Innovative Gasification Technology to produce GREEN HYDROGEN from BIOMASS residues

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HYDROGEN
ONLINE
WORKSHOP
March 23 2023

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We make BIOMASS work

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Scalable Green Hydrogen Production from Biomass

Minnova Renewable Energy invests in new technologies that mitigate climate change by converting waste biomass to energy.

Invest and Develop	 3rd Generation biomass gasification technology can produce a higher hydrogen content syngas Produce carbon neutral pure hydrogen or other valuable biofuels
ESG Focus	 Sustainable Waste to green hydrogen is socially accepted Meets Environmental, Social and Governance (ESG) goals
Bioenergy Opportunity	 Government, industry and society at large are seeking increased sustainable renewable energy supply. Green H_2 and other biofuels from sustainable biomass gasification are an obvious solution

Minnova Renewable Energy

A Bold Vision to be a Leader in Global Energy Transition

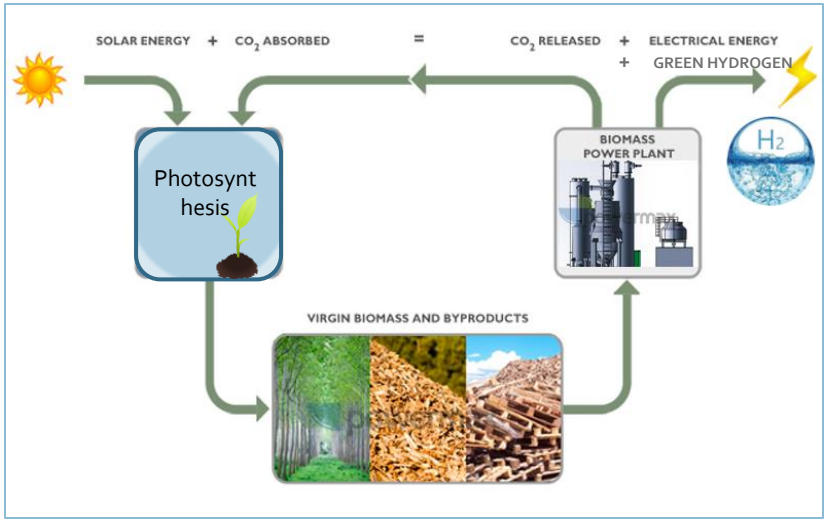
Become a leading global Cleantech company that develops and acquires innovative technologies to create a more a sustainable future:

- Transform biomass to energy
- EFFICIENTLY use WASTE biomass (forest, agricultural and municipal) and MAXIMIZE hydrogen recovery
- Produce GREEN HYDROGEN and a diversity of zero carbon biofuels to accelerate Global Energy Transit to
- Where possible re-use existing and legacy fossil fuel infrastructure (e.g., natural gas pipelines)
- Contribute to reduced fossil fuel use and greenhouse gas emission

Biomass – Living Stored Energy

- Biomass is a natural source of energy from the organic material that makes up plants and organic waste such as:
  •agricultural crop residues • forestry residues • algae • wood processing residues • sorted municipal solid waste (MSW) • algae • industrial wastes • urban wood waste, and food waste to name a few
- Energy derived from biomass contributes 55% of current renewable energy globally, and over 6% of global energy supply[1]
- 3rd generation MRE technology can replace outdated less efficient biomass gasification technology

Energy contained in biomass is stored solar energy which can be converted into green Hydrogen, clean electrical power or other biofuels for Net Zero CO2 balance



Notes: 1) IEA (2022), Bioenergy, IEA, Paris https://www.iea.org/reports/bioenergy, License: CC BY 4.0

Green Hydrogen from Biomass Waste

The World needs more CLEAN ENERGY

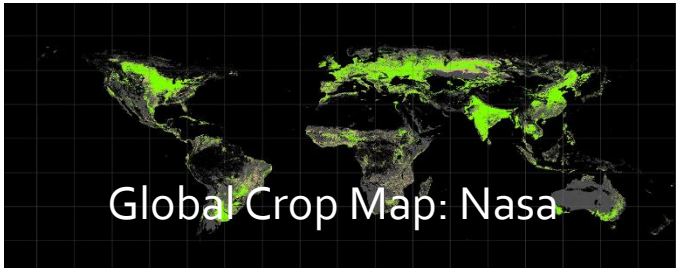
Green hydrogen will be a useful FUTURE FUEL to reduce CO2 emissions

Benefits of **MRE gasification of waste** to produce a clean, high hydrogen content syngas include:

- Sustainable feedstock
- Zero CO2 emissions
- Highly efficient (>50% H2 yield)
- Distributed and scalable
- Simple to operate
- Low maintenance
- Matches NEED with FEEDstock”
- Energy security


Electricity Use: Nasa


Global Forest Map: Nasa


Global Crop Map: Nasa

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Why Hydrogen from Biomass?

- Annual global hydrogen demand estimated at ~100 million tonnes
- Current hydrogen production is GREY hydrogen, produced almost exclusively from fossil fuels, resulting in close to 900 Mt of CO_2 emissions
- Global Energy Transition policies expected to accelerate use of GREEN hydrogen to over 200 million tonnes annually
- MRE's innovative 3rd generation biomass gasification technology focused on:
  - Maximizing yield and recovery of hydrogen in syngas
  - Being low cost
  - Utilizing low value waste biomass
  - Modular scalable design for decentralized and remote applications
  - High reliability compared to intermittent solar/wind electrolytic green hydrogen

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Biomass Gasification

- Biomass gasification process is extremely complex
- Hydrogen yields and concentration are widely affected by the interaction between:
  - Feedstock characteristics
  - Operating conditions
  - Reactor design
  - Temperature and Pressure
  - Fluidized bed material and size
  - And other factors
- Plants at full scale have been operating in Europe for years (Austria, Germany and Italy) producing syngas from different biomasses primarily as Combined Heat and Power (CHP) applications
- **The MRE design integrates gasification and gas purification to realize tar conversion and gas cleaning in a single reactor to achieve >50% hydrogen in syngas to be followed by multiple options for syngas upgrading (WGS, PSA etc.)**

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Gasification Technology Development

DUMA identified high potential for increasing the efficiency of existing DFB gasifier design

A new innovative design was conceived and developed by DUMA with support from University of L'Aquila (ULA) in Italy

ULA is involved in leading edge research and development of biomass gasification and is considered one of the world's experts on hydrogen production via biomass gasification

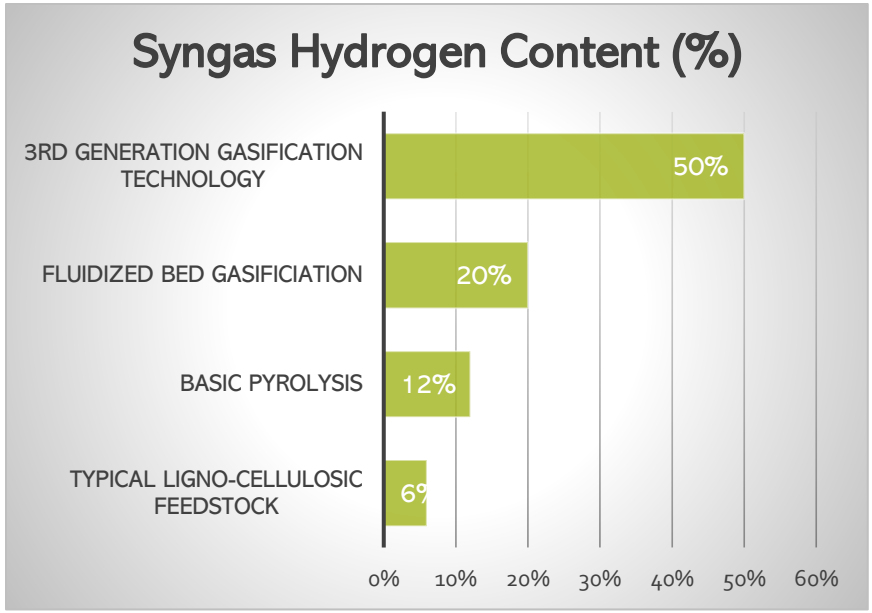
In May 2021, DUMA was awarded an IRAP fund from the Federal Government of Canada through the NRC to develop and test a new DFB gasifier design to produce a hydrogen rich syngas

WIPO process for the patent of the new DFB gasifier configuration in progress

University of L'Aquila laboratory

Innovative New Reactor Design

- 3rd Generation biomass gasification technology is a step change in efficiency
- Innovative design addresses current gasifier limitations and fine-tuned operating parameters.
- Smaller footprint
- High hydrogen content (>50%) syngas can be processed to pure hydrogen and other valuable biofuels or used to produce electrical power
- No external energy requirement post start up

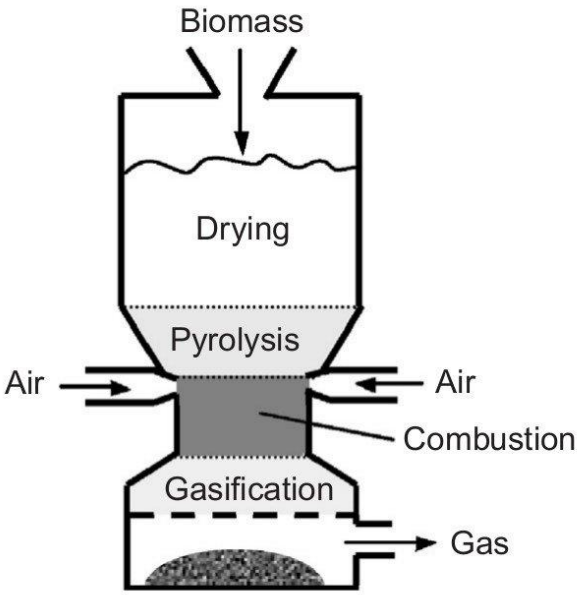


Biomass Gasification Process Description

- Sustainably managed lignocellulosic biomass is used as both the energy source and carbon source for the process. A wide variety of feedstocks are suitable for gasification, in particular to make renewable syngas
- The biomass is shredded and dried in a continuous dryer that uses waste heat from the gasification process
- The dried biomass is sent to a pyrolysis gasifier, where it is transformed into Bio-Syngas and Bio-Char at over 900 degrees Celsius (°C) and in the absence of oxygen.
- Current wood gasification technologies can produce a syngas with hydrogen yields between 8-20% in volume and heating content around 10-11 MJ/kg
- MRE technology has **proven** it is possible to reach >50%$_{vol}$ hydrogen rich syngas, with the heating value above 23 MJ/kg before any upgrading
- Adding a module of Syngas upgrade can increase the H_2 yield up to 70-75%.

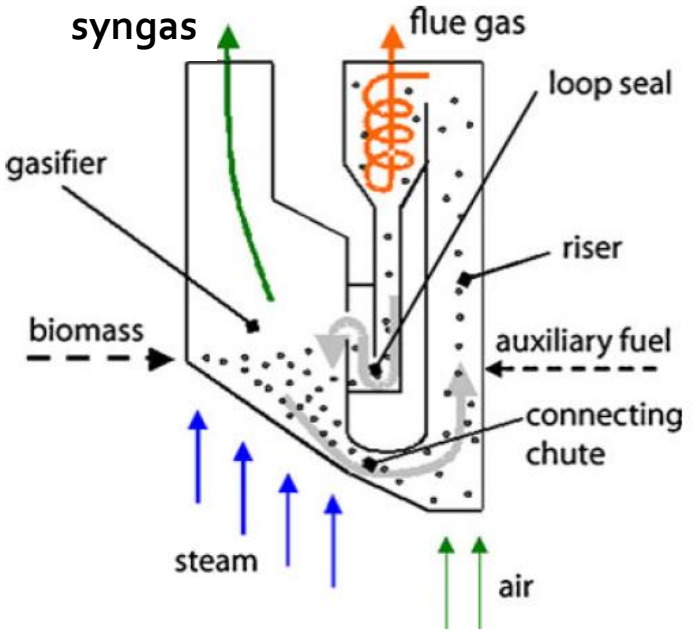
Side by Side Comparison to other Gasifier Designs

DOWNDRAFT GASIFIER



H2 content < 10% vol.

DUAL BED (DFB) GASIFIER



H2 content 50% vol.

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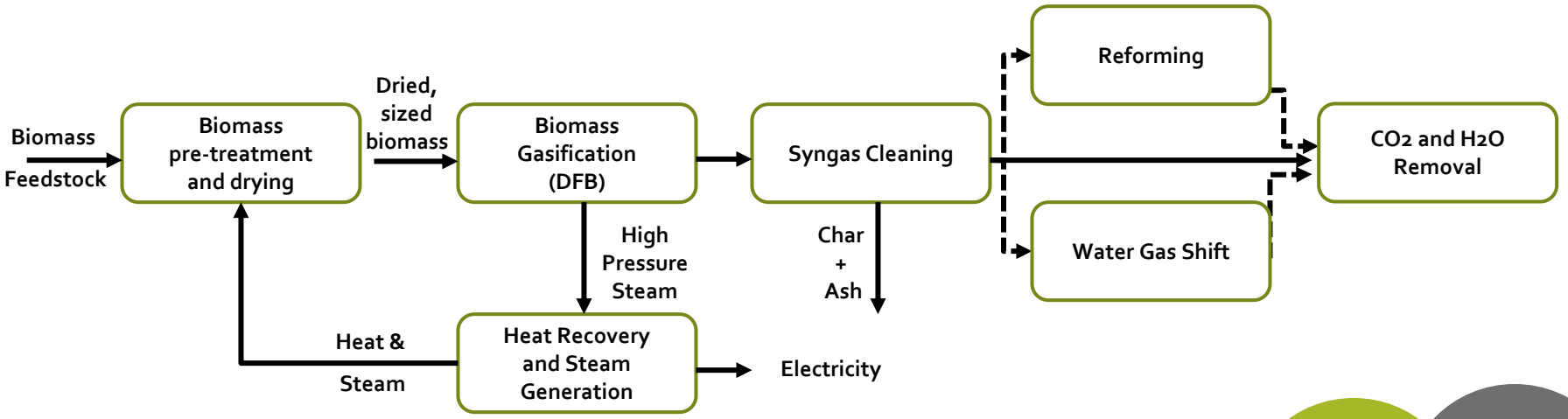
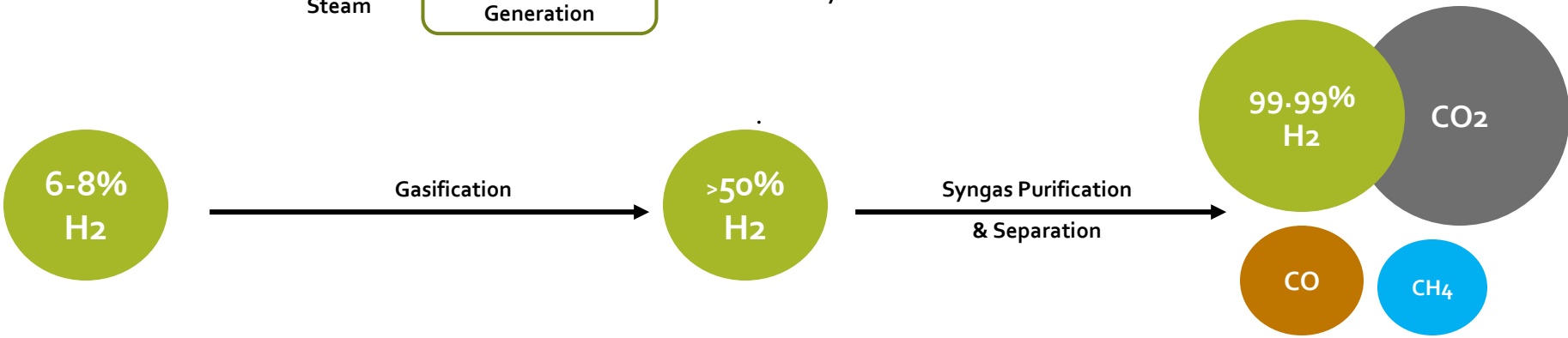
Process - Schematics





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Biomass energy Production Options:

Green Hydrogen – Electrical/Thermal Power or Hydrogen + Ammonia

Modular, scalable design

- Basic 10MW$_{th}$ module requires 15,000 to 20,000 tonnes biomass per annum
- ~10,500 Nm3/hr of high-quality syngas to produce
- Pure H_2 output – 1.4 million kgs per annum

or

- 10MW$_{electrical}$ power plus 30MW$_{thermal}$ power
- Minimal environmental impact with small footprint plant

Operational Inputs and Outputs	Feedstock Input 30 MW$_{thermal}$
	3 Modules
Biomass feedstock (tpa)	45 – 60k
Biomass Input (MW$_{thermal}$)	30
Syngas Production (wet, Nm^3/hr)	~10,500
Generator type[1]	Combined Cycle
Bioenergy Output Options	
Electrical Power (MW$_{electrical}$)	~10
Thermal Power (MW$_{thermal}$)	~30
Future Green H2 (kg/yr)[2]	>4 million
Future Green NH3 (kg/yr)[3]	>12 million
Future Green CO2 (kg/yr)[4]	~35 million

Notes: 1) Subject to feasibility study considering thermal loads (heating and cooling) , 2) Fischer-Tropsch reaction of syngas and upgrade to pure H_2 in support of industry and transport sectors , 3) H2 conversion to ammonia NH_3 in support of agriculture sector, 4) suitable for industrial offtake or CCUS

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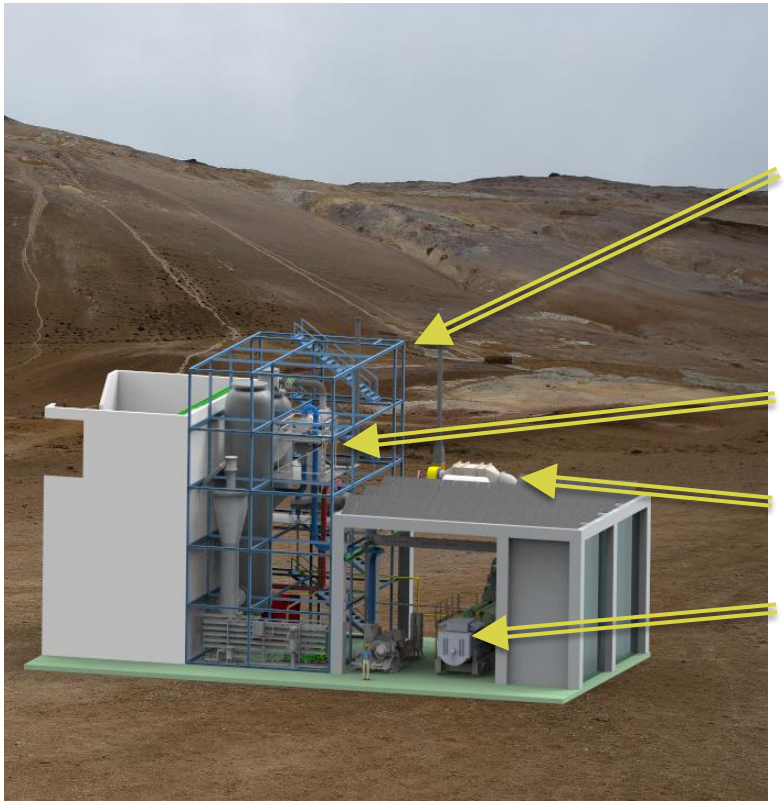
Base 10MW$_{th}$ Module:
2t/h – 2MW Power Plant Layout Shown



150 mTON BIOMASS HOPPER

15 M (50FT) BUILDING HEIGHT

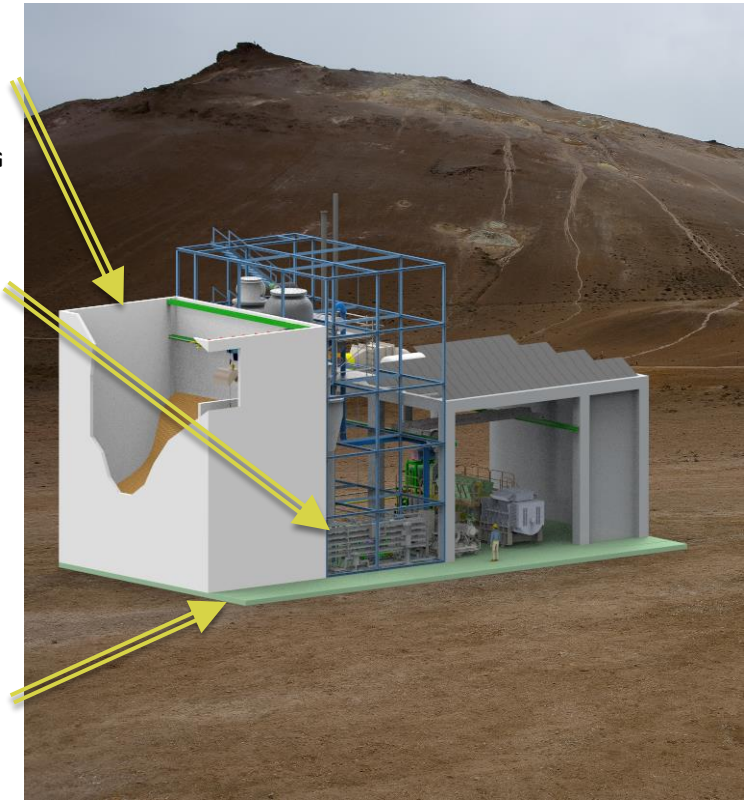
WATER FILTRATION SYSTEM

HEAT EXCHANGERS EASILY SERVICEABLE

SCR UNIT ROOF MOUNTED

2MWe GAS GENSET

THE WHOLE PLANT FITS INTO AN NBA BASKETBALL FIELD



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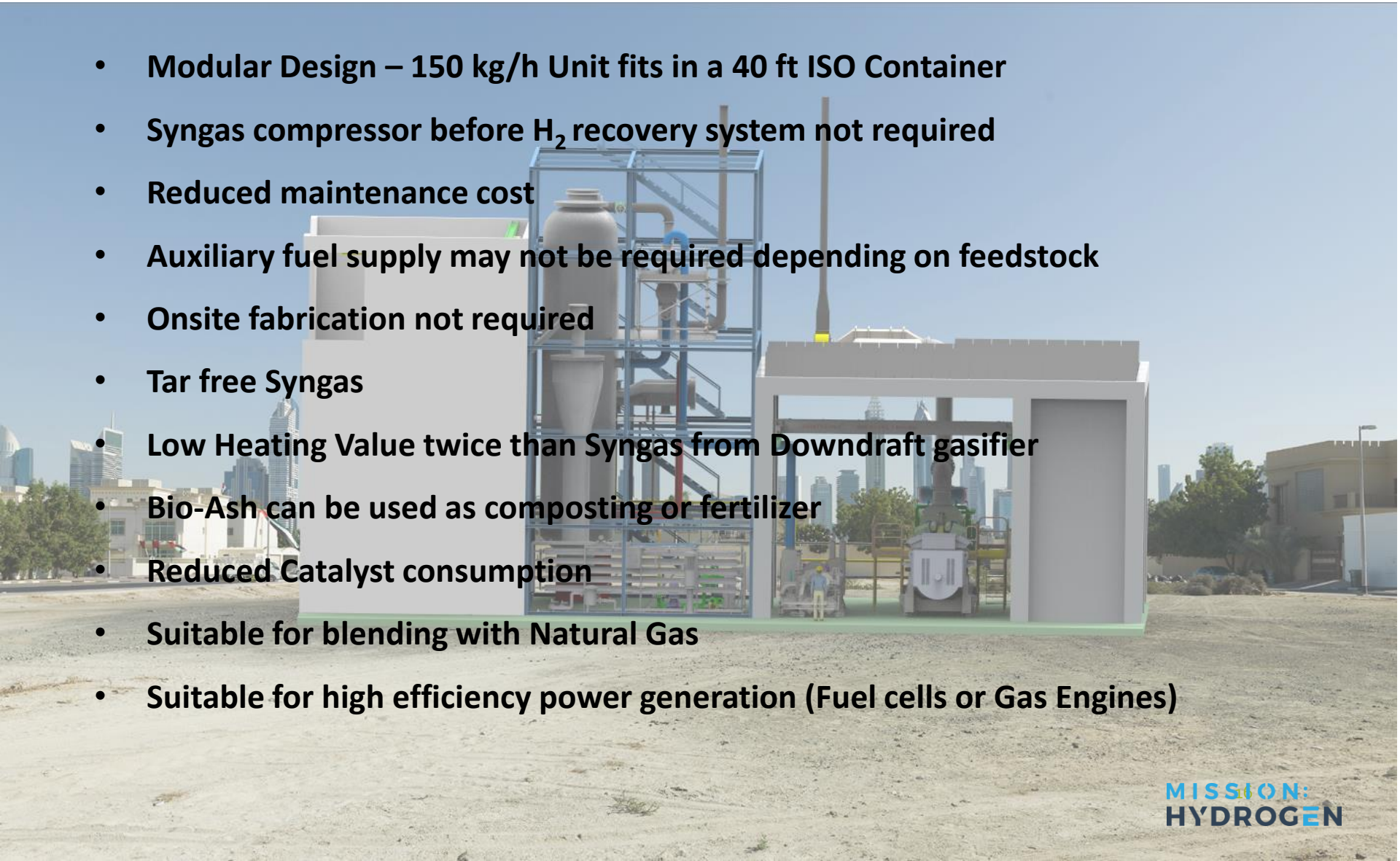
MRE 3rd Generation DFB Design Advantages



- Modular Design – 150 kg/h Unit fits in a 40 ft ISO Container
- Syngas compressor before H_2 recovery system not required
- Reduced maintenance cost
- Auxiliary fuel supply may not be required depending on feedstock
- Onsite fabrication not required
- Tar free Syngas
- Low Heating Value twice than Syngas from Downdraft gasifier
- Bio-Ash can be used as composting or fertilizer
- Reduced Catalyst consumption
- Suitable for blending with Natural Gas
- Suitable for high efficiency power generation (Fuel cells or Gas Engines)

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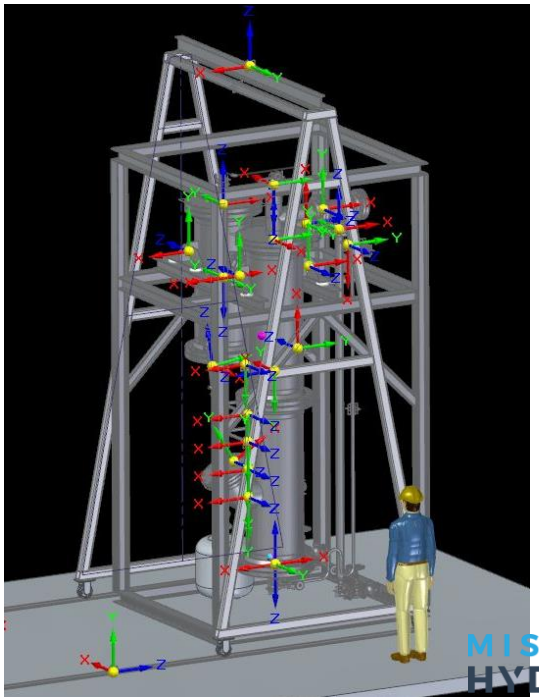
Conclusions and Next Steps

- Gasifying waste biomass addresses priorities such as energy security, climate change, decentralized production and rural economic development
- 3rd Generation gasifier is 60% smaller and 40% cheaper than other gasifiers
- Can use a variety of waste biomass feedstocks
- High hydrogen content syngas (>50% H_2 by vol) with no toxic fly or tars
- Delivering value to all stakeholders
- Site selection and development initiatives are advancing around the world
- Pilot Plant construction is underway in Canada and initial long run rest results target for summer 2023
- Demonstration plant(s) development negotiations underway



Management Team

Gord Glenn

MRE President and CEO

Education: BScH (Geology)

Queen's University

Experience:

GMP · INMET MINING · Griffiths McBurney · Desjardins · MGI Securities · TD · MINNOVA CORP.

Mario Mantaci

DUMA President and Founder
MRE VP of Engineering

Education: Politecnico di Torino

Experience:

Boeing · Collins Aerospace · Avio Interiors · MCI · SKF

Marco Sonnessa

DUMA VP Operations
MRE VP of Business Development

Education: Università degli Studi di Bergamo · University of Manitoba

Experience:

HyLife · DUMA Engineering Inc. · GEO3 Engineering

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DUMA Engineering Inc. Experience & Foresight 2018

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Thank You

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MRE - How to produce Hydrogen from Biomass

Any Questions?

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