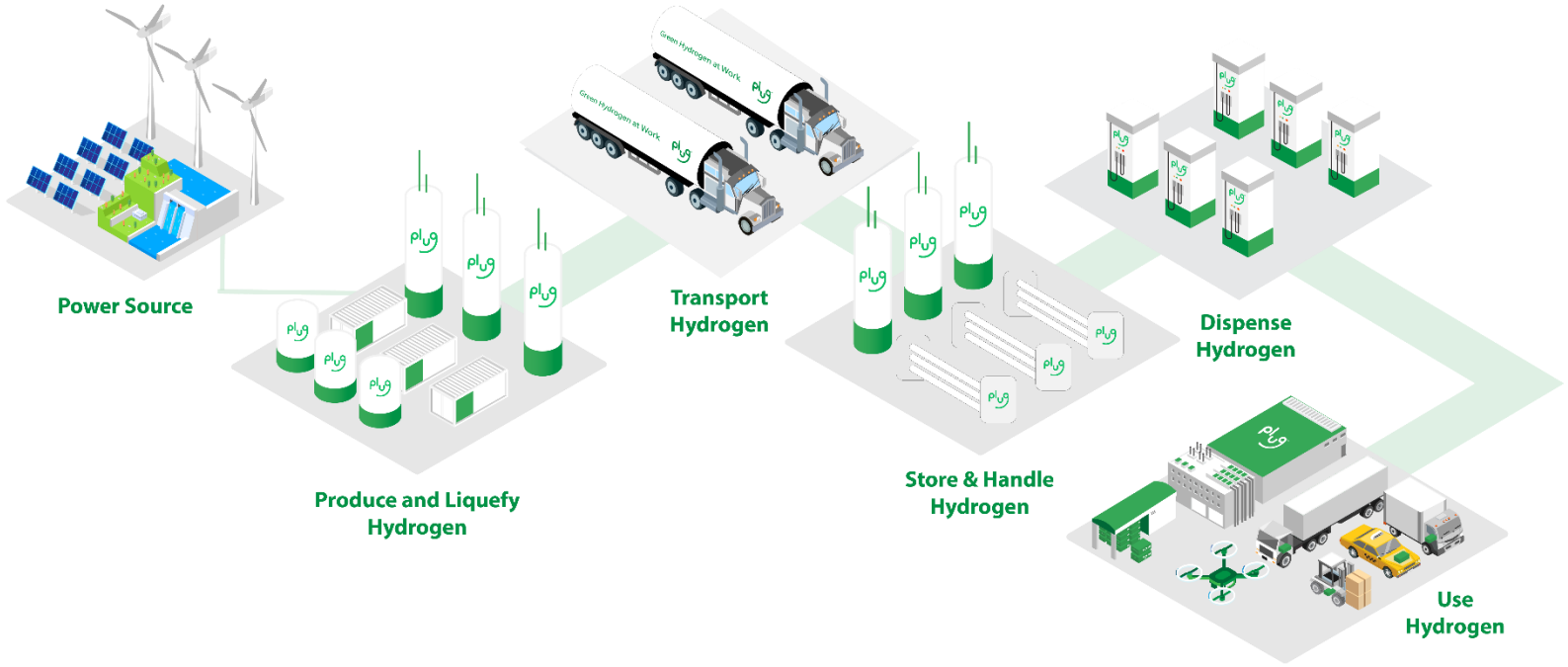
Electrolyzer Deployment at Scale

DOE Electrolyzer Workshop

09.27.2023

Plug’s Green Hydrogen

Ecosystem



- 50 years of innovation
- 3,100+ employees
- World's largest user of liquid hydrogen
- Has built more hydrogen refueling stations than anyone in the world
- Electrolyzer projects underway on 6 continents
- Vertically integrated: industry-leading PEM ELX stack technology and global project execution team

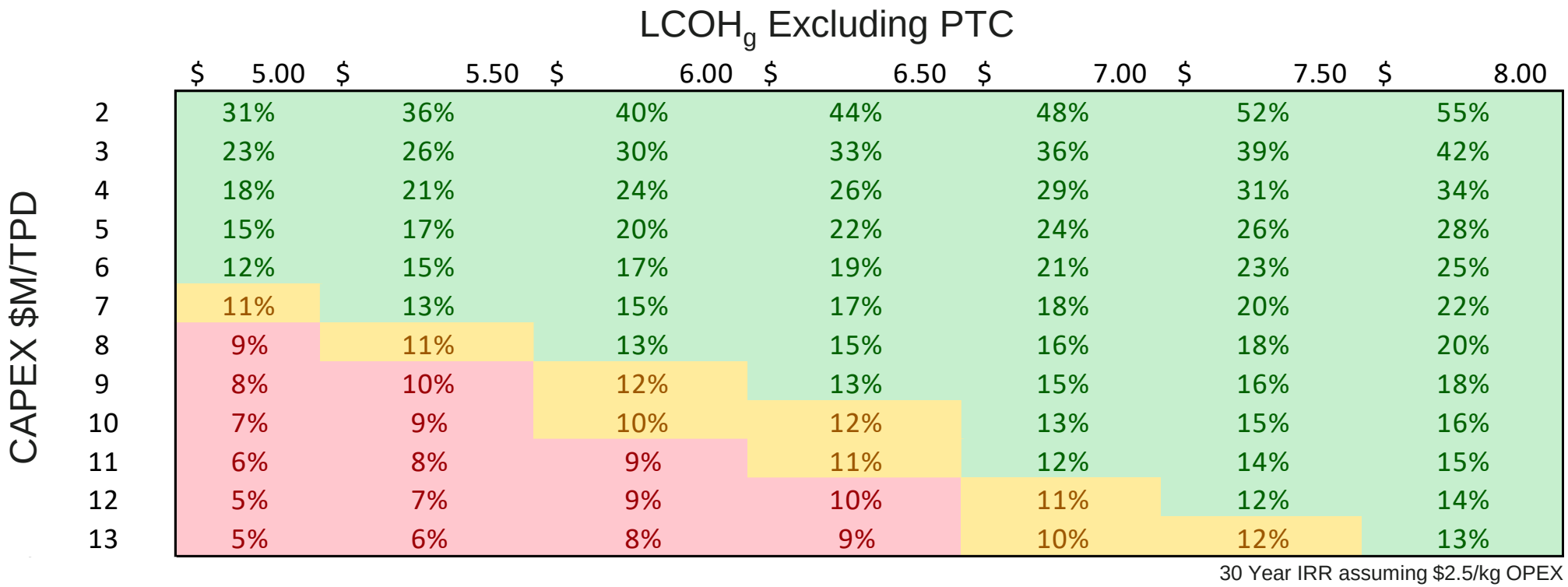
Plug Power Georgia Green Hydrogen Plant (March 2023)


LIQUID
NITROGEN


Plug Power Inc.
Latham, NY
USDOT 956300
MC 1430440
plug
Green Hydrogen
at Work


I25-102
I26-102

Green Hydrogen Return on Capital

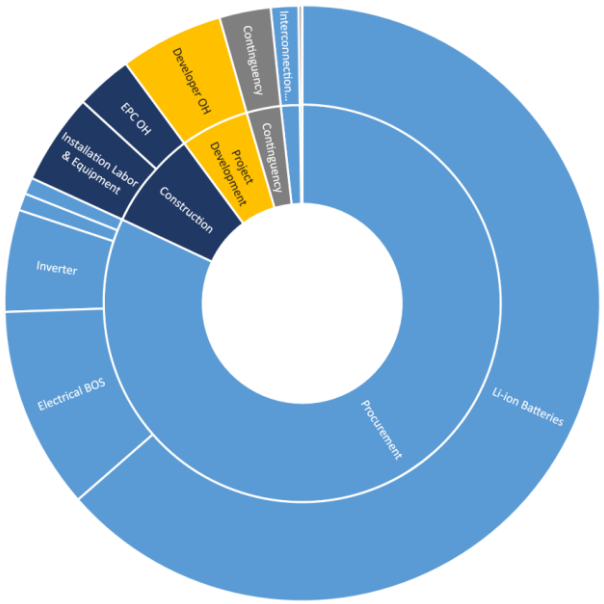


30 Year IRR assuming $2.5/kg OPEX

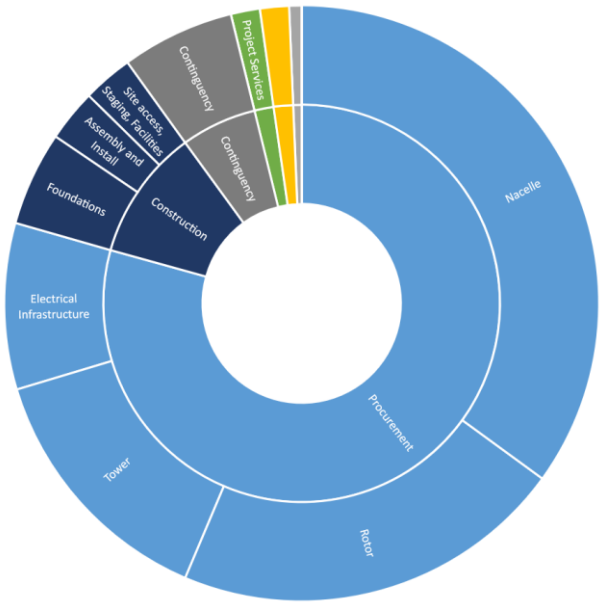
[1]Air Products and AES Announce Plans to Invest Approximately $4 Billion to Build Green Hydrogen Production Facility in Texas. 200 TPD, 1.4 GW Wind **~$10M/TPD**
[2]Air Products to Invest About $500 Million to Build Green Hydrogen Production Facility in New York. 35 TPD **$14.3M/TPD**
[3]Air Liquide takes a further step in developing the hydrogen sector in France. €400M + €190M , 200 MW ELX ~80 TPD, **~$7.9M/TPD**

[1]https://www.prnewswire.com/news-releases/air-products-and-aes-announce-plans-to-invest-approximately-4-billion-to-build-first-mega-scale-green-hydrogen-production-facility-in-texas-301697873.html
[2]https://www.prnewswire.com/news-releases/air-products-to-invest-about-500-million-to-build-green-hydrogen-production-facility-in-new-york-301642745.html
[3]https://www.airliquide.com/group/press-releases-news/2023-09-14/air-liquide-takes-further-step-developing-hydrogen-sector-france

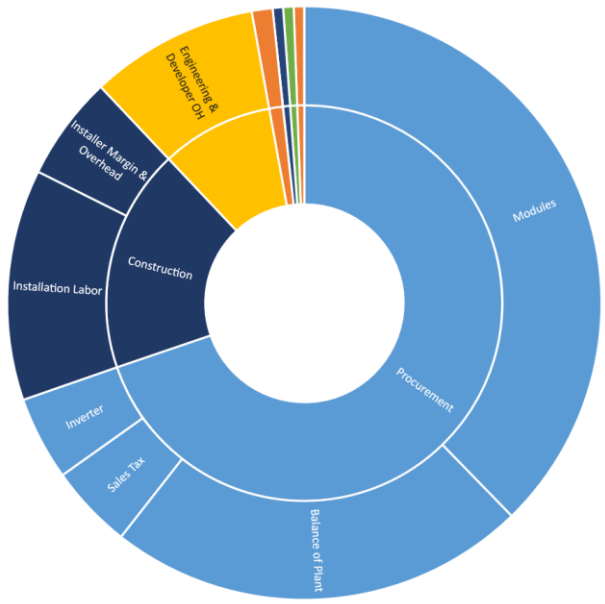
Renewable Energy Project CAPEX Structure



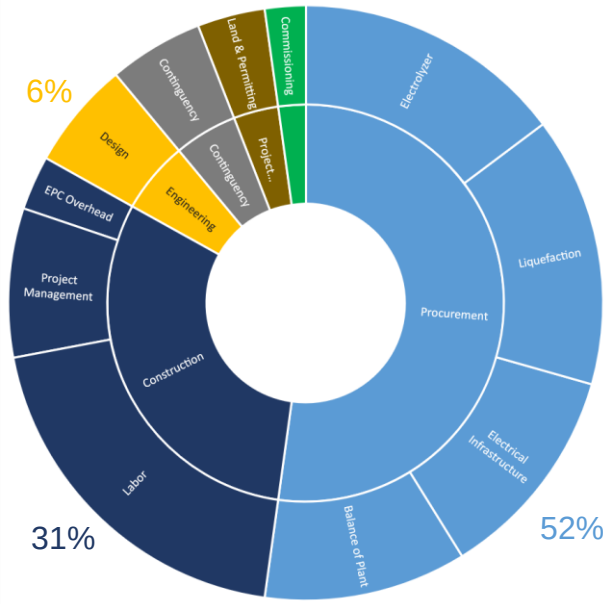
STORAGE



WIND



SOLAR



HYDROGEN

Procurement
Construction
Engineering

https://atb.nrel.gov/electricity/2022/utility-scale_battery_storage
https://www.nrel.gov/docs/fy23osti/84774.pdf
https://atb.nrel.gov/electricity/2022/utility-scale_pv

Key Learning

- CAPEX is too high for acceptable project returns at target LCOH
- Green Hydrogen projects spend a far greater proportion of CAPEX on engineering and especially construction when compared to other renewable projects. They look like petrochemical projects.
- The electrolyzer is only about 15% of the project CAPEX – cheaper equipment doesn't fix the problem
- Electrolyzers need to live outside – the building drove a great deal of the engineering and construction cost. Foundations, erection, systems for ventilation, fire suppression etc.
- Equipment integration is critical – the separation of system components (say pump and motor VFD) drove a lot cost.
- The "Balance of Stack" plant is critical – A PEM stack on its own is almost useless, hard to use safely in a way that won't damage it.
- 5 MW units are too small to build big plants – the more MW in a single package the better.
- Central cooling plants are not cheaper – savings in capital are more than offset by construction costs.

The Path Forward

- Green hydrogen needs to look like battery storage – many plant similarities
- Renewable technologies are modular and built in (very) large factories – they follow learning curves for cost reduction – something never demonstrated for petrochemical plants
- Electrolyzer suppliers need to think, design and deliver like renewable energy suppliers

- Highly integrated equipment with minimal external interfaces
- Outdoor enclosures – minimal foundations & no underground services
- Dry cooling included
- Designed for fast assembly in the field – limited truck deliveries and crane lifts
- Fully engineered plant level solution – the ‘bricks’ need to snap together like Lego for large plants
- Short and simple FEED with fast path to FID/NTP – minimal risk estimating costs and schedule and so minimal contingency

Green Hydrogen at Work™