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Deconstructing the world's problems to create carbon negative solutions

SEATA Clean Energy & Carbon Sequestration Technology

- General Introduction

November 2024

Presentation Outline

Renewable Energy <u>and</u> Carbon Dioxide Removal – 'Having Your Cake and Eating it Too"

- **SEATA - Who we are and what we do**
- **Process Infographics: Biowastes to Valuable Solid Carbon and Syngas/Hydrogen Products**
- **Why bio-hydrogen?**
- **Harnessing Nature to turn biowastes into a circular solution for climate action with CO_2 Removal**
- **Potential Feedstocks** (clean biomass / problematic carbon-based wastes)
- **Deconstruction of Emerging Contaminants** (PFAS, microplastics etc)
- **Indicative hydrogen production at Pilot and Commercial Scales**
- **Completed Milestones and Forward Program**
- **SEATA's fully approved & operational pilot: '*Clean Energy & Carbon Sequestration R&D Centre'***

*" If your house is on fire, you don't tell the fireman to just let it simmer, you want to put the fire **out** ..we need carbon **removal** that actually **keeps the carbon out afterwards** "*

Albert Bates, Co-author of 'Using Fire to Cool the Earth'

<u>Please Note</u>: *This is a generic introduction (high-level). A technical introduction clarifying the critical points of difference in technology design (why/how it works) can be provided separately.*

SEATA - Who We Are and What We Do

- John Winter – Engineering & Patent Developer
- Robert Tew– Chairman & Commercial
- Scott Fairbairn –Energy & Communications
- James Jordan - Fabrication & Construction
- Jim McFarlane –Mechanical Design
- Rob Faraday-Bensley – Legal & Strategic Advisory
- Craig Bagnall – Environment & Approvals

Above: SEATA Clean Energy & Carbon Sequestration R&D Centre (Glen Innes, NSW)

We've developed a technology for industrially-scalable and flexible advanced thermal treatment of carbon-based wastes diverted from landfill/incineration into valuable commodities, aiding energy transition, reducing new emissions, and removing existing carbon from the atmosphere. SEATA - climate action <u>and</u> circular economy.

Technology to help put the brakes on climate change…

Image Credits: Miha Creative AdobeStock_484607003

Diverting Biowastes & Problematic Wastes from Landfill/Incineration into Valuable Gas & Carbon Products

SEATA **deconstructs** wasted biomass and other carbon sources into valuable **chemical building blocks** **for hydrogen, renewable energy, circular fuels, green chemicals and materials**

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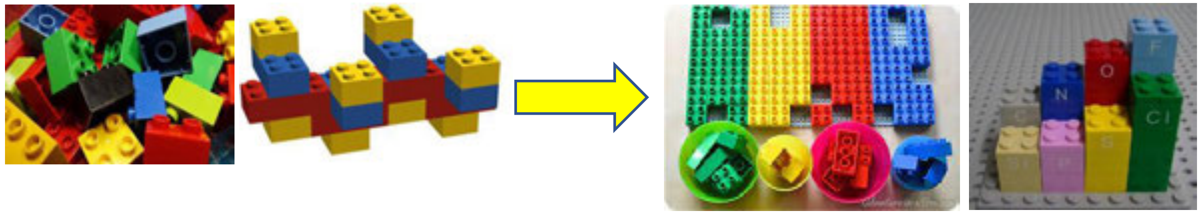
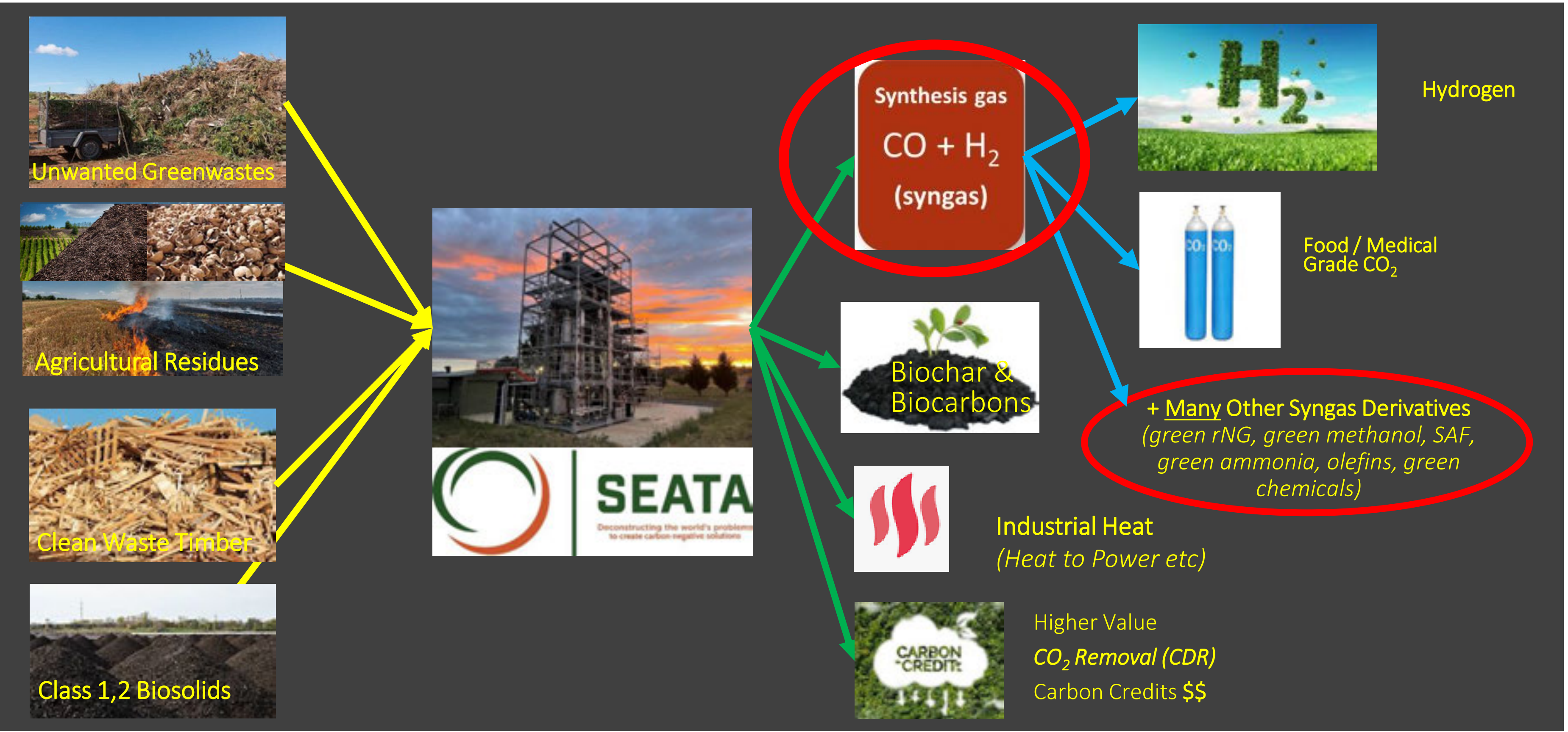


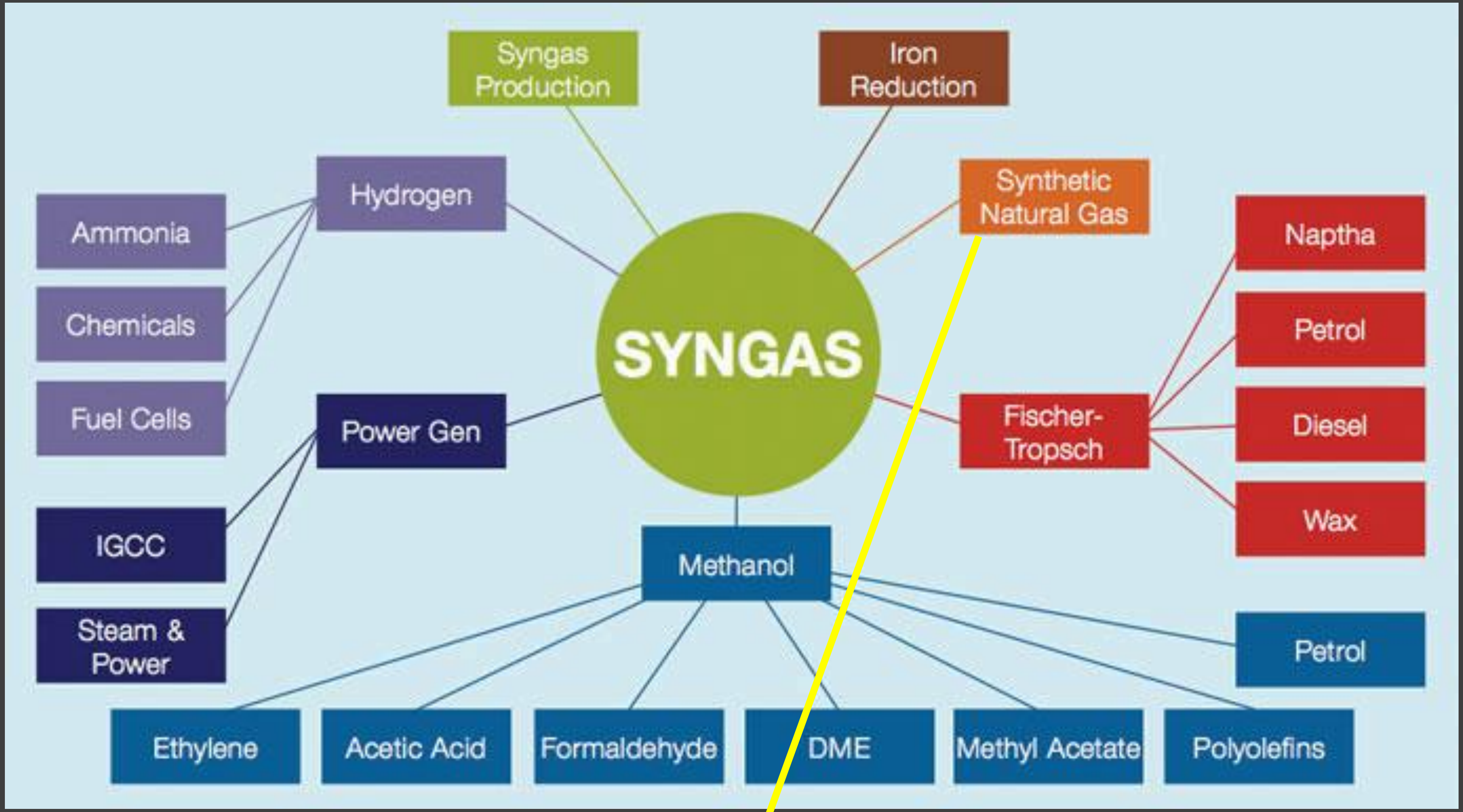
Advanced Chemical and Thermal Looping (CTL) Thermal Technology, employing catalysed pyrolysis and partial gasification



Designed for:

- **Concentrated, High Energy Syngas - Up to 3-4x energy content (Cv)** of conventional.
- **Storable and Compressible Syngas = dispatchable power on demand *and* transportable.**
- **Syngas for direct use in gas engines** with minimal cleanup (>50% energy conversion efficiency), **avoiding need to boil water** to drive turbines as in conventional power gen (~34% ECE via CCGT).
- **HYDROGEN RICH - typically >50% by Volume** (conventional syngas typically <30%).
- **Feedstock flexibility including co-feeds and high moisture feeds (eg biosolids, FOGO etc)**
- **Single-unit scalable** (5-40tph+ industrial scale)
- **Safer management of halogens** (e.g. Cl, F, Br) that inhibit conventional combustion (dioxins etc)
- **Solid Carbon Sequestration =** typically up to 50% of infeed carbon converted to solid biochar/biocarbon (= CDR when made from plant-based biomass).

Syngas Uses - Bioenergy (electricity) *and much more*



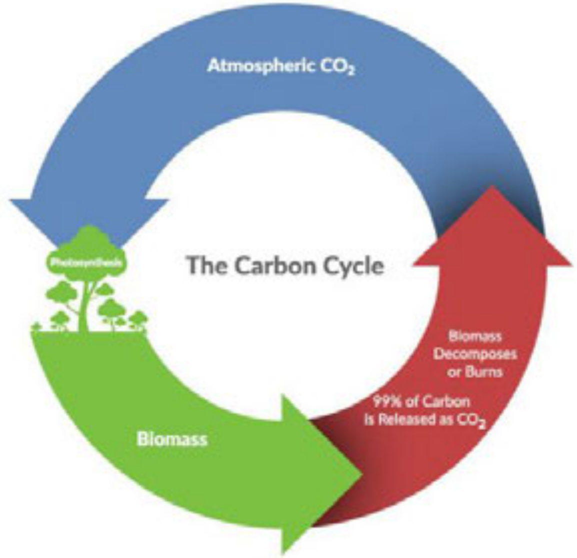
A.k.a 'rNG' – Renewable Natural Gas / Biomethane

- **Chemical building blocks (C, H) of MANY other derivatives** (biofuels, bioplastics / olefins etc)
- **Requires concentrated, clean syngas economically, at industrial-scale**
- **H:C ratios important for scale up** (typically need 2:1, leaving carbon behind in solid char helps this)
- **SEATA design significantly minimizes/eliminates gas cleanup**

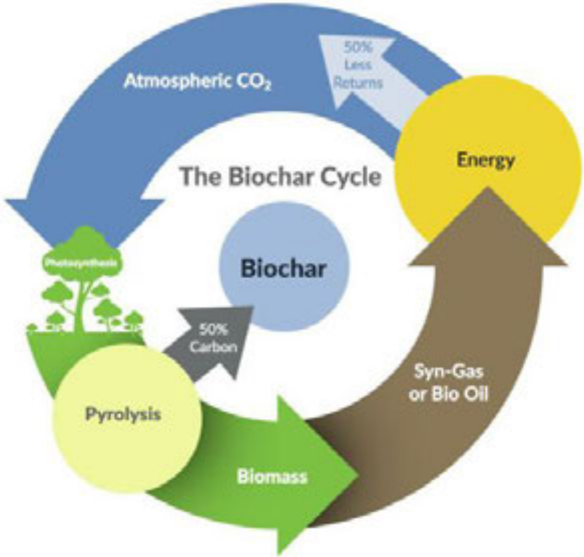
➔ **Clean, concentrated syngas free of atmospheric N_2 facilitates scale & reduces costs (CAPEX, OPEX)**

- **Hydrogen** separation via WSR at scale (or PSA at small scale)

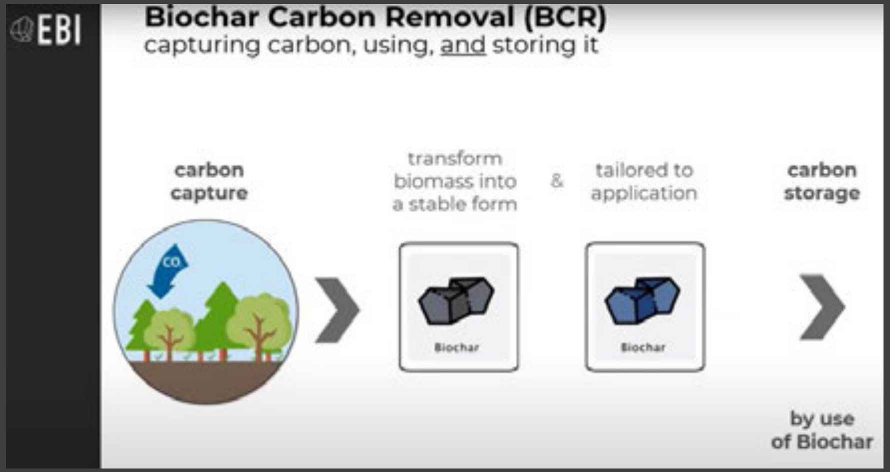
Turning a waste problem into a circular solution for climate change – working *with* nature



Over 99% of CO_2 captured by biomass re-enters our atmosphere as part of the natural carbon cycle.

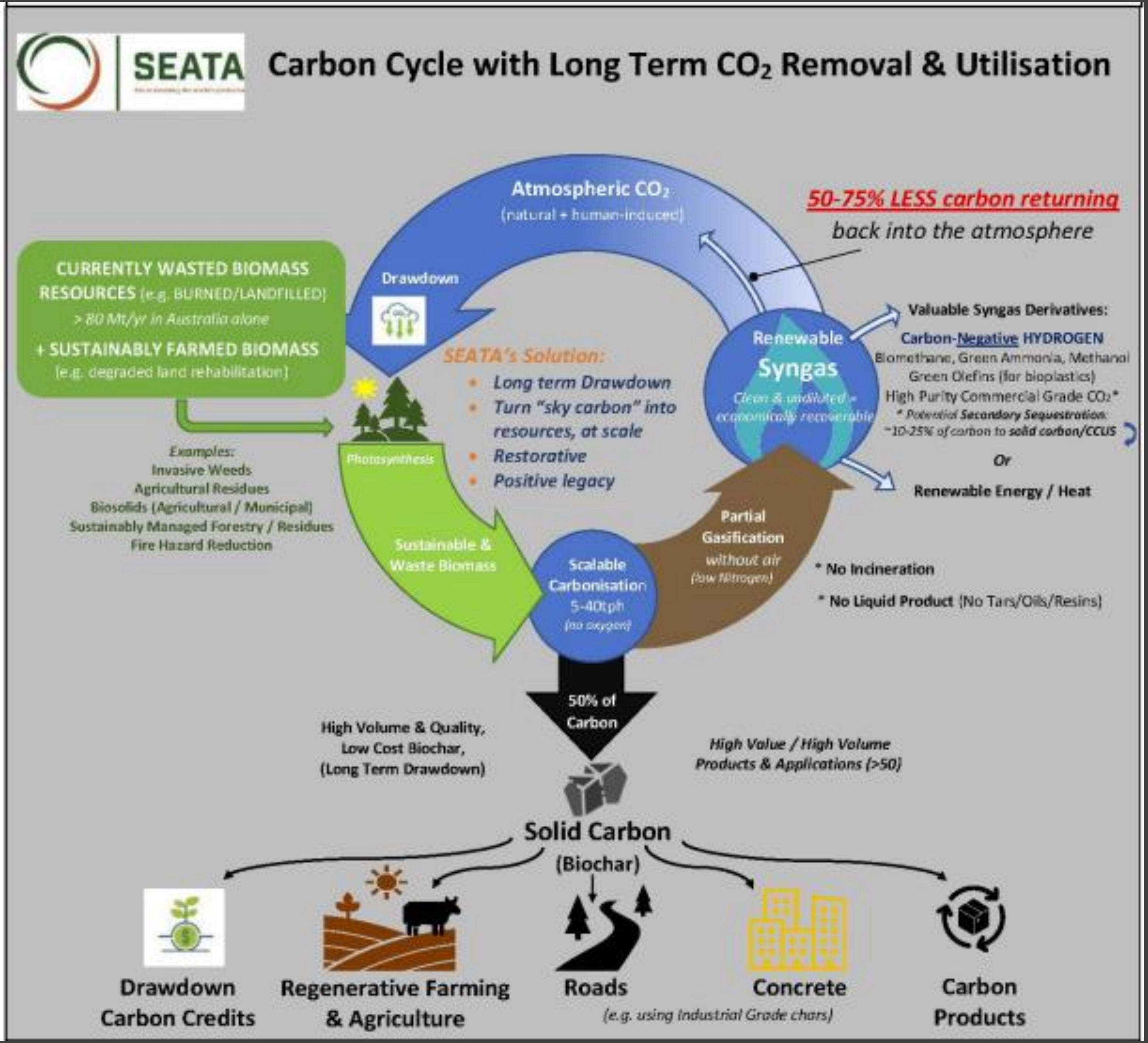


Pyrolysing wasted plant biomass into biochar **intercepts the cycle** and converts carbon into a form that is typically stable for **centuries to millennia**.



*"The **deployment of CDR** to counterbalance hard to abate residual emissions is **unavoidable if net zero** (CO_2 and total GHG) **is to be achieved**."*

IPCC 6th Assessment Report April 2022



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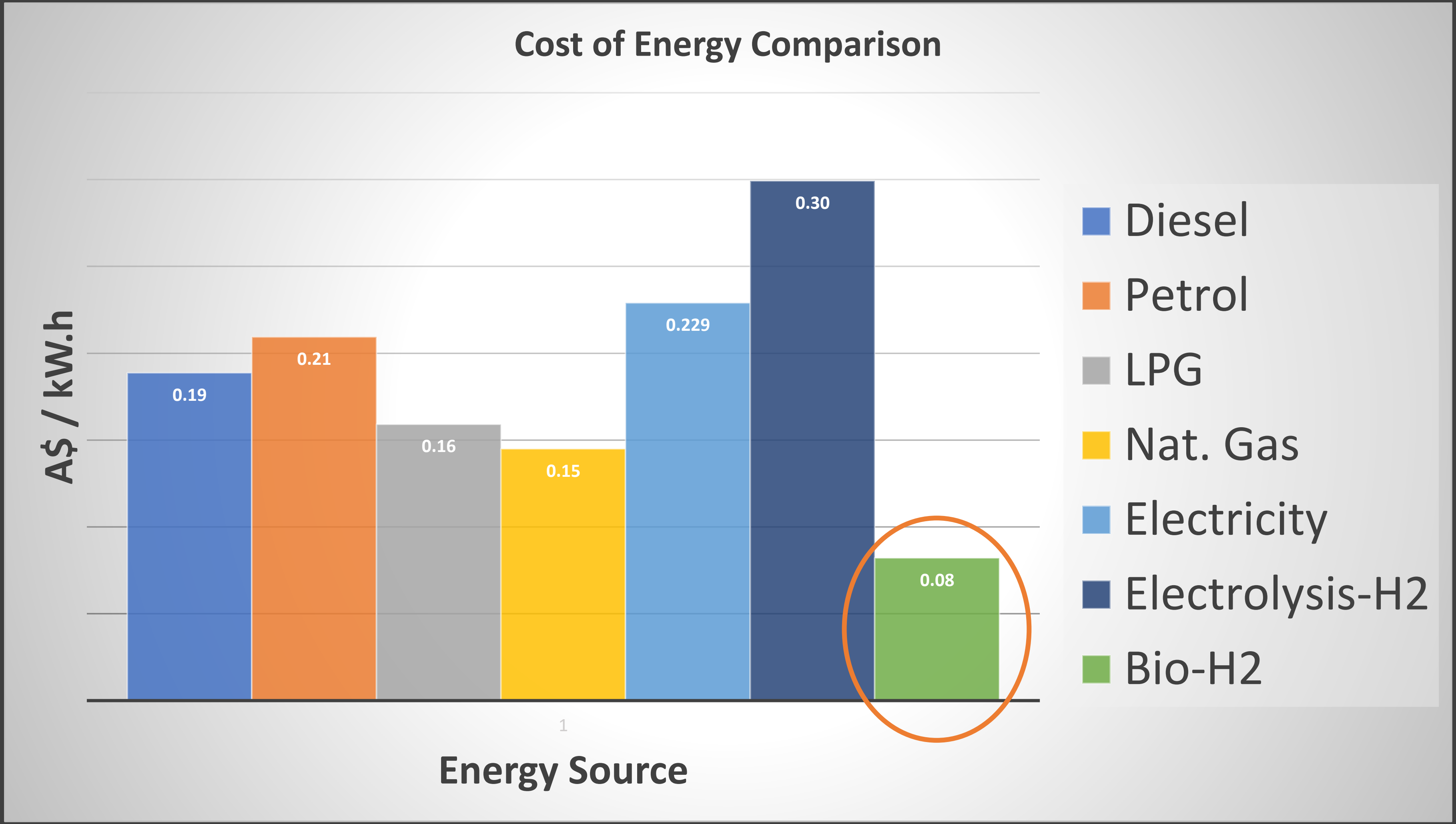
Deconstructing the World's Problems

SEATA:

Biochar CO_2 Removal AND Energy with Valuable Co-Products,

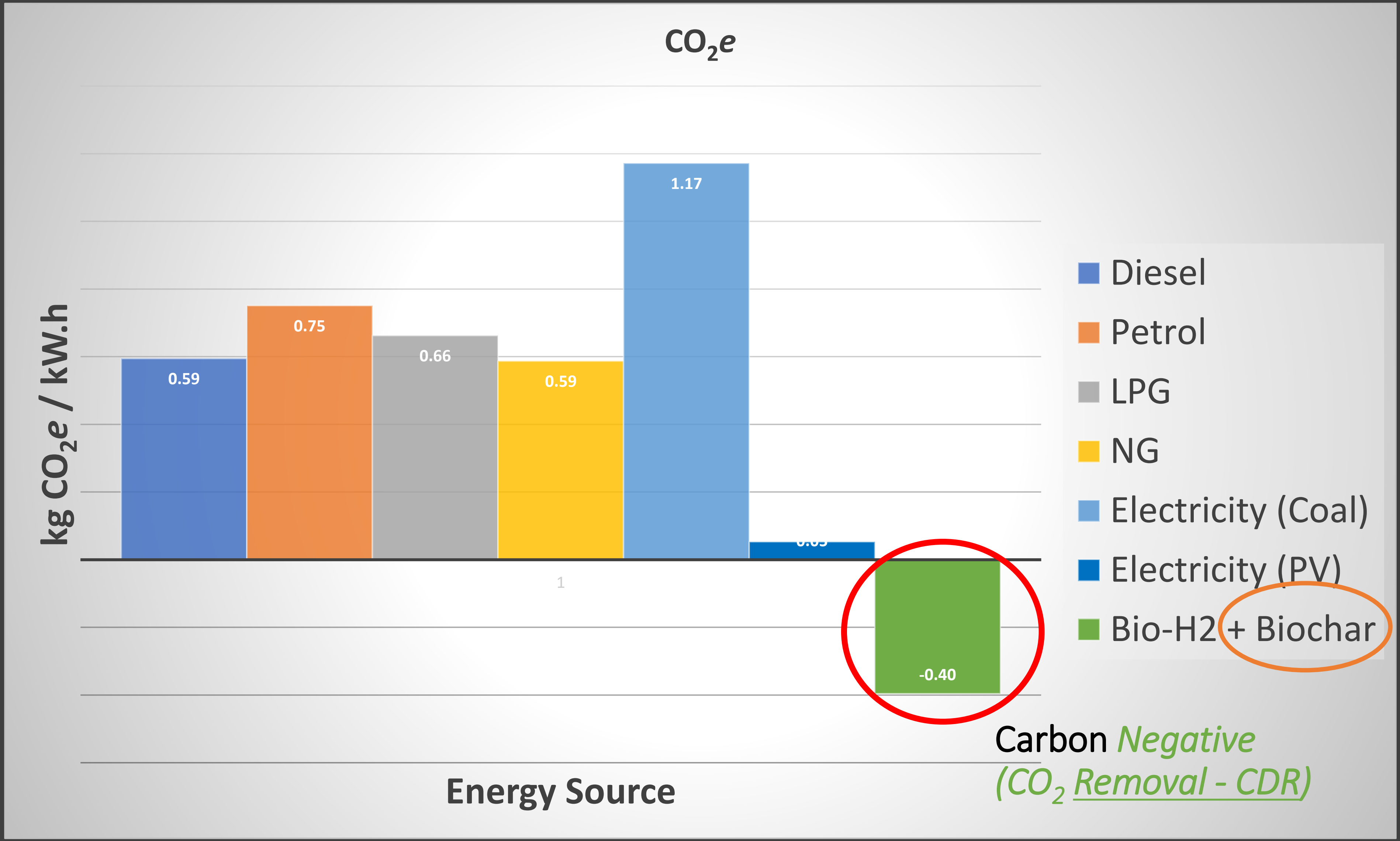
Designed for scalability and flexibility

Why Bio-Hydrogen?



Ref: GlobalPetrolPrices.com, 23 Jan 2023.

‘Greener than Green’ - carbon *negative* hydrogen



Example Potential Scenarios For Urban Green Waste to Bio-Hydrogen

(A) Pilot Scale Demonstration (Hydrogen Trial): Indicative example for a local government area

- SEATA Field Pilot Plant (Glen Innes R&D Centre): Design Annual Infeed (dry) = ~2,250 tpa infeed (@85% utilization)
- SEATA Pilot Scale Potential Annual Hydrogen Yield = ~7% of 2,250 tpa infeed via PSA = **157.5 tpa of hydrogen**
- Council Hydrogen Garbage Truck Demo H_2 Requirement = **~35 tpa of Hydrogen** (~22% of SEATA's pilot scale annual yield)

(B) Indicative Example @ Commercial Scale: 5 tph SEATA Plant *(~120 tonne / day, ~3x 40t truck loads)*

- **~37,000 tpa design infeed** (@85% utilization)
- **~10 tonne / day H_2 (via PSA)** *(current market value >AUD$5,000/t)*
- **~19 tonne / day Biochar** *(current market value ~AUD$600/t)*
- **~19,800 tonnes CO_2e / year Carbon Draw Down** *(current CDR credit value USD>$100/t CO_2e)*

Example Context – Council LGA Green Waste Residues (alone):

- Green waste Generation (Example Council Area) = ~49,000 tpa (dry tonnes per annum)
- ~40-50% Residues (beyond current management/market capacities) **= <24,500 tpa feedstock (to SEATA plant)**

➔ Potential H_2 recovery from 24,500 tpa greenwaste infeed (e.g. via PSA) = ~7% of 25,000 tpa infeed

= 1,750 tpa H_2 hydrogen (from unmanaged greenwaste residues alone, excluding other potential feedstocks)

Hydrogen Production Potential: Comparison with Government Targets

Year	Gigajoule	Equivalent tonnes of hydrogen*	Megawatt equivalent**
2024***	90,000	750	5
2025	360,000	3,000	21
2026	890,000	7,417	53
2027	1,780,000	14,833	106
2028	3,200,000	26,667	190
2029	5,330,000	44,417	317
2030-2044	8,000,000	66,667	476

* Assuming lower heating value of 120 MJ per kilogram of hydrogen
** Estimated assuming 140 tonnes produced per year per megawatt of electrolyser capacity.
*** The 2024 target will not be enforced and no penalty rate will be set.

NSW (Australia) Hydrogen Production Targets & Timing

(OECC, NSW Treasury 2023)

Plant Infeed Size (DM):	RDSM Pilot <300 kg/h	5 tph Infeed Commercial Plant	Up to 40 tph Infeed Industrial Scale Plant
Locations	*SEATA R&D Centre, Glen Innes NSW, Australia*	C&I Site (Elsewhere) (interstate?) (TBC)	Industrial Site **(TBC)**
Potential Design Infeeds (DM) *(@7,500 hrs/yr, ~85% use)*	2,250 tpa	37,500 tpa	300,000 tpa
Potential Carbon Yield *(@~25% yield per tonne of infeed)* *(can customize to <10 to >35%)*	~560 tpa	Up to ~9,400 tpa	75,000 tpa *(current total Aust production <20,000 tpa)*
Indicative Drawdown Via Biochar *(using plant biomass feeds only)* *(+ ~25% more if CO_2 gas also sunk into CCUS (commercial scale)*	**~1,400t** CO_2e/yr *(assuming net ~2.5 tCO_2e per tonne of biochar after LCA)*	Up to **23,500t** CO_2e/yr *(assuming net ~2.5 tCO_2e per tonne of biochar)*	Up to **187,500t** CO_2e/yr *(assuming net ~2.5 tCO_2e per tonne of biochar)*
Design H_2 Yield (as % of infeed)	Flared Initially, (expected ~7% by mass)	7-10% by mass (recovery via PSA or WSR)	**10% by mass** (Recovery eg via WSR)
Potential Annual H_2 Yield *(tpa, uncompressed)*	Nil (no energy recovery)	**2625 – 3750 tpa**	**30,000 tpa**

- **SEATA technology has potential to remove CO_2 from the atmosphere at very significant rates to combat climate change whilst *concurrently* also significantly reducing/avoiding new emissions by assisting energy and fuel transition.**
- Scenarios are theoretical potential pending approvals, funding and successful deployments. Bankable Feasibility Studies to be completed following pilot trials, ahead of commercial plant.

Direct Air Capture + CCS (DACCS) Context:
Project Orca Iceland (operational) = 4,000 tpa (8 x 500 tpa units)
Project Mammoth (const) = 36,000 tpa (72 x 500 tpa units)

SEATA Technology - Potential Hydrogen Production

Based on designs and piloting to demonstrate:

- A *single* 5 tonne per hour SEATA plant could potentially meet the **2025 NSW total H_2 production target**.
- The **2030-2044 NSW annual production target (66,667 tonnes H_2)** could potentially be met by ~2x 40tph SEATA plants (or multiple distributed smaller plants).
- When processing plant-based wastes (green waste, ag residues etc), potential to concurrently provide ***very significant*** **CO_2 Removal (CDR)** toward Net Zero targets (cheaper and far more per unit than DACCS).

Biomass Feedstocks: Sustainable, Regenerative, Gt-Scale Drawdown

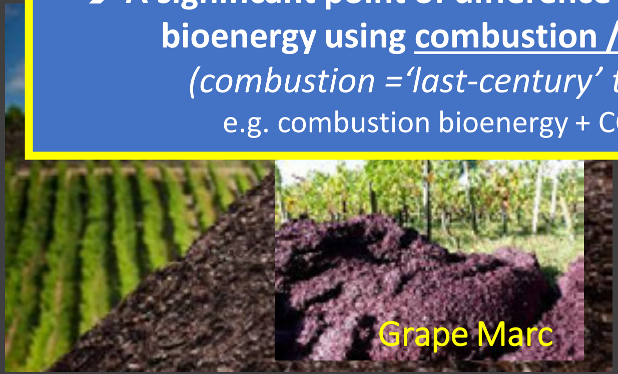
>> 50 Mtpa biomass is burned or landfilled in Australia alone (ANZBIG 2022)

(Up to 80-110 Mtpa of biomass sustainably available, CSIRO 2016). Over 22M tpa biomass residues in NSW alone (NSWDPI 2021)

Globally, biochar CDR potential = up to 6.6 Gt CO_2e/y (up to 1.8Gt/y at <ins><USD$100</ins>/t$CO_2$e) (IPCC, 2022)

Biochar = <ins>Enhanced</ins> food production and security

Biochar bioenergy technologies = **<ins>circular + regenerative</ins>**
➔ **A significant point of difference to historical *<ins>linear</ins>* bioenergy using <ins>combustion / incineration</ins>**
(combustion = 'last-century' technology)
e.g. combustion bioenergy + CCS (BECCS)



Other Potential Co-feeds for Circularity & Avoided Emissions


Textiles Residues


End of Life Plastics


Difficult Plastics (PS, PVC, Soft Plastics etc)


Ocean Plastics

Problematic Organics - EOL & Unrecyclable/Composite Plastics, Textiles, Ocean Plastics
Mixed Waste Organics, Mixed Packaging, Treated Timbers, PFAS soils/media, Biosecurity

→ potentially turned back into industrial carbons and Hydrogen
(and/or Biomethane / Olefins for renewed 'circular' plastics / SAF / Methanol / other fuels)


Biosecurity Event Residues


Painted, Treated and Engineered Timbers


Mixed Waste Organics / FOGO Residues


Compost Overs / Residues

Deconstructing Emerging Contaminants

- PFAS, Microplastics, Pharmaceuticals, Pesticides etc

- Thermal treatments are recognized for deconstructing many organic/carbon-based contaminants. Safe management of **halogens** with suitable air emission controls is key, as is also required for plastics.
- Biological treatment systems (e.g. composting, anaerobic digestion etc) typically do not safely deconstruct PFAS, however biochar bioenergy systems can be used synergistically to complement *and enhance* existing biological systems.
- Pyrolysis and Gasification systems have successfully deconstructed PFAS at both pilot and commercial scales globally. Australian examples include Loganholme (Qld) and South East Water (Vic). Significant success also with microplastics, pharmaceuticals pesticides and herbicides.
- EPA's in at least three (3) European countries (including Denmark) have approved biosolids-derived biochars (BDB) for agriculture, ensuring essential recirculation of phosphorus back into soils whilst safely managing PFAS.
- **SEATA batch/bench scale tests for Hunter Water / DoD demonstrated successful deconstruction of PFAS in biosolids, GAC/PAC and Soil to very low/non-detection levels.** Pilot scale continuous run testing for Class 1 and 2 biosolids is approved for field trials at our Glen Innes R&D facility.
- **WSAA** (Water Services Association of Australia) has submitted a report to the Australian Government encouraging biochar solutions for circular economy and climate action in the water sector, whilst concurrently managing emerging contaminants. WSAA actively promotes biochar on its website and works closely with the ANZ Biochar Industry Group of which SEATA is a founding member.

Milestones

2011+ (P)
Design and Development Work including Patents
ANZ fully secured, international 16 countries lodged, well advanced (pending)

2015+
Bench Scale / Batch System Piloted
(multiple feedstocks, including biosolids, soil, GAC for PFAS).

2019-2022
Construction of Field Scale Pilot (continuous system) *"RDSM"*
HAZOPs Completed

2021-2023
Operational Approvals from NSW EPA, Council for the RDSM / *"SEATA Clean Energy & Carbon Sequestration R&D Centre"* (<300kg/hr)

2024 (Q1-Q3)
Hot Commissioning of Field Pilot Plant (RDSM)

2024 (Q3)
3rd Party Detailed Modelling of Energy Balance *(net export of energy)*

2024 (Q4) (P)
72hr+ Engineering Demonstration to demonstrate energy balance (Proximate and Ultimate analysis)
Continuous feed system (auto loader completed)
External Visits Commence

2024 (Q4)
Detailed Trial (Full Mass & Energy Balance (detailed element level testing)

2025
Ongoing campaign-based trials for clients
(data for commercial scale deployment feasibility)

2025+
Commercial Scale Deployment (5tph infeed)
(~10x scaleup from Pilot).
Potential for problematic co-feeds (beyond clean biomass)

2026+
Industrial Scale Deployment (25-40tph infeed)
(~10x scaleup from commercial)
Theoretically can scale to 100tph (compete with WtE incinerators)

Achieved / Completed
P Near Complete / Pending
Commencing / Planned

SEATA directors have self-funded all development, patents, construction & approvals to date

Milestones cont..

- Design & Development Work (including patents) (2011 onward)
- Bench Scale / Batch System (piloted 2015, ongoing)
- Field Scale Pilot Facility (continuous run capability) (2019 - current)
    - *"SEATA Clean Energy & Carbon Sequestration R&D Centre",* Glen Innes NSW
    - Plant construction completed (2022)
    - Operational Approvals Received from NSW EPA, Council (2021-2023)
    - Cold Commissioning Completed (2023)
    - Hot Commissioning (Q1-Q3 2024)
    - 3rd Party Process Modelling Review of Energy Balance (Q3 2024)
    - Engineering Confirmation 72hr+ Continuous Run (Q4 2024)
    - Detailed Trial (Full Elemental Mass Balance) *(commencing Q4 2024-Q1 2025)*
- Feedstocks
    - a range of biomass and other carbonaceous feedstock resources identified and relationships established (including in NSW & QLD).
    - Industry partner with the Australian Research Centre (ARC) for Transforming Australia's Biosolids Resource (Biosolids Hub), and proposed ARC for Transforming Municipal Organics (TMOR Hub)
    - Over a decade-long relationship with landowner groups of extensive invasive biomass resource in NSW.
- Market Development / Offtake Alignments:
    - Foundation Member of ANZ Biochar Industry Group (2020+)
    - Potential offtake agreements identified for Syngas (energy *and* derivatives), Biochar, and associated Carbon Credits via various applications & commercial interests
    - Letters of Support / MOU from steel, road and other key market applications

SEATA directors have self-funded all development, patents, construction & approvals to date

SEATA Clean Energy & Carbon Sequestration R&D Centre – Glen Innes, NSW (New England Renewable Energy Zone (REZ))

Field Pilot Demonstration Plant:

- ~1/10th commercial scale, continuous run pilot plant.
- **Objective**: Provide high quality field data for client-commissioned feedstocks enabling genuine bankable feasibility for commercial deployment anywhere.
- **Fully approved** (both Development Consent and EPA Licencing).
- **Approved range of 'clean' Biomass and Biosolids Feedstocks** (no plastics etc)
- Approved infeed up to **300 kg/hr** (design capacity 500kg/hr), including co-feeds
- Operates on 'campaign' basis for commissioned tests (24/7 when testing).
- **Regulatory requirements (NSW EfW Policy)** *currently* requires syngas characterization then **flared** at this stage (pilot proof of concept). Future approval modification will be sought to recover energy onsite.
- Excellent working relationship with NSW EPA for over 6 years. SEATA's R&D Centre recently ranked by EPA as *'low risk'* compared to all other licences (EPL) in NSW.

- **Next Steps**:
  - Commence *detailed* testing campaigns of clean feed(s) for commercial clients
  - Engagement to construct **5tph Commercial Scale Plant(s)**
  - **'Dirty' Feedstock R&D Plant / Commercial Plant** *(concurrent with above)*
  - Approval modification to recover energy onsite at Glen Innes as soon as innovation pathway established for such (*concurrent with above)*.

Thankyou. Questions?

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