GTI ENERGY
solutions that transform

IH^2 – For Direct Conversion of Biomass to Fuels- 200t/day Plant Economics and Plans

Terry Marker and Pedro Ortiz-Toral GTI Energy
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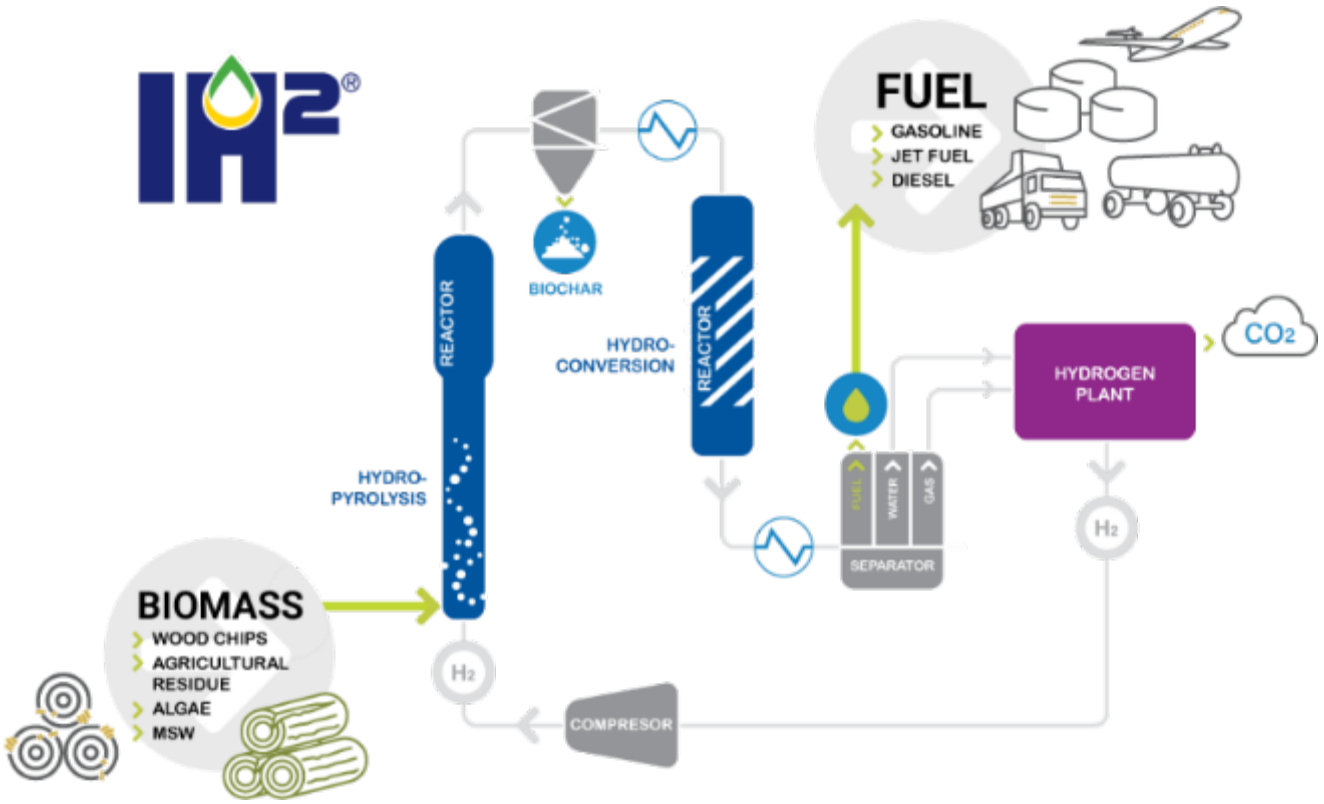
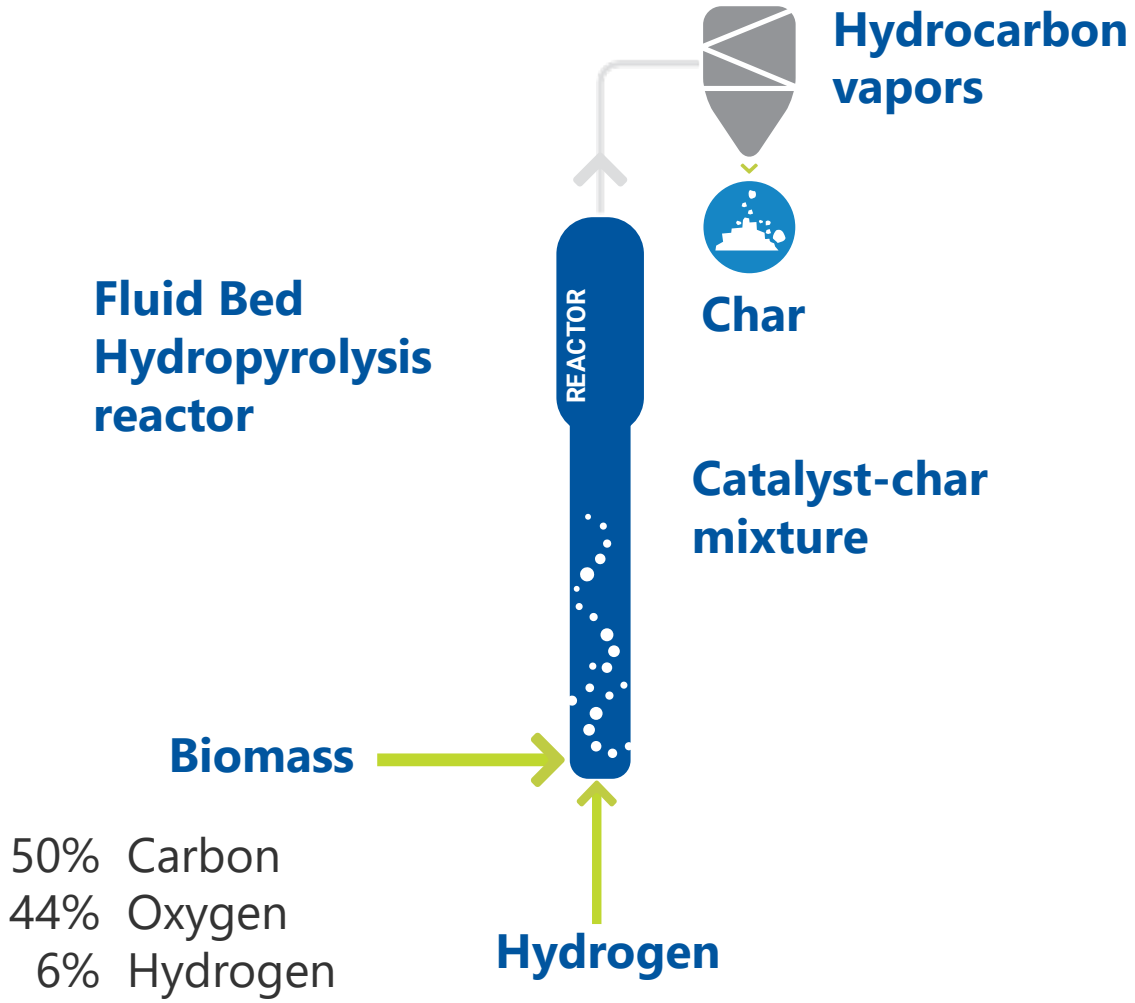
What is IH²® technology?

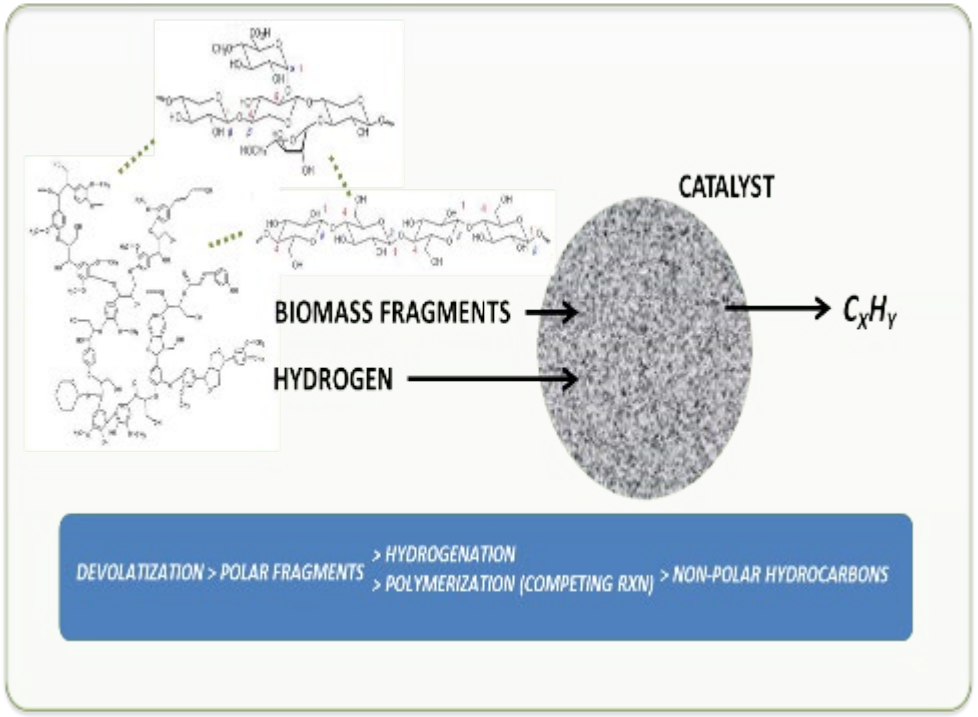


An Innovative Process

- Directly converts solid biomass into liquid hydrocarbon fuels
- Removes all oxygen from the feed and generates high quality gasoline +jet+ diesel boiling range fuels
- Economic at scales relevant to biomass availability (>100 tpd)
- Gives the highest GPT yield of oxygen free transportation fuels of any biomass conversion process
- Can be used to sequester carbon by sequestering char
- Invented by GTI Energy, tested and currently licensed to Shell

Hydropyrolysis Reactor and Chemistry

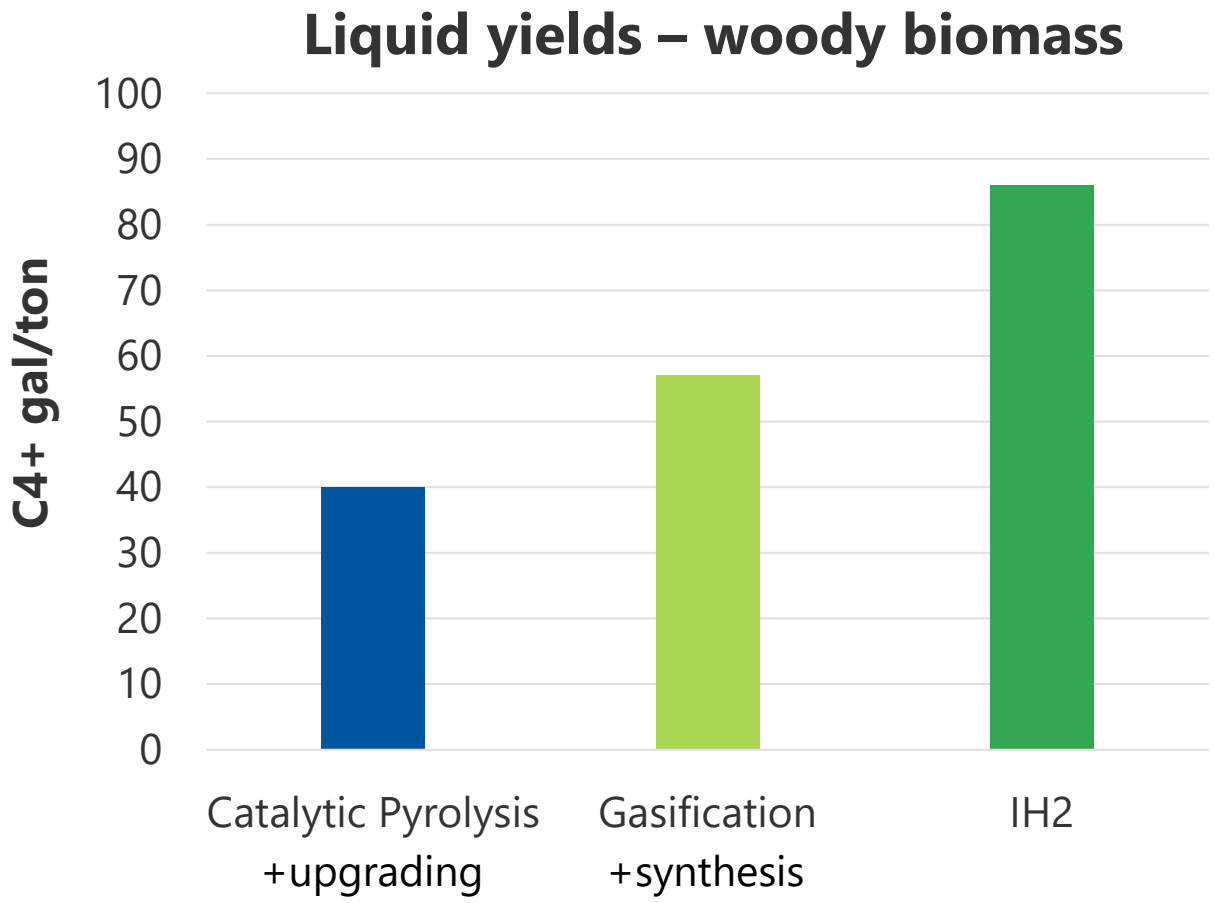


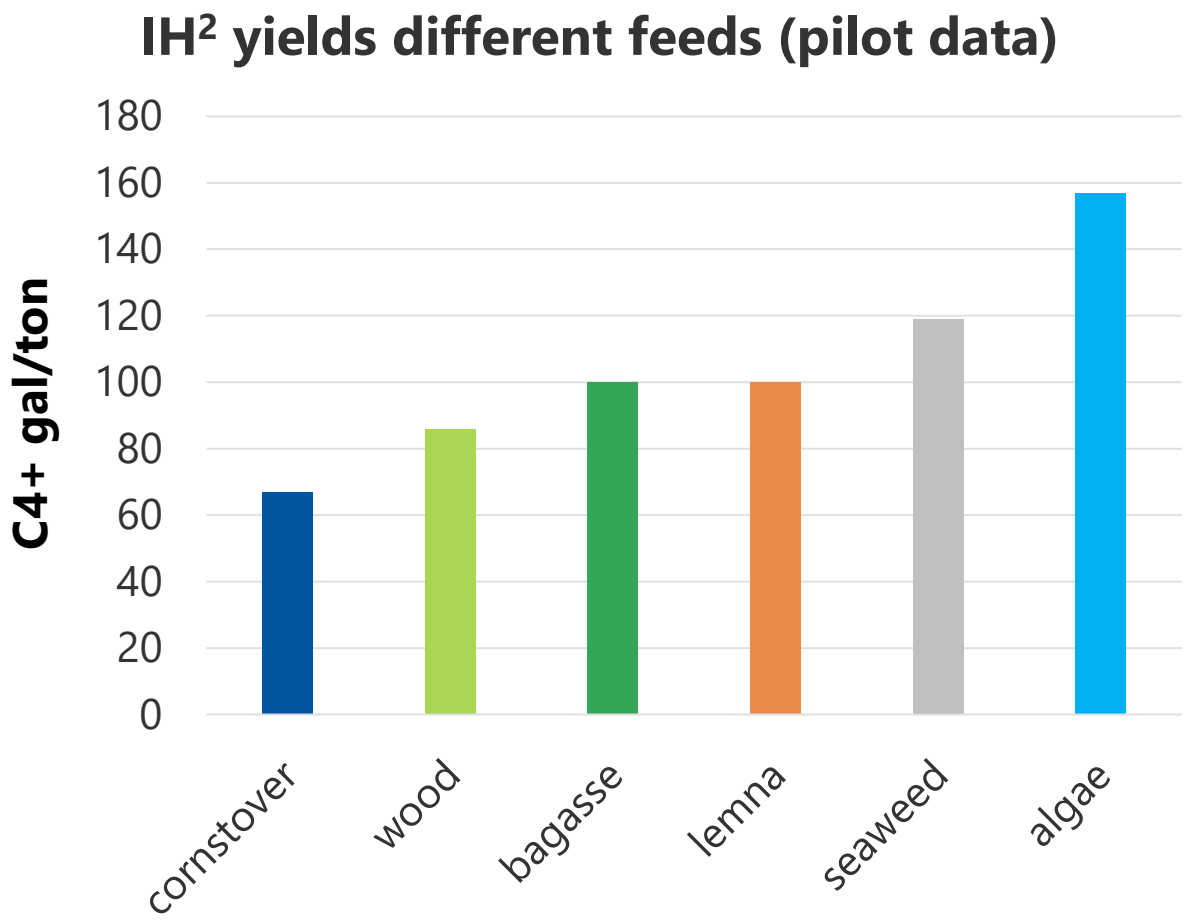


Biomass travels through a bed of catalyst and is converted to char and hydrocarbons which are continuously produced

IH^2 adds hydrogen directly to biomass fragments

Liquid Yields Comparison



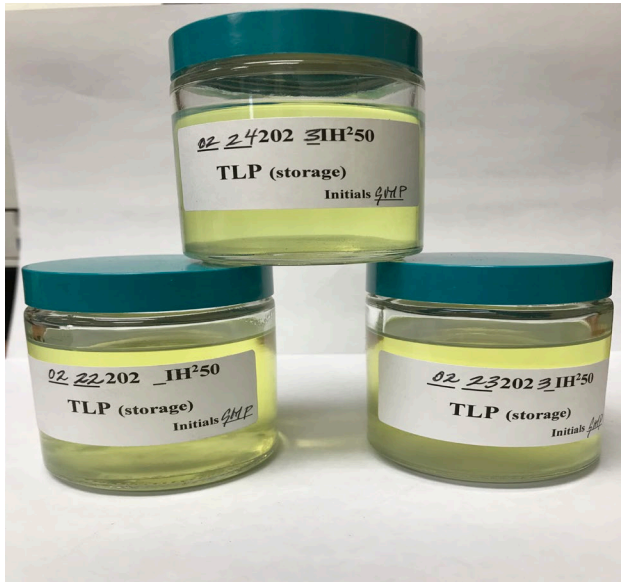


- Gasification+ Synthesis yield from "U-GAS+Cool GTL", Tcbiomasss 2022, Zach El Zahab
- Catalytic Pyrolysis yield from "Critical Review of Fast Pyrolysis of Biomass", Vanderbosch

Liquid Product Quality Comparison

Pyrolysis Oil
50% Oxygen
100-200 TAN
20% water
Non distillable
Poor stability
Heating value 6560 btu/lb.
Hardest to upgrade

Catalytic Pyrolysis oil
10-20% oxygen
40 TAN
Less water
Better Stability
Heating value=8500btu/lb.
Hard to upgrade



IH² Fuels
<1% Oxygen
<.1TAN
No water
Excellent stability
Heating value=18000BTU/lb.
No upgrading needed

Comparison of IH^2 and Catalytic Pyrolysis

	IH^2®	**Catalytic Pyrolysis**
Analogous process	Hydrotreating	FCC
Temperatures, C	380-450	500-600
Pressure, barg	20-35	1.5-2
Hydrogen	Yes	No
Regeneration	No	Yes
Catalyst type	hydrotreating	cracking
% oxygen in the product liquid	<0.4%	10-20%
Requires product upgrading	No	Yes
Liquid Yield GPT	86	40

Comparison of IH^2 and Gasification

	IH^2 with Char sequestration	IH^2 with burn char	Gasification + synthesis
GPT Liquid Yield	86	86	57
Ton CO_2 product per ton of feed	.47	.99	1.3
Power usage MW/1000tpd feed	27	7	13.9
% of feed carbon to CO_2	25	54	71
% of feed carbon to liquid	46	46	29
% of feed carbon to char	29	0	0
% feed carbon to liquid+char	75	46	29

- Gasification sacrifices a high amount of carbon to CO_2
- IH^2 with Char sequestration produce least CO_2

IH² 50kg/day Pilot Plant

Over 13,000 Hours of IH² pilot plant testing

Bangalore India Demonstration Scale IH^2 Plant (Shell)

- GTI Energy supported the design and commissioning of a pre-commercial 5 ton/day demonstration unit located at Shell Technology Center in Bangalore, India (STCB), pictured on right
- **Demo**: Accumulated 3,000 hrs in 2022-23 (5 ton/day)
- Yields consistent with pilot results
- Signed off on engineering design package for commercial scale

Development Scale-up

Risk + Value

1L/week
GTI Chicago
MBU

Prove the Science
2009-2023+

20L/day
GTI Chicago
IH²-50 Pilot Plant
run >13,000 hours

Demonstration
2022-2023

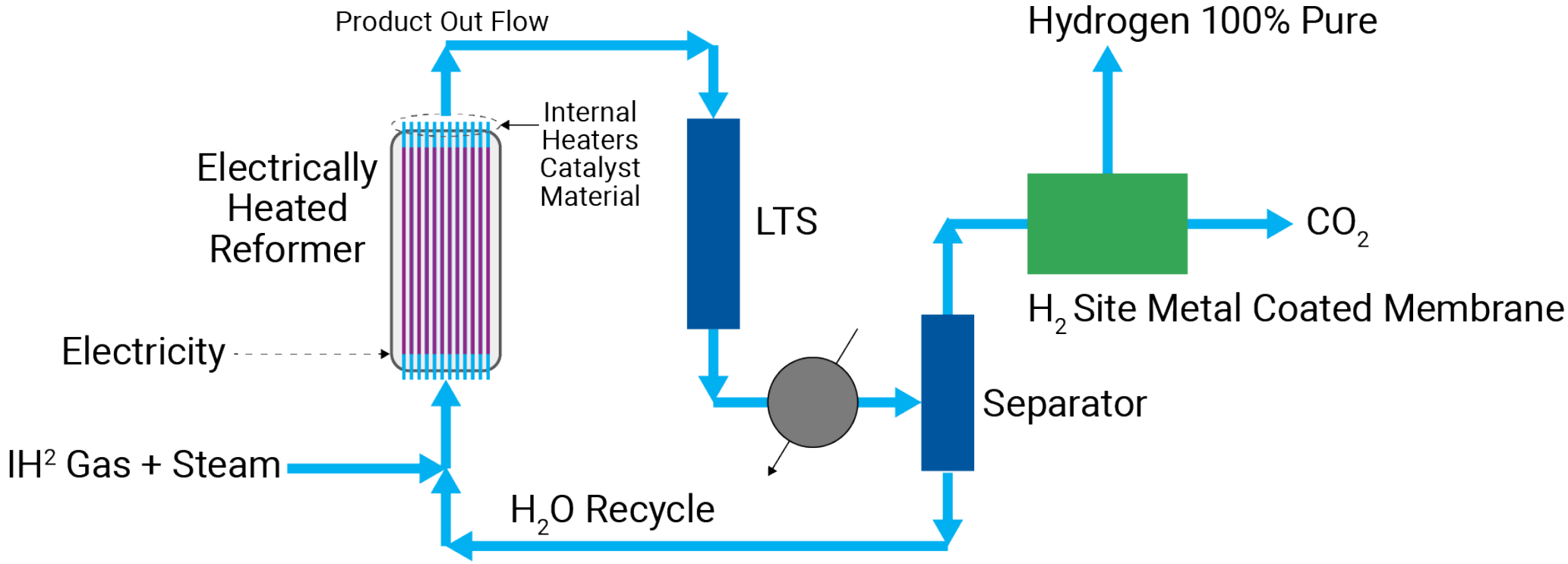
2,000L/day
IH²-5000
Run >3000hrs

First commercial
2026+

>200,000L/day
IH²-1000tpd

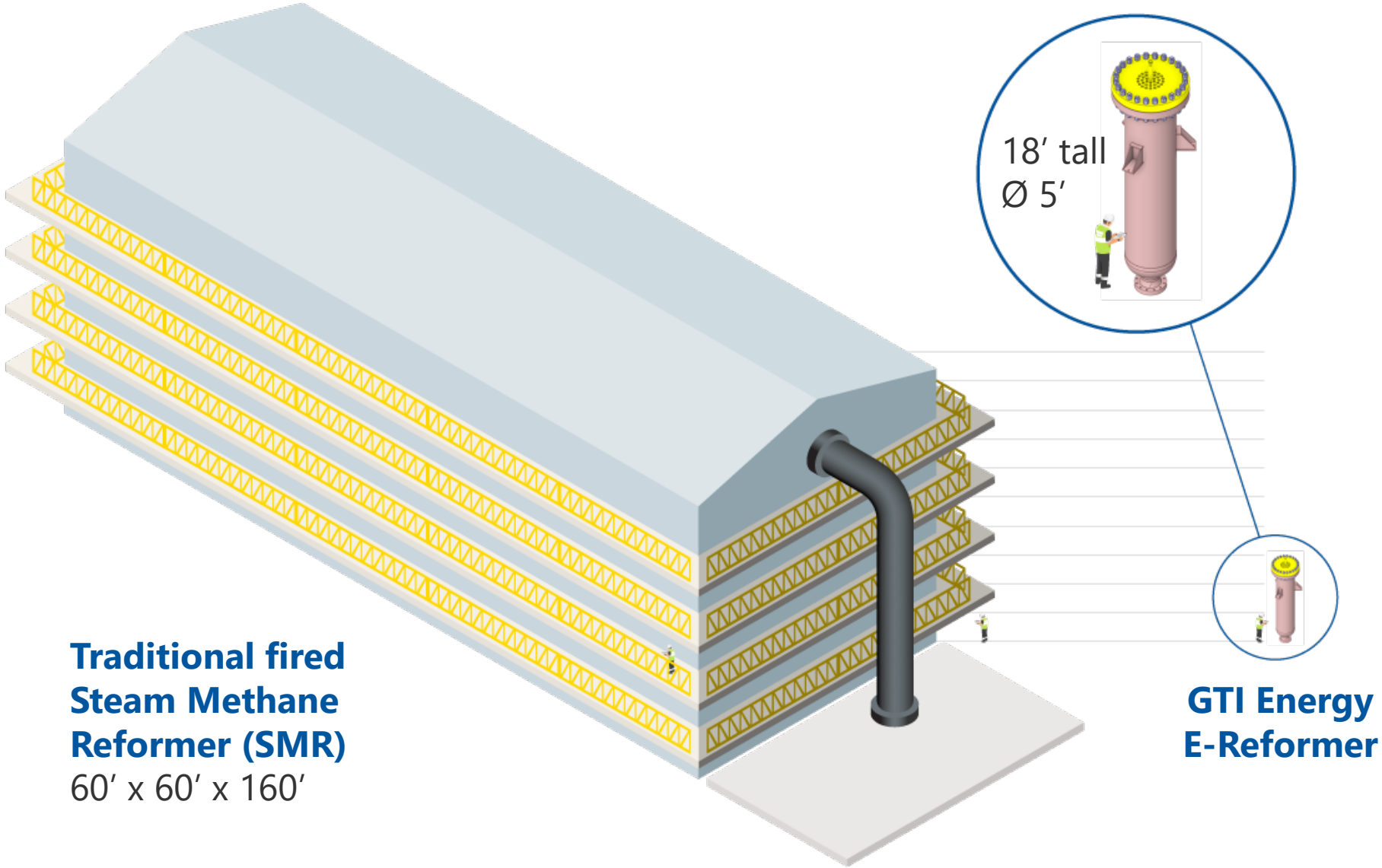
Time and Scale

Latest Innovation—Integrated Electric Reformer for Hydrogen Production



- Simple robust compact low-cost modular design approach for hydrogen production
- Catalyst designed to accept and convert bio-derived gases
- Integrated with IH^2 pilot demonstrated hydrogen self sufficiency

Novel Cool Electric-Reformer Makes Hydrogen or Synthesis gas



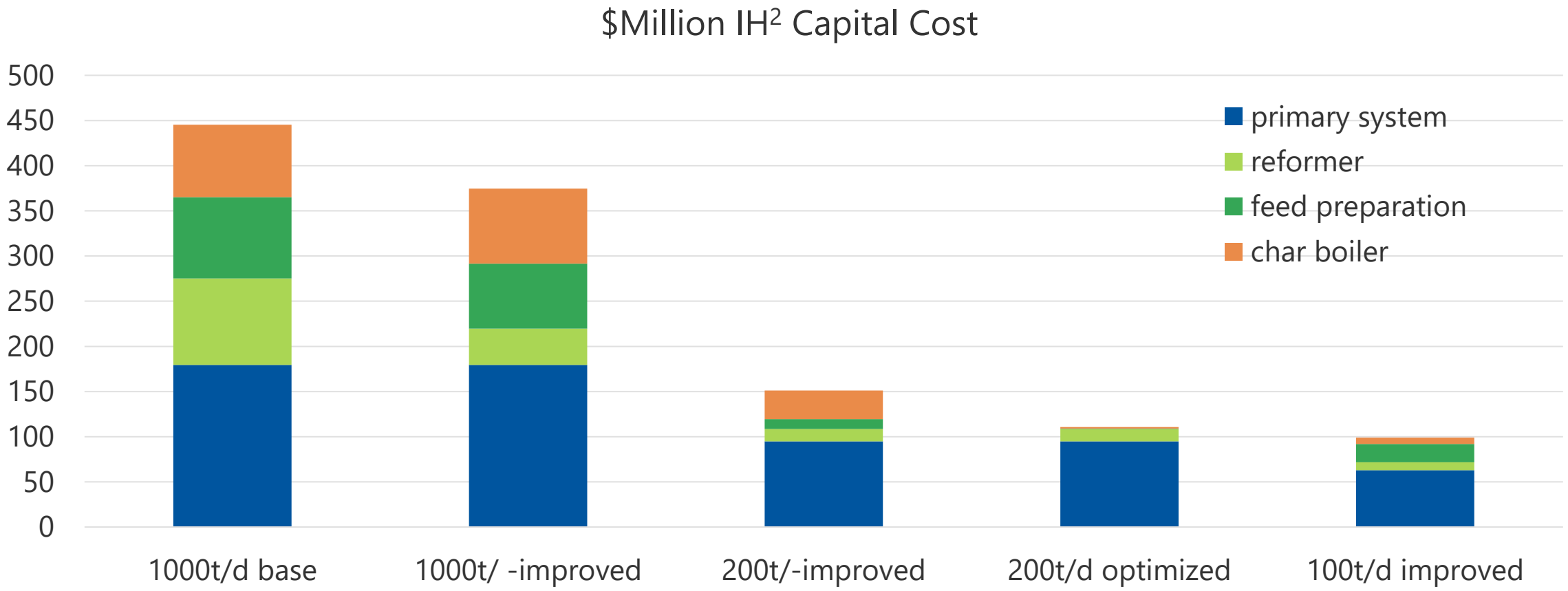
Traditional fired Steam Methane Reformer (SMR)
60′ x 60′ x 160′

GTI Energy E-Reformer

Novel Features

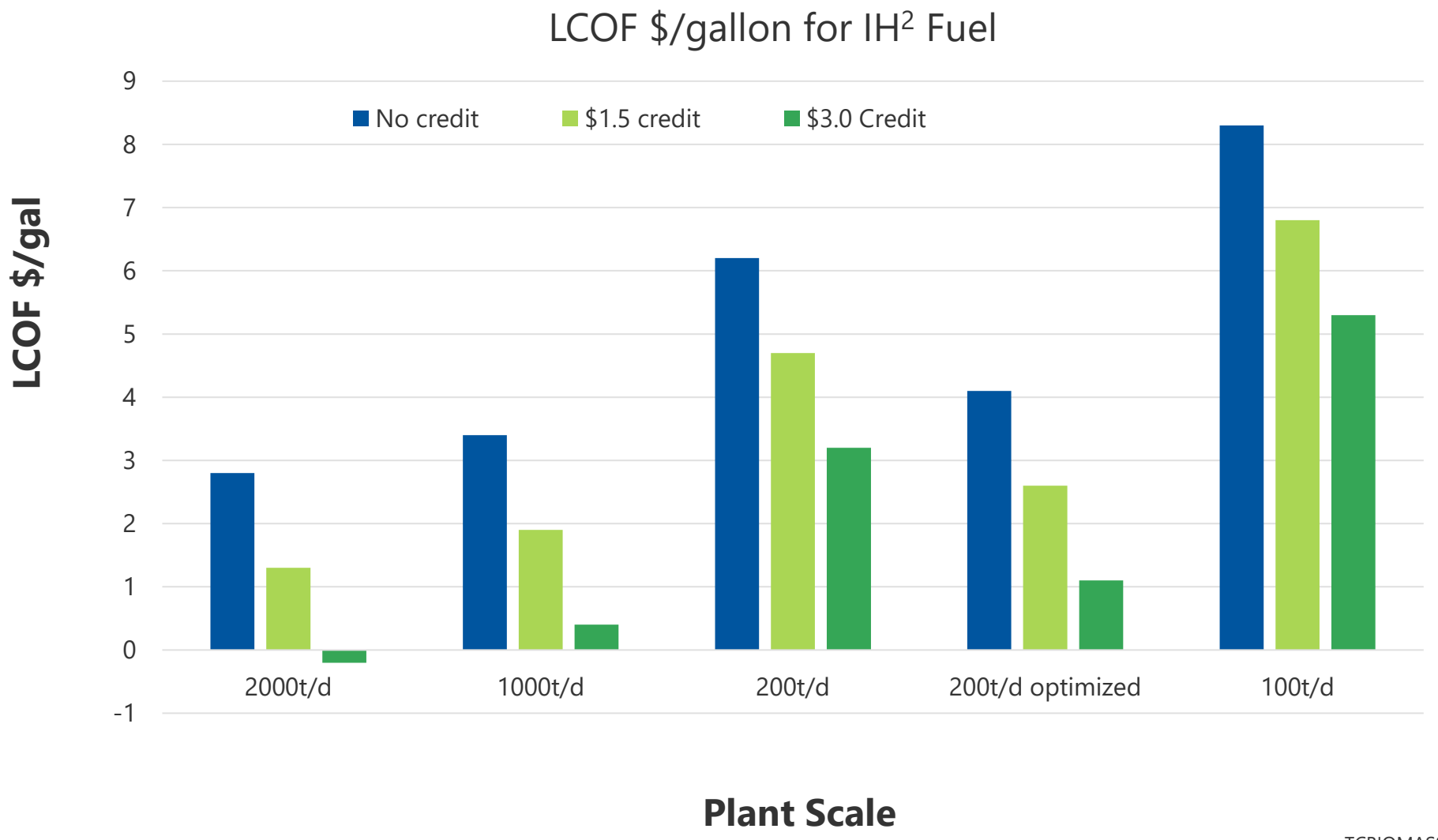
- Unique catalyst
- Unique electric reformer design
- Small footprint
- Modular, low capital
- Utilize renewable electricity to reduce emissions

Small Commercial Plants Mitigate Investment Risk



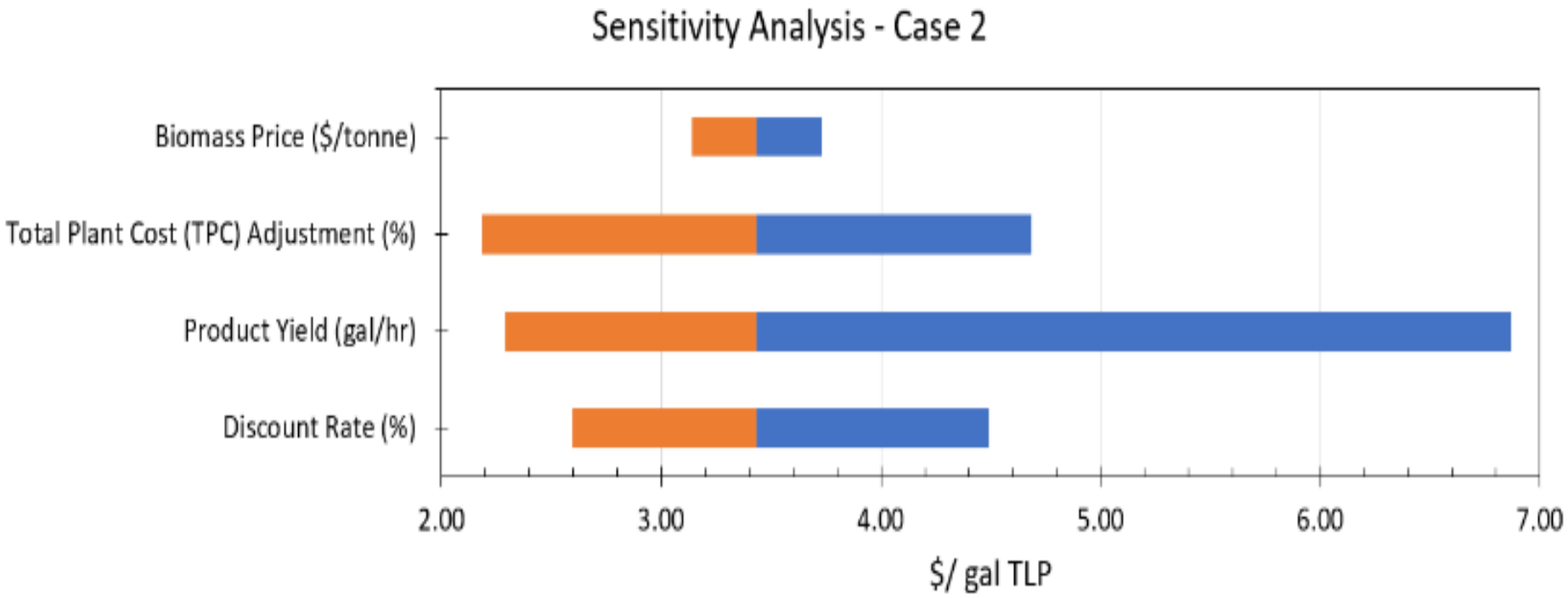
- AACE Class 5 cost estimates
- Optimized case sequesters char and uses sawdust feed

Small Commercial Plants can be Competitive



Sensitivity Analysis

1000t/day- improved



All factors varied from 50 to 150% of there standard values

IH^2 Conclusions/Path Forward

- IH^2 is a unique, innovative biomass conversion technology which produces high quality liquid product at high yields
- IH^2 Technology has been successfully demonstrated for over 13,000 hours at GTI Energy at 50kg/day and for months at 5t/day scale
- IH^2 is H_2 self sufficient
- 200 t/day size good first of a kind approach to lower risk, minimize investment—still modular
- A good way to improve economics—keep reducing capital costs and simplifying system
- Need more detailed 100-200t/d cost estimates
- **Available for licensing through GTI Energy**

Questions?

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