficient
- Recommended improvements: weight emissions reductions by production; set targets out to 2050 to provide clarity



https://www.forbes.com/sites/energyinnovation/2023/08/13/colorados-next-big-climate-solution-is-reducing-industry-emissions/

[3] Policies Driving Industrial Electrification

MASSACHUSETTS: Clean Energy and Climate Plan (CECP) for 2050 sets target for industrial and nonenergy sectors of 76% GHG reductions by 2050 (relative to 1990 levels)

- **Mass Save** commercial and industrial programs in both efficiency and electrification (1% EE increase year-over-year + electrification of 52% of final energy in industry)
- **MassDEP regulations limiting SF_6 leaks** in new equipment and scheduling a phaseout for SF_6 use in electric T&D system
- **Gas System Enhancement Plans (GSEP) Working Group** to propose legislative reform regarding gas pipelines
- **Solid Waste Master Plans** to prepare and implement in 2030, 2040, and 2050 (reduce waste disposal 90% by 2050)

Energy Efficiency	Electrification
Increases in efficiency in the sector average 1% total energy savings year over year. Efficiency remains a cost-effective way to reduce GHG emissions.	Nearly all HVAC and manufacturing machinery and about 50% of all process heat and steam production are electrified. Electricity use nearly doubles in the entire sector.
Clean Fuels	**Carbon Capture & Storage**
Total fuel use decreases by roughly 75%. Hydrogen and advanced bio-based fuel blends enable lower emissions from continued fuel use.	Carbon capture and storage technologies can be deployed at certain difficult-to-decarbonize industrial facilities as technologies improve and become more economic.

https://www.mass.gov/doc/2050-clean-energy-and-climate-plan/download

[3] Policies Driving Industrial Electrification

Industrial decarbonization incentives

Funding programs

- Colorado's Clean Air Program (CAP) Grants
- California's Industrial Decarbonization and Improvement of Grid Operations (INDIGO) program
- New York's Commercial and Industrial (C&I) Carbon Challenge
- Pennsylvania's Reducing Industrial Sector Emissions in Pennsylvania (RISE PA) program

Grant programs for energy efficiency in industrial facilities

- Maine's Commercial and Industrial Prescriptive Initiatives
- Maryland's Commercial, Industrial, and Agricultural Grant Program
- Mississippi's Industrial Energy Efficiency Program

Low-carbon building materials tax exemptions and credits

- New Jersey's purchase and use of low embodied carbon concrete
- Colorado's Exempt Eligible Decarbonizing Building Materials

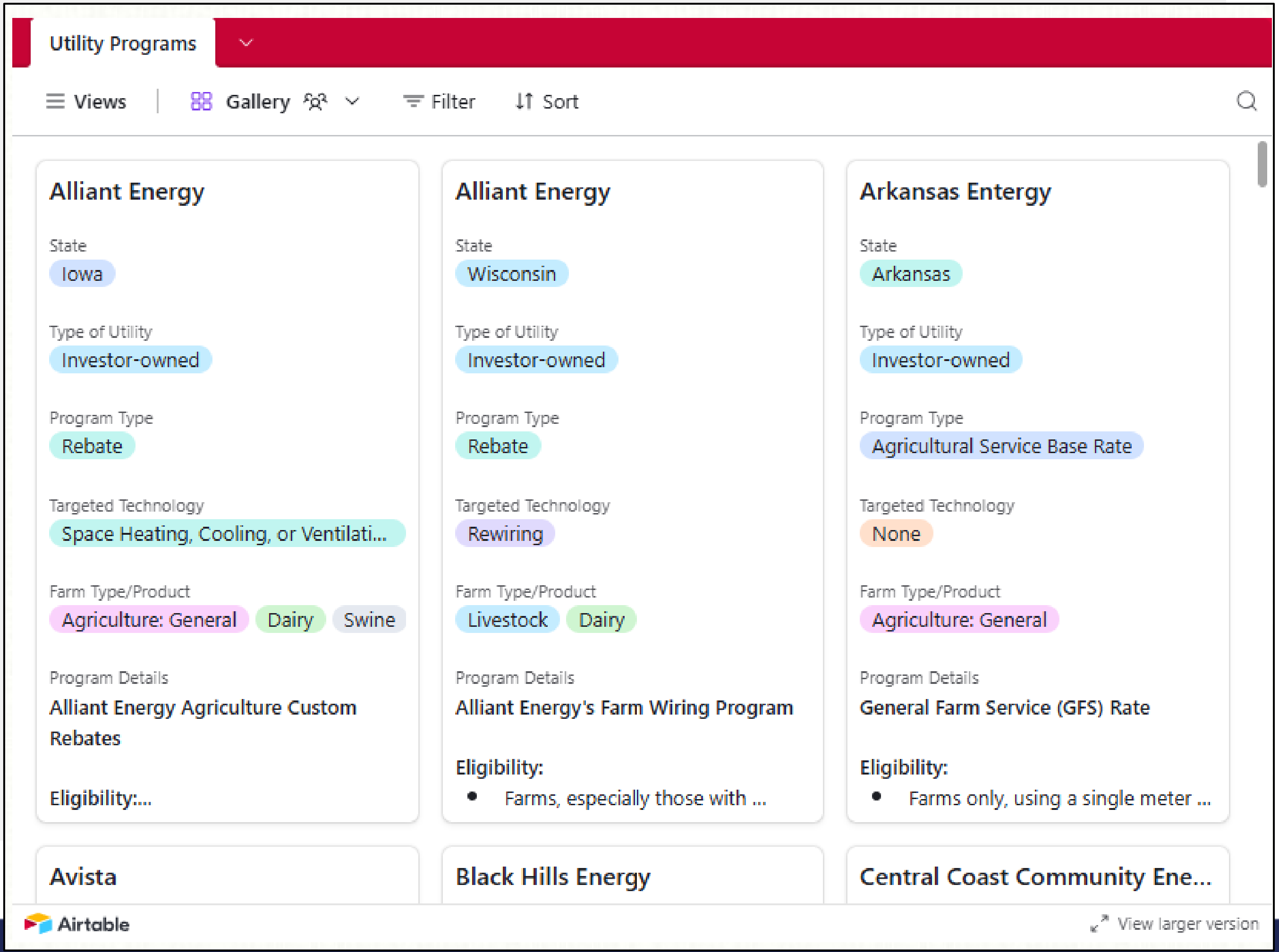
Buy Clean and Green Public Procurement programs

- Numerous states (including Oregon) have such programs
- But, materials coverage could be expanded – e.g., Oregon's program covers steel and concrete but not wood (while Washington's program does also include wood)

[3] Policies Driving Agricultural Electrification

Key resource: Farm and Energy Initiative's Agricultural Electrification Program Database

- Programs often target specific technologies like pumping/irrigation, heating, vehicles, processing, drives, etc.
- Programs typically offer discounted rate structures for ag businesses or incentives for efficiency upgrades
- Programs are primarily run by utilities and rural co-ops, but some state agencies are also involved (e.g., Connecticut grants, Michigan incentive program)
- Database includes three existing programs in Oregon



https://farmandenergyinitiative.org/projects/beneficial-electrification-in-agriculture/utility-programs/

[3] Policies Driving Agricultural Electrification

Farm and Energy Initiative's Policy Opportunities for Beneficial Electrification on the Farm (2024)

- Includes a range of case studies on utility incentives targeting agricultural end uses (pages 17-33)
- Includes detail on beneficial electrification legislation in ME and CO (pages 43-45)

Navigant's Electrified Agriculture: Best Practice Guide for Farmers (2019)

- Identifies key of making electricity cheaper than diesel – fuel costs are just as or more important than equipment capital costs
- Pairing electrification w/ distributed generation allows farms to act as microgrids

National Rural Electric Cooperative Association's Farm Beneficial Electrification: Opportunities and Strategies for Rural Electric Cooperatives (2018)

- Includes county-level indicators of the sales potential for tractor, irrigation pump, and space heating electrification (suggesting the former two could be good for Oregon)

Simple programs with intuitive webpages can help with implementation – see:

- Central Coast Community Energy's (CA) landing page on ag electrification
- Connecticut Department of Agriculture's grant programs w/ technical assistance

[3] Coordinated Electric and Gas Utility Planning

Three key resources:

- Electricity Advisory Committee's Natural Gas and Electric Critical Infrastructure Coordination: Recommendations for the Department of Energy paper (2024)
- Joint RTOs' Strategies for Enhanced Gas-Electric Coordination: A Blueprint for National Progress paper (2024)
- Regulatory Assistance Project and Lawrence Berkeley National Lab's Opportunities for Integrating Electric and Gas Planning paper (2025)

- Focused more on demand side—steps to increase coordination among electric and gas utilities as they plan their respective distribution systems in the face of greater electrification and reduced gas demand
- Such planning efforts have largely been limited to a few dual-fuel utilities where relevant service territories have significant overlap, such as Pacific Gas & Electric **(CA)**, Xcel Energy **(CO)**, and ConEdison and Central Hudson Gas & Electric **(NY)**
- Massachusetts and Washington have emerging requirements for electric-gas collaboration
  - **MA:** utilities must consider integrated planning
  - **WA:** Puget Sound Energy (dual-fuel utility) must use integrated planning (though statute has since been amended by a ballot initiative)

[4] Managing Existing Gas Network Costs

This is a nascent but important area for more research and experience.

- Starting point policies should focus on ways to **limit expansion of the existing natural gas distribution system** – for example, via:
  - **Eliminating subsidies for natural gas line extensions and new gas hookups** (e.g., CA, though looks like Oregon has already done this)
  - **Adjustments to depreciation schedules** that reduce incentives to build new long-life infrastructure (e.g., Colorado requires stranded asset risk assessment + potential changes to these schedules)
  - **Clean heat standards** (e.g., Colorado, with decisions for Xcel and Black Hills, predominantly supporting electrification and efficiency, with some support for RNG and little-to-none for H2)
  - **Frameworks for achieving decarbonization goals** (e.g., MA DPU decision, rejected RNG and H2)
  - **Building performance standards** and **energy codes** (e.g., NYC Local Law 97) (see also: ACEEE)
- There may also be opportunities to begin **unwinding parts of the system,** such as via California's SB 1221, which establishes 30 pilot projects (beginning in 2026) to identify and transition entire neighborhoods off of gas—especially where gas pipeline repairs would be needed

[4] Pivoting Pipeline Business Models

There are several potential options that can help gas utilities and pipeline companies evolve:

- **District heating or thermal energy networks** using pipes to move heat rather than gas/fuel
  - E.g., Eversource's geothermal pilot project in Framingham, MA
  - Other thermal energy network provisions in MN, NY, CO, WA, MD, VT, CA (see table)
- **Enhanced geothermal systems** (for providing power or heat)
  - E.g., Colorado's Geothermal Energy Grant Program and Geothermal Energy Tax Credit Offering
- **New or repurposed hydrogen pipelines** for industrial-scale purposes, i.e., moving H2 from producers or other states to peaking power plants, steel plants, e-fuels facilities, etc.
- **Renewable natural gas** to serve niches (e.g., identified by EER) that may struggle to electrify
- **Carbon transport and storage** to serve CCUS needs (if any)

Concluding Thoughts

- There is still a lot of work to do in promoting electrification of vehicles, buildings, industry, and agriculture – and this (plus cleaning the grid) should take priority
- Seek ways to change the types of biomass being procured and begin redirecting it from vehicles to aviation, industry, and (maybe) marine shipping
- There is lots of room for research, planning, and early procurement, including RFIs and RFPs for dispatchable electric capacity (for seasonal/multi-annual storage) as well as for enhanced geothermal and thermal energy networks
- Look toward long-term infrastructure needs – based on modeling results, avoiding higher/stranded costs might mean at least slowing growth of gas distribution system and situationally unwinding it alongside electrification, plus being careful about what types of hydrogen infrastructure are developed

Discussion

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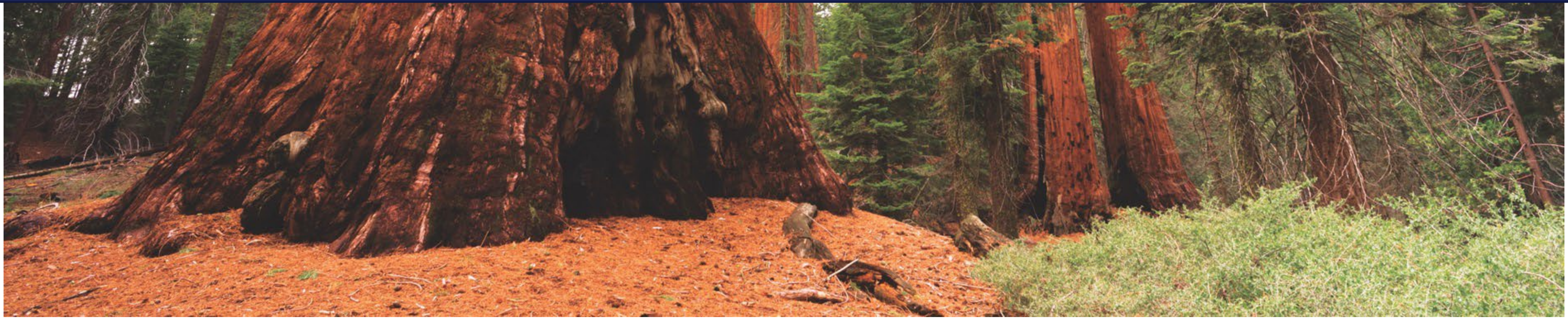
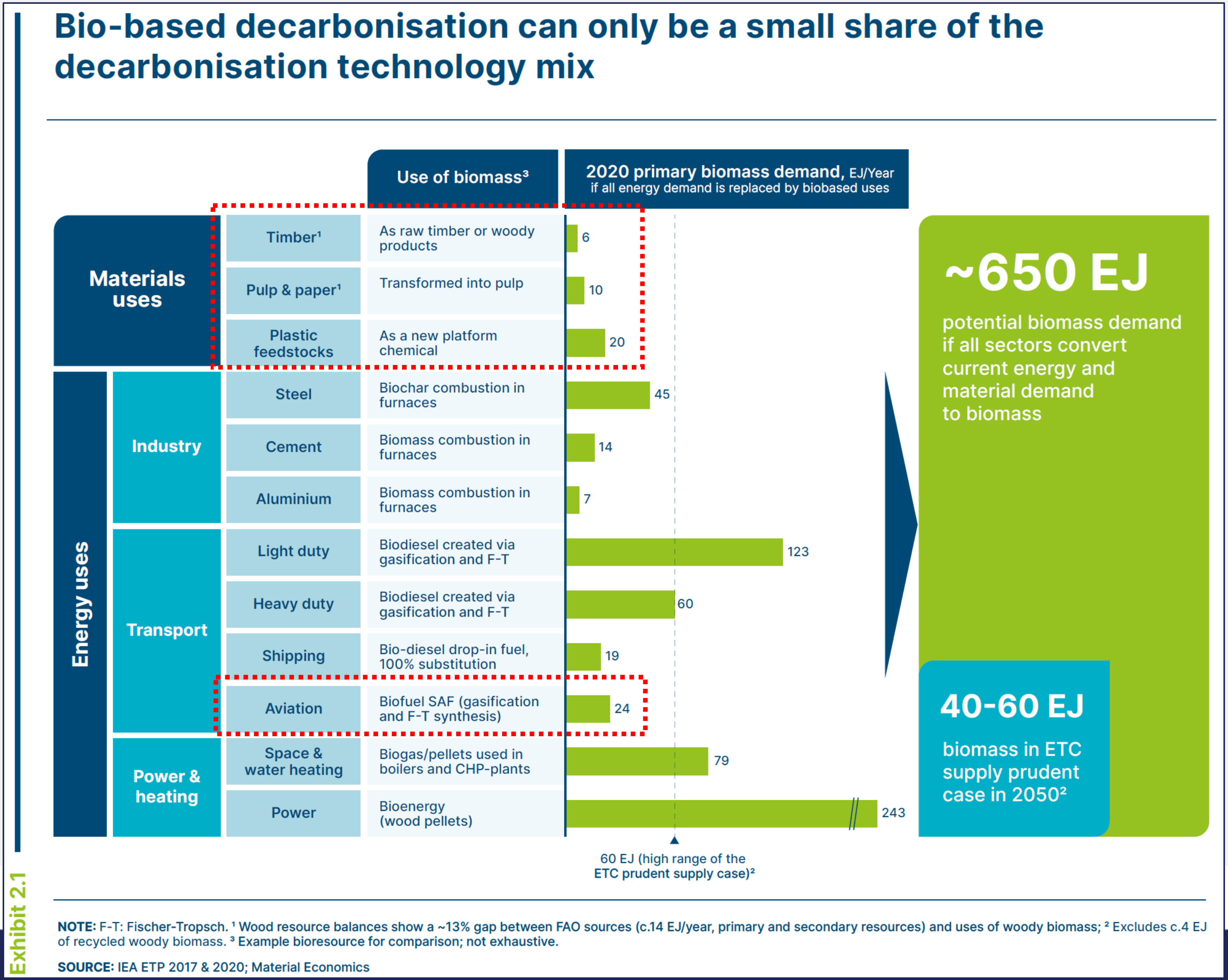


Appendix



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