Transport and Infrastructure Net Zero Consultation Roadmap

Take the survey

Department of Climate Change, Energy, Environment and Water

Response received at:
August 12, 2024 at 9:48 AM GMT+10

Response ID:
sbm2fd9f001b13b745bbc505

1 Confirm that you have read and understand this privacy notice.
Yes

2 Please indicate how and if you want your submission published.
Public

3 Published name
SEATA Group

4 Confirm that you have read and understand this declaration.
Yes

5 First name
Not answered

6 Last name
Not answered

7 Email
Not answered

8 Phone
Not answered

9 Who are you answering on behalf of?
Organisation

10 Organisation name
SEATA Group

11 What best describes you or your organisation?
Not answered

12 What sector do you represent?
Not answered

13 What state or territory do you live in?
New South Wales

14 Postcode
2990

15 What area best describes where you live?
City

16 1. Do you support the proposed guiding principles?
Not answered

17 1.1 Please add details to your response.
Not answered

18 2. Do you support the use of the avoid-shift-improve framework as a tool to identify opportunities for abatement?
Not answered

19 2.1 Please add details to your response.

Not answered

20 3. Do you agree the development of a national policy framework for active and public transport will support emissions reduction?

Not answered

21 3.1 Please add details to your response.

Not answered

22 4. What should be included in a national policy framework for active and public transport and how should it be developed?

Not answered

23 5. What additional actions by governments, communities, industry and other stakeholders need to be taken now and in the future to ensure the movement of people contributes to transport emissions reduction?

Not answered

24 6.1 What additional actions by governments, communities, industry and other stakeholders need to be taken now and in the future to ensure that the movement of goods contributes to transport emissions reduction?

Not answered

25 6.2. How would these actions address the identified challenges and opportunities for emissions reduction in the movement of goods?

Not answered

26 7. Do you agree with the proposed net zero pathway for light road vehicles?

Not answered

27 7.1 Please add details to your response.

Not answered

28 8. The Australian Government is currently developing an Australian New Vehicle Efficiency Standard and has already begun to implement actions in the National Electric Vehicle Strategy.8.1 What additional actions by governments, communities, industry and other stakeholders need to be taken now and in the future to reduce light vehicle emissions?

Not answered

29 8.2 How would these actions address the identified challenges and opportunities to reduce light vehicle emissions?

Not answered

30 9. Do you agree with the proposed net zero pathway for heavy road vehicles?

Not answered

31 9.1 Please add details to your response

Not answered

32 10. The proposed pathway for heavy road vehicles relies on a mix of battery electric, hydrogen fuel-cell and low carbon liquid fuels.Rank from 1 to 3, the order in which these should be prioritised for emissions reduction.

Not answered

33 10.1 Please add details to your response. Why did you rank them in that order?

Not answered

34 11. What role should low carbon liquid fuels play in the heavy vehicle

decarbonisation?
Not answered

35 12. What additional actions by governments, communities, industry and other stakeholders need to be taken now and in the future to reduce heavy vehicle emissions?
Not answered

36 13. Do you agree with the proposed net zero pathway for rail?
Not answered

37 13.1 Please add details to your response.
Not answered

38 14. The proposed pathway for rail relies on a mix of battery electric, hydrogen fuel-cell and low carbon liquid fuels.Rank from 1 to 3, the order in which these should be prioritised for emissions reduction.
Not answered

39 14.1 Please add details to your response. Why did you rank them in that order?
Not answered

40 15. What role should low carbon liquid fuels play in rail decarbonisation?
Not answered

41 16. What additional actions by governments, communities, industry and other stakeholders need to be taken now and in the future to reduce rail emissions?
Not answered

42 16.1 How would these actions address the identified challenges and

opportunities to reduce rail emissions?
Not answered

43 17. Do you agree with the proposed net zero pathway for maritime?
Not answered

44 17.1 Please add details to your response.
Not answered

45 18. The Australian Government is engaging in consultation as part of the development of the Maritime Emissions Reduction National Action Plan and those consultations will also inform the final Roadmap and Action Plan. 18.1 What additional actions by governments, communities, industry and other stakeholders need to be taken now and in the future to reduce maritime emissions?
Not answered

46 18.2 How would these actions address the identified challenges and opportunities to reduce maritime emissions?
Not answered

47 19. Do you agree with the proposed net zero pathway for aviation?
Not answered

48 19.1 Please add details to your response.
Not answered

49 20. The Australian Government has already engaged in consultation on aviation decarbonisation through the development of the Aviation White Paper and those consultations will also inform final Roadmap and Action Plan.
Not answered

50 20.1 What additional actions by governments, communities, industry and other stakeholders need to be taken now and in the future to reduce aviation emissions?

Not answered

51 21. Do you agree with the proposed net zero pathway for transport infrastructure?

Not answered

52 21.1 Please add details to your response.

Not answered

53 22. What additional actions by governments, communities, industry and other stakeholders need to be taken now and in the future to reduce transport infrastructure emissions and ensure that transport infrastructure is ready for and enables low-emission transport modes?

Not answered

54 22.1 How would these actions address the identified challenges and opportunities to reduce transport infrastructure emissions?

Not answered

55 23. What additional actions by governments, communities, industry and other stakeholders need to be taken now and in the future to ensure the energy mix is ready to support transport emissions reduction?

Not answered

56 24. How should the use of low carbon liquid fuels (LCLFs) be prioritised across different transport modes over time to achieve maximum abatement?

Not answered

57 25. What are the best ways for the Australian Government to work collaboratively with industry, business, governments and communities to implement the proposed pathways?
Not answered

58 25.1 What are good domestic or international examples of partnership and collaboration on transport and transport infrastructure emissions reduction that could inform the final Roadmap and Action Plan?
Not answered

59 25.2 What opportunities can Government leverage to show leadership in Australia and internationally?
Not answered

60 26. What measures and metrics should be used to evaluate the final Transport and Infrastructure Net Zero Roadmap and Action Plan?
Not answered

61 26.1 What other data and evidence could governments use and how could this offer further insights on the pace, scale and location of transport emissions reduction pathways?
Not answered

62 27. Do you have any feedback on the proposed review process?
Not answered

63 28. Do you have any further feedback on the Consultation Roadmap and proposed pathways?
Not answered

64 28.1 Is there anything missing? Are the sections appropriately integrated? Is the Roadmap appropriately ambitious?
Not answered

65 29. Is there any further information or documentation that you wish to be considered with your submission?
Not answered

66 Would you like to upload a document?
Yes

67 Have you removed any identifying information from your submission?
Yes

68 Upload a submission
SEATA Full Doc.pdf

69 Upload a submission
SEATA_Submission_Transport_Infrastructure_Net_Zero_Consultation_Roadmap_20240808 .b87bc

70 Upload supporting file
Not answered

71 Upload supporting file
Not answered

SEATA Holdings Pty Ltd, trading as **SEATA Group**
Suite 1, Level 1, 160 Pacific Highway Charlestown NSW 2990
E: info@seatagroup.com.au
ABN: 87 628 218 342 **ACN**: 628 218 342

9th August, 2024

Net Zero Unit
Commonwealth Department of Infrastructure, Transport, regional Development, Communications and the Arts

Submitted via email: netzero@infrastructure.gov.au

Re: Feedback Submission - *Transport and Infrastructure Net Zero Consultation Roadmap*

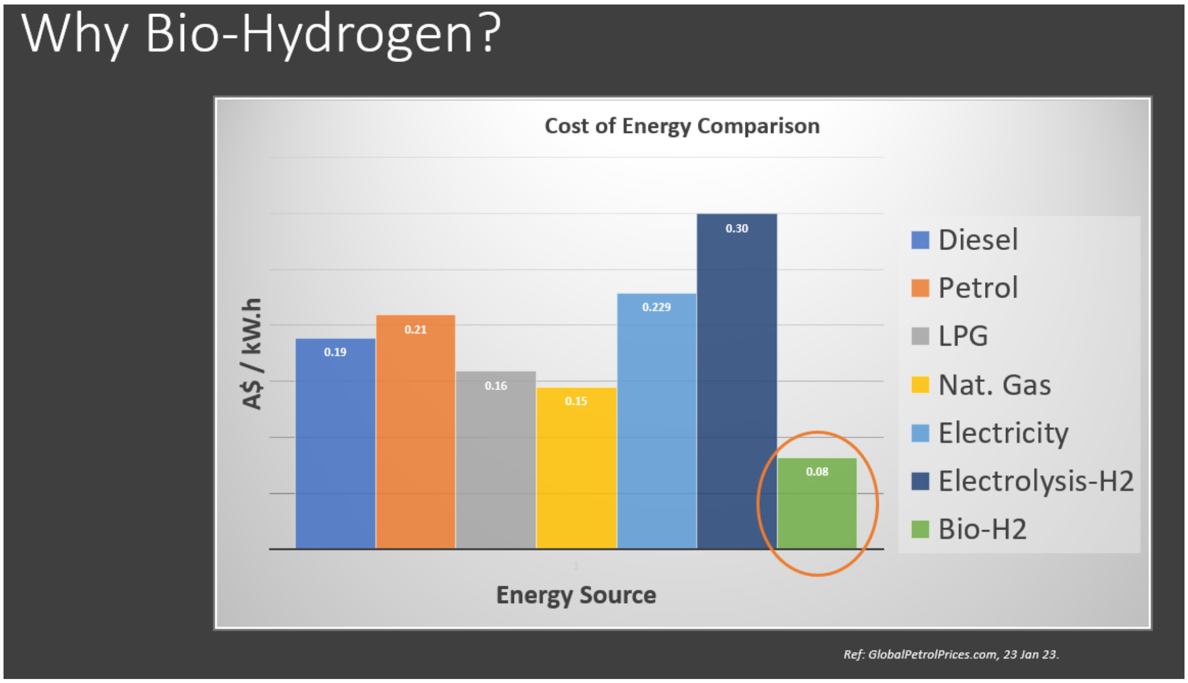
Thank you for the opportunity to provide a submission on the Transport and Infrastructure Net Zero Consultation Roadmap ('Consultation Roadmap'). **SEATA Group (SEATA)** has developed a new advanced thermal technology (currently at field pilot in NSW) designed to produce high quality biochar and concentrated high grade syngas (in a single stage process) providing the chemical building blocks to economically produce valuable syngas derivatives such as **a range of biofuels/LCLF** and **carbon *negative* hydrogen**, **at commercial and industrial scales**. As outlined further below, to provide an indication of the potential for biohydrogen production, a single 5 tph SEATA plant is designed to provide the equivalent of the *entire* 2025 hydrogen target set by the NSW Government (3000 tpa), along with all the co-benefits of biochar (refer to separate submission by the Australia New Zealand Biochar Industry Group). The technology is designed up to 40 tph infeed (8-40x larger than conventional pyrolysis plants for biochar to date), and in theory can provide significantly larger capacities. This could provide a genuine renewable and sustainable alternative superior to conventional large combustion and incineration for both distributed and dispatchable peaking or baseload energy, at a fraction of the cost and with many environmental, economic and social benefits. A technical introduction to SEATA technology is provided in **Appendix 1**, with introductory high-level illustrations in the figures further below.

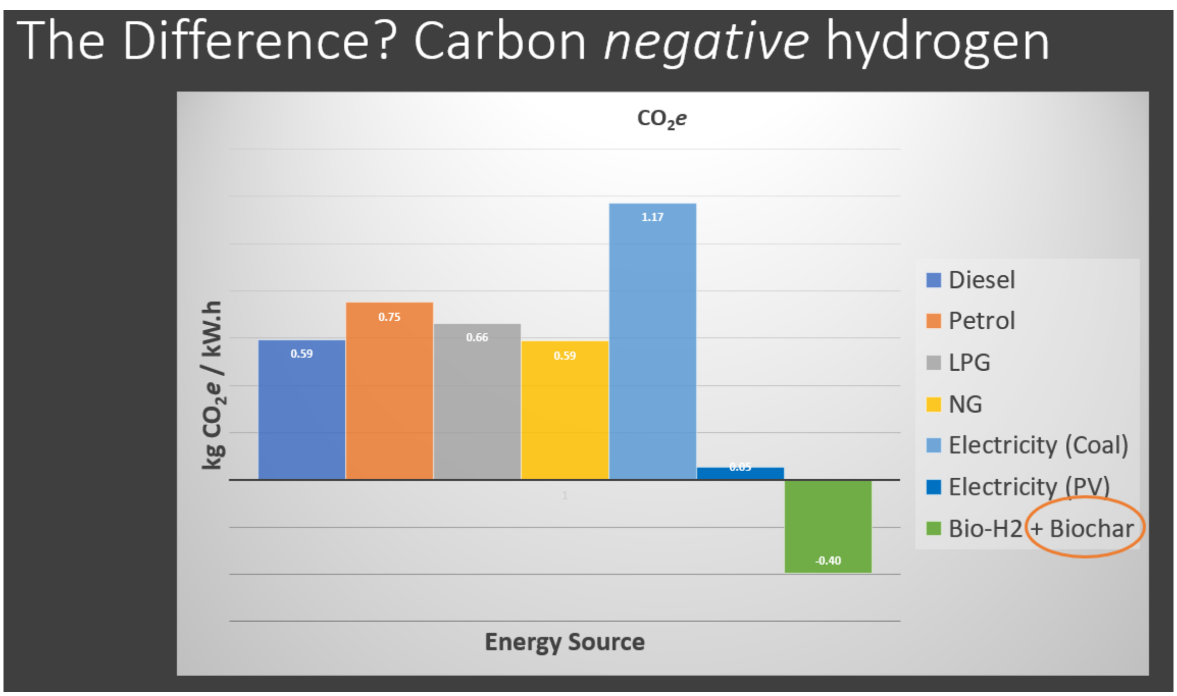
SEATA strongly supports the initiatives of the Consultation Roadmap, **in relation to the opportunities for bioenergy to assist decarbonisation**. Due to the unique nature of our Australian technology outlined above, we are also writing to inform the Department of the emergence this technology which has significant potential to provide **low-cost carbon-*negative* hydrogen and/or a range of biofuels and related derivatives including SAF, methanol, biodiesel, green ammonia, olefins etc, at industrial scale.** Our pilot facility in Glen Innes NSW (shown below) has **already been constructed and approved** and has commenced hot commissioning.

Above: SEATA Pilot Facility - Clean Energy and Carbon Sequestration R&D Centre, Glen Innes NSW (New England REZ).

Figures 1, 2: "Greener than Green": Carbon-Negative Hydrogen

Please also find enclosed a copy of a presentation based on one made by SEATA at *Bio360* in France in January 2023, *"Hydrogen with Benefits – Carbon **Negative** H_2"*. Two notable screenshots from the presentation are shown below.





High grade syngas and hydrogen *at low cost* (at scale) facilitates competitive delivery of a range of biofuels including SAF. SEATA is confident the design of our emerging technology could significantly contribute to **lowest-cost SAF** for Australia over current renewable SAF production techniques. Low cost SAF has been identified in the Consultation Roadmap as the critical challenge to enable decarbonisation of aviation transport. SEATA welcomes further discussion on how we can assist this urgently required transition which could be highly beneficial for Australia (including export).

Figure 3: SEATA Syngas and Biochar from Biowastes

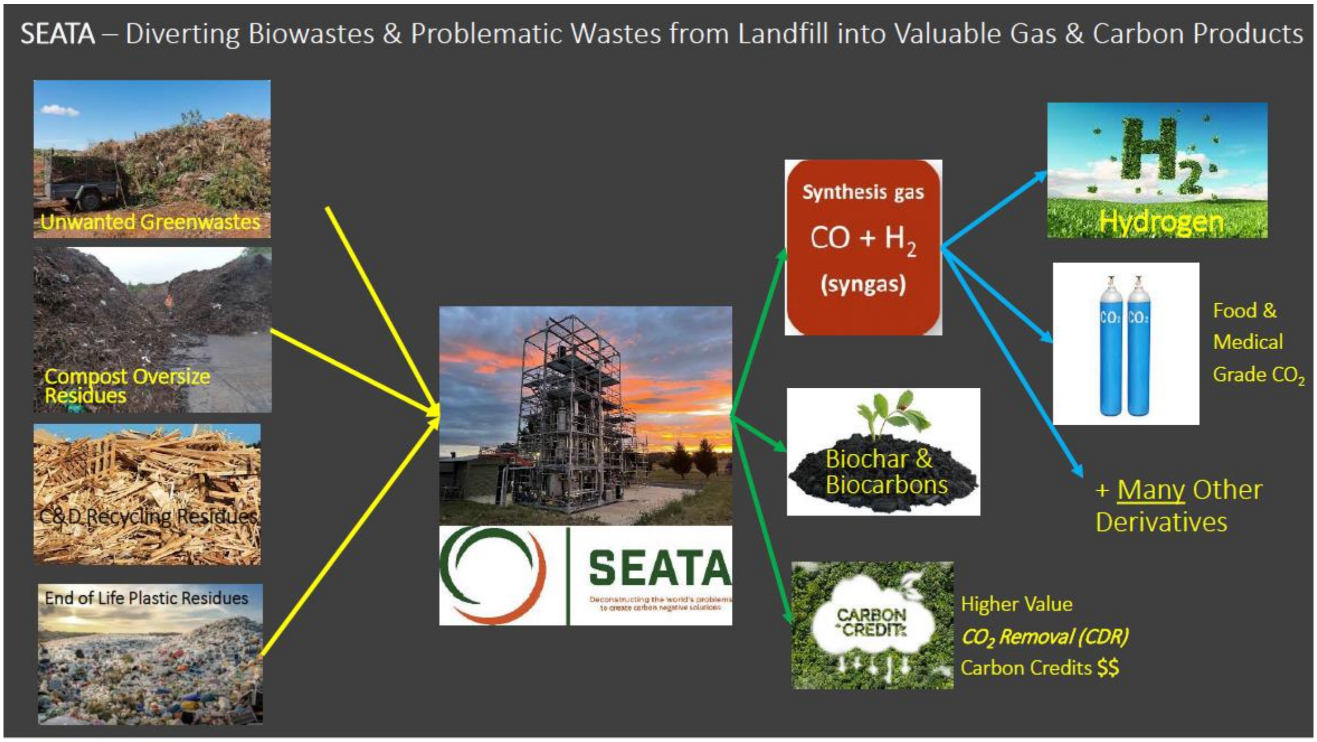
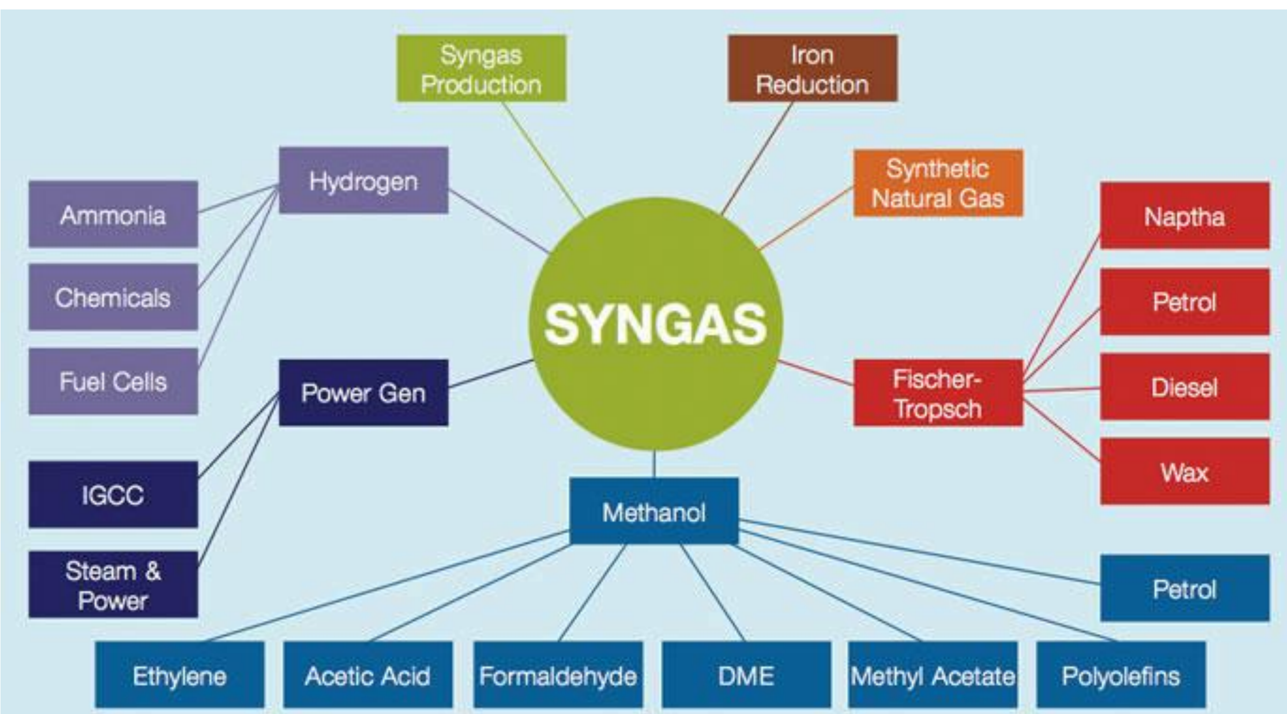


Figure 4: Syngas Derivatives – Bioenergy and Multiple Valuable Biofuels. A key factor for industrial scale deployment of *syngas to fuel* pathways is the need for high grade concentrated syngas without costly cleanup, which is exactly what SEATA technology has been designed to provide. SEATA syngas has a very high energy (Cv) and hydrogen content. All liquids/tars/resins typically produced in conventional technologies are transferred to gas phase, and the syngas has no dilution by air (atmospheric nitrogen).



SEATA Holdings Pty Ltd, trading as **SEATA Group**
Suite 1, Level 1, 160 Pacific Highway Charlestown NSW 2990
E: info@seatagroup.com.au
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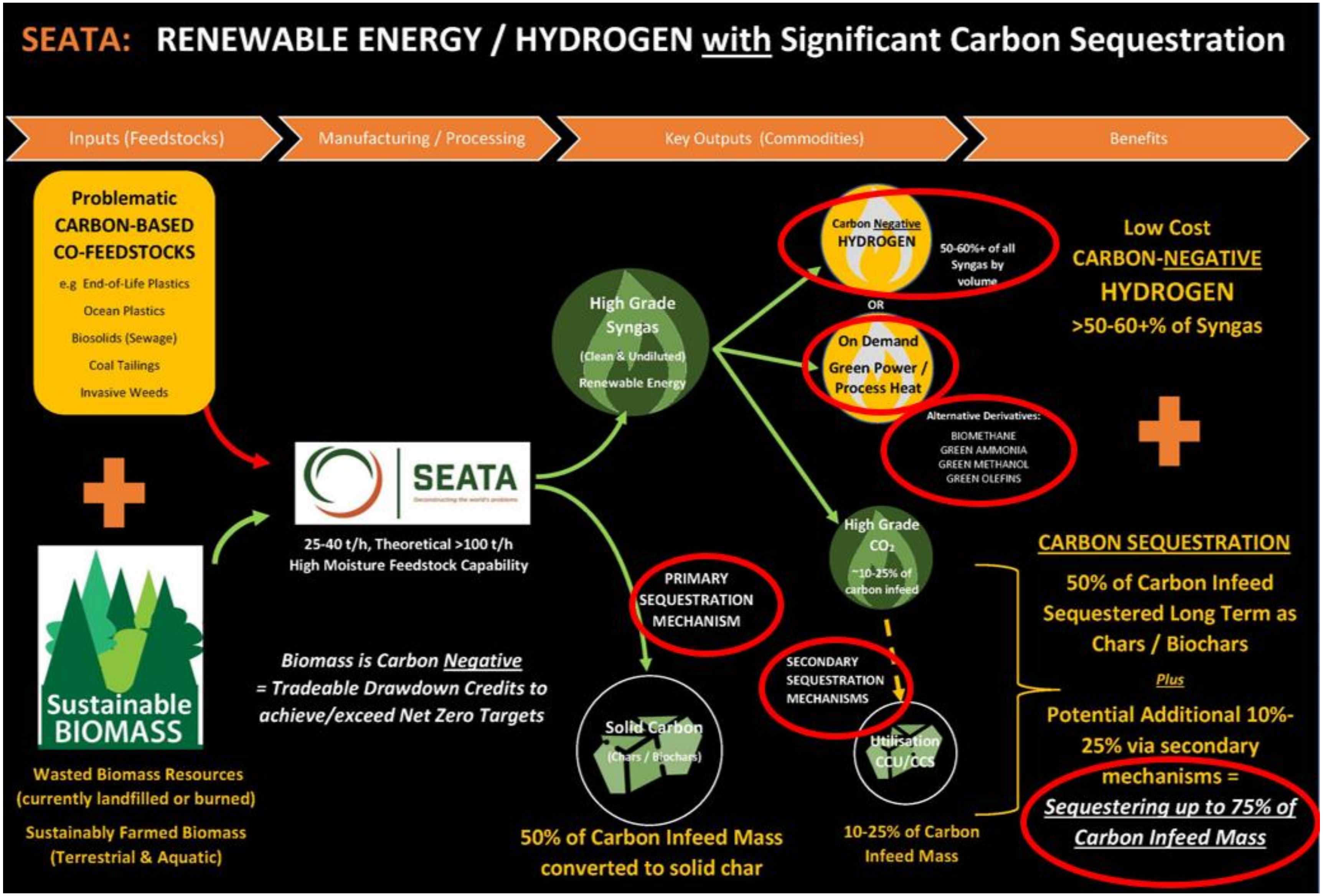


Combustion Vs Gasification Vs Pyrolysis...Vs SEATA CTL

ECONOMIC PERFORMANCE Design Factors	Incineration* (full combustion, high excess oxygen)	Conventional Air-blown Gasification (partial oxidation) (air-blown, high N_2)	Conventional Pyrolysis (low/no oxygen)	SEATA Catalysed Pyrolysis & Partial Gasification via chemical looping (indirect O_2 transfer from air, low N_2 in syngas)
Economic Scalability & Throughput	**High** (>100's tph per module)	**Moderate** (10's tph per module)	**Low** (~1 tph per module)	**High** (5-40 tph per module current designs, with >100 tph possible in the future)
Target Application	Large Scale, centralised	Med scale centralised	Small scale decentralised	**Flexible small to large scale, central or decentral**
Energy Efficiency *(thermal energy available for other processes, i.e., generation of electricity)*	**Moderate** (50-60%), Using Rankine cycle	**Moderate** (40-65%) Two-stage combustion, plus Rankine cycle	**Moderate** (60%), **with C capture** High parasitic heat losses, only ~1/3 of the input energy available for combustion as syngas, syngas can use in combined cycle gas engines after further cleaning	**High** (70-80%), **with C capture** Lower heat losses due to scale of operation, higher process intensity, high proportion of clean syngas (~2/3 of the input feed) that is ready for use in gas engines, therefore combined cycle power generation possible
Technology Readiness	**Mature**, proven at scale	**Mature**, proven at scale	**Maturing**, proven at small scale	**Emerging** (TRL 6)
Parasitic Load Losses	**Moderate**	**Moderate**	**Moderate**	**Low**
Feedstock Moisture Content Capability *(Technical)*	**High**	**Moderate** Typically, 10-20%, max 50% feedstock pre-drying required	**Low** feedstock pre-drying to 10-20% required, as all heat transfer is indirect	**High** Typically, 20-30%, but can handle up to 70-80%, however net output energy is lowered
Linear Economy Vs Circular Economy	**Linear**	**Linear**	**Circular** (biochar & liquids, syngas for immediate energy only)	**Circular** (Full Potential) (biochar and storable syngas for derivatives/products OR energy on demand)
Feedstock Compatibility / Flexibility	**High**	**Moderate** Limited feedstocks and particle sizing is important	**Moderate**	**High** Good flexibility / versatility
Primary Reaction Temperature in commercial systems	**High** 800-1450°C	**Moderate** 750—1000°C (airblown)	**Low** 350-700°C	**Low** 350-700°C (primary reactor), all syngas from primary reactor treated to 850°C to achieve complete thermal decomposition of all volatile tars and oils.
Atmosphere	Air	Partial Air	Low /No Oxygen	Low Oxygen (O_2 supplied via chemical looping
Pressure (bar)	1	1-10	1	1 (and can be designed in future to be pressurised)
Stoichiometric Ratio	>1	<1	0	0 – 0.2
Principle Outputs (Products) ***Products:***	**Heat & Combustion Products only**	**Lean Syngas**	**Char + Liquids + Rich Syngas (dirty)**	**Char + Rich Syngas (clean)**
Gases:	Combustion Products Only *(No Syngas)*	Combustible Lean Syngas	Combustible Rich Syngas	Clean Rich Syngas = economically recoverable products or energy, including energy on demand
Liquids:	No liquid products *(scrubber waste only)*	0-20% Liquid product, *(plus scrubber waste)*	Liquids (products & waste), *(plus scrubber waste)*	No problematic liquid products *(minor scrubber waste only)*
Solids:	High ash waste, No targeted products	Low char, High Ash waste (char <10% of feed by mass)	High quality but expensive biochar (~30% of feed by mass)	Low-cost, high-quality biochar (15-35% of feed by mass)
Principle Gas Components	**CO_2 and H_2O**, O_2, N_2 + Other gases e.g., SO_x, NO_x, etc.	**CO and H_2, N_2, CO_2**, CH_4, H_2O, + Other minor gases	**CO and H_2**, + hydrocarbons, H_2O, CO_2, CH_4 + Other minor gases including nitrogen compounds, dioxins and furans	**High purity H_2, CO**, CO_2 No hydrocarbons dioxins & furans H_2 content >50% by volume.
By-Products / Waste *(throughput inefficiencies)*	Toxic bottom ash or slag to dispose, High volumes scrubber waste	Toxic Bottom Ash to dispose, High volumes scrubber waste	Tars, resins, oils, pyrolysis water (plus, syngas scrubber waste)	Minimal inert scrubber waste only. No Ash/Liquids (no tars, resins, oils)
CAPEX	**High** Due to extensive off-gas scrubbing requirements	**Moderate** Scalable with moderate off-gas cleaning requirements	**High** Due to limited reactor scale-up, requiring multiple units to achieve scale of operation	**Low to Moderate** Good scalability and low gas cleaning duty
OPEX	**Moderate** High cost for gas scrubbing reagents and disposal of the resulting waste streams	**Moderate**	**High** High maintenance and high number of operating personnel	**Low**

The combination of a high grade concentrated syngas with biochar sequestering around half the carbon (by mass) in the feedstock, results in a syngas H:C molar ratio of ~2:1, providing chemical building blocks in an economical single-stage process for synthesis to valuable secondary derivatives such as biofuel products and applications (noting conventional biofuel processes are typically *multi-stage*). When recovering hydrogen from the syngas, the valuable coproduct is high grade CO_2 (medical and food grade) also capable of use in many secondary durable "sink" processes including enhanced weathering and building products such as synthetic gyprock (carbonates) and other emerging applications (e.g. polycarbonate bioplastics).

SEATA's process offers a more efficient alternative to conventional bio-diesel production with a higher crop yield to diesel ratio in a new carbon / short carbon cycle with the added benefit of biochar carbon removal with co-benefits. SEATA is designing for biodiesel /middle distillate production at less than $2/L at scale dependent on feedstocks.

SEATA intends to be in a position to make a decision in relation to a commercial scale plant in late 2024. With appropriate requisite support (financial, policy/regulatory and market-specific), **SEATA could be ready to produce carbon-*negative* green hydrogen at scale <u>in 2025-26,</u>** providing measurable and early action towards hydrogen and other related climate and Net Zero objectives of the Federal government. As an example, in NSW where SEATA is based the state government has set a green hydrogen production target of **750 tonnes by 2024**. Based on our designs, we expect this goal could be met by **a single** 5 tonne per hour SEATA plant - our initial *smaller* commercial plant design. Further, the NSW **<u>2030-2044 target</u>** of 66,667 tonnes of H_2 could potentially be met by just over **two (2)** 40 tph SEATA plants and potentially well ahead of the 2030-2044 target, as indicated in the two screenshots below. The process does not require any significant water inputs, and is synergistic with rural and regional Australia where water is a precious and scarce resource which complicates deployment of conventional electrolysis.

SEATA would welcome the opportunity to engage further with the Commonwealth on the economic potential of our technology could bring to Australia via low cost carbon-*negative* hydrogen an biofuels **rapidly** at industrial scale, and requests an in-person meeting with the Department at your convenience. SEATA also invites representatives of the Department to visit our pilot facility in Glen Innes.

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.

Left:

NSW Govt Targets (OECC)

'Drawdown' Potential (CO_2 Removal) – Removing carbon from the atmosphere to address Climate Change, at scale.

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)**

Left:
SEATA Design Targets

Potential Scenarios to Address Green Waste Residues - Examples

***(A) Pilot Scale Demonstration (Hydrogen Trial)*: Indicative Example in LMCC Context**

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

***(B) Indicative Example @ Commercial Scale*: 5 tph SEATA Plant (120 tonne / day = 3 truck loads)**

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

***Example Context – Local Government Green Waste Residues (indicative LGA)*:**

- Green waste Generation from LGA = ~49,000 tpa
- ~40-50% residue (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)

SEATA supports the actions listed within the Consultation Roadmap. **Additionally, we suggest the following recommendations could significantly enhance the roadmap to accelerate decarbonization efforts:**

- **Increase government procurement** of low carbon products and services (including those using CDR) in transport and associated infrastructure. Government created demand through targeted decarbonisation mandates reducing fossil carbon content would drive confidence and certainty for a new biochar/LCLF/biofuels industry. Design of a mandate, low carbon fuel standard, targets and/or other demand options should all include requirements for a certain proportion of fuel use be drawn from *Australian-produced* LCLF/biofuels - creating demand for Australian produced LCLF within Australia would be the main reason for developing a local industry, 'Made in Australia' for Australia. At present the vast majority of aviation fuel and diesel is imported (90% and 87% respectively) – it would be prudent to strategically target a progressive reduction of reliance upon imports (perhaps staged). Perhaps consider 40% reduction in the initial 5 years followed by 30%, 20 % and finally 10% over the following decade to becoming a net *exporter*.

- **Establish Carbon Dioxide Removal (CDR) targets to complement Emissions Reduction targets in government policy** to drive investment in CDR applications to accelerate decarbonisation toward genuine Net Zero by 2050. This should include setting **interim targets** for 2030 ahead of Net Zero by 2050.
    - **Incentivize ER and CDR achievement**, with base line incentives for minimum targets (with support granted where increased actions are *completed* toward targets), and higher incentives for above-target emission reductions and CDR.

- **Support adoption of a Biochar ACCU Methodology** which could help government agencies and private sector companies to procure low carbon CDR products and services that can measurably assist their decarbonisation and Net Zero commitments.

- **Support commercial scale demonstrations in all states** of low carbon products and services (including those using CDR) in transport and associated infrastructure.

- **SEATA technology is well positioned to concurrently facilitate demonstration and commercial scale up of soil and non-soil applications for biochar & biocarbons requiring high volumes of char at lower cost** (currently a supply-limited and cost-limited market), maximizing CDR outcomes for Australia.
- For soil applications, we believe that composting, spraygrass/hydromulch, and agricultural uses are the largest available markets.
- For industrial applications (industrial grade biochars), we believe that roads (particularly sub-base stabilisation) are currently the largest available *long-term* sink, with concrete rapidly emerging (particular non-structural uses initially until standards are certified). Biocarbons to displace fossil-carbon in steel production (avoidance ER, no long-term CDR) is currently the largest demand overall.
- These high-volume markets require low cost supply to be competitive. Biochar systems which maximise the value of syngas co-products (particularly through high value derivatives such as biohydrogen, methanol, biodiesels, SAF etc) have the highest potential to deliver this. SEATA technology has been specially designed to provide this. Government support to both production and use of biochar can significantly accelerate scale up and hence ER and CDR outcomes for Australia (along with all the other benefits these provide).

- **Develop enhanced mechanisms to provide low-cost capital** into the biochar bioenergy sector, particularly for new and emerging innovation to aid commercialization. This should include a range of low/no interest loans, significant and rapid tax incentives, and grants with alternatives to matched co-funding and academic partnership requirements which currently inhibit private sector take-up. Grant funding currently appears to dominate into inefficient long term research-driven programs compared to more efficient, outcomes-driven private sector demonstration and commercialization. Increased focus on the latter for balanced funding could potentially realise more rapid commercialization for genuine decarbonization outcomes for Australia. It would be most advantageous if proposed projects could be guaranteed commercial viability/offtakes *for a stipulated timeframe* through government support mechanisms ("cradling"). Feedstock price and offtake price could be set to ensure commercial viability to encourage further development and scale up. Projects would still need to raise capital but could do so in an environment of *certain profitability for a set timeframe* – recognising a necessary timeframe of steady returns on the capital outlay. Government procurement could also be integrated and utilized to help facilitate this. Sound technologies, well managed would thrive in such environment and advance relatively quickly, shining a light on the best pathways and technologies.

- **Re-direction of existing *fossil fuel* rebates** (e.g. fossil diesel rebates) from major fossil industries into renewable LCLF/biofuels, biohydrogen and biochar could significantly assist with supporting uptake of these sustainable low carbon commodities in lieu of traditional fossil fuel. Different rates of incentive could be utilized to prioritise alignment and timing if/as desired (e.g. biodiesel and biohydrogen, then SAF, then others). These should be mindful of the same technologies also producing the chemical building blocks for many 'green chemicals' (e.g. methanol, olefins) for other sectors too which could be enhanced (or inhibited) and should be concurrently considered.

- **Support innovation pathways and government/3rd party independent testing** to validate and accelerate new low carbon technologies, products and services used by the transport and infrastructure sector that would otherwise arrive to market far later without such support. Support for associated national/International standards and certifications where relevant.

- **Establish a climate and sustainability ranking methodology** for LCLF/biofuel production technologies to facilitate comparison on climate and sustainability performance. This should prioritise highly circular, regenerative and carbon-negative technologies over linear, low / carbon-neutral or carbon-positive approaches, and reward industry innovation toward higher priorities.

- **Support ANZBIG and the *Australian Biochar Industry 2030 Roadmap*** – The biochar bioenergy sector and its roadmap for industry scale up to help Australia decarbonise is yet to receive any significant government support. This outlines 10 key Initiatives and supporting actions (some of which contribute to the dot point recommendations earlier above) to scale the industry to potentially reduce Australia's net carbon emissions by 10-15% and provide up to 20,000 permanent jobs, including in rural and regional areas.

- **Consider and support additional low-cost feedstocks for Low Carbon Liquid Fuels (LCLF) –**
  - One area that shouldn't be ignored is the opportunity for low-cost feedstock supply on marginal land, farming through a regenerative cropping methodology (see related comments immediately below). A whole of industry approach including feedstock security will be required for a successful LCLF industry. That said incentives should be short term and easy to administer and access, a *per-litre-produced* approach may present the simplest option.
  - Biochar bioenergy technologies can help widen the available feeds for biofuel generation, including green waste (aiding other government objectives for diversion from landfill); woody weeds and woody biowastes (lignin-based feeds) releasing infested lands for higher value use; purpose-grown biocrops on marginal lands that are not currently croppable (such as the successful NSWDPI native woody biomass trials under the Biomass for Bioenergy program which has significant potential to help regenerate marginal lands); and seaweeds and algae as fast growing regenerative feedstock.

- **Support and enhance awareness and education** of low carbon products and services for the transport and infrastructure sector using biochar CDR and bioenergy, including case studies and business cases to leverage and showcase commercial scale demonstrations (noted separately above). Support for public messaging **to build 'social licence'** regarding the benefits of local LCLF/biohydrogen/biochar industries that includes regenerative farming, marginal land cropping, jobs for rural Australia, cleaner plane travel and independent fuel security for the transport needs of our country.

SEATA's vision for rural Australian towns is a future that including a network of bio-fuel, bio-energy and bio-batteries, mini networks of decarbonisation energy with carbon removal. We have held talks with a small number of rural town councils who have been very receptive to date and recognise the value a LCLF industry can add to a rural town. SEATA invites further engagement with the Commonwealth toward this vision.

We would also like to draw attention to the Department of the related importance of the ***Australian Biochar Industry 2030 Roadmap*** which was recently launched by the ANZ Biochar Industry Group (ANZBIG). **Biochar facilitates carbon-*negative* biohydrogen, sustainably, with multiple co-benefits across all sectors of the economy, with particular benefits to rural and regional Australia** (and other industry sectoral plans such as Agriculture)**,** consistent with objectives in the Transport and Infrastructure Net Zero Consultation Roadmap**.** The Australian Biochar Industry 2030 Roadmap has significant potential to facilitate many related aspects for the production of industrial scale biochar (circular and sustainable carbon).

A list of Appendices to our submission is provided further below.

We appreciate the minor extension in timing granted for this submission. SEATA would be happy to clarify or expand on any aspects if/as required. Please do not hesitate to contact us with any queries at all.

Yours sincerely,

John Winter	Craig Bagnall
Director, Process Engineering	Director, Environment & Regulatory
SEATA Group	**SEATA Group**

[redacted]

W: www.seatagroup.com.au	W: www.seatagroup.com.au

Appendices:

1. **Introduction to SEATA Technology:** *Hydrogen with Benefits- Carbon* ***Negative*** *H_2* (SEATA, 2024)
2. **Commercial Examples of High Volume Applications for Biochar *CDR*** *(Note: this includes some additional information separate to the ANZBIG submission).*
3. **Figures - soil and non-soil applications and markets for biochar and biocarbons** (ANZBIG, 2023)
4. **Biochar Technical Paper Extract from *'Help Us Help You'* submission** by Water Industry to the Circular Economy Ministerial Advisory Group (CEMAG), (WSAA, 2024)

SEATA Holdings Pty Ltd, trading as **SEATA Group**
Suite 1, Level 1, 160 Pacific Highway Charlestown NSW 2990
E: info@seatagroup.com.au
ABN: 87 628 218 342 **ACN**: 628 218 342

Table 1: SEATA Responses to 29 Questions Posed within the Consultation Roadmap (we note these are generally consistent with ANZBIG's submission)

Note: We have answered each question as if it could be read independently in isolation to others if required. Whilst we have tried to cross reference when appropriate we apologise for any resulting commonalities and repetition.

Roadmap Consultation Questions	Responses
Chapter 1 - Introduction	

s1.2 The Approach (pg16)
Q1. Do you agree with the proposed guiding principles?
 	
1. *Maximise Emissions Reduction*
2. *Value for Money*
3. *Maximise Economic Opportunity*
4. *Inclusive and Equitable*
5. *Evidence-based*
	We support the five guiding principles, but would also advocate for the following:
	• **1. Maximise emissions reduction (ER) and carbon dioxide removal (CDR)** – the two critical elements for climate action to reach 1.5 degrees targets. ER (reducing new emissions each year) and CDR (removal of existing excess atmospheric CO_2) put downward pressure on atmospheric CO_2 concentrations to reduce and (in time) reverse the effects of climate change. Both aspects require strong advocacy in the #1 guiding principle. This will aid genuine *Net* Zero. It is also important to note that **the IPCC have stated that ER alone is no longer sufficient to meet Net Zero:**
	  ○ *"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.
	• Include additional guiding principles that leverage investment and support via the roadmap to meet **multiple policy objectives** of the Australian government concurrently with decarbonisation:
	  ○ **6. Improve Transition from Linear to Circular Economy** –higher circularity also commonly reduces carbon footprint.
	  ○ **7.Enhance Sustainability** – in line with the UN Sustainable Development Goals and inbound financial disclosure reporting for sustainability
	  ○ **8. Seek Co-benefits** – across multiple facets (e.g. environmental, economic, social and policy among others). This includes positive contribution toward other government policy objectives (such as those listed on pages 13-14 of the consultation roadmap) **and other industry sectoral plans:** *the Built Environment; Agriculture and Land; Electricity and Energy, Resources; Industry*. This encourages "bang for buck" in government action and resourcing.

Q2. Do you support the use of the *avoid-shift-improve* framework as a tool to identify opportunities for abatement?	As currently defined on page 15 of the consultation roadmap, we do not believe that "all available opportunities for abatement" will be identified as intended. Indeed, many (if not all) of the opportunities raised in our submission likely would not fall into the existing definitions. Just one example is decarbonisation of embodied carbon within transport infrastructure. Commercial 'shovel-ready' opportunities to displace fossil carbon are available with more emerging (e.g. concrete, asphalt, erosion control, water management etc). We also note that whilst *avoidance* of new emissions is strongly supported, we support strategic measures to **both** (i) rapidly and significantly **reduce new emissions**, and (ii) **remove** existing CO_2 from the atmosphere (CDR). **The roadmap could be significantly enhanced regarding the latter**. Biochar CDR and bioenergy can help decarbonisation of supply chains through **displacement of fossil carbon currently used in products and services** used in construction and operation of transport and infrastructure (at all levels of government and in public-private partnership projects such as motorways). For examples, refer figures provided in **Appendix 3**. Biochar bioenergy systems provide immediate "shovel-ready" solutions to assist the Australian Government to achieve both these measures. For more information please refer to our website www.anzbig.org and the ***Australian Biochar Industry 2030 Roadmap***.
Chapter 2 – Rethinking Transport Networks & Systems	
s2.1 Movement of People: promoting active and public transport (pg32) Q3. Do you agree the development of a national policy framework for active and public transport will support emissions reduction?	Yes. Policy frameworks are critical to facilitate public and private sector investment and procurement. We advocate strongly for recognition and inclusion of biochar bioenergy within the roadmap to guide national, state and local government best practice in emissions reduction and carbon dioxide removal to mitigate climate change and decarbonise/de-fossilise transport and infrastructure networks.
Q4. What should be included in a national policy framework for active and public transport and how should it be developed?	Public transport typically involves heavier vehicle modes such as buses and trains. Biofuel substitution for diesel and biohydrogen technologies can greatly assist decarbonisation of heavier transport modes where electrification is otherwise difficult/inhibited. Biochar bioenergy technologies can assist this transition whilst concurrently (and likely uniquely) providing CO_2 removal (drawdown).
Q5. What additional actions by governments, communities, industry and other stakeholders need to be taken now and in the future to ensure the movement of people contributes to transport emissions reduction?	We suggest the following actions could significantly accelerate decarbonization efforts: • **Support commercial scale demonstrations in all states** of low carbon products and services (including those using CDR) in transport and associated infrastructure. • **Increase government procurement** of low carbon products and services (including those using CDR) in transport and associated infrastructure. • **Establish Carbon Dioxide Removal (CDR) targets to complement Emissions Reduction targets in government policy** to drive investment in CDR applications to accelerate decarbonisation toward genuine Net Zero by 2050. This should include setting **interim targets** for 2030 ahead of Net Zero by 2050.

	• **Support adoption of a Biochar ACCU Methodology** which could help government agencies and private sector companies to procure low carbon CDR products and services that can measurably assist their decarbonisation and Net Zero commitments. • **Support and enhance awareness and education** of low carbon products and services for the transport and infrastructure sector using biochar CDR and bioenergy, including caste studies and business cases to leverage and showcase commercial scale demonstrations (noted separately above). • **Support innovation pathways and government/3rd party independent testing** to validate and accelerate new low carbon technologies, products and services used by the transport and infrastructure sector that would otherwise arrive to market far later without such support. • **Support ANZBIG and the Australian Biochar industry 2030 Roadmap** – *"help us to help you"*. The biochar bioenergy sector and its roadmap for industry scale up to help Australia decarbonise is yet to receive any significant government support. This outlines 10 key Initiatives and supporting actions (some of which contribute to the dot point recommendations earlier above) to scale the industry to potentially reduce Australia's net carbon emissions by 10-15% and provide up to 20,000 permanent jobs, including in rural and regional areas. We welcome and encourage further engagement with the government on this.
s2.2 Movement of goods – Decarbonising freight and supply chains (pg38) Q6. The Australian Government has already engaged in consultation on the 2023 review of the *National Freight and Supply Chain Strategy* and those consultations will also inform the final Roadmap and Action Plan. 6.1. What **additional actions** by governments, communities, industry and other stakeholders need to be taken now and in the future to ensure that the movement of goods contributes to transport emissions reduction?	Australia is seeking transition to non-carbon polluting transport, which is challenging in heavy freight systems and supply chains. **Biofuels** can provide significant assistance for transition. Biofuels made by biochar bioenergy processes additionally provide CDR concurrently, and can process woody biomass (lignin-based) not commonly targeted by other forms of biofuel production (i.e. biochar bioenergy is also complementary to existing technology investments). Some biochar bioenergy systems also have capability for low-cost and **carbon-*negative* biohydrogen** for carbon-free transport fuels of the future. Biohydrogen from biochar bioenergy systems is not currently discussed within the roadmap (only AD and electrolysis). Syngas from biochar bioenergy systems is comprised primarily of hydrogen and CO as the chemical building blocks to facilitate synthesis of a range of other important biofuels and biochemicals (e.g. methanol, ammonia, olefins etc) as illustrated on **Figure 3**. **Biochar** to displace fossil carbon in products and services can also be used throughout **supply chains** and in transport **infrastructure (e.g. greener concrete, steel, asphalt, stabilisation and water treatment among other aspects). Every tonne of biochar typically contributes 1.9t-2.5CO_2e CDR per tonne of biochar used in applications where the carbon is stored in the long term**. **Displacement of previously used fossil carbon products and services can also provide additional *avoided* emissions along with CDR within the biochar itself.** Refer figures showing

	many example applications for circular carbon with CDR via biochar in **Appendix 3,** and commercial examples including winners of the *Australian Biochar Users Awards* in **Appendix 2.** Over 50 Million tonnes of biomass is currently being burned, landfilled or otherwise decomposing back into the atmosphere beyond natural ecosystem requirements. **Accordingly, the biochar bioenergy industry represents significant opportunity for Australia and should be supported in addition to existing actions within the consultation roadmap.** Ten (10) key initiatives and supporting actions to support rapid scale up of the biochar bioenergy industry are identified in the *Australian Biochar Industry 2030 Roadmap* (ANZBIG, 2023) which can concurrently be supported to leverage benefits. Please also refer to responses to **Q5, Q28 and Q29, and 6.2 below**.
6.2. How would these actions address the identified challenges and opportunities for emissions reduction in the movement of goods?	A number of the challenges identified in the consultation roadmap relate to applications where the triple bottom line benefits of circular carbon and biochar bioenergy can play a positive role in the economies of both urban and regional/rural areas. In addition to benefits of particular applications (e.g. cycleways as outlined below), a number of **positive co-benefits** provided by biochar bioenergy industries can help provide important green *and interesting* jobs and help stem the tide of people (particularly young people) moving away from the regions, helping build a better future in rural and regional Australia just when it so critically needed. This can be significantly encouraged through positive government policy and greener procurement for public transport infrastructure to stimulate those industries and jobs. Just one example of many includes public transport **cycleways** in Perth which have incorporated biochar into the pavement (including colours), providing a lower carbon cycleway that enhances circular economy and safety. There are numerous opportunities for such synergies across active and public transport. Accordingly, biochar bioenergy should be included within policy and regulatory frameworks to encourage circular low carbon products and services in transport and infrastructure. This includes the ***Infrastructure Procurement Statement (IPS),*** the ***National Urban Policy*** and the ***National health and Climate Strategy***, among others. The *Australian Biochar Industry 2030 Roadmap* was prepared following extensive stakeholder and industry consultation over a number of years, including a national summit specifically for the roadmap development held in Adelaide in 2022. Consultation identified ten (10) key themes requiring action to address current hurdles hindering accelerated scale up of the industry, these included: 1. **Collaboration and partnerships** 2. **Communication of Economic Value and Benefits** 3. **Accelerate Markets** 4. **Encourage Policy Recognition and Support** 5. **Standards and Certification**

	6. **Harmonise Regulatory Frameworks** 7. **Encourage Investment** 8. **Focus innovation and Research** 9. **Facilitate Industry Scale Up** 10. **Funding and Resourcing Support** To address these key themes, ten (10) specific **initiatives** with supporting actions were developed within the roadmap. ANZBIG encourages further engagement with the Government to discuss these initiatives and potential collaboration to support scale up to assist decarbonisation within transport and infrastructure.
Chapter 3 – Net Zero Pathways for each Transport Mode	
s3.1 Road – Light Vehicles (pg45) Q7. Do you agree with the proposed net zero pathway for light road vehicles?	In general support the proposed approach. We would also draw attention to rural and regional Australia where distances between charge points are significant. Policy incentives for hybrid **bio**diesel-electric vehicles could be considered to encourage substitution of diesel 4WDs commonly used in agriculture and mining, helping to further decarbonise those important industry sectors too.
Q8. The Australian Government is currently developing an *Australian New Vehicle Efficiency Standard* and has already begun to implement actions in the *National Electric Vehicle Strategy*. 8.1 What additional actions by governments, communities, industry and other stakeholders need to be taken now and in the future to reduce light vehicle emissions?	• Electrification (including hybrid biodiesel-electric vehicles) and hydrogen fuel cell technologies can both benefit from biochar bioenergy systems. • **Sustainable batteries** using carbon from biochar bioenergy systems (instead of fossil carbon black) represents a **significant opportunity for concurrently improving circular economy, climate action and resilience (economic/geopolitical) in a profitable manner, generating jobs** and enhancing objectives consistent with a *'Future Made in Australia'*, providing fast charging (and discharging), high performance at low temperatures and a renewable, scalable, sustainable battery solution: o EV market share of sales is to reach >40% by 2030 and >75% by 2040 (Bloomberg NEF, 2024) o Demand for EV batteries increased 40% in 2023 from 2022 alone. o Battery carbon demand (graphite) is expected to 3.1M tonnes by 2030 (S&P Global 2024) o The vast majority (>90%) of EV batteries come from China (IEA Global EV Outlook 2024). o Biochar is already being used commercially in Li-ion battery technology in Europe, including partnerships with vehicle manufacturers toward climate neutral vehicles. o The Australian water industry (via WSAA) is researching battery opportunities via their collaborative *"biochar 2 batteries"* project with RMIT and Deakin Universities and partner water utilities.

	• Biodiesel and biohydrogen from biochar bioenergy systems can also assist light vehicle decarbonisation as noted separately earlier in this submission. • Biomass bioenergy is also **dispatchable on demand** to provide **nighttime generation** to complement conventional daytime renewables (via **heat to power** and **syngas to power**), to leverage investment through lower cost 24/7 generation. • There are opportunities to decarbonise supply chains all the way up to manufacturing of *vehicles themselves.* For example, BMW and Audio are backing a biochar-bioplastics company in Germany to help decarbonise the automotive industry, this could be replicated in Australia too, among many other applications for circular carbon in transport and infrastructure. Globally, the race is on to profitably use CO_2 from capture technologies (DACCS, BECCS, PYCCS etc), as the chemical building blocks for constructing **biofuels (including SAF) and bioplastics**. Companies like Twelve are partnering with Mercedes Benz and others to develop **biofuels, SAF** and **polycarbonate** applications.
8.2. How would these actions address the identified challenges and opportunities to reduce light vehicle emissions?	The identified challenge of circularity and sustainability of batteries can be significantly aided via biochar carbon batteries. Improved charging of synthetic biographite (relative to fossil graphite) can aid the identified challenge of availability and reliability through enabling faster charging and reduce time and increased throughput for charging stations. Production of biodiesel and biohydrogen can aid decarbonisation of more challenging heavier SUV and 4WD markets. Displacement of fossil carbon to reduce emissions and provide CDR may also aid marketing for EV transition via important action on climate change. Potential co-benefits include enablement of circular regional economies for new green jobs in regional Australia.
S3.2 Road – Heavy Vehicles (pg52) Q9. Do you agree with the proposed net zero pathway for heavy road vehicles?	We note and support key points raised including a mixture of hydrogen / LCLF (e.g. renewable biodiesel) and battery electric approaches; addressing regulatory barriers, and providing charging infrastructure (especially in regional Australia), addressing road pavement issues, and providing finance mechanisms to help address up front costs for emerging technology solutions. ALL of these aspects have relevance to biochar bioenergy to assist decarbonisation of heavy vehicle transport, especially in regional and rural Australia.
Q10. The proposed pathway for heavy road vehicles relies on a mix of battery electric, hydrogen fuel cell and low carbon liquid fuels. Rank from 1 to 3 the order in which these should be prioritised for emissions reduction. (why did you rank them in this order?)	See also related response for Q8 earlier above. Circular carbon via biochar is already emerging commercially for an important role in displacing fossil carbon black in anodes for **batteries** to decarbonise storage systems and complement deployment of conventional renewables (e.g. StoraEnso Li ion batteries in Finland, who are partnering with automotive companies). Australian water utilities are also partnering with multiple universities to investigate biochar for sodium carbon batteries, and other companies are investigating biochar for carbon thermal batteries. This is a significant synergy with the roadmap.

	Biohydrogen from biochar bioenergy systems have potential to provide carbon *negative* hydrogen for fuel cells for heavy transport. Refer Q12 for further details. **Biofuels**, including *drop in fuels*, have the potential to be synthesised from syngas from biochar bioenergy systems. Refer details below in Q12. As such, the biochar bioenergy sector can readily and rapidly assist **all three pathways**. We do not have a preference in ranking as they vary depending on basis of ranking (e.g. climate benefit biohydrogen would be ranked highest but least in commercial network readiness). Our industry stands ready to assist in any and all three cases.
Q11. What role should low carbon liquid fuels play in heavy vehicle decarbonisation?	We advocate for the inclusion of both **biofuels** in decarbonisation of heavy vehicles. Importantly, we note that thermal bioenergy systems such as pyrolysis and gasification can also produce syngas for making biofuels, with the benefit of additionally and concurrently providing CO_2 Removal (CDR) and processing biomass feedstocks not commonly targeted by other conventional biofuel pathways (e.g. lignin-based feeds, weeds etc). This is potentially also the only carbon-*negative* way to generate biofuels (<u>and</u> carbon-negative hydrogen too). As such, it could be recognised in the consultation roadmap. We would be pleased to provide further information/discussions to support this if required.
Q12. What additional actions by governments, communities, industry and other stakeholders need to be taken now and in the future to reduce heavy vehicle emissions?	Biohydrogen and biodiesels(+battery electric hybrid systems) are emerging as potential decarbonisation solutions for heavy transport. Much of our heavy transport moves through rural and regional Australia, including those servicing our agricultural and mining industries as well as regional cities and towns. Biomass waste in Australia is dominated by agricultural residues. There is high potential for biochar bioenergy to process agricultural and other biowaste residues across Australia (particularly in areas where water for electrolysis is more precious for food production) to help service these decarbonisation fuels (biohydrogen, biodiesels and carbon for batteries) and to complement conventional renewable power generation with dispatchable power for 24/7 generation (assisting charging networks among others) as noted earlier in this submission). Roads constructed with biochar-based pavements are commercialised in Australia now and are indicating increased strength and reduced maintenance, with reduced water ingress to underlying sub-base (further information on this can be provided on demand, ANZBIG has recorded webinars available for example). The *Australian Biochar Industry 2030 Roadmap* outlines 10 initiatives and actions the Australian government can support to accelerate industry scale up to assist decarbonisation across the economy, including the transport and infrastructure sector. Addressing <u>regulatory barriers</u> (as also identified in consultation roadmap) and undertaking commercial scale demonstrations across the country to foster rapid innovation,

	uptake and scale up are just two of those initiatives which can be supported. We welcome further engagement on how we can collaborate on this.

12.1. How would these actions address the identified challenges and opportunities to reduce heavy vehicle emissions?	• Regional and rural processing of agricultural and other biowastes to provide:
	  ○ distributed biofuel and biohydrogen generation to assist low cost decarbonised fuel distribution.
	  ○ Dispatchable 24/7 power generation in regions to complement conventional 'daytime renewables' to assist regional energy decarbonisation, charging networks and biohydrogen fuel networks.
	  ○ Biohydrogen is the only carbon-***negative*** hydrogen (with CDR), critical for climate action, and does not require significant water resources (excellent for inland regional Australia).
	• Improved road pavements and sub-base stabilisation to assist increased road mass on road pavements identified as a challenge in the consultation roadmap.

s3.3 Rail (pg58) Q13. Do you agree with the proposed net zero pathway for rail?	We support the consultation roadmap statement that "*decarbonisation of our rail sector requires the roll-out of* ***infrastructure to support hydrogen and battery-electric trains***". We note also that existing rail infrastructure can also benefit from biochar bioenergy in regards to circularity through upcycling of used treated timbers (railway sleepers etc) into industrial grade biochars for use in industry including *roads*.
Q14. The proposed pathway for rail relies on a mix of **battery electric**, **hydrogen fuel cell** and **low carbon liquid fuels**. Rank from 1 to 3 the order in which these should be prioritised for emissions reduction. (why did you rank them in this order?)	Refer related answers for Q10 earlier above.
Q15. What role should low carbon liquid fuels play in **rail** decarbonisation?	Noting the identified challenge in the consultation roadmap of LCLF *energy density* for use in rail, in future *high grade biodiesel* made from the chemical building blocks in syngas generated by biochar bioenergy systems may provide a suitable solution for drop-in replacement fuels for conventional diesel.
Q16. What additional actions by governments, communities, industry and other stakeholders need to be taken now and in the future to reduce rail emissions?	As per other sections, help us to help you - enhancing the Australian biochar bioenergy sector will help aid decarbonisation of the transport sector. Refer actions under the *Australian Biochar Industry 2030 Roadmap*. We encourage support for innovation and development to accelerate rapidly emerging options including biofuels for drop in substitutions for conventional diesel in rail.
16.1. How would these actions address the identified challenges and opportunities to reduce rail emissions?	Syngas pathways for chemical synthesis of biofuels have potential for high energy LCLF's to address the low energy density issue faced via conventional LCLF pathways. We encourage further government innovation pathway support for these avenues, as well as related circular options in rail to aid other transport decarbonisation such as treated timber wastes to industrial chars for roads etc.

s3.4 Maritime (pg64) Q17. Do you agree with the proposed net zero pathway for maritime?	We are supportive of biohydrogen and biofuels/LCLF to aid the transition of maritime fuels, including hydrogen-derived fuels (ammonia, methanol etc). We advocate for additional inclusion and recognition of biohydrogen (for biomethanol etc) in addition to electrolysis (e-hydrogen) for e-methanol etc. We would welcome further engagement with government to discuss economic and technical rationale for its inclusion.
Q18. The Australian Government is engaging in consultation as part of the development of the *Maritime Emissions Reduction National Action Plan* and those consultations will also inform the final Roadmap and Action Plan. 18.1. What additional actions by governments, communities, industry and other stakeholders need to be taken now and in the future to reduce maritime emissions?	There is significant potential for biochar bioenergy to produce biofuels and biohydrogen (and related derivatives such as biomethanol noted above) in addition to the current roadmap focus on e-hydrogen production alone. Significant maritime companies such as Maersk have identified *green methanol* as a preferred low carbon fuel. Conventional green methanol production can be challenged by social licence issues associated with potential to threaten food security (food vs fuel debate). Biochar bioenergy has the potential to *enhance* food security by increasing crop yields through its use, and biochar can be made from organic residues and other biomass sources that don't compete with cropping land for food production (and even potentially enhance it through native Australian species grown on marginal land to aid land restoration), and accordingly enhance positive social licence.
18.2. How would these actions address the identified challenges and opportunities to reduce maritime emissions?	This has been outlined in Q18 above.
s3.5 Aviation (pg71) Q19. Do you agree with the proposed net zero pathway for aviation?	We support transition via SAF and LCLF. Syngas from biochar bioenergy systems has the potential to provide the chemical building blocks for SAF and other LCLF as illustrated in **Figure 3**. Biochar bioenergy also has the potential to (quite uniquely) generate carbon-***negative*** biohydrogen for emerging hydrogen-based aviation, playing a beneficial role toward net zero objectives domestically and internationally (noting the ICAO's objective of net zero carbon emissions by 2050).
Q20. The Australian Government has already engaged in consultation on aviation decarbonisation through the development of the *Aviation White Paper* and those consultations will also inform final Roadmap and Action Plan. 20.1. What additional actions by governments, communities, industry and other stakeholders need to be taken now and in the future to reduce aviation emissions?	Australia could be a world leader in this space, including for SAF, biodiesel and C-negative hydrogen with CDR via biochar bioenergy. Establishment of an Australian carbon credit unit (ACCU) method for biochar could significantly assist the aviation transport sector. ANZBIG has previously received enquiries from a major aviation company regarding potential for ACCU carbon credits from biochar bioenergy. Additional actions to accelerate the industry are outlined in the *Australian Biochar Industry 2030 Roadmap*. ANZBIG welcomes discussions on how we can collaborate to deliver this.

20.2. How would these actions address the identified challenges and opportunities to reduce aviation emissions?	Other pathways to make SAF and LCLF can be challenged by feedstock (including competing with productive food). Biochar bioenergy provides maximum feed flexibility by also processing woody lignin based feedstocks, including woody weeds (e.g. prickly acacia) and short rotation native species on marginal (non-cropping) land which require no watering after planting trialled by NSW DPI, potentially opening up massive tracks of degraded land for beneficial restoration (syngas for SAF and biochar for soil restoration). Biochar bioenergy can also utilise problematic urban feedstocks such as FOGO (food organics and garden organics) currently searching for diversion pathways from landfill as they aren't expected to be readily absorbed by composting/landscaping markets alone (and also face other challenges). Valuing co-benefits of biochar bioenergy for SAF generation (including CDR for ACCUs) could potentially also lower the net cost of SAF which the roadmap identifies as critical.
Chapter 4 - Supporting Transport's Net Zero Pathways	
s4.1 Transport Infrastructure Q21. Do you agree with the proposed net zero pathway for transport infrastructure?	We noted the Consultation Roadmap's recognition that globally infrastructure consumes more than half the world's materials annually (GHub 2021), and that emissions associated with **infrastructure across the energy, transport, water, waste, digital communications and building sectors is related to 79% of all greenhouse gas emissions globally** (UNOP 2021). Emissions associated for transport infrastructure alone represent 3% of Australia's total emissions. **Embodied carbon** in materials such as **concrete, steel, roads and aluminium** is significant. We support the roadmap's recognition that "***the main emission reduction pathways are through materials"*** *(to use low-carbon input materials such as green steel, concrete/cement, asphalt, aluminium and low carbon recycled materials),* ***or by design*** *(**through circular economy principles** such as no-build situations, better maintenance, refurbishment, or using more efficient planning, design, and building techniques)"*. Biochar and biocarbon bioenergy systems are positioned to significantly assist decarbonisation of these materials and increase circular economy. Major companies such as **BlueScope Steel** have run successful trials (discussed in Q22 below) and presented at the Sydney forum of the rollout of the *Australian Biochar Industry 2030 Roadmap*. Accordingly, we are supportive of the measures within the Consultation Roadmap to **decarbonise materials for infrastructure**, **however identified solutions for this requires significant expansion within the roadmap to include the extensive role of circular carbon via biochar bioenergy**. As noted in the summary introduction, biochar and biocarbons can be used extensively to displace fossil carbon across supply chains as illustrated in the figures of **Appendix 3** and commercial examples in **Appendix 2**, and discussed further in Q22 below.
Q22. What additional actions by governments, communities, industry and other stakeholders need to be taken now and in the future to reduce	Biochar and biocarbons can be used to displace embodied fossil carbon in transport and infrastructure via:

transport infrastructure emissions and ensure that transport infrastructure is ready for and enables low-emission transport modes?	• **Road pavements** – biochar has potential for use to improve strength and durability of surface pavements concurrently with sinking carbon in a durable form (refer examples in Appendix 2). Coloured pavements use in cycleways have also been successfully installed (e.g. Perth WA). • **Road sub-base stabilisation** – is a significant opportunity for immediate and significant action (refer examples in Appendix 2), and can use ~10x more biochar than surface asphalt pavements. Further, the ability to use local/recycled material for these applications can result in significant displacement of virgin quarried material being hauled long distances to road projects, avoiding further emissions. • **Unsealed roads -** There are also opportunities for stabilising dust for high traffic unsealed roads, and for improving access productivity on unsealed roads in high rainfall areas (e.g. northern Australia), with successful trials on the latter in northern WA. • **Concrete** (both structural and no-structural, with significant and immediate potential for easy deployment in non-structural concrete as 'low hanging fruit) • **Batteries** for EVs and other storage of renewable energy (anode materials in Li-ion batteries, sodium carbon batteries and carbon thermal batteries) • **Erosion Control and Rehabilitation** (e.g. spraygrass/hydromulching, soil stabilisation and revegetation) • **Stormwater treatment and control** (e.g. water filtration – one of the largest markets for biochar in the USA). Pyrolysed carbon (which makes biochar) is the basis of activated carbon production. Low cost pseudo activated carbons via activated biochar has significant potential for Australian transport systems. Biochar also been used for filtering emerging contaminants in road runoff including microplastics. • **Catalysts** to displace fossil carbon and other catalysts in biofuel production and use. Materials such as **steel** and **aluminium** can be decarbonised via: • Displacement of fossil carbon in BF steel making (e.g. as a result of successful trials by BlueScope (ARENA supported), they are now seeking the equivalent of over 10x total national production of biocarbon/biochar per annum), noting further potential use of biochar bioenergy systems for EAF and DRI steel production too. • Circular carbon for Aluminium production, **displacing fossil carbon recarburizers** Example references to support the above are provided in **Appendix 2**, and further supporting information (including webinars on some of these topics run by ANZBIG) can be provided upon request. Additionally, biochar **bioenergy** (and synthesis of biofuels and biohydrogen) can be used to displace fossil energy in production of energy and materials, further reducing Scope 3 emissions.

	Accordingly, **we recommend that biochar bioenergy be recognised and included within the *Infrastructure Policy Statement*** (IPS) as a key potential solution opportunity. We also recommend that the role of CDR be recognised alongside ER and that associated targets be included and adopted. We encourage support of the *Australian Biochar Industry 2030 Roadmap* to accelerate and scale the industry to support decarbonisation of the transport and infrastructure sector. We also encourage further discussion on collaboration and partnership opportunities for this.
22.1. How would these actions address the identified challenges and opportunities to reduce transport infrastructure emissions?	Positive support for biochar, biocarbons and associated bioenergy (including biohydrogen, biofuels and bioplastics) including the actions in Q21 and elsewhere in this submission have significant potential to help address challenges identified in the Consultation Roadmap including commercial feasibility of input materials, address limited data, measurable track and report on associated ER and CDR, significantly improve circular economy, and assist rural and regional communities in particular who face unique and complex challenges.
s4.2 Transport Energy Use Q23. The Australian Government invited views on aspects of the energy transformation that represent the most material challenges and opportunities for the electricity and energy sector. Submissions closed on Friday 12 April 2024 (AEDT). This feedback will be used to inform the development of the Electricity and Energy Sector Plan and Net Zero Plan. The Australian Government will be undertaking targeted consultation to identify options for production incentives to support the establishment of a made in Australia low carbon liquid fuel industry, including through the release of a low carbon liquid fuels consultation paper. Feedback heard through this process will also inform development of the final Transport and Infrastructure Net Zero Roadmap and Action Plan. *What additional actions by governments, communities, industry and other stakeholders need to be taken now and in the future to ensure the energy mix is ready to support transport emissions reduction?*	We support the Consultation Roadmap's recognition of the need to displace fossil carbon fuels used heavily in the Australian transport system, and that electrification and LCLF substitutions (including renewable diesel and SAF) will be required and supported. As noted earlier in our submission, the biochar bioenergy industry is positioned to readily support all of these aspects, from **decarbonising batteries** for electrification and storage of renewable energy generation (including distributed systems in rural and regional Australia) to potential use of high grade syngas for biofuels including carbon *negative* **biohydrogen, biodiesels and SAF**, among others. The industry is ready to scale economically to meet the challenge (we are happy to discuss this further) and represents an excellent diversified approach to provide resilience and a large range of co-benefits, whilst also avoiding some limitations faced by conventional bioenergy. We draw your attention to the range of recommendations identified throughout our submission, and to the request for recognition and support to implement the ***Australian Biochar Industry 2030 Roadmap***.
Q24. How should the use of low carbon liquid fuels be prioritised across different transport modes over time to achieve maximum abatement?	It is important that actual transition to non-fossil and **sustainable** solutions occurs to decarbonise the economy. We encourage prioritisation of LCLF which measurably provide maximum sustainability concurrently with climate action. We understand that electrification of light vehicle transport is readily viable, whilst heavy transport is far more difficult Given that rail is already efficient in regards to emissions density (per tonne of cargo), decarbonising heavy road transport should be prioritised first. All measures to assist this should be considered, including those presented elsewhere in our submission where our industry has potential to assist.

SEATA
Deconstructing the world's problems

Chapter 5 - Achieving Net Zero Together	
s5.1 Travelling in Partnership (pg88) Q25. What are the best ways for the Australian Government to work collaboratively with industry, business, governments and communities to implement the proposed pathways?	*Peak bodies* representing industry (and also in the community) provide excellent forums for consultative engagement, collaboration and partnerships. We would welcome further industry engagement via the ANZ Biochar industry Group (ANZBIG), especially in relation to leveraging the significant synergies with the *Australian Biochar Industry 2030 Roadmap*. Six working groups have been established by ANZBIG to deliver the ten key initiatives of roadmap, including an Innovation Working Group that includes promoting commercial scale demonstrations across Australia.
25.1. What are good domestic or international examples of partnership and collaboration on transport and transport infrastructure emissions reduction that could inform the final Roadmap and Action Plan?	In regards specially to the biochar bioenergy industry, ANZBIG collaborates extensively with member groups both domestically (states and within NZ), and internationally with the International Biochar initiative (IBI) in the US and the European Biochar Industry Consortium in Europe, among many others globally. Accordingly, ANZBIG is an excellent conduit to global movements in bioenergy with biochar carbon removal and for engaging and partnering within the transport and infrastructure sector. We invite further engagement and collaboration in regards to how we can contribute to the *Transport and Infrastructure Net Zero Roadmap,* including engagement with roadmap authors/managers and other key government groups such the **two decarbonisation working groups** established by the Transport and Infrastructure Ministers' Meeting (ITMM), the **consultation group** for MERNAP, the Jet Zero Council, and the Net Zero Economy Agency/Authority. If appropriate, we would also welcome engagement with the range of relevant international partnerships promoting decarbonisation and hydrogen technologies.
25.2. What opportunities can the government leverage to show leadership in Australia and internationally?	The *Australian Biochar Industry 2030 Roadmap* is a **world first** for the biochar industry globally, providing leadership in climate action and sustainability, with all of the roadmap initiatives aligned with specific UN Sustainable Development Goals. ANZBIG and its members are recognised world leaders in research, production and use of biochar in soil and industrial applications. Partnering with ANZBIG to deliver the *Australian Biochar Industry 2030 Roadmap* and the potential benefits it could bring to the transport and infrastructure sector could readily lead the world in multiple aspects (e.g. demonstrations across Australia). We welcome further engagement on this potential.
s5.2 Measuring Success (pg90) Q26. What measures and metrics should be used to evaluate the final Transport and Infrastructure Net Zero Roadmap and Action Plan?	With decarbonisation as a key objective, 'SMART' KPIs for both emissions reduction (ER) and also CO_2 Removal (CDR) should be set within the plan, with associated targets (interim 2030 and 2050) against which they are measured and reported. Due to inherent synergies, sustainability and circularity should also be considered.

	The Australian Biochar Industry 2030 Roadmap includes KPI's for all initiatives and supporting actions, and is aligned over 2/3 of with the UN Sustainable Development Goals (SDG's), a framework Australia reports under. Use of biochar in transport and infrastructure can be readily measured and assisted in relation to both climate reporting (both emissions reduction and CDR) and in sustainability reporting, both of which are focal areas of the new IFRS S1 and S2 standards for financial reporting frameworks. As such, our industry stands ready to measurably assist both decarbonisation and improved sustainability and circularity in transport and infrastructure projects.
26.1. What other data and evidence could governments use and how could this offer further insights on the pace, scale and location of transport emissions reduction pathways?	As noted above, targets and reporting for CDR need to be included in addition to ER to assess progress toward genuine Net Zero, with monitored reporting providing further insights into the large opportunities for CDR to complement ER across the transport and infrastructure sector. Establishment of an ACCU method for biochar will also help to accelerate decarbonisation opportunities and pathways. Setting targets alongside an ACCU method is also likely to also encourage **new innovation** for decarbonisation pathways yet to be identified/commercialised, further enhancing efforts toward Net Zero. Concurrent targets and reporting of **sustainability** and **circularity/recycling** (including diversion from landfill) will also assist significantly and represent opportunities for enhancement of the Consultation Roadmap concurrent with efforts elsewhere by government and industry on these related aspects. We note that **IFRS S1** and **S2 financial disclosure reporting** for ASX listed companies is expected to be rolled out in the near future which should also be dovetailed with these efforts.
Q27. Do you have any feedback on the proposed review process?	We note that annual updates in reports and statements combined with *detailed review every 3-5 years* is proposed. New opportunities for innovation and deployment are rapidly emerging and the next couple of years have been identified as being critical for climate action (this is the critical decade), noting the global carbon budget is under threat. **We advocate for additional inclusion of <u>innovation pathways</u>** and **<u>rapid deployment mechanisms</u>** (using appropriate checks and balances) to accelerate opportunities as they emerge. This includes opportunities to decarbonise supply chains all the way up to **manufacturing of *vehicles themselves* and beyond.** e.g. in Germany BMW and Audio are backing a biochar-bioplastics company to help decarbonise the automotive industry itself, this could be replicated in Australia too, among many other applications for circular carbon. Circular carbon provides enormous opportunities to accelerate and improve decarbonisation, sustainability and circular economy in a profitable way, generating employment and regional jobs at the same time. Every opportunity to accelerate these opportunities should be encouraged with supportive policy that facilitates rapid development and deployment.

Q28. Do you have any further feedback on the Consultation Roadmap and proposed pathways?	We commend the government for preparing this roadmap toward net zero in transport and infrastructure. We provide the following additional suggestions in the sub-section 28.1 below for improvement and enhancement, and also in Q5 earlier.
28.1. Is there anything missing? Are the sections appropriately integrated? Is the Roadmap appropriately ambitious?	• Whilst its mentioned in places in the consultation roadmap, increased focus on the critical role of **procurement** in decarbonisation is required. For example, inclusion in the government's role in decarbonisation in Chapter 1 among many other areas (e.g. Table 2 "Government's role in Decarbonisation"). Government spending (federal, state and local) is a very significant policy and economic lever for decarbonisation and circular economy which should be given a pivotal role with high focus within the roadmap. Leveraging on well establish actions in the circular economy and recycling industry spaces to assist this should be undertaken (and complements other government policies to accelerate those too). • Government support has been central in rapid development of the Chinese EV and solar/renewable industries over the last few decades that has resulted in them being highly globally competitive to the extent of dominating. Australia could consider a range of intelligent integrated government support mechanisms that provide high 'bang for buck' to foster rapid growth in Australian transport decarbonisation. Australia has world-leading technologies and innovation in biochar bioenergy and biochar applications in transport and infrastructure (including roads, concrete and stabilisation among many others) that could be readily 'turbo-charged' here more easily than most places in the world. There is significant opportunity for 'low hanging fruit' with appropriate government support. • *Low cost access to finance* has been central to expansion in renewables in both Chaina and the US (including low and no interest loans in addition to grants systems). Australia commonly requires *matched funding* to obtain most grants which significantly inhibits rapid innovation and commercialisation, particularly for pilot demonstrations. • The USA and the European Commission governments have instigated significant government policy support mechanisms to enhance decarbonisation and investment in renewables and associated technologies. Australia should review and leverage these here, including **tax incentives** beyond existing R&D tax incentives alone (e.g. 45V, 45Q from USA). • The Qld government has just announced potential for government ownership of petrol stations and capped fuel pricing to help address fossil fuel price gouging. This model could be flipped to foster **decarbonised fuels** in particular to help level the playing field with fossil fuels, increasing competitiveness. Trials could be undertaken on this as part of regional circular economy. • As noted earlier above, we would like to see significantly expanded sections for decarbonising transport **infrastructure** within the roadmap, including the many opportunities for decarbonisation via biochar and bioenergy. For example: 1. **Displacement of fossil carbon in infrastructure and supply chains using biochar** – for example greener concrete, asphalt, sub-base stabilisation, erosion control

	(spraygrass/hydromulching), water filtration and other applications. Refer Figures in **Appendix 3** and example commercial companies offering these in **Appendix 2**. 2. **Carbon farming of roadside vegetation** (both construction/clearing and ongoing operations) to make bioenergy, biofuels, biohydrogen & biochar as a continuous "carbon removal pump" for carbon and energy - ***grow, harvest, biochar+bioenergy, applications/use, repeat***. Rapid decarbonisation through concurrent emissions reduction *and* CDR. 3. **Vegetation clearing for construction** roads and associated infrastructure. In addition to the above mentioned carbon farming of vegetation on existing roads, there are opportunities also for cleared vegetation during construction beyond mulching and composting alone, and also managing **'oversize'** *uncompostable* material. This can make high quality (soil grade) biochars for sequestration in multiple uses including rehabilitation, erosion and sediment control, water/air filtration, increased water holding capacity in water infrastructure (drains, basins), and drought-resilient rehabilitation in road infrastructure. Carbon from biochar can also provide significant roles in water holding capacity in green roofs for government buildings Additionally, we note opportunities for upcycling and circular management of previously problematic wastes into higher value products (into industrial grade chars etc): • **Treated timbers (e.g. Railway sleepers, power poles)** – Treated timbers can be managed in a circular, climate-positive way which subsequently also provides industrial chars for use in roads and concrete infrastructure projects. ~ 23 million sleepers each year are replaced in the USA, from the 620 million sleepers across 207,000 miles of rail track, with pyrolysis potentially displacing conventional management by combustion for energy (potentially halving emissions whilst concurrently making a valuable product). Refer research evidence here; an investigation by the US Department of Transport here, and an Australian commercial example here. We would welcome further discussion and engagement regarding the above.
Q29. Is there any further information or documentation that you wish to be considered with your submission?	We would like to see recognition of the significant opportunities with biochar-based bioenergy systems, including cross-referencing of the *Australian Biochar Industry 2030 Roadmap* within the department's Transport and Infrastructure Net Zero Roadmap. The Australia New Zealand Biochar Industry Group (ANZBIG) seeks to collaborate and partner with the government and the transport industry to accelerate these significant opportunities and welcomes further engagement on this to assist decarbonisation of the transport sector.

C-TWELVE

Carbon Sequestration Solutions

Bio Char for Industrial applications

21st March 2024

JASON LEE

C-Twelve Overview

Who Are We

- We are Australian owned and operated business
- We are Carbon sequestration solutions specialists in volume
- Leading the way with sustainable road construction practices disrupting the traditional markets with proven track records and trusted partners.
- Not competing with the conventional biochar markets and opening opportunities by adding hard-to-manage waste streams.

Reducing environmental pollution


Kwinana

2

Why Is Bio Char so Important to Us?

We need it in Volumes to meet our projected targets

Not all Biochar will meet the high standards to be used in the Agriculture industry.

C-Twelve can utilise all **Industrial Biochars**, increasing the potential applications of the Pyro process to manage hard-to-manage waste products

We see this as our challenge as well as our opportunity

Click for example project videos here:
[C12 PROJECT MULTIMEDIA (google.com)]

4

CASE STUDY

WATHEROO GRAIN RECEIVAL CENTRE

Our client identified a problematic area at one of their sites, which was addressed by C-Twelve. The outcome? A superior, durable cold mix asphalt surface projected to endure well beyond a decade. Notably, this solution also sequesters carbon, deriving from on-site grain processing.

The enduring value of such endeavors is evident in the reduction of landfill dependence and streamlined logistical operations, resulting in significant cost and resource savings. This underscores the attractiveness of utilising the advanced C-Twelve Black Cold Mix product.

Moreover, the potential to generate substantial carbon credits further enhances the appeal of widespread adoption of C-Twelve Black. The prospect of such large-scale implementation is indeed thrilling.

CASE STUDY (Cont.)

WATHEROO GRAIN RECEIVAL CENTRE

7

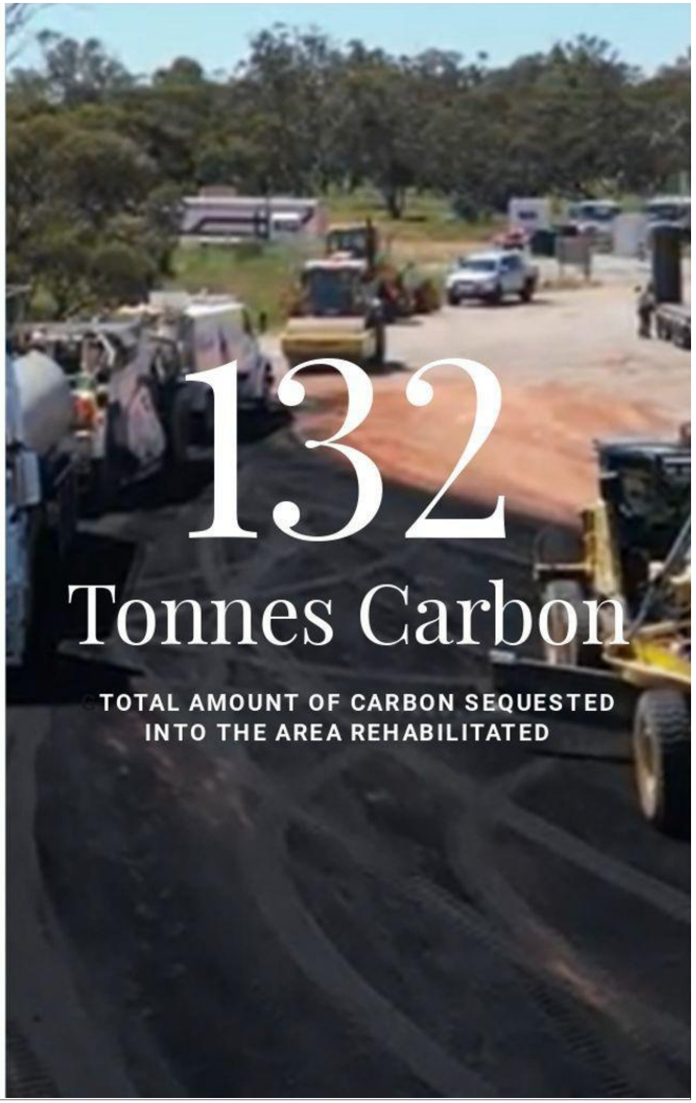
Tonnes of Tarps

CBH TARPS NOT GOING TO LANDFILL

2500

M2

TOTAL AREA THE TEST WAS CONDUCTED AT WATHEROO



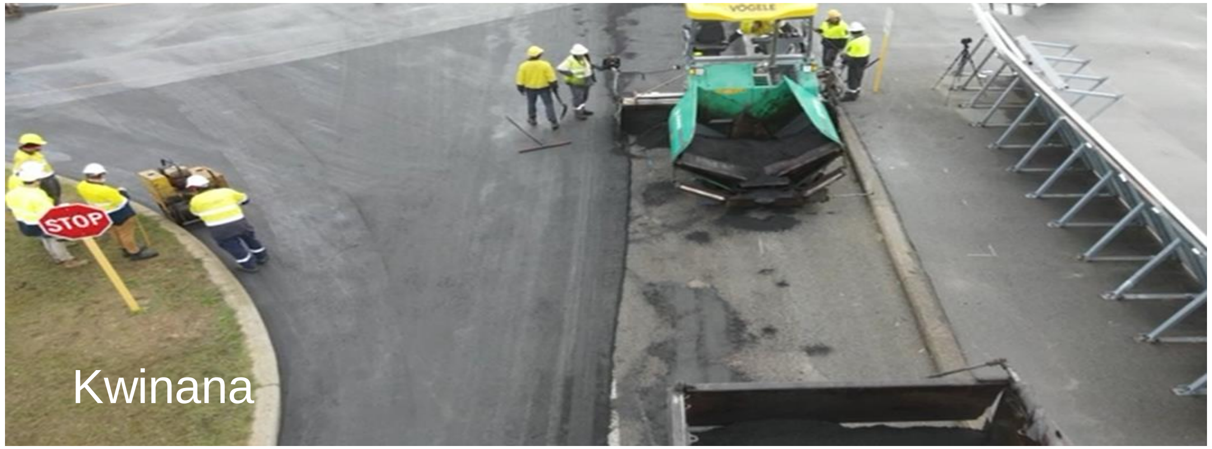
C-Twelve Sequestration

Sequestration Rates our challenge

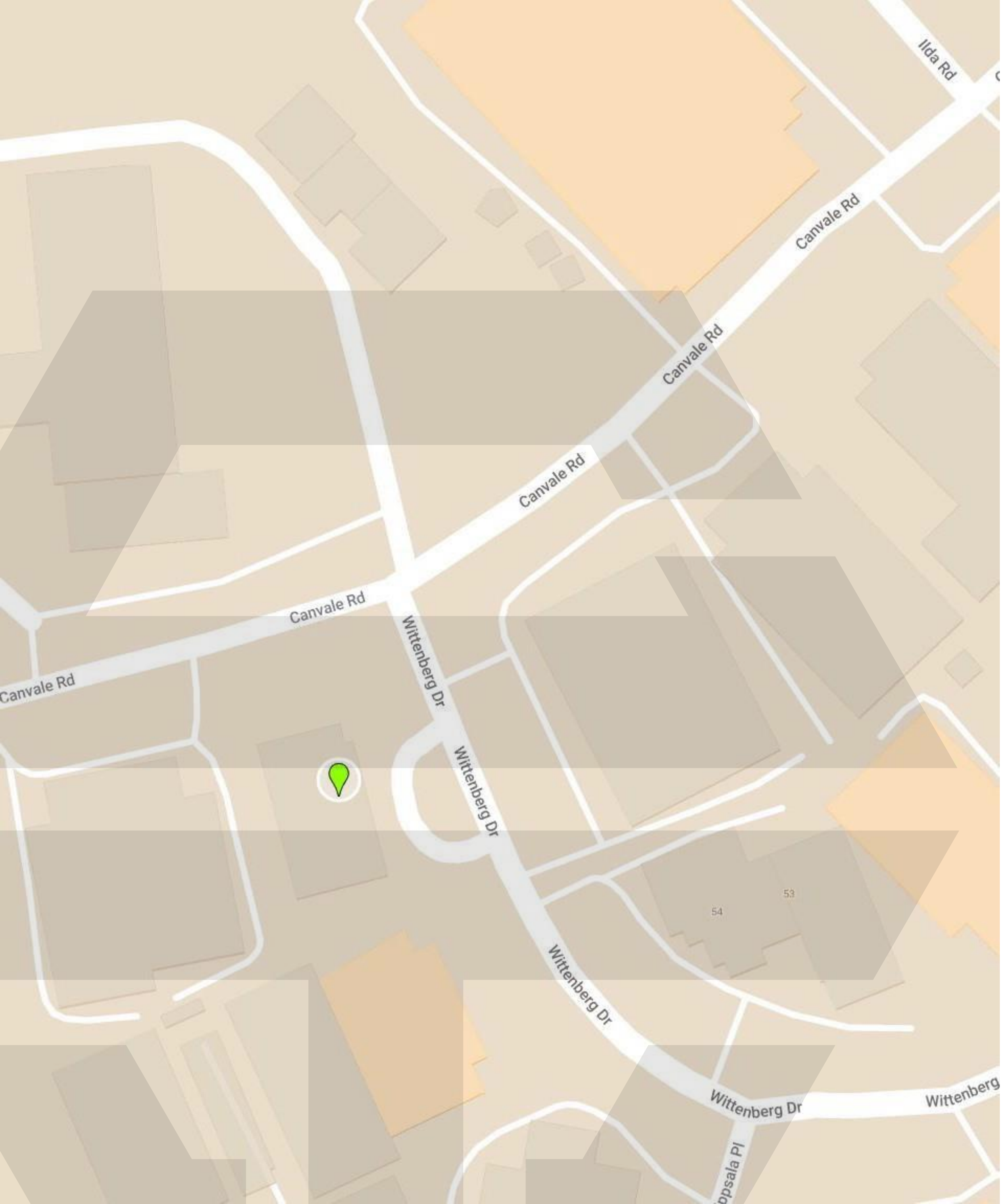
A study published in "Nature Communications" in 2019 estimated that biochar application to soil could sequester carbon at rates ranging from 0.6 to 1.8 tCO2e/ha per year over a 20-year period, depending on soil and climate conditions

C-Twelve can Sequester Carbon rates of 1250 tCO2e/ha for the life of the installation. Depending on the road recycling method it may not ever be released into the atmosphere again.

1250 / (1.8x20) = 36 = 3372% increase in Carbon sequestration per hectare.



Completed Project



Questions

C-TWELVE PTY. LTD.

ADDRESS: 62-64 Wittenberg Drive, Canning Vale, Western Australia 6155

EMAIL: info@c-twelve.com.au

WEB: www.C-Twelve.com.au

Paving the Way to Sustainable Road Construction

C-TWELVE COLD MIX

DEVELOPING INDUSTRIAL SCALE CARBON SEQUESTRATION SOLUTIONS FOR A SUSTAINABLE FUTURE

C-TWELVE

C-12 BLACK COLD MIX ASPHALT

C-Twelve - Developing carbon sequestration solutions for a sustainable future. C-Twelve is an innovative business, developing road products to be Environmentally Friendly and Carbon Negative. With a team of experienced professionals, C-Twelve is at the forefront of the development and application of sustainable road construction practices.

C-Twelve Pty Ltd - Developing Carbon Sequestration Solutions for a sustainable future. C-Twelve is an innovative business, developing road products to be Environmentally Friendly and Carbon Negative.

With a team of experienced professionals, C-Twelve is at the forefront of the development and application of sustainable road construction practices.

By leveraging its expertise in pyrolysis and chemical engineering, C-Twelve is able to produce biochar from a wide range of waste materials that would otherwise be discarded, reducing the amount of waste and environmental pollution.

The company's innovative approach to road construction offers numerous benefits, including improved durability and reduced costs, making it an attractive option for local authorities, infrastructure companies, and construction firms alike. With a commitment to sustainability and innovation, C-Twelve is poised to revolutionize the road construction industry with its cutting-edge technology and sustainable solutions.

Biochar increases strength, stiffness, and resistance to moisture damage

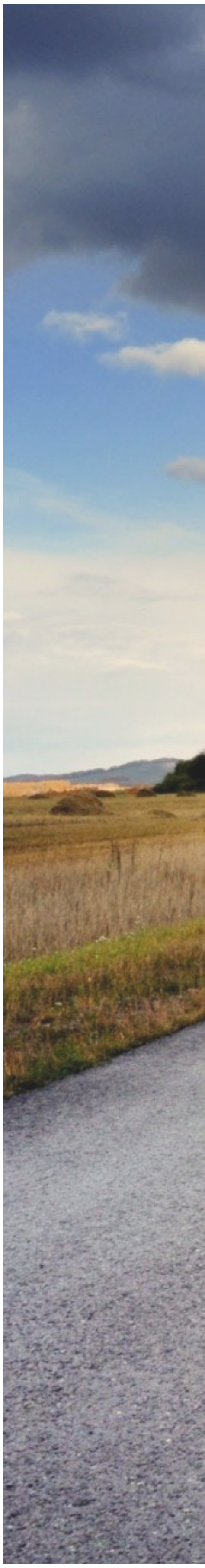
> "AT THE FOREFRONT OF SUSTAINABLE ROAD CONSTRUCTION PRACTICES."

The use of biochar in Cold Mix Road Surfacing (CMRS) products has several advantages. Firstly, it has been found to improve the mechanical properties of the CMRS mixture, including increased strength, stiffness, and resistance to moisture damage.

This is due to the high surface area and pore volume of biochar, which allows it to effectively bind with the asphalt binder and aggregate. Secondly, the incorporation of biochar into CMRS can also reduce the amount of asphalt binder required, which reduces costs and the environmental impact associated with the production of asphalt binder.

The production of biochar from waste materials, such as municipal waste, light industrial waste, and agricultural and forestry residues, can also provide an additional benefit by reducing waste and improving resource efficiency. This is because these waste materials would otherwise be burned or discarded through landfill or other processes, releasing greenhouse gases and contributing to environmental pollution.

Several studies have investigated the use of biochar in CMRS, and have found that it is a viable option for road construction. For example, one study1 found that the addition of biochar to CMRS improved the mechanical properties of the mixture and reduced the amount of asphalt binder required by up to 25%. Another study2 found that biochar can also improve the fatigue resistance of CMRS, which is an important property for road durability.



C-12BLACK

Engineered to withstand heavy traffic & extreme weather conditions

COLD MIX THAT IS CARBON NEGATIVE, LAB TESTED, & PROVEN TO CREATE HARD-WEARING ROADS

This green solution is designed to meet the highest standards of quality, durability and performance. **C-12 Black** has been tested and proven to withstanding extreme weather conditions and the harshness of the Australian environment.

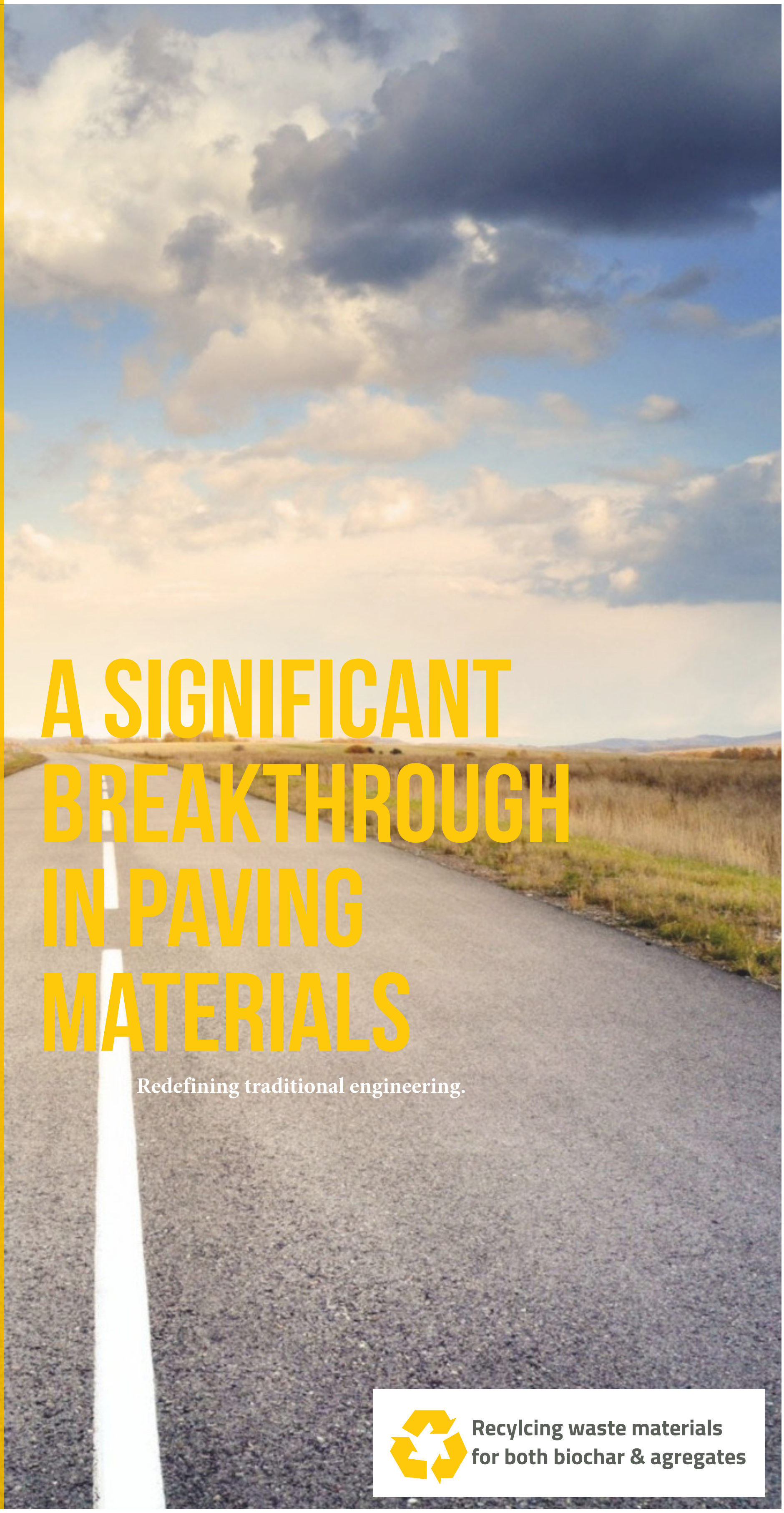
C-12 Black's unique blend of cold mix, biochar, and emulsion solution creates a uniquely strong solution that has superior resistance to wear and tear compared to traditional hot mix asphalts.

C-12 Black is carbon negative, meaning it removed more carbon from the environment than the process of creating and applying it, its unique formula hugely reduces the environmental impact of road construction, making it an ideal choice for all applications as we worktowards carbon net zero targets.

Superior Durability: C-12 BLACK is engineered to withstand heavy traffic, extreme weather conditions, & regular wear & tear. Our advanced formulation ensures a robust road surface that lasts, reducing the need for frequent repairs and maintenance.

Environmental Sustainability: C-Twelve is committed to minimizing the environmental impact of road construction. Our Cold Mix is manufactured using biochar, derived from waste materials, sequestering carbon & promoting a greener future.

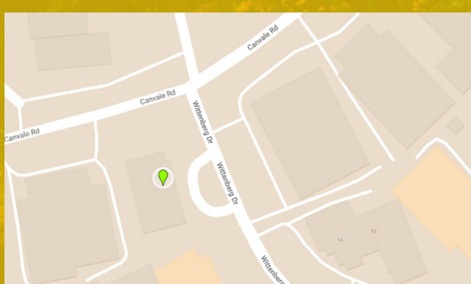
Applications: C-Twelve Cold Mix is highly versatile and suitable for a wide range of applications. Whether you need to pave urban streets, rural roads, highways, or even airport runways, our technology delivers exceptional results. With its adaptability and performance, C-Twelve Cold Mix is the ideal choice for any road construction project



A SIGNIFICANT BREAKTHROUGH IN PAVING MATERIALS

Redefining traditional engineering.

Recylcing waste materials for both biochar & agregates



C-TWELVE Head Office is located at 62-64 Wittenberg Drive, Canning Vale, Western Austalia 6155.

DEVELOPING INDUSTRIAL SCALE CARBON SEQUESTRATION SOLUTIONS FOR A SUSTAINABLE FUTURE

C-Twelve is an innovative business, developing road products to be Environmentally Friendly and Carbon Negative.

For more information about our products, projects or research and development efforts, please don't hesitate to get in touch with one of or helpful team.

C-TWELVE

62-64 Wittenberg Drive, Canning Vale, Western Australia 6155

Telephone: 0401 334 421
E-mail: info@c-twelve.com.au

WWW.C-TWELVE.COM.AU

C-TWELVE

CARBON NEGATIVE ROAD SURFACING MATERIALS

CORPORATE PROFILE PRESENTATION

28th APRIL 2023

JASON LEE

Our Mission:

“ Using technological innovation to build a sustainable future ”

1

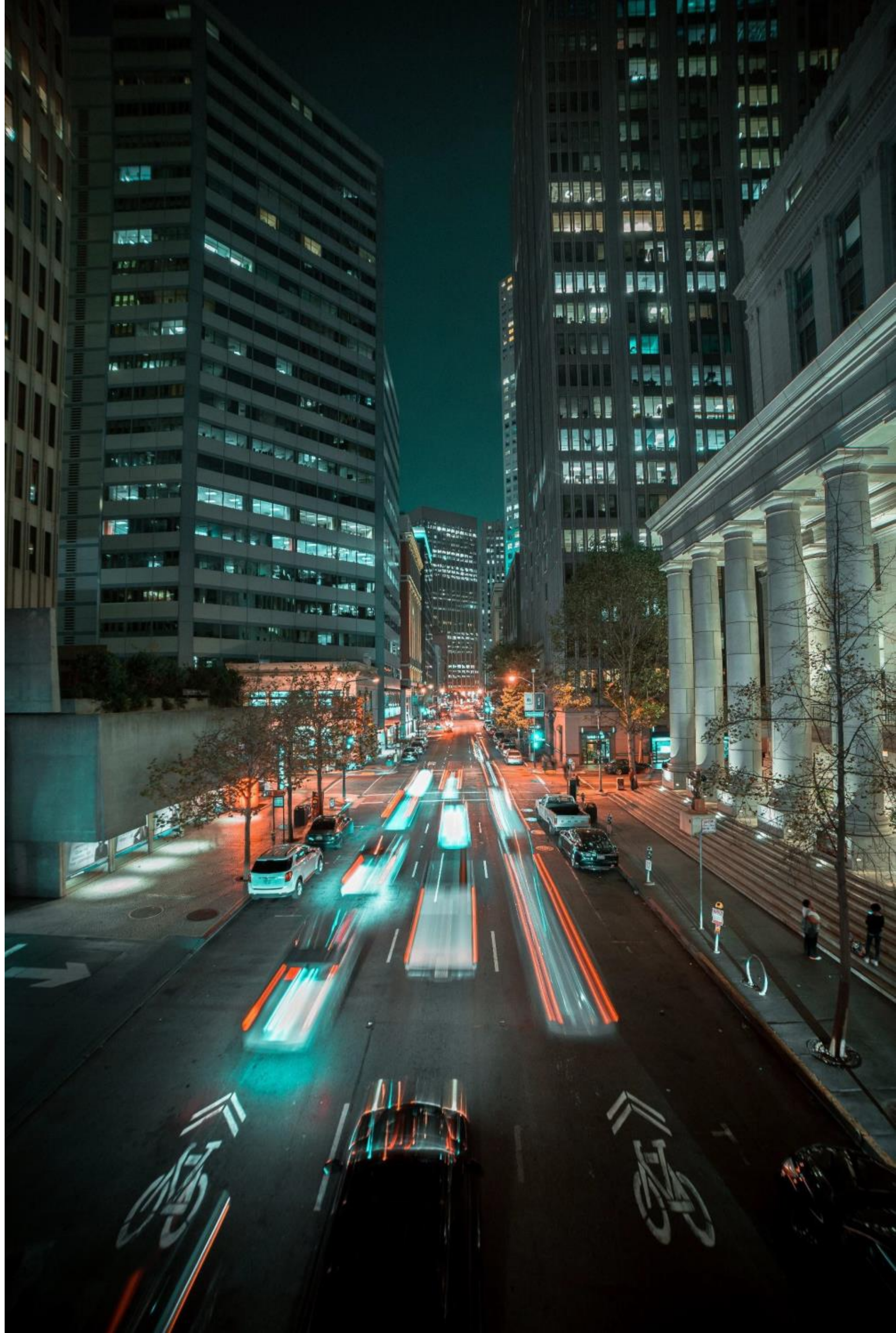
ABOUT US

C-Twelve Pty Ltd - Developing Carbon Sequestration Solutions for a sustainable future. C-Twelve is an innovative business, developing road products to be Environmentally Friendly and Carbon Negative.

With a team of experienced professionals, C-Twelve is at the forefront of the development and application of sustainable road construction practices.

By leveraging its expertise in pyrolysis and chemical engineering, C-Twelve is able to produce biochar from a wide range of waste materials that would otherwise be discarded, reducing the amount of waste and environmental pollution.

The company's innovative approach to road construction offers numerous benefits, including improved durability and reduced costs, making it an attractive option for local authorities, infrastructure companies, and construction firms alike. With a commitment to sustainability and innovation, C-Twelve is poised to revolutionize the road construction industry with its cutting-edge technology and sustainable solutions.



OUR TEAM

2

Ryan Grieve – Technical Director

Ryan has over 25 years of experience working in the Materials Engineering and Construction testing fields in both the private sector and at Main Roads WA, Materials Engineering Branch.
The past 18 years as Owner/Director of LABSWA. Focussing on applicable to the Construction Materials industries for civil engineering and mining projects.
In 2005, Ryan established Liquid Labs WA, an independent testing laboratory focusing on the research and development of innovative products and procedures in the Construction Materials Testing fields, providing solutions to engineering consultants, and government and private sectors for projects through WA.
In 2021, Ryan established New World Laboratories as a specialist testing and research laboratory whilst leading the research, development, and implementation of the C-Twelve range of products.

Jason Lee – Chief Executive Officer

Jason has over 20 years of mining experience majority in Iron Ore. Jason has led large operational teams and technical teams. For 12 years focused on remote technologies in automation and optimisation.
Over the last 7 years, Jason has been running and re-structuring multiple businesses. Increasing revenue and streamlining the businesses processes.

Jason brings a strong strategic planning and commercialisation and contract development to the business. Also a strong view on the future growth of the business.

Ryan Groves – Managing Director

Ryan has over 30 years of experience working in the Materials Engineering and Construction fields. Commencing in 1991 at Main Roads WA, Materials Engineering Branch working his way through Concrete, Pavements, and Surfacing Section and later progressing to Regional Materials Manager for the Goldfields-Esperance Region.

Ryan has extensive knowledge and experience in road building materials sourcing and stockpiling, compliance specifications, laboratory testing and auditing, road pavement investigation for new works and ascertaining reasons for failures and remediation options, as well as providing Pavement and Surfacing Designs for various projects statewide.

In 2011, Ryan moved into the private sector of Construction Materials Testing as General Manager at Materials Consultants increasing the company's productivity and capabilities whilst managing large Metropolitan and Regional Projects for the civil and mining industries.

2019 Ryan partnered with former colleague, Ryan Grieve as Managing Director for Liquid Labs WA before establishing New World Laboratories as a specialist testing and research laboratory in early 2021.

OUR PARTNERS

CBH GROUP

HIWAY GROUP

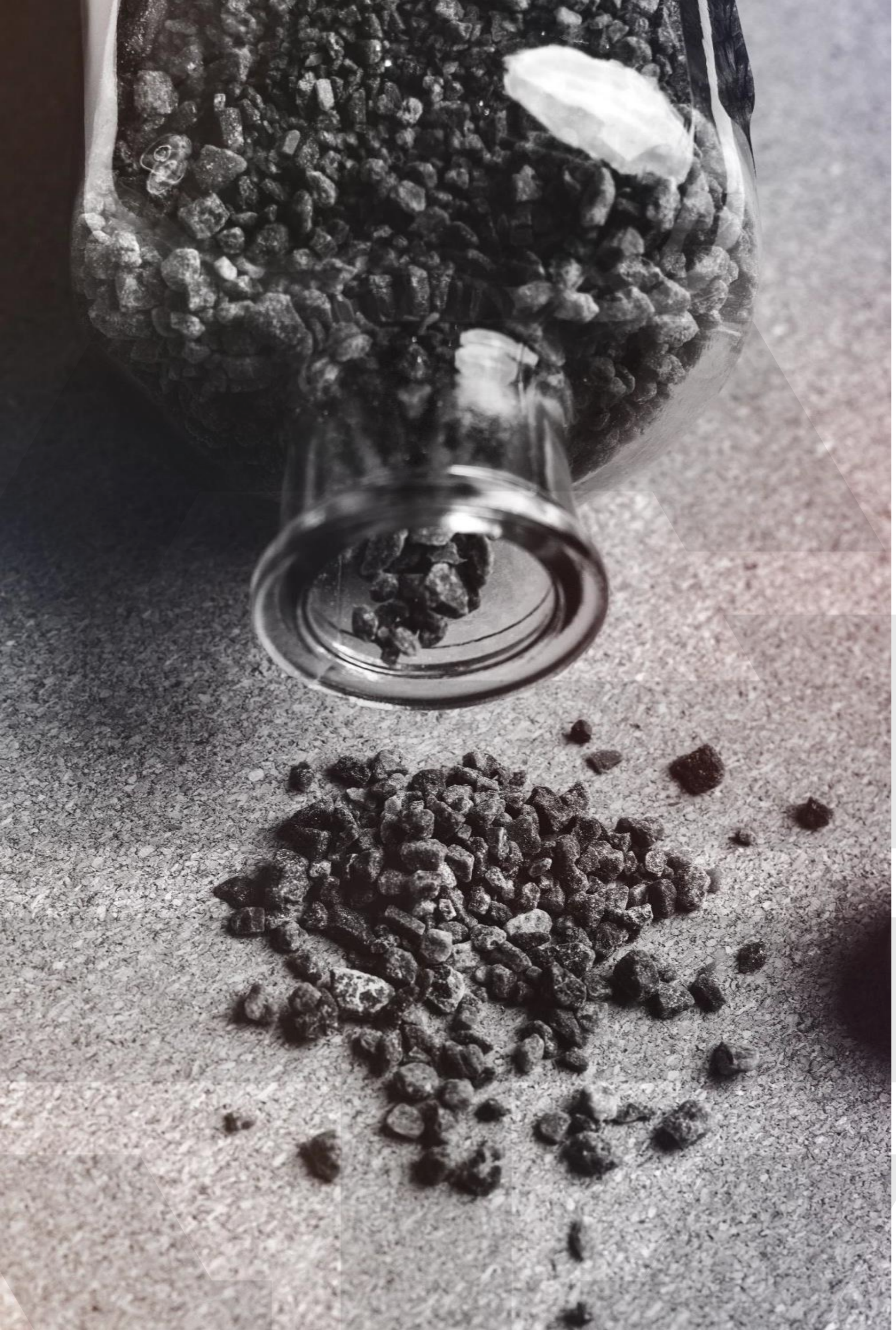
NEW WORLD LABORATORIES

BITUTEK Pty Ltd
ALL THINGS BITUMEN
Supply • Transport • Application

ANZ BIOCHAR INDUSTRY GROUP

Curtin University

Civil Sciences & Engineering



OUR TECHNOLOGY

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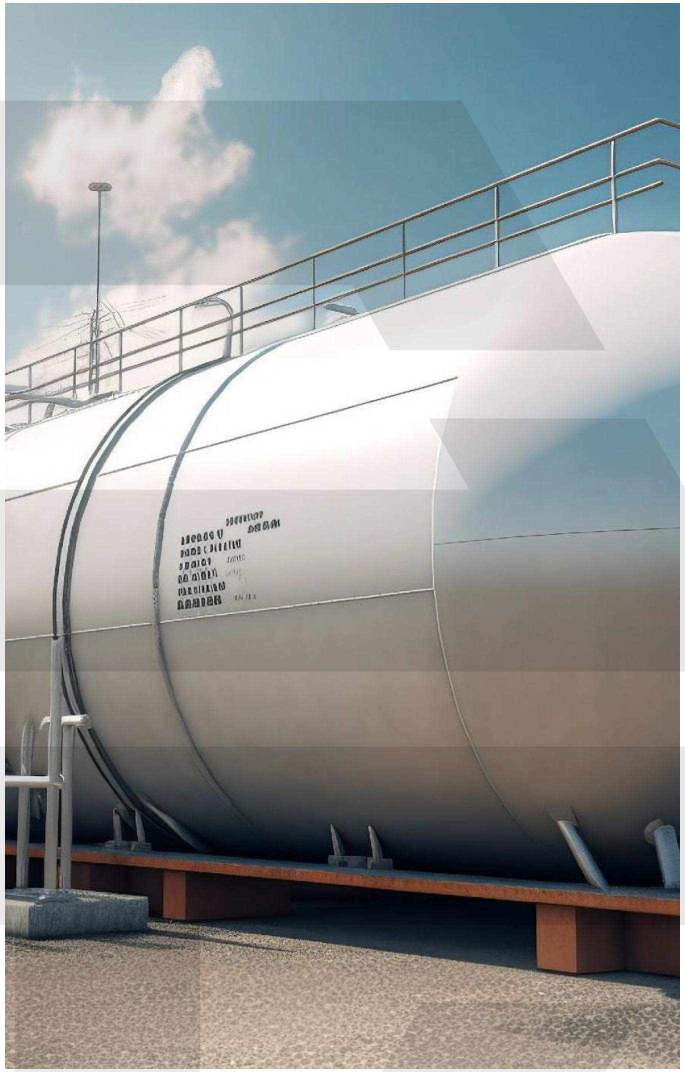
Several studies have investigated the use of biochar in CMRS, and have found that it is a viable option for road construction. For example, one study[1] found that the addition of biochar to CMRS improved the mechanical properties of the mixture and reduced the amount of asphalt binder required by up to 25%. Another study[2] found that biochar can also improve the fatigue resistance of CMRS, which is an important property for road durability.

1. Shu, X., Wen, H., Li, Y., Li, Z., Li, G., & Chen, L. (2017). Effects of biochar on the mechanical properties of cold-mix asphalt mixture. Journal of Cleaner Production, 150, 119-128.

2. Wang, S., Wang, D., Wang, X., Guo, M., & Luo, M. (2021). Experimental study on the effect of biochar on the fatigue performance of cold mix asphalt. Construction and Building Materials, 303, 124912.

5 PYROLYSIS



Pyrolysis is a thermal decomposition process that breaks down organic materials into smaller molecules in the absence of oxygen. The resulting product, known as biochar, is a highly porous carbonaceous material that has many applications in waste management and carbon sequestration.

Pyrolysis can be used to treat a wide range of organic waste materials, including agricultural residues, forestry waste, and municipal solid waste. By converting these waste materials into biochar, pyrolysis offers a sustainable and cost-effective solution for waste management that can help to reduce greenhouse gas emissions and improve soil health in agriculture or be used for industrial applications such as construction and road surfacing materials.

One of the key benefits of pyrolysis is its ability to sequester carbon. When organic materials are pyrolyzed, the resulting biochar can be used to store carbon in the soil or construction materials and roads for hundreds or even thousands of years. This makes pyrolysis an important tool for mitigating climate change, as it can help to reduce the amount of carbon dioxide in the atmosphere. Additionally, biochar has been found to improve soil health by increasing soil organic matter, improving water retention, and enhancing nutrient availability. This can lead to increased crop yields and improved soil fertility, making pyrolysis a valuable tool for sustainable agriculture.

OUR PRODUCTS

C-Twelve Emulsion Stabilised Pavement - C-12+

This innovative pavement solution is carbon negative and green! **C-12+** is an emulsion of BioChar, a unique, high-performance mix that provides a sustainable and long-lasting solution to road surfaces. With its carbon-negative capabilities, **C-12+** stands out as the perfect choice for eco-friendly infrastructure solutions. Its robust and strong pavement provides superior resistance to wear and tear, as well as superior protection against moisture and freezing. Plus, its easy-to-use, non-toxic composition makes it ideal for a variety of applications. **C-12+** is the perfect choice for any project requiring a reliable and environmentally friendly asphalt solution.

Plant Mixed C-Twelve Cold Asphalt - C-12 Black

The revolutionary cold mix, biochar, and emulsion solution that is carbon negative, lab tested, and proven to create hard-wearing roads. This green solution is designed to meet the highest standards of quality, durability and performance. **C-12 Black** is a great choice for those looking for a high-performance product that is capable of withstanding extreme weather conditions. Its unique blend of cold mix, biochar, and emulsion solution creates a uniquely strong solution that is resistant to wear and tear. With lab-tested results, you can trust that your roads will be built to last. **C-12 Black** is the perfect solution for those looking for a green, eco-friendly product that is carbon negative. Its unique formula reduces the environmental impact of road construction, making it an ideal choice for those who want to do their part in preserving the environment. So why wait? Try **C-12 Black** today and experience the difference it can make on your roads. With its hard-wearing course and carbon-negative green solution.

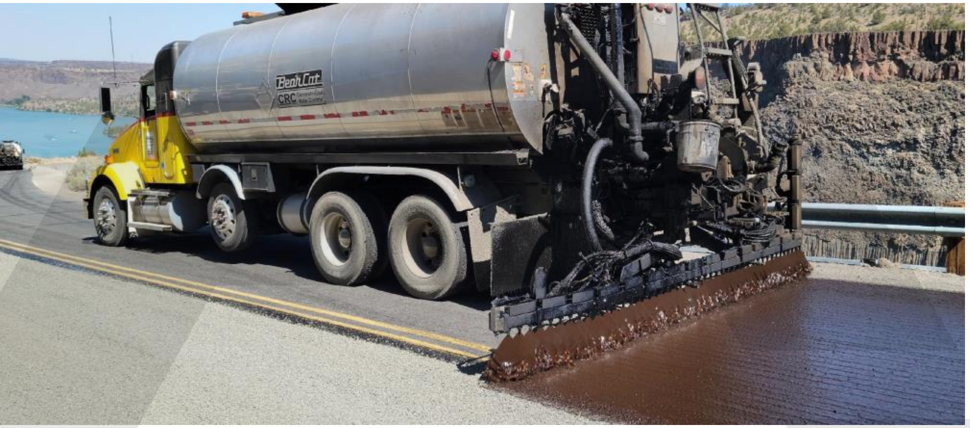
RESEARCH & DEVELOPMENT

C-Twelve's research and development efforts have resulted in the development of a revolutionary emulsion that works in combination with biochar from waste materials.

C-Twelve has conducted extensive testing and experimentation to prove the effectiveness of their innovative emulsion-biochar combination in various applications. Their research has shown that the emulsion-biochar combination provides a durable and long-lasting surface that is resistant to wear and tear, making it highly effective at sealing roads. Additionally, the emulsion-biochar combination has been found to be highly effective at suppressing dust in a range of industrial applications, helping to improve worker safety, reduce environmental impact, and enhance productivity.

In conclusion, C-Twelve's research and development efforts into the use of emulsion in combination with biochar have yielded impressive results. This innovative approach offers significant potential for revolutionizing road construction and dust suppression while providing valuable benefits for the environment, the economy, and society as a whole. With a continued focus on innovation and excellence, C-Twelve is well positioned to lead the way in sustainable road construction and industrial dust suppression. withstanding

RESEARCH & DEVELOPMENT



In addition to the Soil Stabilisation and Cold Mix products, C-Twelve is continually developing new applications and new products.

Two such products in development currently are:

C-Twelve Spray Seal - For application in a thin layer onto road surfaces, followed by the placement of aggregates, which is then rolled into the bitumen to create a durable and long-lasting surface. Spray seals are commonly used on rural and urban roads as a cost-effective way of extending the life of a road surface.

C-Twelve Dust Suppression - Using C-Twelve's proprietary emulsion with biochar, the company has identified its capacity for use in dust suppression in a range of industries, including mining. The biochar used in the emulsion acts as a natural filter, absorbing moisture from the surrounding air, or from applied water and binding to dust particles, thereby reducing their mobility and preventing them from becoming airborne. When the emulsion is applied to dusty surfaces, the biochar works to suppress dust by capturing and immobilizing it. The resulting surface is not only safer for workers, but also more environmentally sustainable, as it reduces the amount of dust that is released into the atmosphere. This innovative approach to dust suppression offers significant potential for improving worker safety, reducing environmental impact, and enhancing productivity in a range of industries.

9

CASE STUDY

CBH - WATHEROO GRAIN RECEIVAL CENTRE

Using grain covering tarpaulins from CBH Group that were destined for disposal through landfill in Perth Western Australia, C-Twelve pyrolyzed a mix of grain waste and tarpaulins to make the biochar required for the resurfacing of the entire grain receival area.

The result was a superior, hard wearing cold mix asphalt surface that will last well over ten years, while at the same time sequestering carbon from the process of grain processing from the very site the work was being done at.

The long term saleability of such projects indicates the money and resources saved in similar operations from reducing landfill reliance and minimising the logistics required for such activities positively impacts the already appealing affordability of using the superior C-Twelve Black Cold Mix product.

This combined with the potential to generate significant carbon credits from such projects makes the large scale adoption of C-Twelve Black very exciting.

CASE STUDY (Cont.)

WATHEROO GRAIN RECEIVAL CENTRE

7

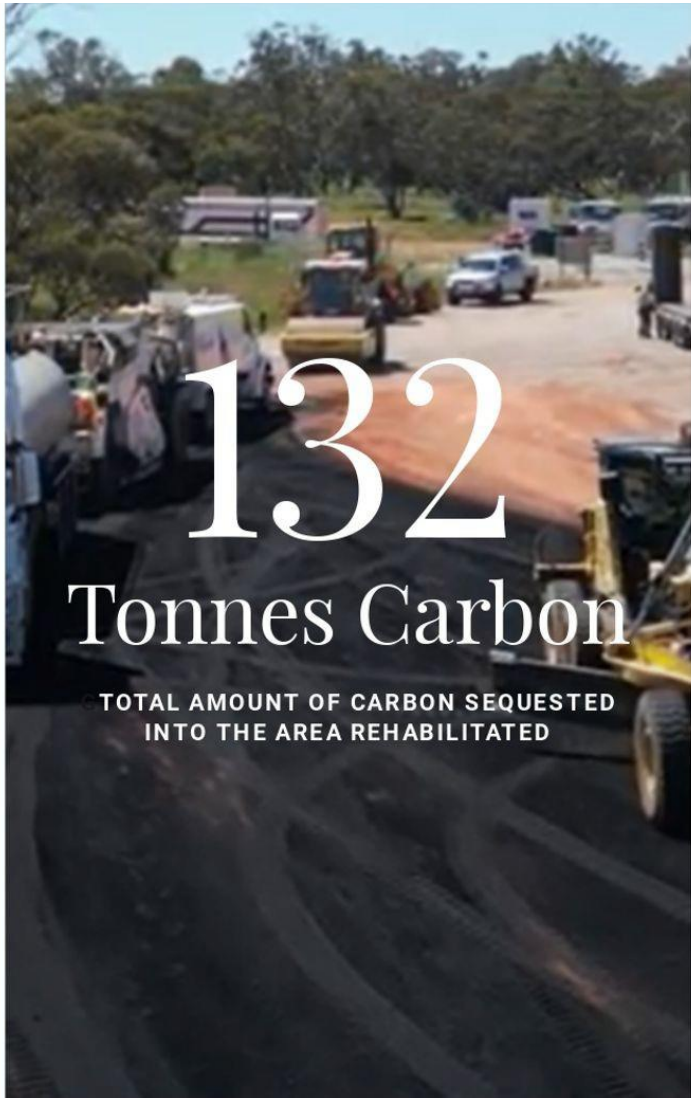
Tonnes of Tarps

CBH TARPS NOT GOING TO LANDFILL

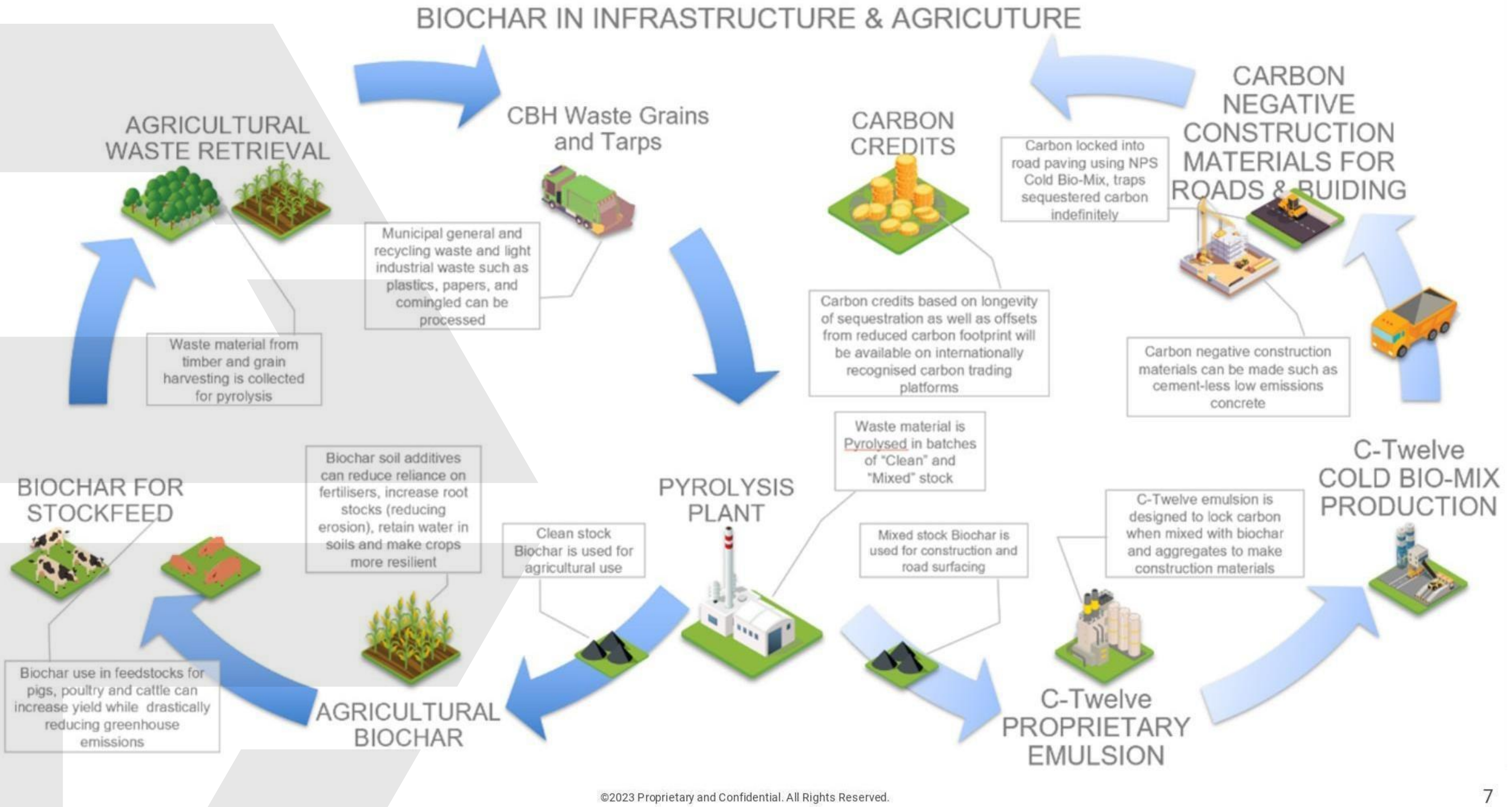
2500

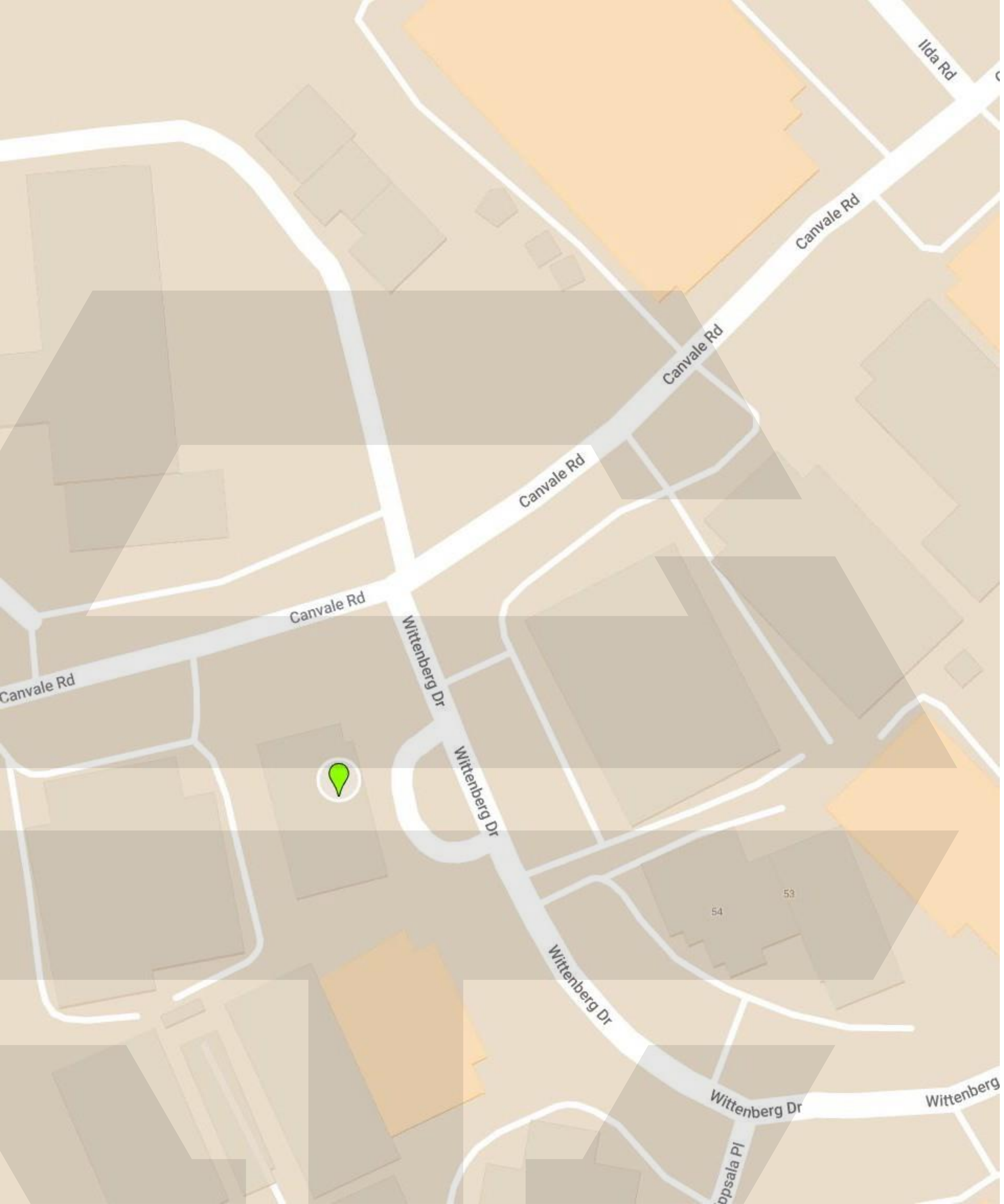
M2

TOTAL AREA THE TEST WAS CONDUCTED AT WATHEROO



11 THE BIOCHAR<> COLD MIX CYCLE





CONTACT US

C-TWELVE PTY. LTD.

ADDRESS: 62-64 Wittenberg Drive,
Canning Vale,
Western Australia 6155

PHONE: 0401 334 421

EMAIL: jlee@c-twelve.com.au

WEB: www.C-Twelve.com.au

SEATA

Deconstructing the world's problems to create carbon negative solutions

Introduction to SEATA Technology

Hydrogen with Benefits – Waste to Value

Co-production of clean syngas and biochar from multiple feedstocks, at distributed or centralised scale

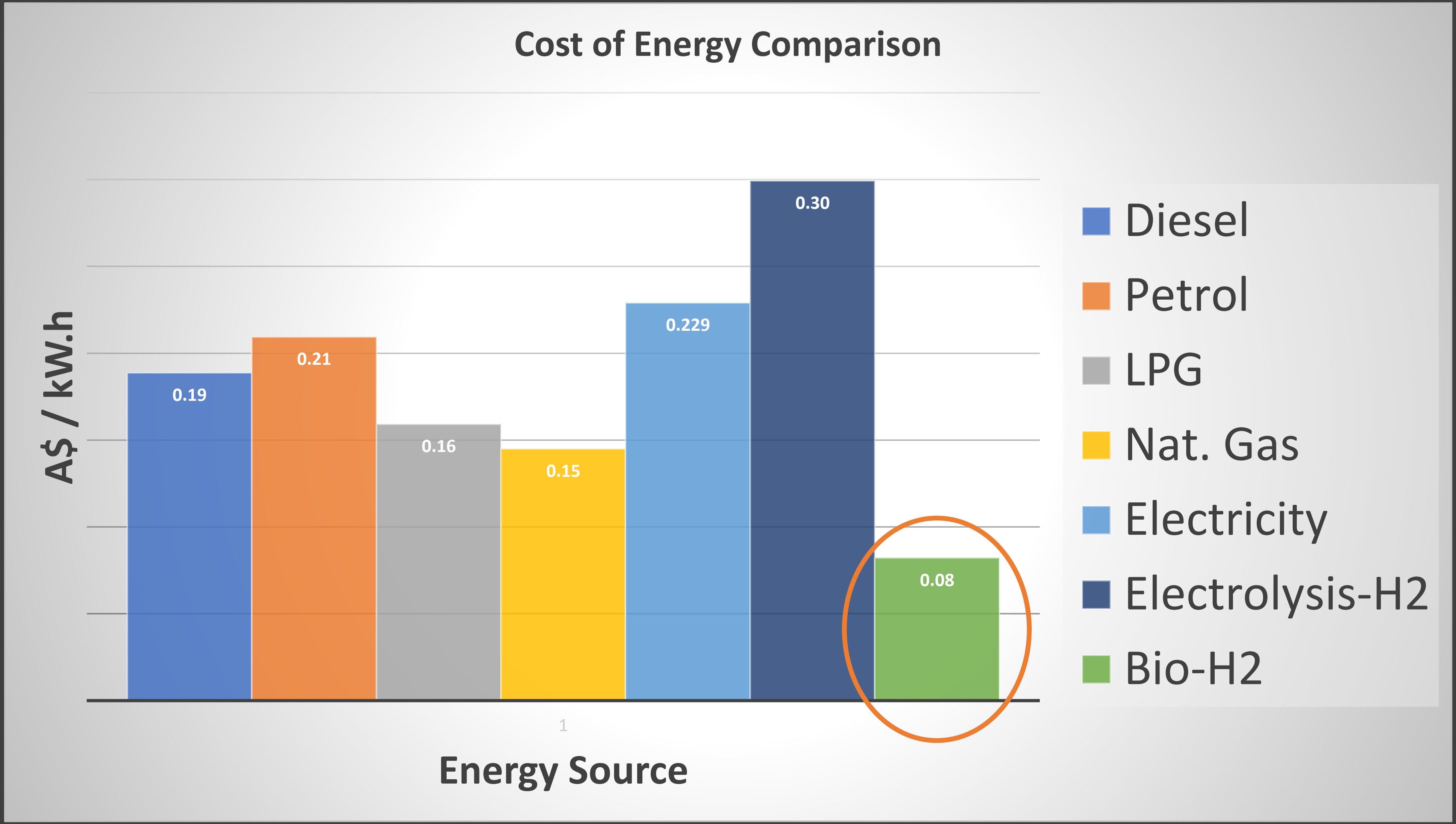
=> Carbon ***Negative*** *H_2*

June 2023

John Winter
Director Engineering & Technical, SEATA Group

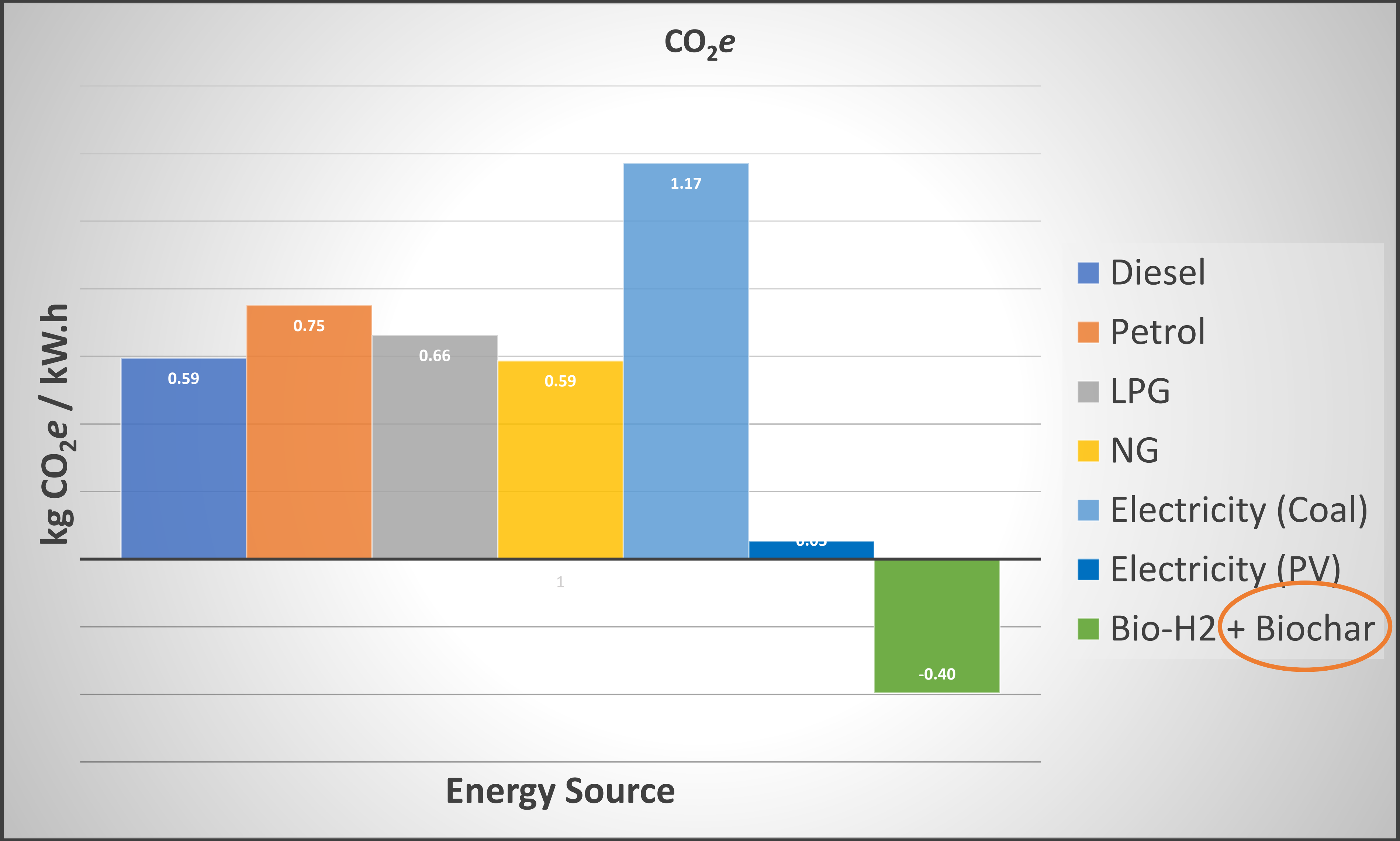
Craig Bagnall
Director Environment & Regulatory, SEATA Group

Why Bio-Hydrogen?



Ref: GlobalPetrolPrices.com, 23 Jan 23.

The Difference? Carbon *negative* hydrogen



Outline

- **Introductions –** SEATA Directors

Part I : Rethinking Design to Maximise Value

  - **Existing Technologies**
  - **SEATA technology and Key Points of Difference**

Part II: Rethinking Carbon – waste to value

- **Why CDR? Biochar = drawdown with *value***
- **Feedstocks**
- **Biochar Soil & Non-Soil Applications and Markets**

SEATA Clean Energy & Carbon Sequestration R&D Centre (NSW, Australia)

*"Carbon sequestration **could bring many opportunities to Australia's regions and rural and remote areas,** including new income streams, jobs, and valuing and protecting the knowledge and practices of First Nations Australians"*

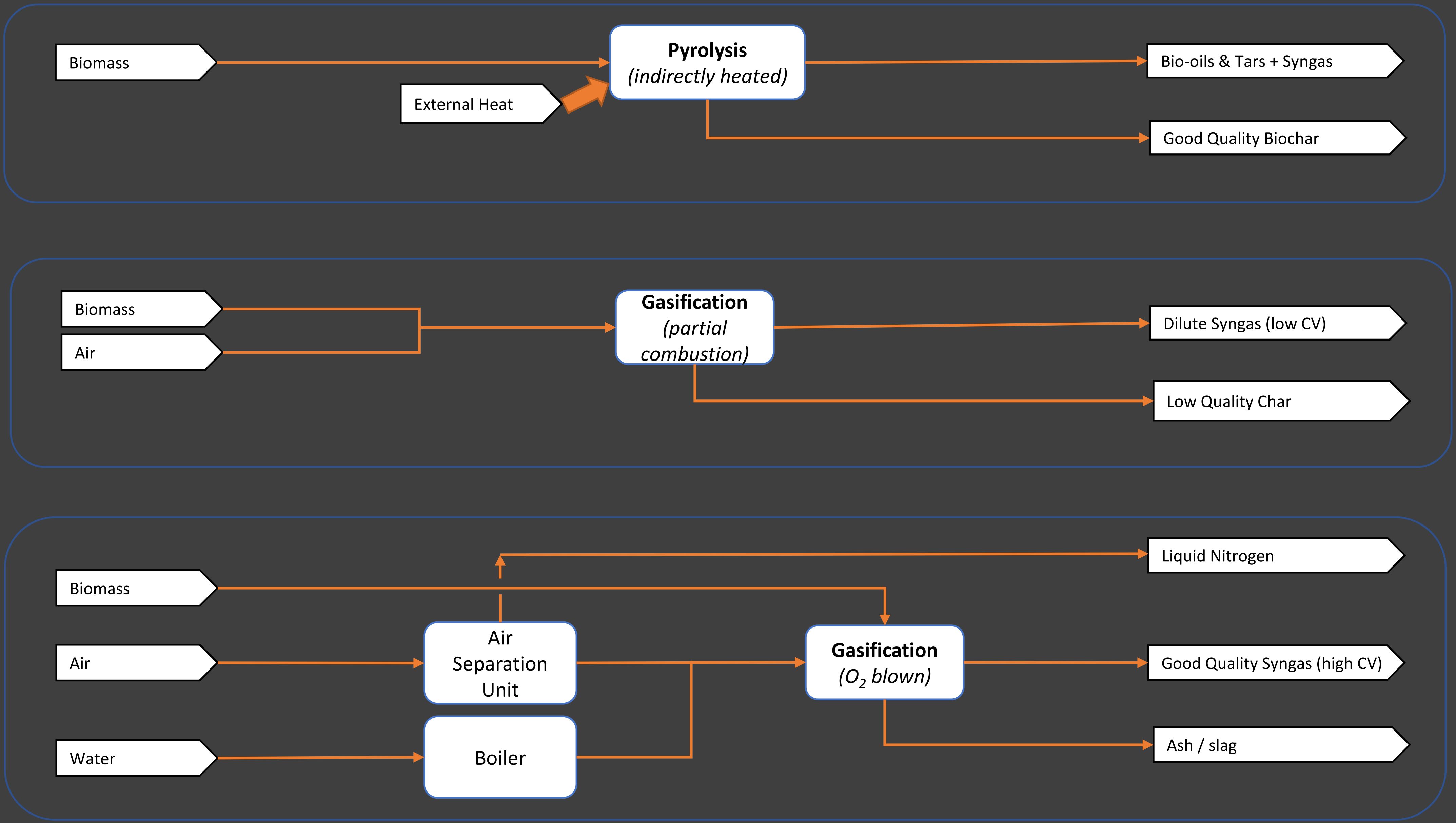
Brad Archer, CEO Climate Change Authority
December 2022

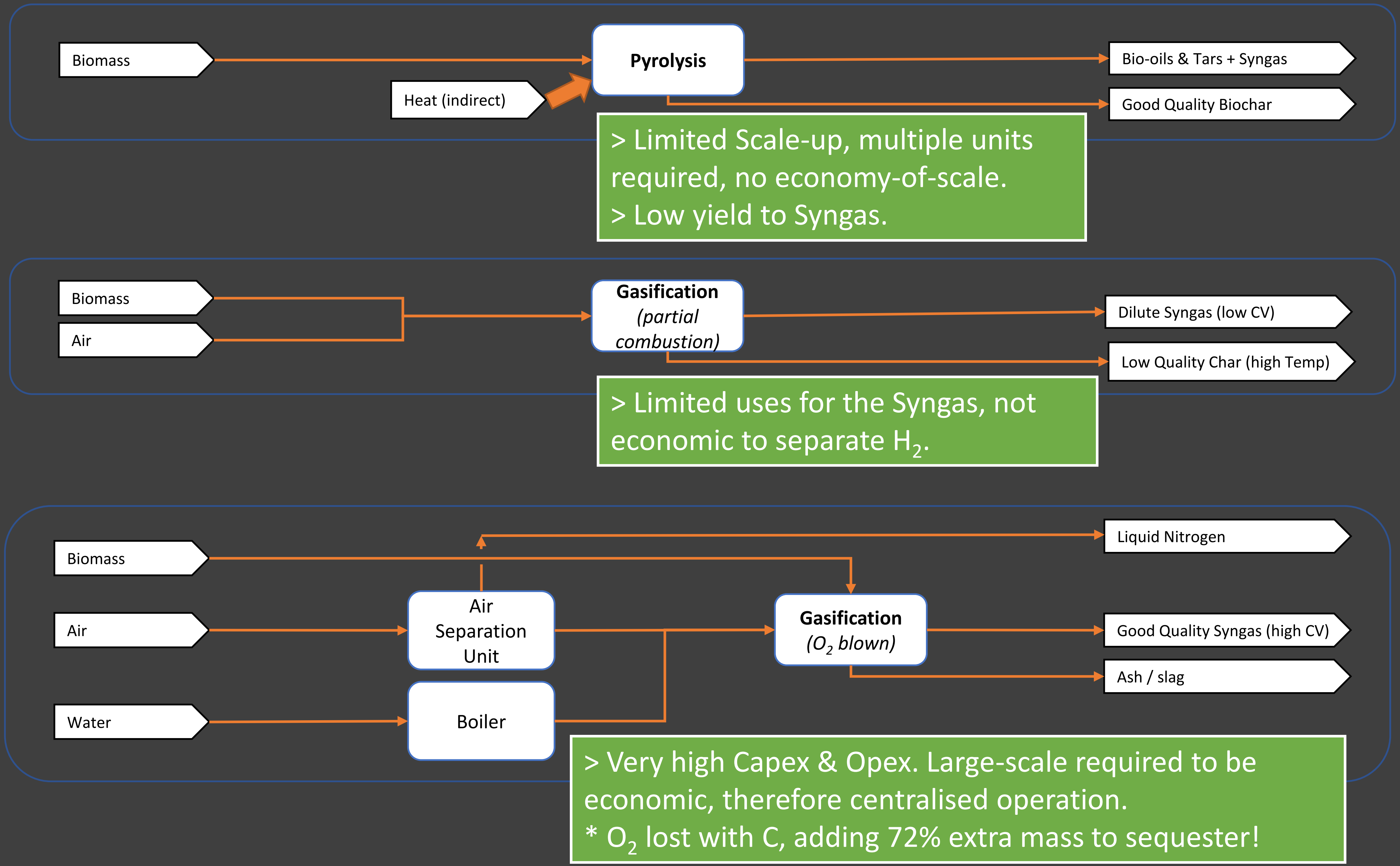
Introductions

SEATA:

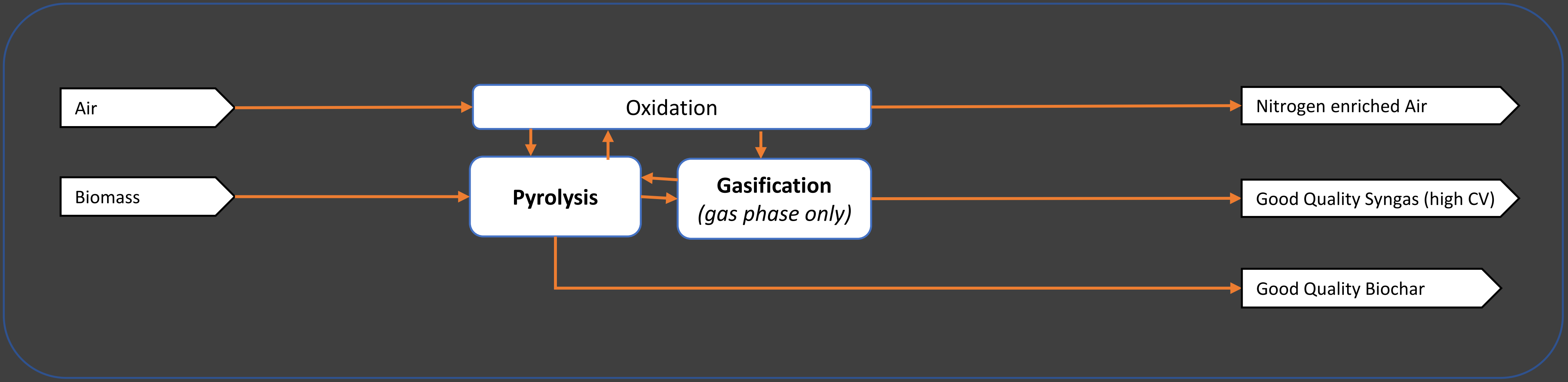
- John Winter – Director: Engineering & Patent Developer
- James Jordan - Director: Fabrication & Construction
- Jim McFarlane – Director: Mechanical Design
- Robert Tew– Director: Chairman & Commercial
- Scott Fairbairn – Director: – Energy & Communications
- Rob Faraday-Bensley – Director: Legal &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

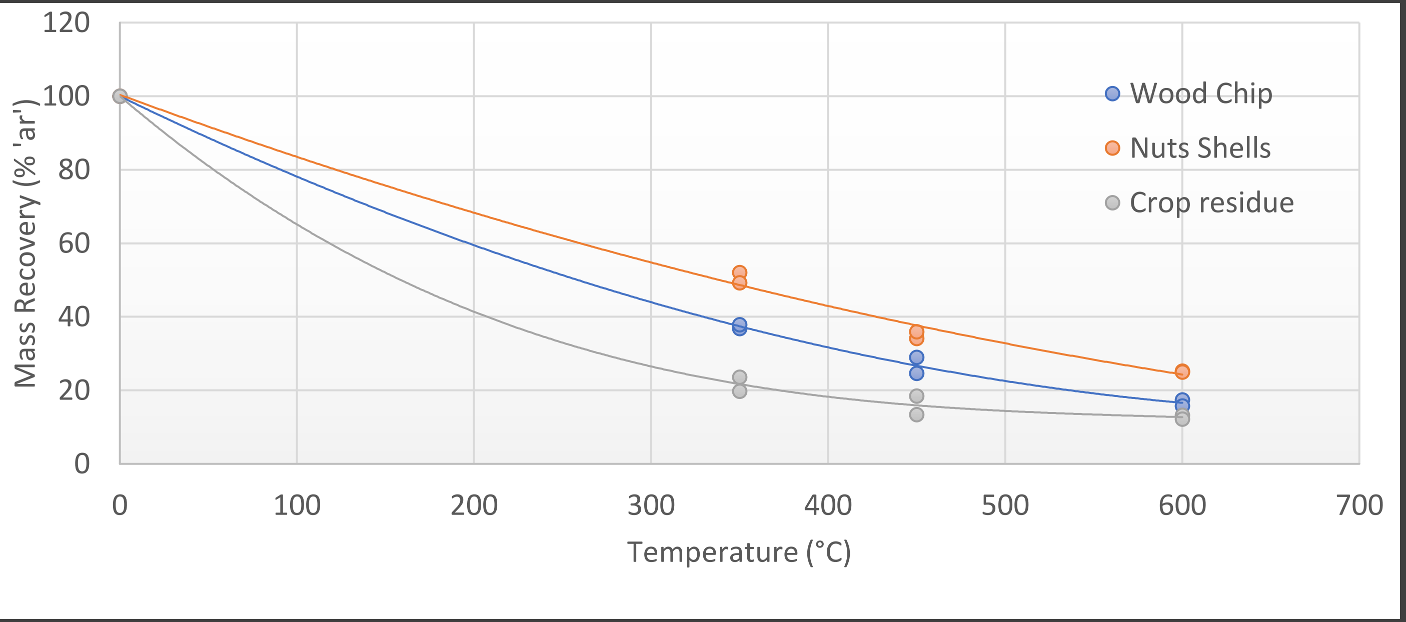
Conventional Pyrolysis and Gasification Technologies:




Biomass
Heat (indirect)
Pyrolysis
Bio-oils & Tars + Syngas
Good Quality Biochar
> Limited Scale-up, multiple units required, no economy-of-scale.
> Low yield to Syngas.
Biomass
Air
Gasification (partial combustion)
Dilute Syngas (low CV)
Low Quality Char (high Temp)
> Limited uses for the Syngas, not economic to separate H_2.
Biomass
Air
Water
Air Separation Unit
Boiler
Liquid Nitrogen
Gasification (O_2 blown)
Good Quality Syngas (high CV)
Ash / slag
> Very high Capex & Opex. Large-scale required to be economic, therefore centralised operation.
* O_2 lost with C, adding 72% extra mass to sequester!

SEATA technology - Chemical + Thermal Looping (CTL)



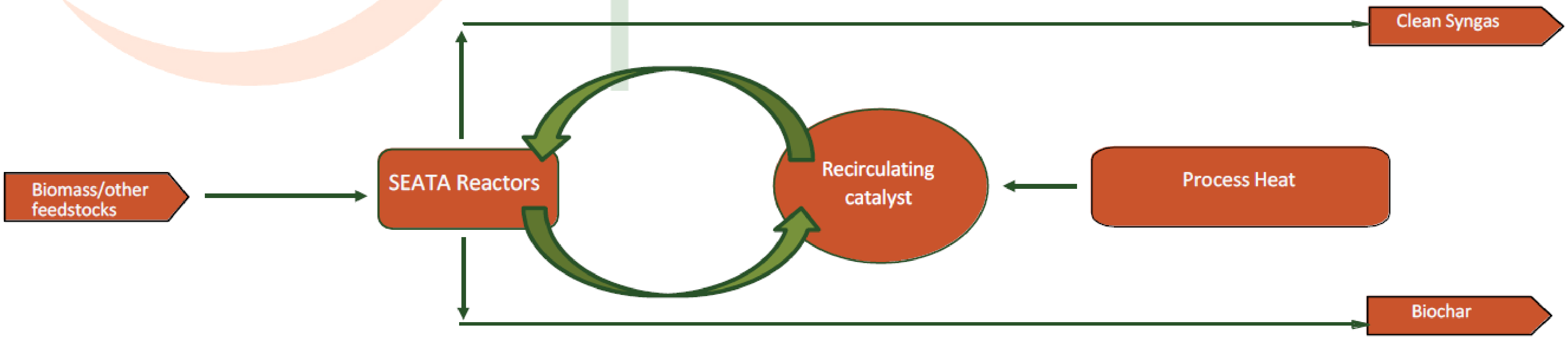


- High Quality Products, Syngas + Biochar.
- **Single-unit-scalable** process design
- Minimised energy consumption.
- Minimised syngas volume, Maximised concentration.
- Controllable Syngas composition.
- Syngas suitable for synthesis into methanol, F-T, methanation, etc.

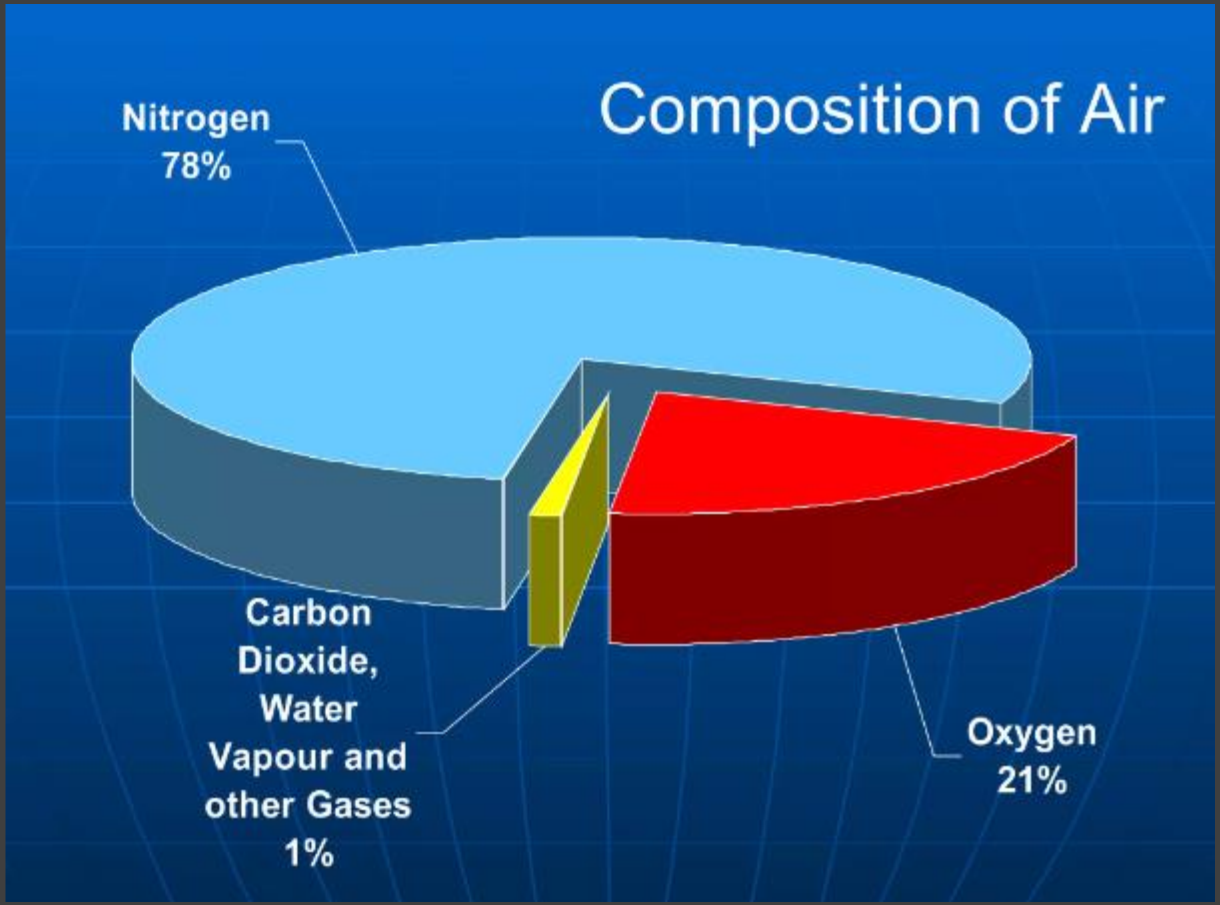
SEATA – Process Summary

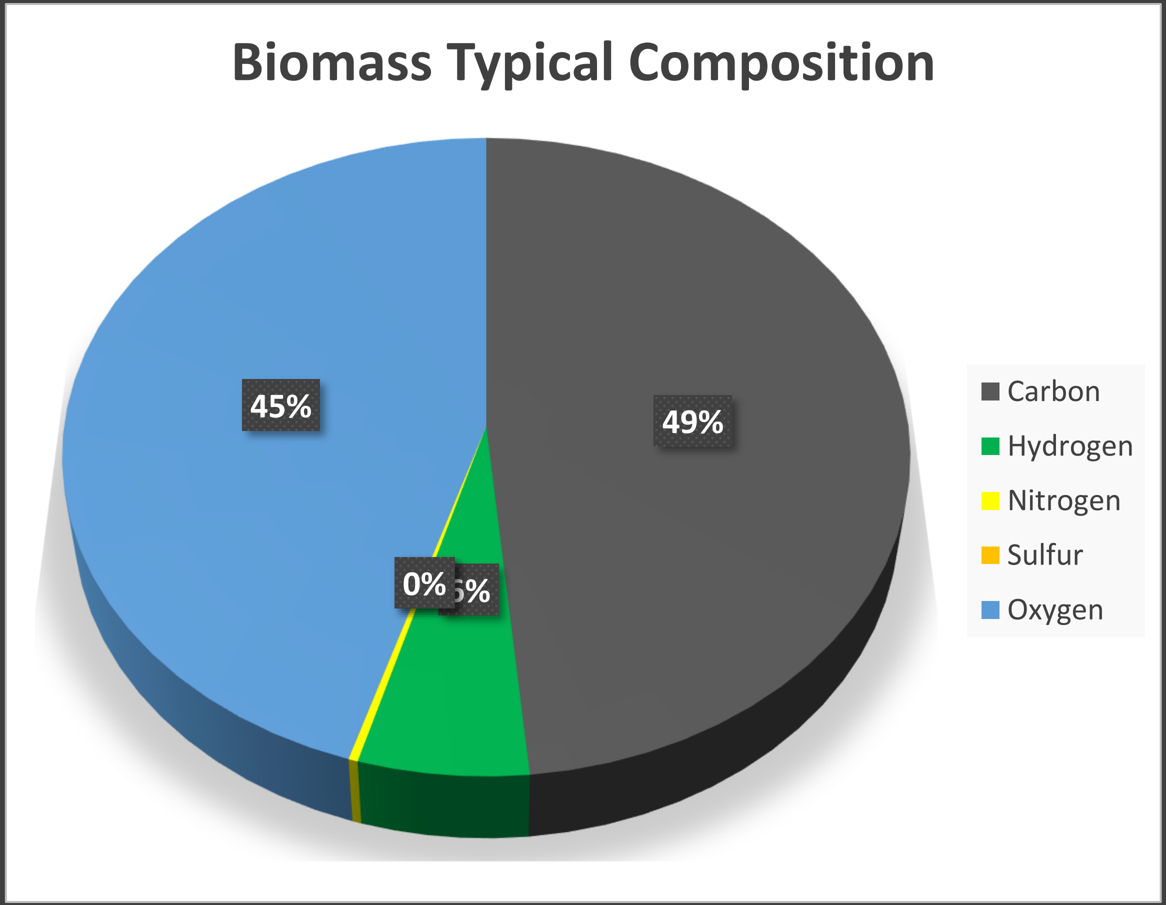
- Combination of thermal and chemical looping principles, providing optimum pyrolysis and gasification outcomes, i.e. high yield of quality biochar and clean syngas not diluted with atmospheric nitrogen.
- Low pressure operation
- Being based on chemical looping, separation of oxygen from air is not required, therefore saving energy while producing similar syngas quality as conventional oxygen blown gasifiers.
- The media is a solid state heat and oxygen carrier that is recirculated within the process. There are a number of suitable minerals to use as heating media. Only minor make-up quantity required.
- Preferred moisture content of feedstock is ~ 20% but can handle higher moisture content dependent upon blending with biomass.
- Syngas can be used for generation of electricity or in the process to supply thermal energy or for drying of feedstock.
- Because the syngas is not diluted with nitrogen, the calorific value is high, allowing economical storage of the syngas (either in gas-holders or as compressed gases). This stored energy source allows generation of electricity on demand.

SEATA Process – Reactor Schematic



Note: Detailed PFD's / P&ID conditionally available on request


Composition of Air
Nitrogen
78%
Carbon
Dioxide,
Water
Vapour and
other Gases
1%
Oxygen
21%


Biomass Typical Composition
45%
49%
0%
Carbon
Hydrogen
Nitrogen
Sulfur
Oxygen

Indicative Example:

5 tonne / hour SEATA Plant

(120 tonne / day = 3 truck loads)

- **10 tonne / day H_2 (via PSA)**
- **19 tonne / day Biochar**
- **19,800 tonnes CO_2*e* / year Carbon Draw Down**

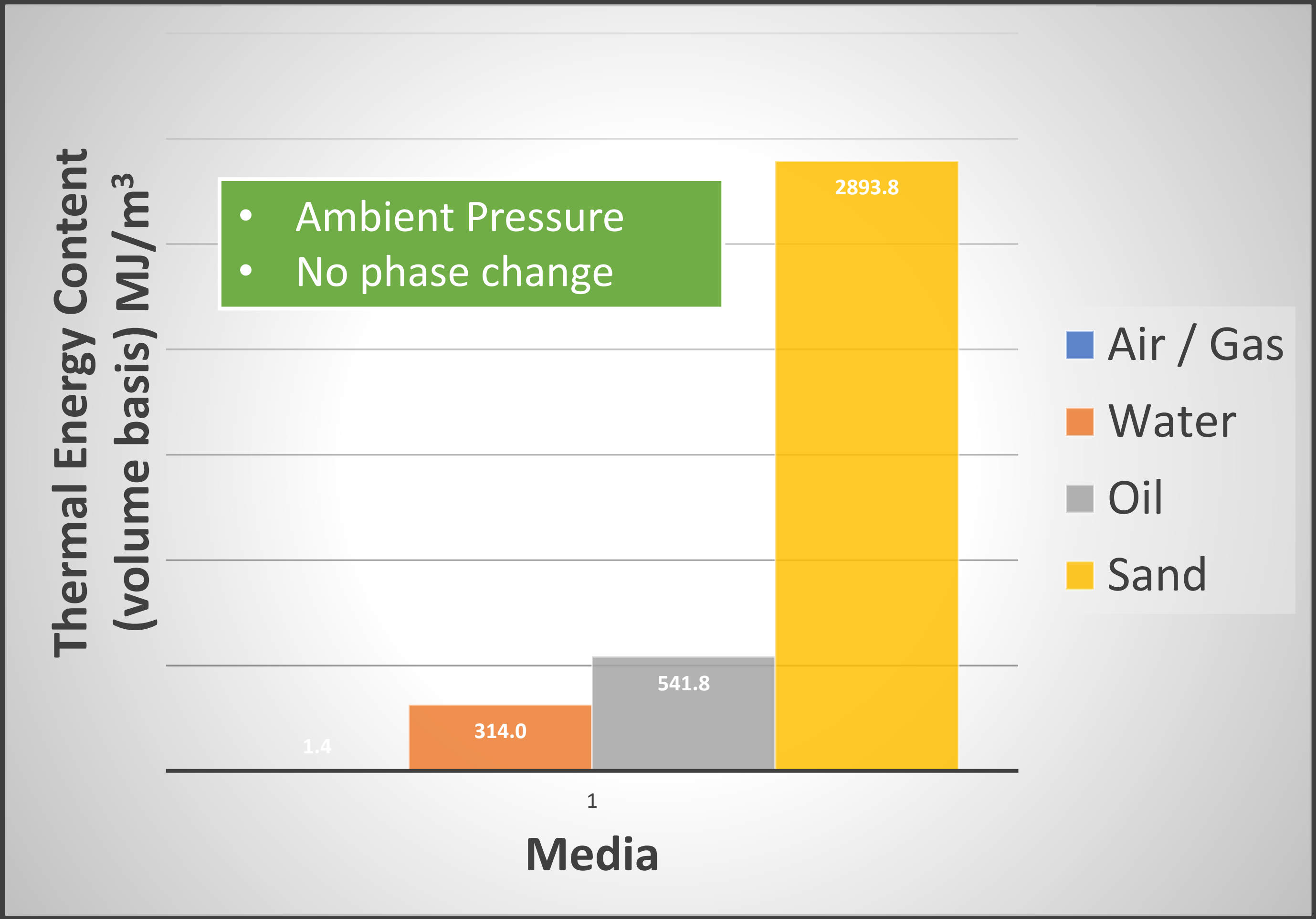
Agricultural Residues
82 bales / truck @ 500-600kg / bale


Invasive Woody Weeds
220,000 km^2 in Northern Australia

- **Biomass can be stored**
- **Syngas can be compressed using renewable electricity (for storage or processing)**
- **Syngas can be used for "on-demand" electricity generation**
- **Biomass can be re-grown (enhanced with Biochar)**

Process Intensification:

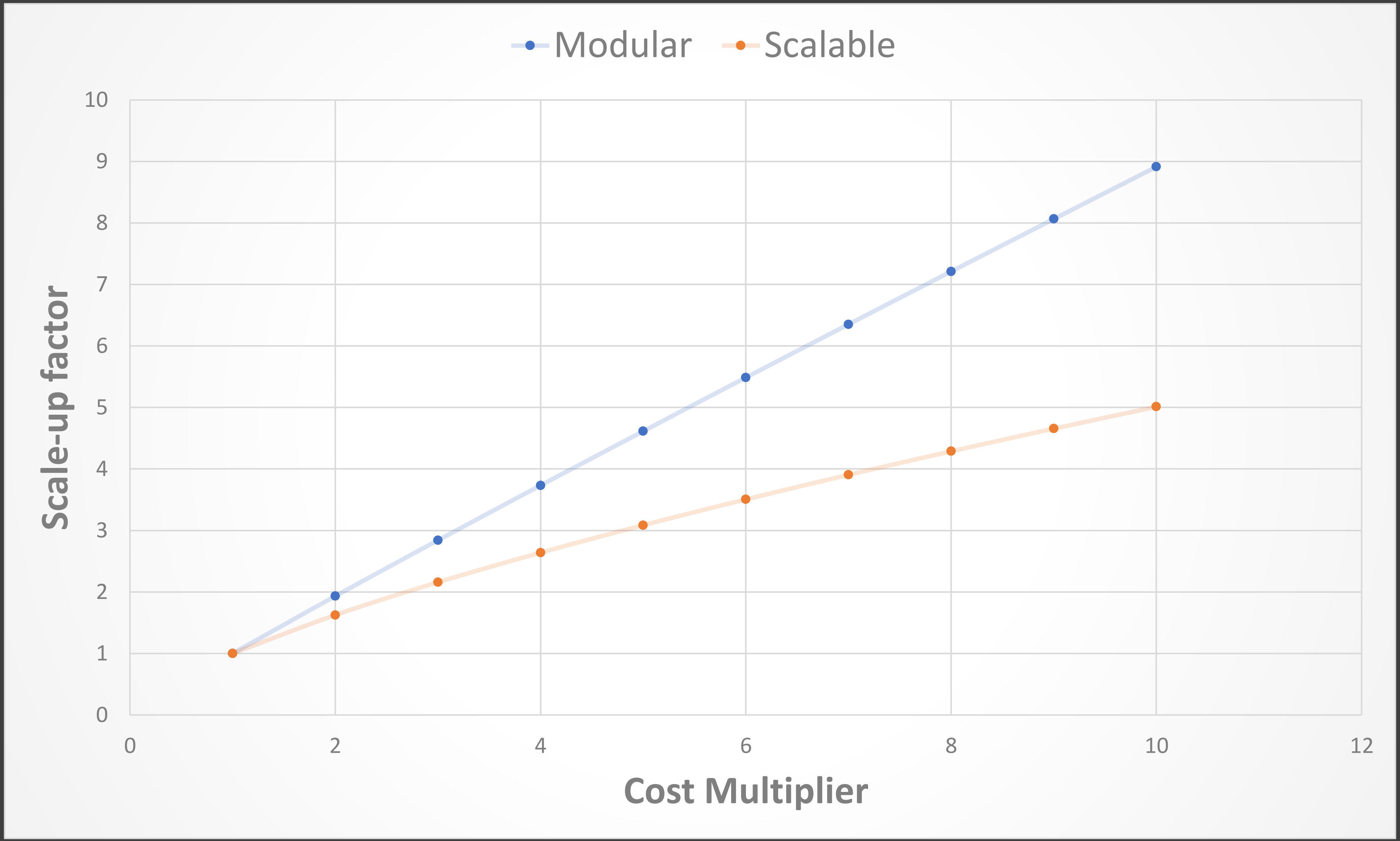
Biomass feed rate = 1000 kg / h



Conventional Indirectly Heated Pyrolysis

SEATA – Thermal + Chemical Looping equivalent (9 x increase)

Scale-up cost:



Environmental Performance Design Comparison

ENVIRONMENTAL PERFORMANCE Design Factors	Incineration *(combustion, excess oxygen)*	Conventional Air-blown Gasification *(partial oxidation)* *(air-blown= high N_2)*	Conventional Pyrolysis *(low/no Oxygen)*	SEATA Catalysed Pyrolysis & Partial Gasification via chemical looping *(indirect O_2 transfer from air, low N_2 in syngas)*
Off-gas volume to be treated	Very high	High	Moderate	Low *(not directly airblown (air is 78% N_2), therefore up to 78% less volume)*
General Environmental Performance	Lowest	Lower key advantage over combustion is lower NOx formation	Better (if bio-oils are dealt with correctly)	Higher benefits of pyrolysis and gasification combined, hence only clean syngas and biochar produced
Linear / Circular Economy *(Resource Recovery)*	Linear, Poorest LCA single use of resources	Linear, Poor LCA syngas linear due to dilution with N_2, marginal resource recovery as charcoal	Circular syngas linear due to tar contamination, some resource recovery as biochar, bio-oils difficult to process / limited uses	Circular syngas derivatives possible due to the high concentration of H_2 and CO plus functional biochar resource, with no bio-oils generated – all converted to useful syngas
Dispatchable Energy	No – heat must be used immediately via steam cycle (base load)	No – heat must be used immediately via steam cycle (base load)	Yes – via syngas storage and bio-oils, but multiple units required to scale with, no increase in thermal efficiency.	Yes – via syngas storage and derivative of syngas, e.g. H_2 Much higher thermal efficiency (particularly at scale) = net energy *producer*
GHG Emissions (incl CO_2)	Very High	High	Low to carbon negative	carbon negative energy
Carbon Abatement / Sequestration	None all carbon infeed is converted to CO_2	Low 10% Carbon in feed converted to charcoal, remainder to CO_2	High ~50% Carbon in feed reports to solid char	High ~50% Carbon in feed reports to solid char, *plus* potential future recovery of carbon in syngas (e.g. high grade CO_2 into CCUS, total removal potential increases to over 75%+)
Harmful Pollutant Emissions *(Particulates, Heavy Metals, VOC's, POPs, NOx, Dioxins & Furans)*	Highest Off-gas requires significant treatment	Moderate Lower off-gas volume to treat than incineration but still large, lower NOx	Moderate Low off-gas volume to treat, syngas still contains tars, dioxins and furans. Hence specially designed combustion systems required to destroy tars, dioxins & furans.	Low All syngas generated by the process is pre-cleaned at high temperature in the presence of a catalyst to destroy residual tars & halogenated compounds (second reactor), then wet quenched / scrubbed to remove soluble components and avoid reformation of dioxins and furans. Clean product syngas capable of economic recovery for derivatives, or for lower emission combustion without post-treatment (similar to natural gas or LPG for example)
Emission Control Systems (ECS)	Critically Dependent on Pollution Controls Multiple additives required to scrub pollutants, generating further waste streams for disposal, plus large unit operation to treat the high gas volume	Highly Dependent on Pollution Controls (Similar to incineration, but lower gas volume to treat and lower NOx)	Highly Dependent on Pollution Controls Syngas requires further pre-combustion cleaning before use. ECS requirements scale dependent. Complicated with halides and dioxins and furans.	Low Dependency Pollutants are dealt with as part of the process, e.g., alkali metals remain with the biochar; tars and oils destroyed (deconstructed), syngas is wet scrubbed; so the resulting syngas is clean & ready for use. Downstream users of syngas do not require additional ECS.
Water Usage	High Evaporative cooling and make-up water for the steam system	High (Same as incinerators)	Low Water consumed for capture of bio-oils and indirect cooling	Low Make-up water for wet quench / scrubber only
Problematic Liquid Produced (Oils, Tars, Resins, Water)	Yes Boiler blow-down brine and evaporative cooling system purge water plus scrubber water (if a wet system is utilised)	Yes Up & down draft gasifiers generate tars plus spent scrubber water	Yes Alot of tar and oil by-products, reported beneficial wood vinegar, plus scrubber water	No All oils and tars destroyed. Only a small purge of water from the quench / scrubber to manage solids accumulation. This can be further evaporated to form a solid if required
Bottom & Fly Ash for Disposal *(Potentially Toxic Solid Waste)*	Significant Ash dam required, portion of the ash is super-fine	High Ash dam required	No Ash Ash remains with the biochar	No Ash Ash remains with the biochar, metals bound / not bioavailable.

SEATA vs Conventional Industrial Scale Gasification Plants including Methanation For Hydrogen

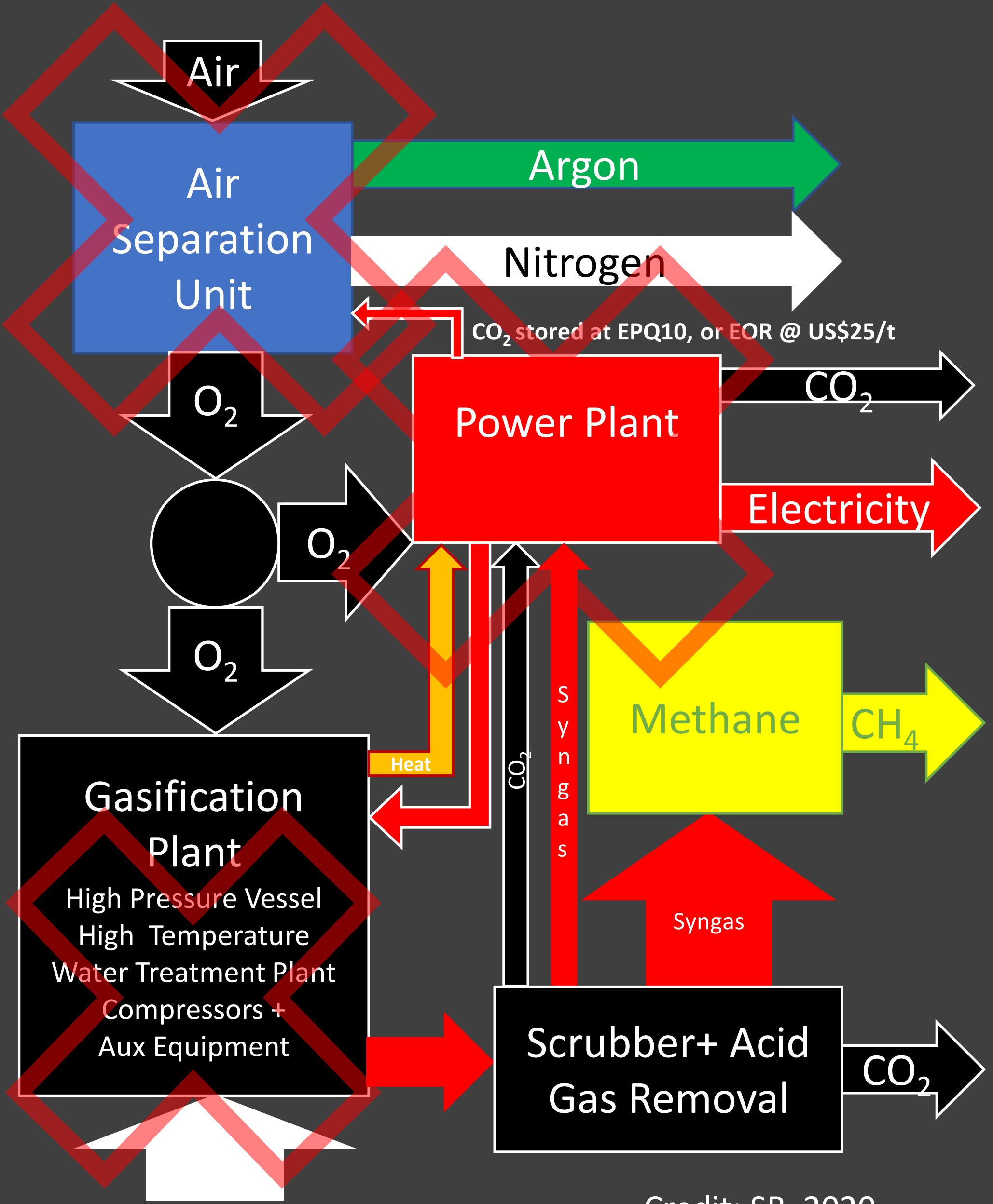
No ASU + No Power Plant + No High Pressure

Carbon Reports to Char in SEATA Plant

- Up to half infeed carbon reports to Char
- Gasification Matches Methane CO_2
- Process Efficiencies compensate for Carbon losses in Char

Chemical looping simplifies gasification

- Reduced Thermal Process Energy Losses
- No Air Separation Unit (ASU) - $$$ very high CAPEX
- No High Pressure Compressors
  - SEATA at atmospheric pressure
- No slag water quenching
  - No black water treatment plant
- No Power Units
  - Low power consumption
  - Co-generation plant unnecessary



Credit: SB, 2020

‘Drawdown’ Potential (CO_2 Removal) – Removing carbon from the atmosphere to address Climate Change, at scale.

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)**

HYDROGEN WITH BENEFITS:

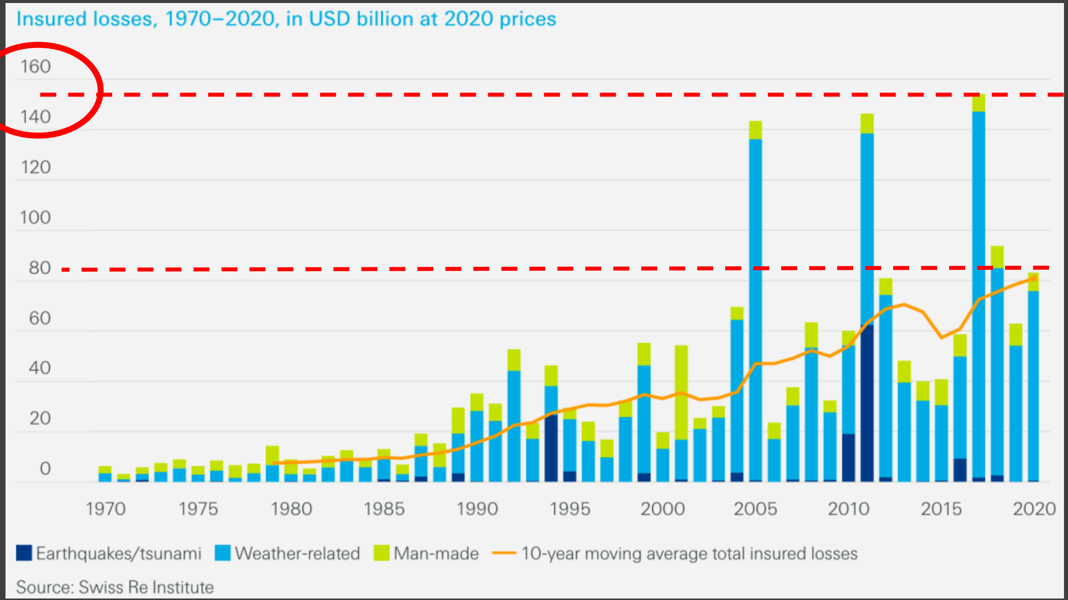
PART 2: Rethinking Carbon – waste to value

- **Why CDR? Biochar = drawdown with *value***
- **Feedstocks**
- **Biochar Uses**

SEATA R&D Centre, NSW, Australia

Why does the world need CO2 Removal (CDR)?...Multiple Converging Drivers

- **Emissions Reduction not sufficient**, **IPCC** calls for CO_2 Removal (CDR) **at scale**
- **More frequent, severe impacts ($$$$)**
- **Net Zero Commitments (2050, 2030)**
- **Policy change (**US IR Act, EU Green Deal, UN Global Compact, FM Coalition)
- **Circular Economy** transition
- **Premium Carbon Credit Value** (typically >100 Euro/tCO_2e)



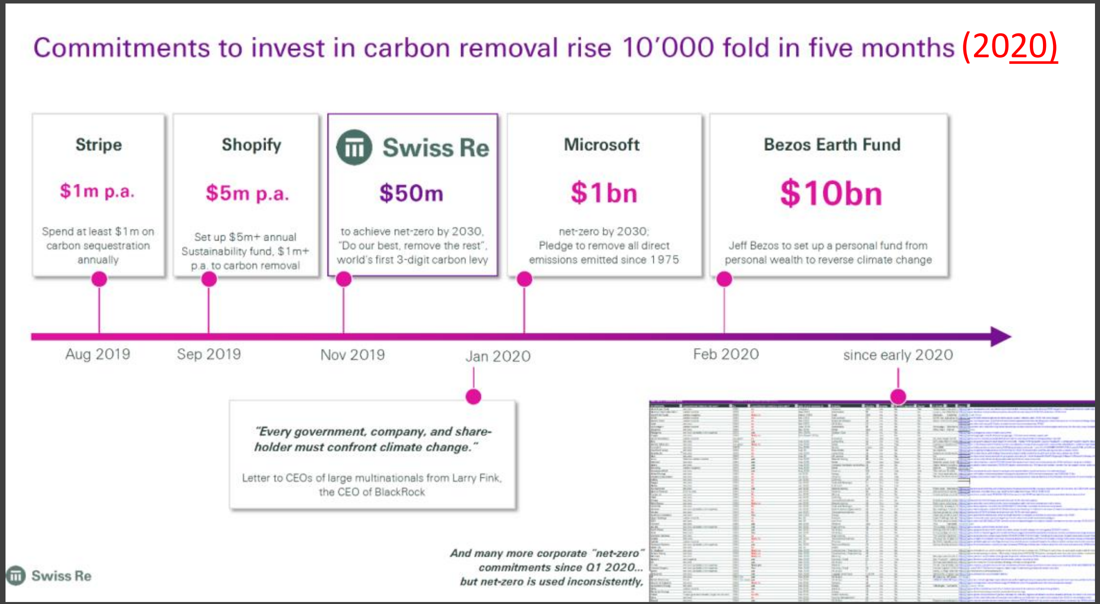
2021 US$320B *(total)*

***2022** US$240B* *(total)*

(insured ~$120B)

Source: Munich Re

Credit: Swiss Re



Source: BBC.com

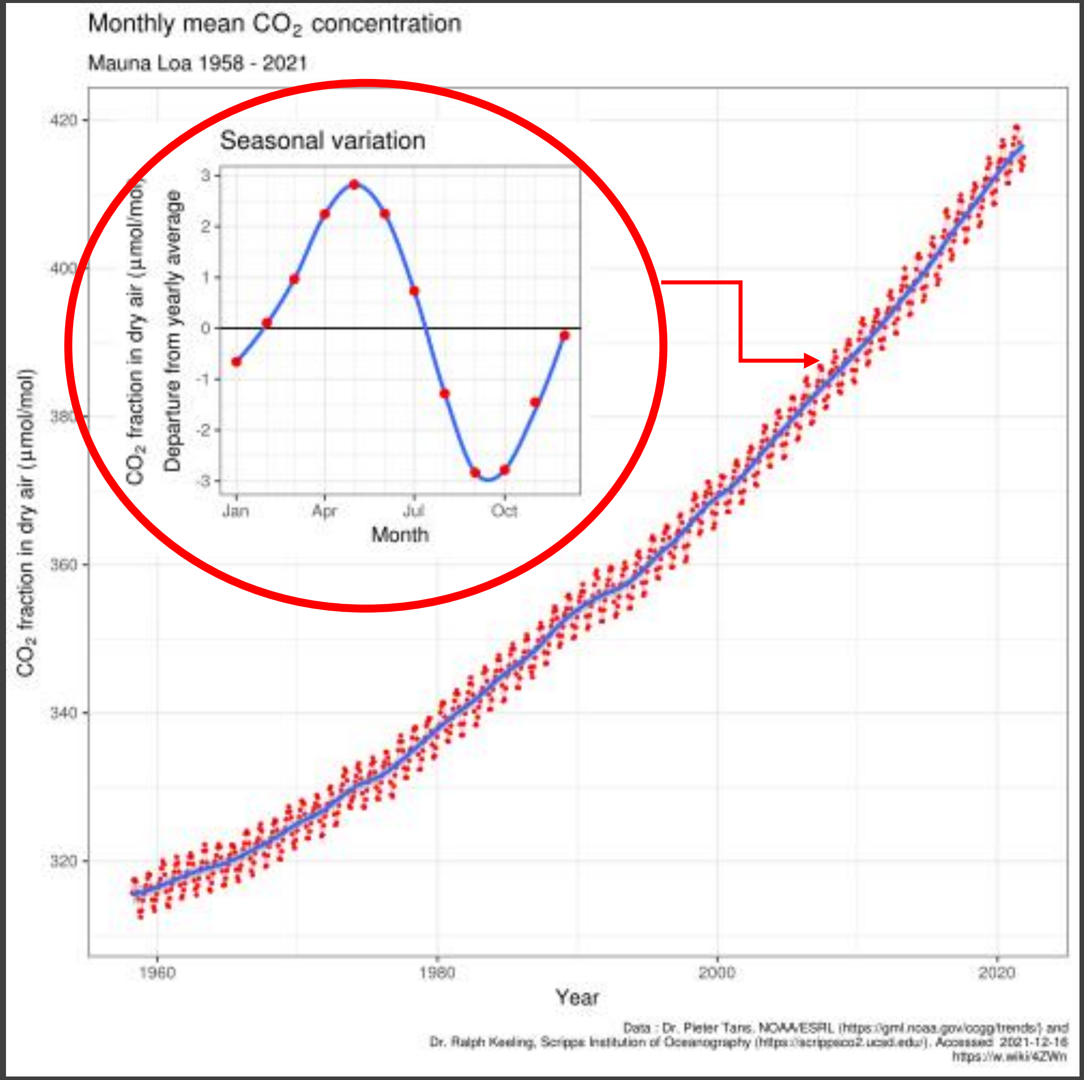
Source: nationalreview.com

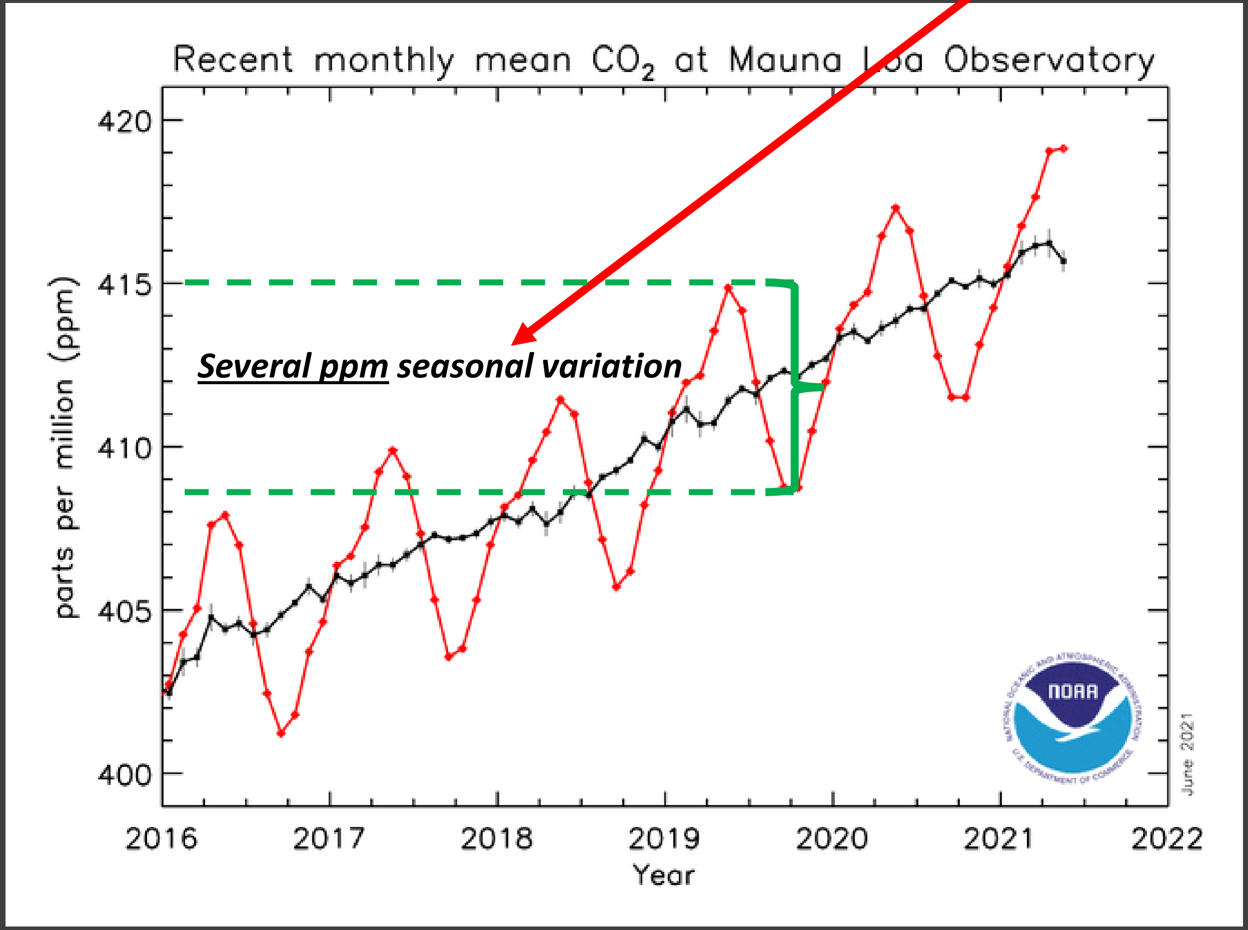
Source: nbcnews.com

Nature shows us how we can enhance natural CDR: ….notable in the Keeling Curve

$$6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$$

Large annual** variations are due to seasonal **Photosynthesis

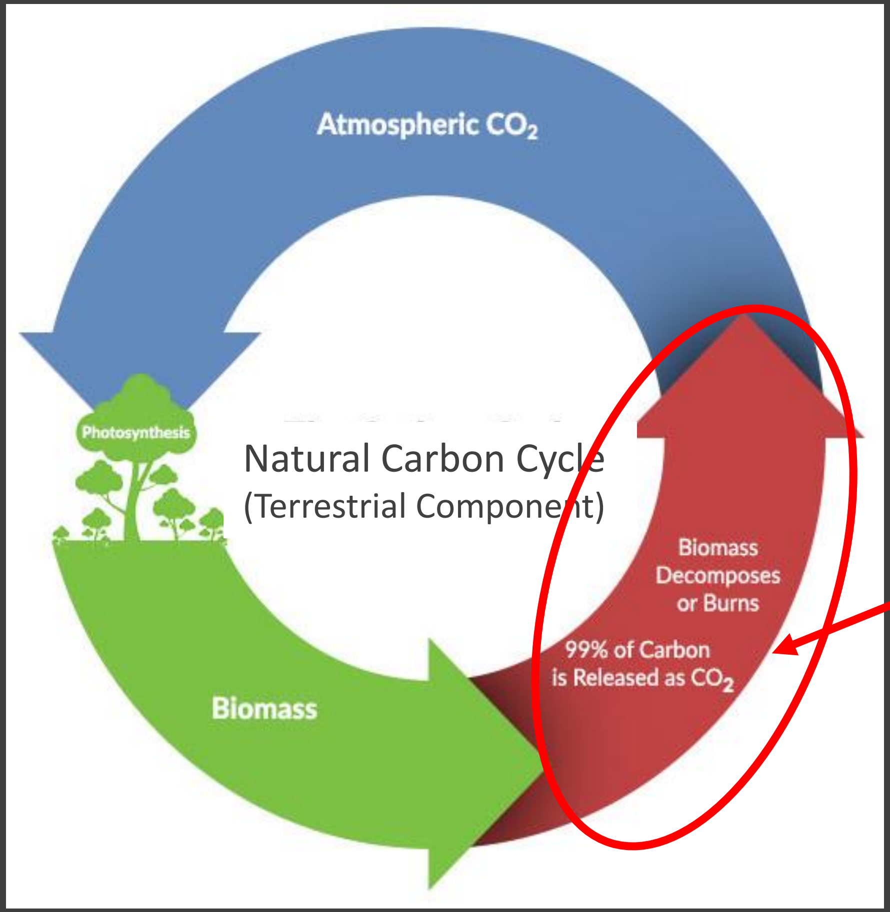




➔ ***Can we make that seasonal carbon stable in the long-term?….***

can we mimic and turbo-charge nature at Gt-scale economically?

How does Biochar achieve Drawdown?



99% of C re-released in natural cycle = opportunity to intercept / prevent

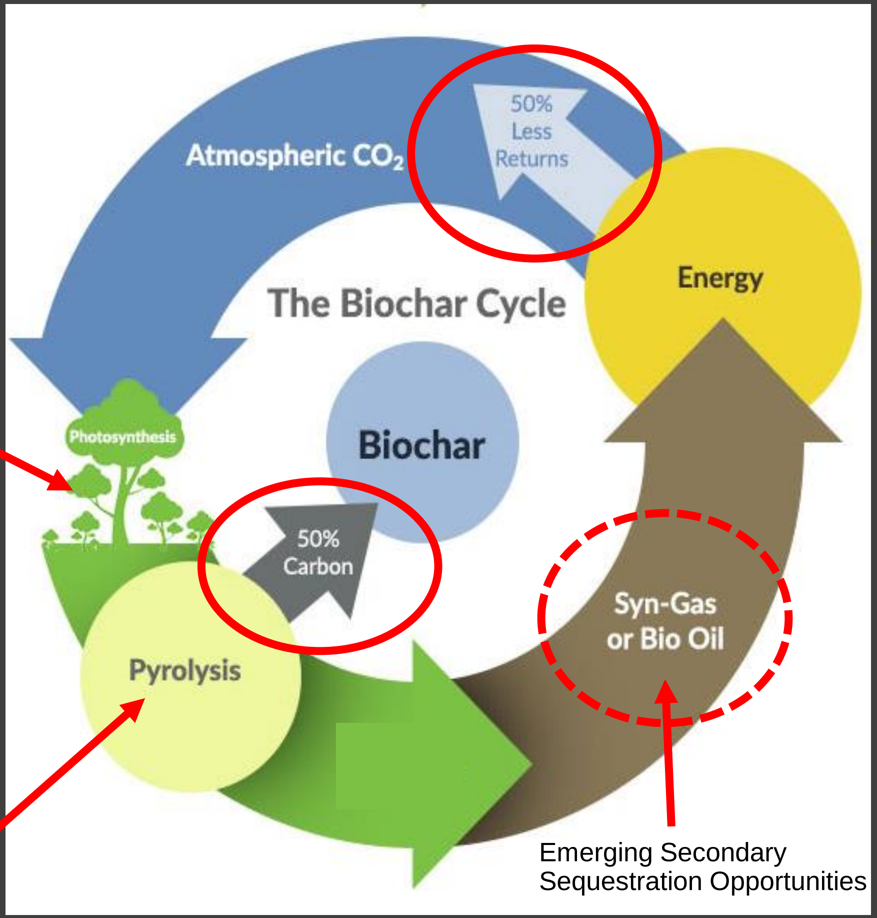
CDR Drawdown by plant photosynthesis

*>80 Mtpa of surplus plant residues n Australia alone**

** CSIRO 2017*

Capture & Utilisation (CCU) by technology

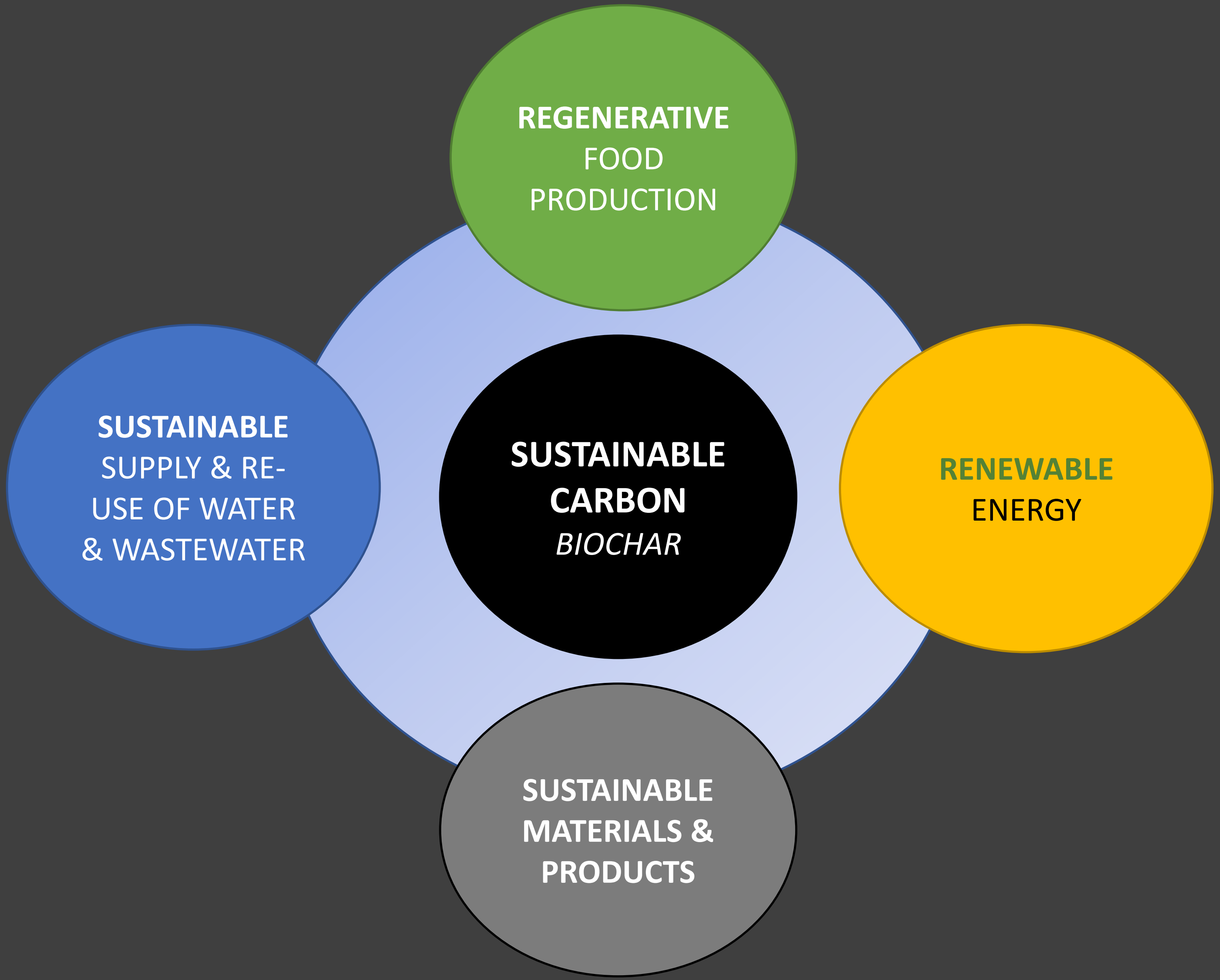
Half the C in pyrolyzed biomass is captured in long term stable solid form (biochar)



Pyrolysis char ~30-50% of infeed C (much lower for gasification)

Net drawdown: Life Cycle Analysis (LCA) is required for '*cradle to grave*' assessment (upstream emissions, production and use)

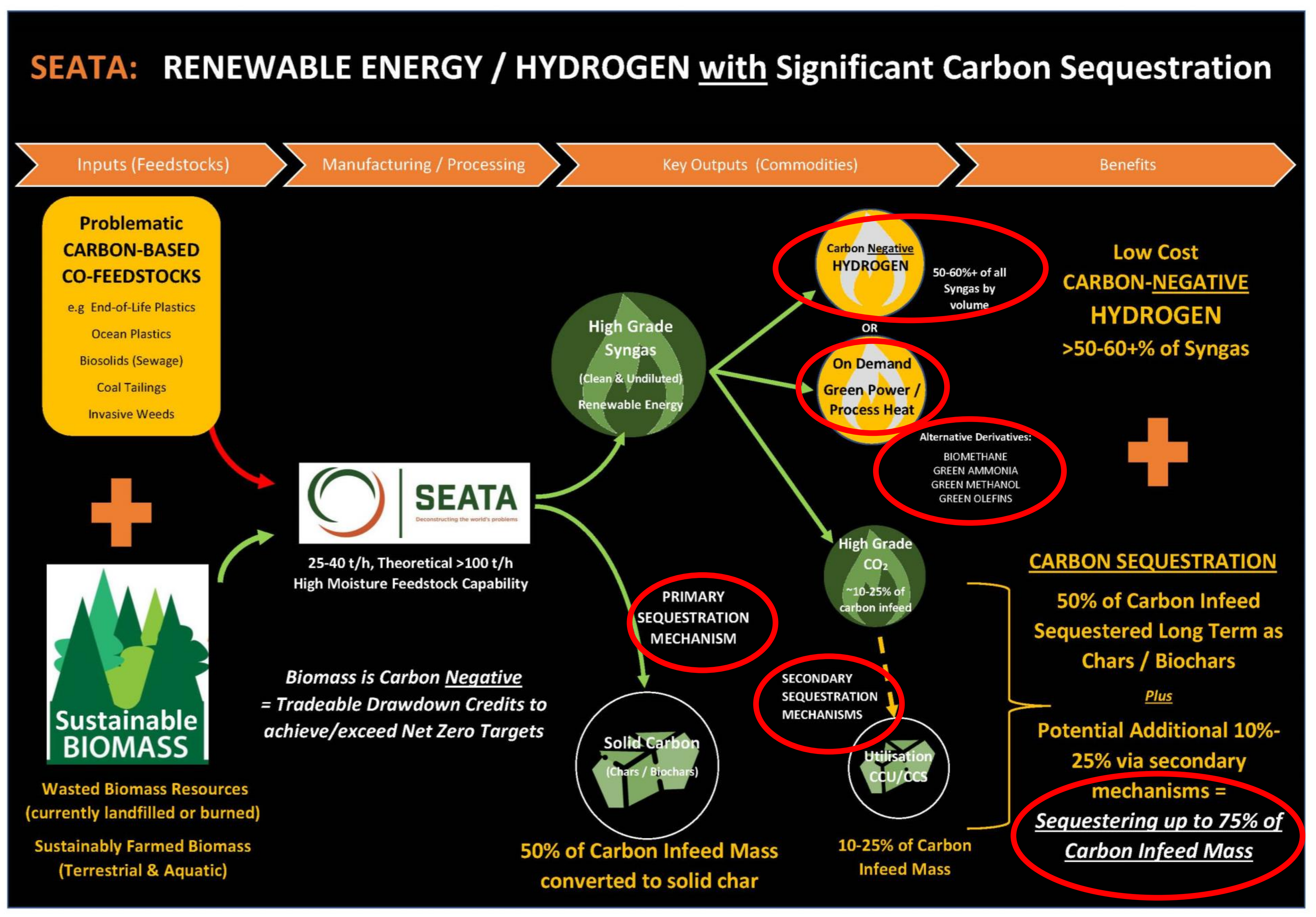
Carbon plays a key role in the food-energy-water nexus…



Carbon is the building block of all Life and for many of the things we make and use

…we need to **remove** the *excess* carbon from the sky and **bring it back down into our soils and materials where it is needed most**.

SEATA - Carbon *Negative* Hydrogen with co-benefits



Carbon Commodity Applications - *'Horses For Courses'*

'Clean' Feedstocks without significant contaminants

ANZBIG Standard (or Feed) Grade Biochar

Higher Order Use of 'clean' resource

Agricultural / Soil Applications

Example High Volume Applications:

- Broadacre Agriculture, Silviculture, Land / Mine Rehabilitation
- Amendment for Bulk Compost & Organic Fertilisers
- Feed Chars, Low Odour Animal Bedding / Litter

Example High Value Applications:

- High value Orchards / Horticulture
- Non-bulk/boutique distribution (e.g. bagged biofertilisers)
- Water filtration (cheaper substitute for activated carbon)

Code of Practice for the Sustainable Production and Use of Biochar in Australia and New Zealand

Version 1.0 – November 22, 2021

ANZ BIOCHAR INDUSTRY GROUP

ANZBIG Biochar Grades:

1. Feed Grade
2. Standard Grade (Soils)
3. Industrial Grade

'Unclean' Feedstocks not suitable for soil application

Higher Order Use of 'unclean' resource

ANZBIG Industrial Grade Biochar

Industrial / Non-Soil Applications

Example High Volume Applications:

- Roads & Construction / Concrete
- Carbon batteries (emerging)
- Fillers in plastics,
- Inks (carbon black substitute)

Example High Value Applications:

- Carbontech (broad range)
- Composites / Bio-plastics
- Contaminant Filtration (pseudo activated carbon)

Biomass Feedstocks: Sustainable, Regenerative, Gt-Scale Drawdown




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

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

(up to 80-110 Mtpa of biomass sustainably available, CSIRO 2016)

Clean Biomass = <u>biochar</u> for soil applications
= <u>Enhanced</u> food production and security, drought resilience




‘Unclean’ /Problematic Biomass Feedstocks:




Treated, painted and stained timbers, composites/laminates, mixed waste organics (MWO)

‘Dirty’ feeds = industrial grade biocarbons for non-soil applications




Other Potential Co-feeds for Circularity & Avoided Emissions



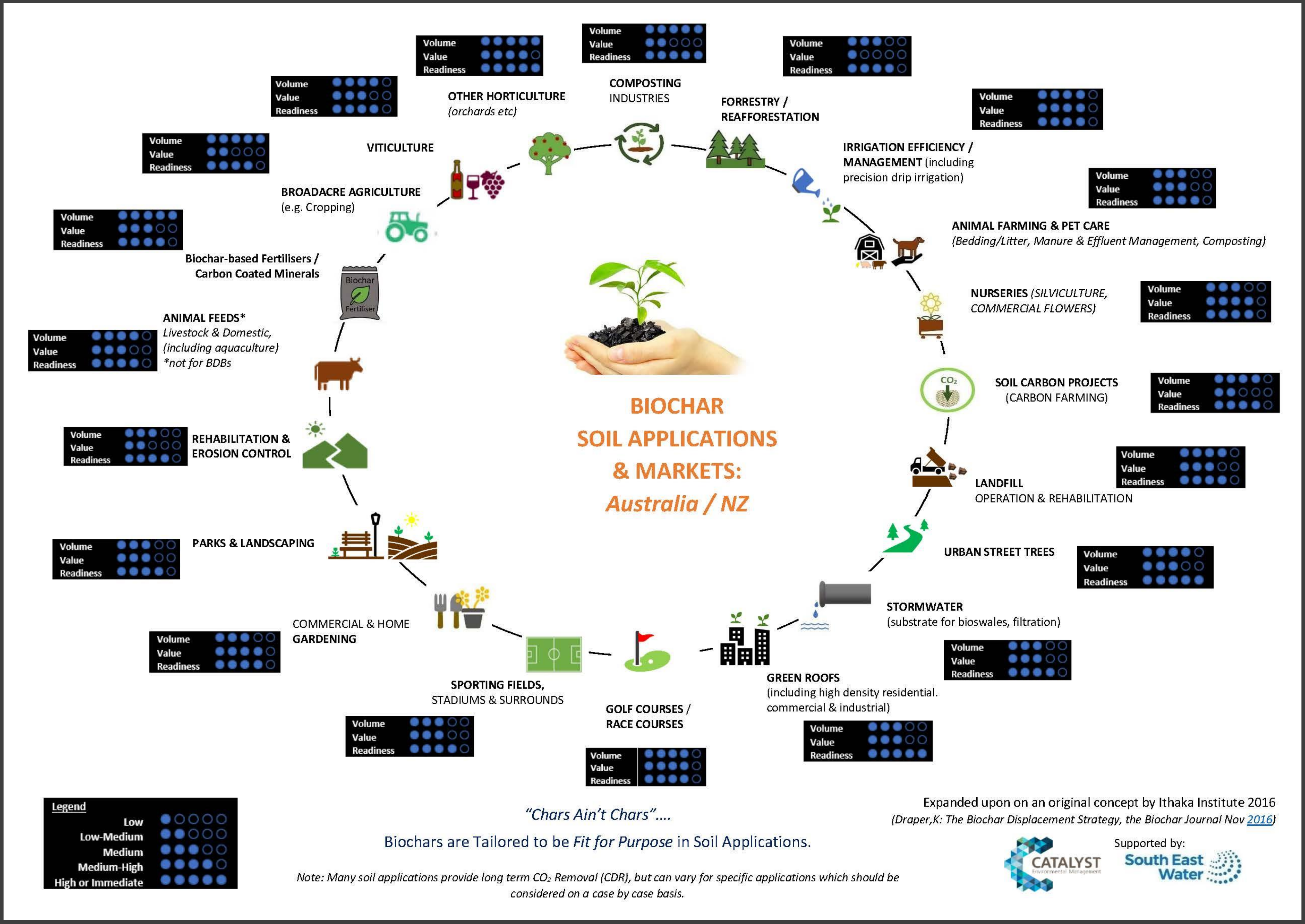

Problematic Organics - Ocean Plastics, EOL & Unrecyclable/Composite Plastics, Textiles, Mixed Waste Organics, Mixed Packaging, Treated Timbers, PFAS soils/media, Biosecurity

➔ Turned back into industrial carbons and Hydrogen
(and/or Biomethane / Olefins for renewed 'circular' plastics)

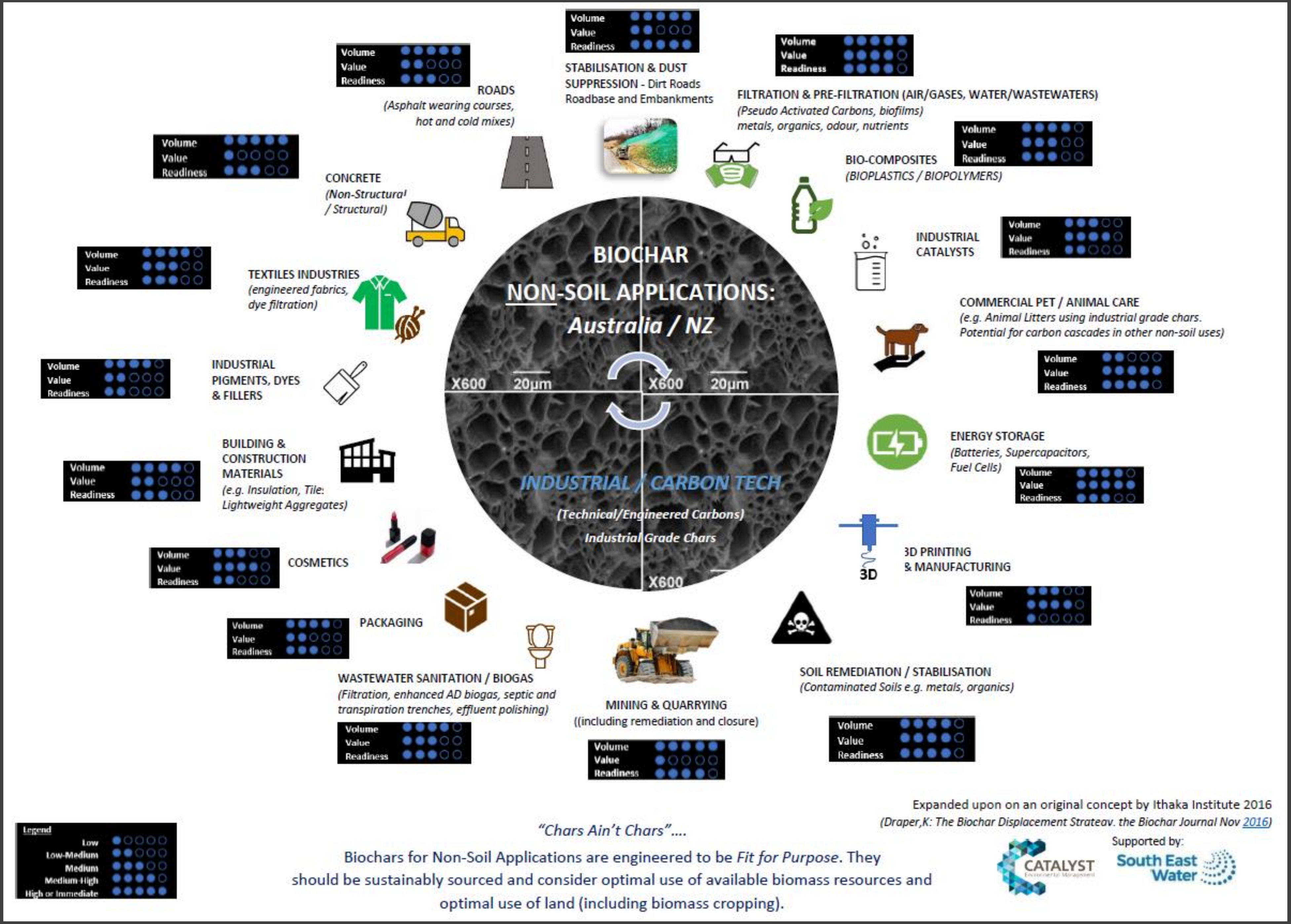



Building the new carbon economy…

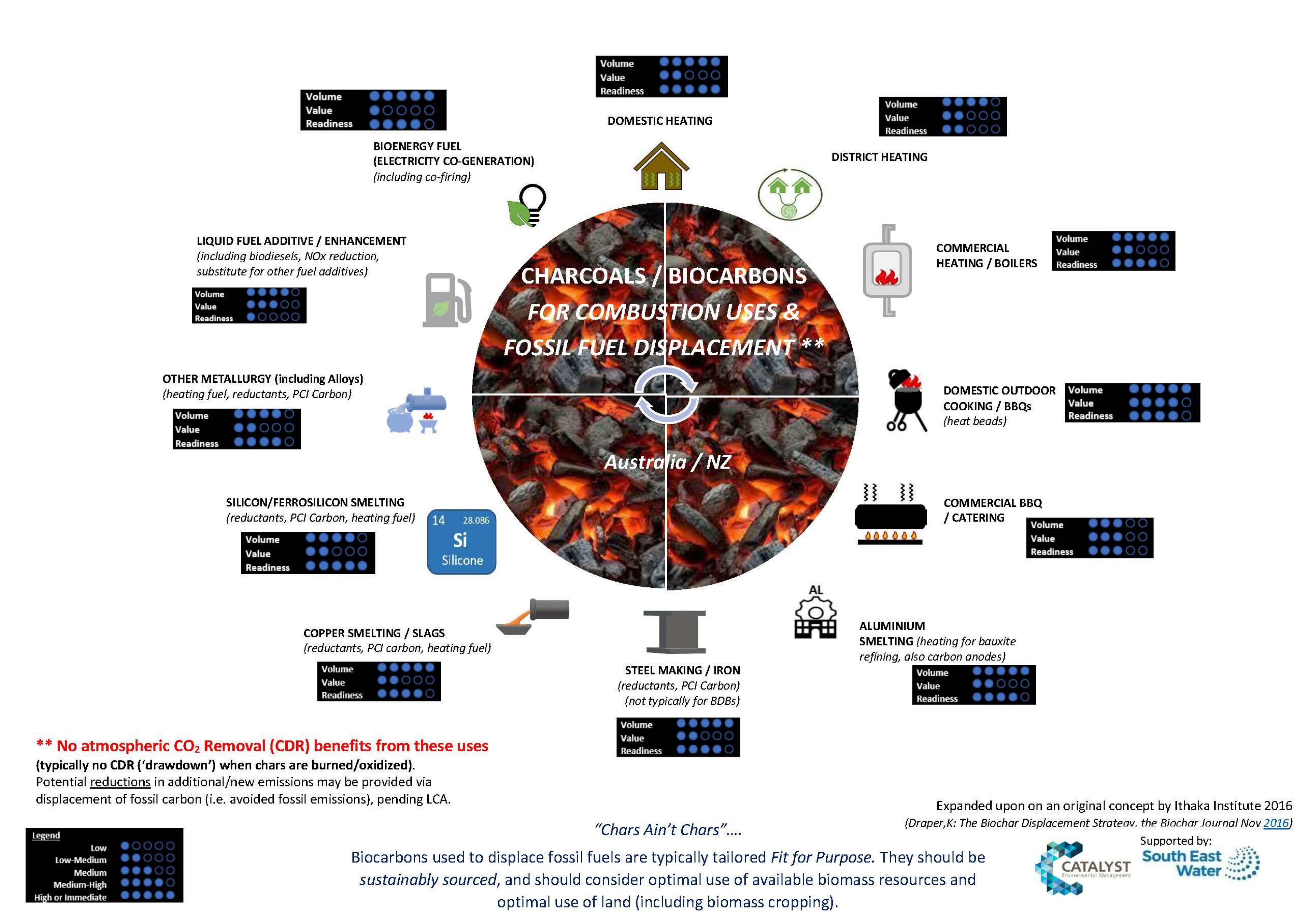
What is Biochar Commercially Used For?



What is Biochar Being Used For?



What is Biochar Being Used For?

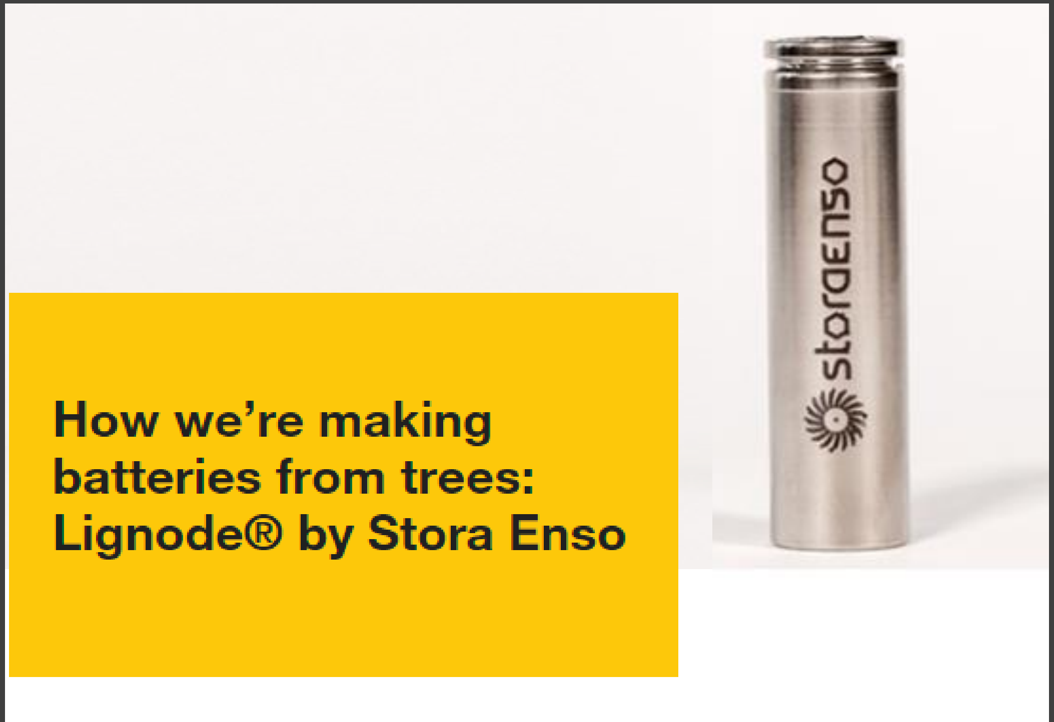


Example:
Beyond Soil: Emerging uses in Energy Storage – Carbon Batteries (various types)

- **Li Ion Batteries** (anodes) **– Finland making lignin biochar battery**. High potential market. BDB technical alignment uncertain, further investigation required.

- **Thermal batteries -** Australian producer seeking 5000 tpa suitable carbon in 2023, 40,000 tpa by 2025. High specific conductance required. Metals ok. Amorphous ok but graphitized better (high temp chars). Testing required.

- **The Future?: Sodium Ion Batteries** – potential technical alignment for BDB. At research level but high potential as low-cost energy storage.



Biochar can assist increasing demand for conventional renewables and help solve the critical issue of *energy storage*

Thankyou. Questions?

E: john.winter@seatagroup.com.au
M: (0407) 892 343

E: craig.bagnall@seatagroup.com.au
M: (0408) 114242

*"During WWII no-one asked, 'Can we afford to fight the war?' We could not afford **not** to fight it. The same goes for the climate crisis."*

Joseph Stiglitz, 2019

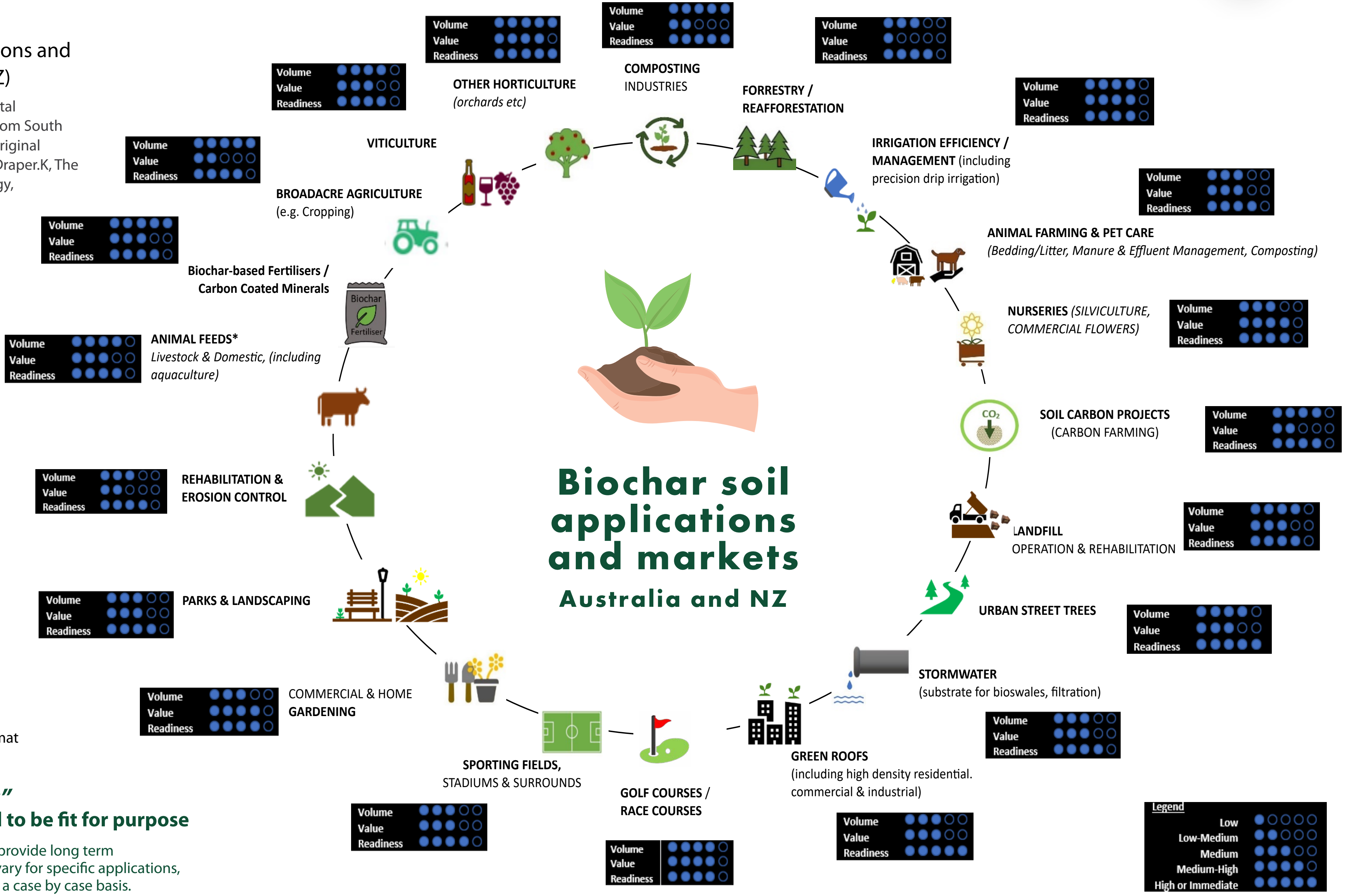
Biochar soil applications and markets

Figure 1.

Biochar Soil Applications and Markets (Australia/NZ)

Source: Catalyst Environmental Management with support from South East Water Expanded on an original concept by Ithaka Institute (Draper.K, The Biochar Displacement Strategy, The Biochar Journal, **2016**)

ANZ BIOCHAR INDUSTRY GROUP



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"Chars Ain't Chars"
Biochars are tailored to be fit for purpose

Note: Many soil applications provide long term CO_2 Removal (CDR), but can vary for specific applications, which should be assessed on a case by case basis.

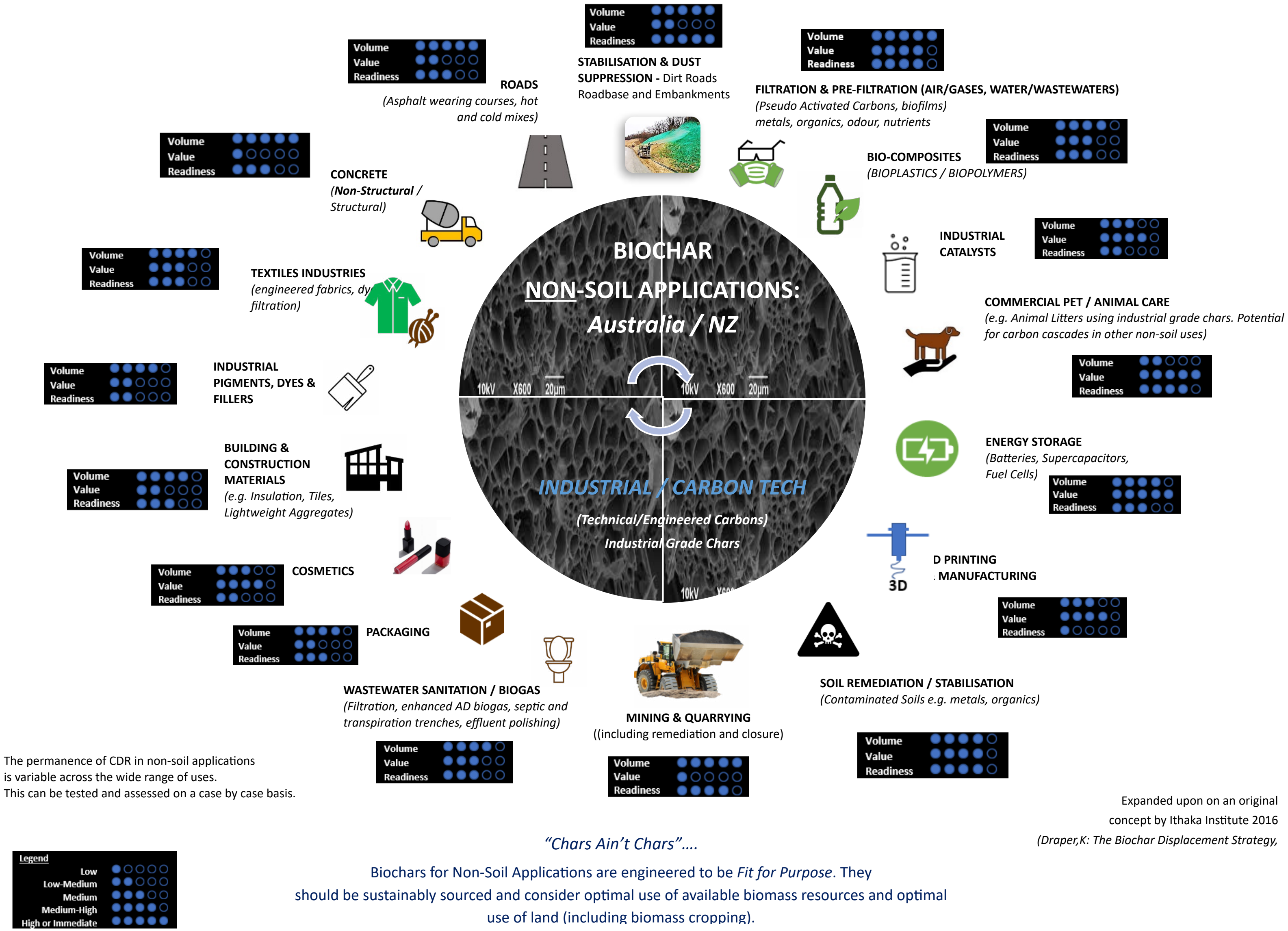
APPENDIX A

Other Non-Soil Uses of Biochar and Biocarbons

Figure 1. Biochar Non-Soil Applications and Markets (Australia/NZ) – Industrial / Carbon Tech

Source: Catalyst Environmental Management with support from South East Water Expanded on an original concept by Ithaka Institute (Draper.K, The Biochar Displacement Strategy, The Biochar Journal, 2016)

ANZ BIOCHAR INDUSTRY GROUP



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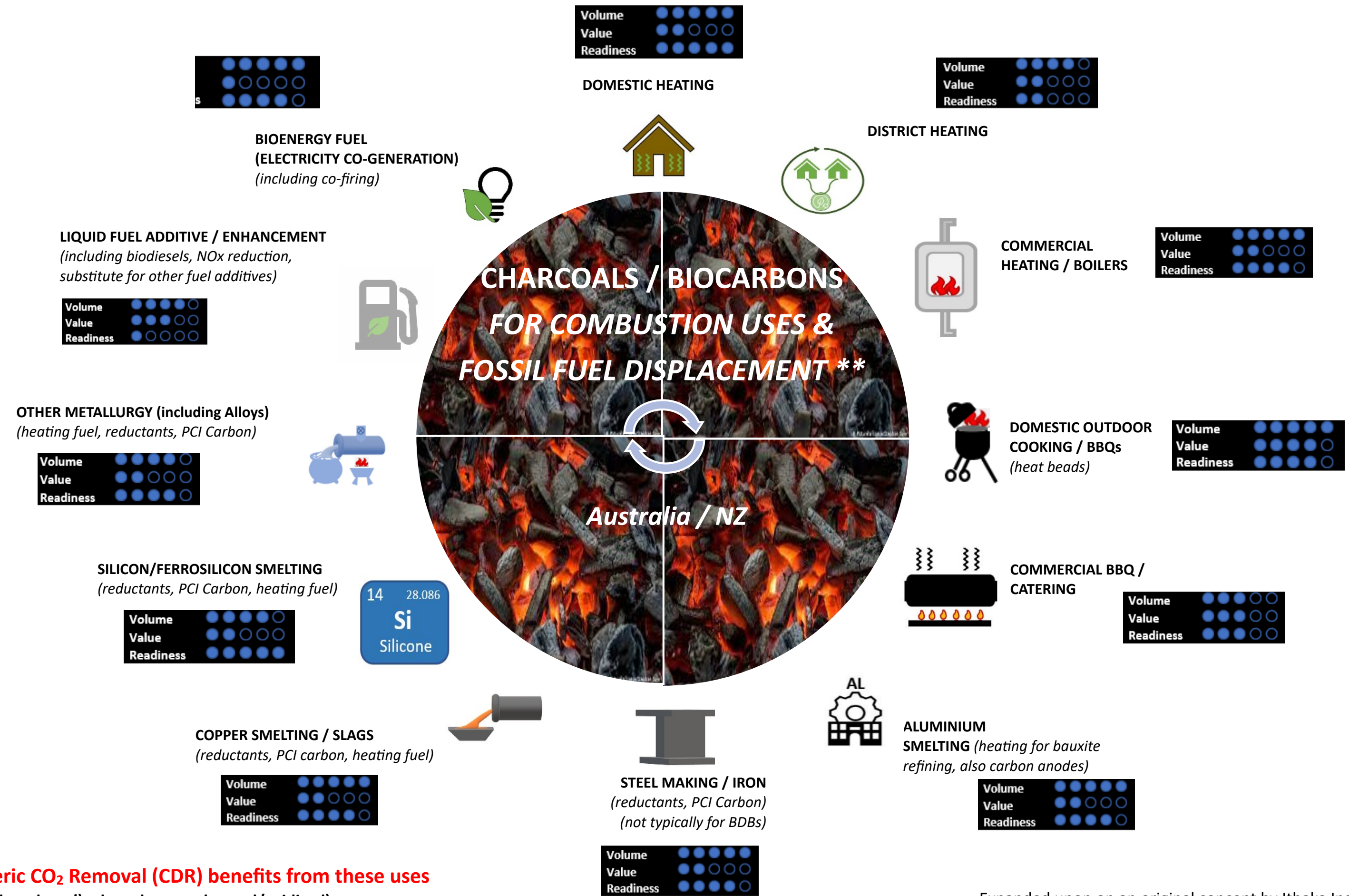
Other Non-Soil Uses of Biochar and Biocarbons

Figure 2. Charcoals/Biocarbons for Combustion Uses and Fossil Fuel Displacement

Source: Catalyst Environmental Management with support from South East Water Expanded on an original concept by Ithaka Institute (Draper.K, The Biochar Displacement Strategy, The Biochar Journal, 2016)

ANZ BIOCHAR INDUSTRY GROUP



**** No atmospheric CO_2 Removal (CDR) benefits from these uses**
(typically no CDR ('drawdown') when chars are burned/oxidized).
However, potentially significant reductions in additional/new emissions may be achieved via displacement of fossil carbon (i.e. avoided fossil emissions), pending LCA.

Expanded upon on an original concept by Ithaka Institute 2016
(Draper,K: The Biochar Displacement Strategy, the Biochar Journal Nov 2016)

Please note: this document is intended for printing and viewing in A3 landscape format

Legend
Low ●○○○○
Low-Medium ●●○○○
Medium ●●●○○
Medium-High ●●●●○
High or Immediate ●●●●●

"Chars Ain't Chars"….

Biocarbons used to displace fossil fuels are typically tailored *Fit for Purpose.* They should be *sustainably sourced*, and should consider optimal use of available biomass resources and optimal use of land (including biomass cropping).

3 HELP US HELP YOU OPPORTUNITY TECHNICAL PAPERS

OPPORTUNITY 1: BIOCHAR - TECHNICAL PAPER

WSAA's Key Insights from our 2023 Biochar Seminar includes key insights for biosolids specifically

We can transform biosolids from wastewater treatment around Australia, into a reliable carbon-capture and storage product – one that can also provide valuable soil benefits, and solve water industry waste management challenges.

What is it?

Biochar is a stable, carbon-rich material produced by heating sustainably obtained biomass under controlled low oxygen conditions using a clean technology, which is specifically used to store carbon in a durable form (in both soil and non-soil/industrial applications). Biochar can be made from many biomass feedstocks, such as forestry residues, crop straw, manure, urban green-waste and biosolids from wastewater treatment. Biochar can be used as a soil improver and has a range of other non-soil potential applications (water management, road construction, cement, building materials, and more) that provide multiple benefits.

Biochar is not the only option for how our industry could beneficially reuse organics. Other avenues including incineration are also relevant. However, it is an opportunity that offers multiple benefits, and for which there is a well-documented roadmap, so it is a good candidate to try and accelerate progress.

Biochar is recognised by the IPCC as an effective method for climate change mitigation, providing a double benefit from emissions reduction and CO_2 removal, with a potential abatement of up to 6.6 Gt CO_2e per year globally [6]. This is estimated to be roughly equivalent [7] to all US CO_2e emissions.

Disposal/reuse of biosolids from wastewater treatment is a growing challenge for water utilities globally. There are increasing operational costs such as transport costs, and increasing regulatory attention to contaminants of emerging concern, such as PFAS and microplastics. The water industry does not create these contaminants – they arise in industrial effluents, firefighting, and the manufacture and use of domestic, household and clothing items. However they become 'our problem' as they can be found in the effluents that make their way from communities to our wastewater treatment plants.

Water utilities have a major opportunity to turn this problem into a benefit for emissions reduction, soil and waterway health. This could also boost our revenue base through the production of biochar offsets.

[6] IPCC, 2022. Sixth Assessment Report, Climate Change 2022: Mitigation of Climate Change. https://www.ipcc.ch/report/ar6/wg3/
[7] ANZBIG Biochar Roadmap 2022, p7

Alignment with circular economy

Biochar helps deliver on all three pillars of a circular economy:

- It eliminates biosolids waste, by destroying pollutants of emerging concern such as microplastics and PFAS, thus enabling beneficial reuse.

- It harnesses otherwise wasted resources, and returns them to the economy as high-value products, building new revenue streams for water utilities. This includes domestic sales as an agricultural amendment, industrial agent in concrete, asphalt, inks, and resins[8], and potentially export (for example, Pacific nations are an emerging market for biochar products).

- When used in soil amelioration it helps add carbon to soils, which is beneficial for soil structure; reduces air emissions [9] (compared to biosolids which biodegrade); improves soil fertility and productivity through reduced nitrogen leaching and stabilising of new organic matter; increases water holding capacity, and immobilises contaminants. It can promote regeneration of degraded land and improve productivity on production land – by supporting the resilience of natural systems.

Technology required

Pyrolysis or gasification plants are two ways to provide thermal conversion of biosolids. These are relatively high cost assets. Water utilities looking at investing may need to consider factors including the volumes of wastewater/biosolids needed, potential savings in other areas such as transportation costs/emissions, and potential product sales. The industry is doing some national work currently to understand the scale, which may include regional agglomeration, that would create a feasible business case for water utilities to undertake this.

[8] https://anzbig.org/biochar-industry-2030-roadmap/

[9] Non-carbon greenhouse gas emissions - especially N2O, but also NH4, indirect GHG

Scope of benefits (across Australia)

The water industry is scoping a piece of work to develop realistic estimates of the potential scale of biochar production from biosolids, and model associated revenues and job impacts, across Australia. We would like to work with the CE MAG and other relevant organisationson this, and request consideration of CE MAG funding. The work will cover aspects including:

- the scale of biosolids capacity required to make biochar production cost effective – which in some regions, could only be achieved through regional agglomeration;
- identify key drivers, including opex, and emissions from truck movements of biosolids
- exploration of improvements gained from other feedstock inputs eg food/organic garden wastes to add volume and quality to the biochar produced, noting that pyroysis facilities can be beneficial in addressing other waste management challenges for other sectors
- producing a high-quality biochar requires considerable cross sector collaboration to ensure high quality inputs including plant and animal wastes – insights and learnings
- This work focusses on the supply side – we would be keen to engage with the CE MAG on the demand side as well, as consumer markets for biochar products also need to be supported for biosolids-biochar solutions to be effective.
- We are deliberately engaging with the CE MAG now, to explore how we could work on this collaboratively. There may be greater potential benefits gained when government policy-makers and industry scope and deliver the work together.

The Australia New Zealand Biochar Industry Group (ANZBIG) has previously assessed the scope of the overall biochar industry (including a range of feedstocks) and estimates that modern biochar systems could reduce Australia's national carbon footprint by 10-15%, provide up to 20,000 permanent jobs, improve soil health and the productivity of millions of hectares of farmland each year and provide high quality environmental, social and governance (ESG) investment opportunities in the order of billions of dollars (ANZBIG, 2022 Roadmaphttps://anzbig.org/biochar-industry-2030-roadmap/). These estimates are not water-specific, and water industry estimates are not available yet. Achieving high quality inputs through cross-sector collaboration could add millions to the economy.

Biochar also supports State/Territory and Commonwealth Circular Economy and waste reduction targets as indicated in the National Waste Policy Action Plan 2019. If used in agricultural and urban soils, it helps promote climate change adaptation through improved farm productivity, water efficiency, and street tree growth, helping to deliver on the National Climate Resilience and Adaptation Strategy.

In Australia the water industry produces about 350,000 dry tonnes of biosolids annually (1.4 million wet tonnes) of which on average 75% is reused in agriculture, 12% stockpiled around 3% sent to landfill[10].

[10] ANZ Biosolids Partnership, 2021. Australian Biosolids Statistics: Biosolids production in Australia 2010-2021. https://www.biosolids.com.au/guidelines/australian-biosolids-statistics/

Project Value: $240,000
Cash: $150,000
In-Kind: $90,000

- Partners:
- DEECA
- Barwon Water
- South East Water
- Intelligent Water Networks (IWN)
- The City of Greater Geelong

Value: A world-first project that uses biochar from biosolids to power Na-ion batteries. Unlocking economic potential for the water-sector and expanding an advanced Circular Economy.

However, the amount of biosolids reused in agriculture has been declining year on year since 2017[11], with stockpiles increasing due to regulatory uncertainty around contaminants of emerging concern within biosolids and the perceived or real risk to agricultural soils, products and markets.

Advanced thermal treatment processes producing biosolid-derived biochar have demonstrated the destruction of PFAS, pathogens, pharmaceuticals and a significant reduction of microplastics. This reduces the risk of human health and environmental impacts from land spreading of biosolids, in an environment of increasing regulatory attention on biosolids management. This means water utilities can be leaders in risk reduction for these problematic substances whilst advancing circular economy policies.

Biochar can also be substituted for carbon black in any manufacturing product that uses fossil fuel-derived carbon black, which effectively gives a double mitigation benefit. The carbon within the biochar is sequestered in the product, and the product substitutes carbon black produced from fossil fuels with biochar. There is already research underway in the water industry itself looking at biochar for superconductor batteries (see Barwon Water case study).

Energy efficient biochar production therefore presents the industry with an opportunity to advance the wastewater circular economy, provide a high value resource to other industries and ensure that carbon and nutrient-rich biosolids are beneficially reused while managing any contamination present in biosolids and/or other feedstocks.

[9] As above

Regulatory context

The potential production of biochar has touch points in policy and legislation at both federal and state/territory government levels. Enabling change can be a complex process that needs to consider:

- The appropriate instrument (ie. regulation, policy or legislative change)
- Scale and regulatory impact
- Alignment with other jurisdictions
- Impact on markets

A key next step would be to pinpoint the exact changes to regulatory instruments that would help. While we have outlined some areas of change below that have been researched to a degree through the Australia New Zealand Biochar Roadmap 2030, to fully scope all legal changes required across federal, state and territory regimes as regards water utilities, is a substantial body of work. We are requesting funding from the CE MAG to conduct this additional work collaboratively.

Federal government responsibilities

- National waste policy including:
  - Determining whether biochar and associated feedstocks are classified as waste under state legislation (as sewage is exempt from the nationally-agreed National Environment Protection Measure for Movement of Controlled Waste)
  - Developing changes to the waste hierarchy
  - Meeting National Waste Policy Action Plan targets
- Commonwealth policy supporting Australia's Nationally Determined Contributions towards the Paris Climate Agreement goals
- Delivering the National Climate Resilience and Adaptation Strategy (2021-2025)
- Funding and policy settings of agencies involved in managing the ACCU Scheme, ARENA and the Clean Energy Finance Corporation
- Grant federal funding support and incentive schemes
- Communication with the public on the circular economy, including the benefits of biochar

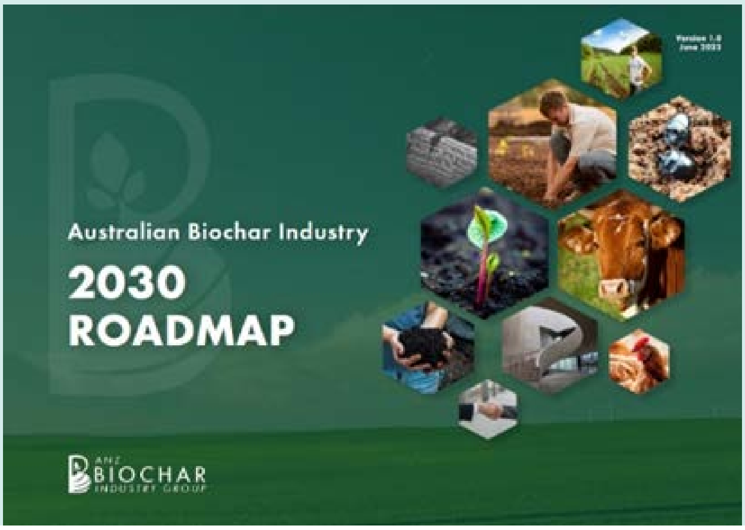
State/territory government responsibilities

- Responsible for regulating waste management, state government owned water utilities, and the economic, health and environmental regulatory frameworks governing what can be achieved in the circular economy (including management of biomass residues, and regulation of soil amendments)
- Grant funding support and incentive schemes
- Enabling and promotion of alternative public sector governance models for the circular economy (eg. local government & water utility co-ownership of limited liability entities consolidating multiple lines of feedstock)
- Communication with the public on the circular economy, including the benefits of biochar

Cost recovery framework & government investment support sought

- Urban water is a full cost recovery business, with prices for water and wastewater services independently regulated to varying degrees across Australia. However, cost recovery applies to the core business purpose set out for each utility, which traditionally means wastewater treatment and disposal (as under historic linear thinking, wastewater has been considered a waste product).
- The state-based cost recovery frameworks do not extend as easily to extensions of that paradigm – such as treating the biosolids to a higher level than the minimum required under EPA licensing obligations, converting it to a marketable product, and then trading that product. The existing environmental obligations create less of a regulatory mandate to do this where it is not the least cost way of meeting the environmental obligations. It is not impossible, but it is challenging – unless the water sector can make a very strong case to justify the investment (which may include demonstrating a very high proportion of customers are willing to pay the additional costs), it is harder for economic regulators to consider such investment as prudent and efficient.
- Put simply, if biochar represents the least cost way to dispose of wastewater solids, it will be relatively easy to invest in the technology necessary.
- However, if it is not the least cost way of disposing of wastewater solids, additional funding support may be needed. This can happen if:
  - a government or other entity provides actual funding, eg a grant
  - governments provide a mandate (ie a formal direction, either generally for circular economy, or specifically for solids reuse such as biosolids upcycling) to a water utility to undertake the activity and recover the costs through its normal cost recovery channels, ie its customer base.
- Significant grant funding has been needed to get some projects off the ground, eg Logan Water received a $6m ARENA grant to establish their flagship water industry biochar project.

Barriers – What's holding us back?



Biochar is a good initiative for the CE MAG to focus on, as resources like the ANZBIG Biochar Roadmap to 2030 have already set out a detailed pathway for accelerating circularity. The Roadmap seeks to progress biochar from various feedstocks, of which biosolids is just one.

Biochar is a proven method of carbon capture and storage, which the IPCC lists as an emissions reduction and CO2 removal pathway (AR6 WGIII Chapter 12 section 12.3 and also Technical Summary Table TS.7). However biochar is not included in Australia's Nationally Determined Contributions toward Paris climate goals or in its national greenhouse gas inventory – this means there is no driver for the Clean Energy Regulator to develop a method to generate ACCUs from biochar. Having an ACCU Scheme method would likely improve investment opportunities. A method could be considered under the 'proponent-led' pathway to be implemented based on recommendations of the Chubb review.

- Water industry regulatory environment:
  - Strong environmental & health regulation and wastewater/biosolids discharge licenses can be an indirect driver for biochar production, if pyrolysis were to be the lowest cost means of means of meeting the environmental obligations. across states and territories
  - Regulation of biochar use in soil applications currently varies substantially across different state jurisdictions[12] (harmonisation would be valuable to facilitate market access); and is further supported via established industry codes of practice and standards, both nationally and internationally, such as the ANZBIG Biochar Industry Code of Practice 2021).
  - No specific regulation or policy for biosolids to biochar in Australia, and the existing regulations for biosolids and biochar vary across states and territories.

- Biochar's classification as waste is severely limiting in the market - significantly devalues the material, prevents innovation/circular economy opportunities and creates an unnecessary burden on water corps in terms of attracting a waste levy

- Market development – We have an opportunity to create a successful biochar market if we invest in market development from the outset – which could include:
  - in order to improve biochar project viability as well to scale up projects, we need development and support for the end-use markets (ie markets for both soil and non-soil products).
  - investment into R&D (such as commercial demonstrations) to prove/establish products and emerging markets
  - it may also include government policy incentives. This can include subsidies, tariffs or other measures to make the cost for consumers of choosing the circular option, to be less than the linear option – once this occurs, investment is more likely to follow. In the US, tax incentives (eg 45V, 45Q tax credits) have been effective.

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[12] In New South Wales, biosolids are regulated by the Environment Protection Authority under the Protection of the Environment Operations (Waste) Regulation 2014, while biochar is considered a soil conditioner that must conform to relevant Australian and international standards. In contrast, in Victoria, biosolids are regulated by the Environment Protection Authority under the Environment Protection (Industrial Waste Resource) Regulations 2009, while biochar is not explicitly mentioned in any legislation.

What does success look like?

01

ERF method for biochar that enables scale up of biochar projects

02

Clearer utility understanding of their biosolids resource and local market dynamics before settling on a technology

03

Fit for purpose regulation of biosolids that supports biochar's classification as a resource and allow its movement across state borders

04

Exploring co-location of feedstocks and innovative governance models that support economies of scale across aligned sectors, eg, water, local government and waste

05

Business cases focusing on market potential not just solutions to emerging contaminants in biosolids

06

Work towards source control of PFAS

07

Revision to the waste management hierarchy that separates out pyrolysis and gasification from incineration

Excerpt from WSAA Biochar Seminar Highlights (2023)

Policy reforms - What are we asking for?

Federal actions (WSAA can prepare letters of support or slide packs for advocacy on these issues, allowing the CE MAG to support these issues with other government departments and stakeholders):

1. Support the water industry's strong advocacy for the National Water Initiative to include an objective for all governments to work towards optimising the use of biosolids for biochar. This objective could encompass regulatory, market, collaboration and research and education actions. WSAA can draft a letter of support on behalf of the CE MAG if desired.
2. Commonwealth government to update Australia's emissions inventory methods to account for biochar, as per IPCC guidelines and progress an ACCU method for biochar including a biosolids feedstock pathway, which could be considered under the 'proponent-led' pathway to be implemented based on recommendations of the Chubb review. This would facilitate quicker ROI and scaling of investment through ACCU generation. WSAA made a submission to the ACCU scheme, which can be provided on request.
3. Request IPCC include biochar emissions reduction in future climate scenario projection modelling.
4. Encourage the Federal government to explicitly call out biochar's role in both mitigation and adaptation in the National Climate Resilience and Adaptation Strategy, and in the sectoral decarbonisation plans under the Net Zero 2050 Plan - for soil carbon, farm productivity and water efficiency benefits as well as decarbonisation
5. Support and resourcing for the biochar industry, particularly for ANZBIG and the Australian Biochar Industry 2030 Roadmap which is facilitating and expediting implementation, with broad benefits for circular economy, climate action and other co-benefits for many sectors.
6. Work with State/territory governments to develop a supportive policy framework and a harmonised and consistent regulatory framework that can be adopted by the States & Territories that recognises and supports biosolids to biochar as a beneficial use option that can achieve multiple environmental, social and economic outcomes.
   a. One step in this could be to fund development of risk-based guidelines for metals concentration in biosolids-derived biochar, which would help unlock end uses and markets
   b. Ensure that the existing state/territory-based biosolids guidelines are adapted for application to biochar (eg. for heavy metals bioavailability and co-feedstocks)
   c. Develop application-rate-based guidelines that reflect the metal-binding capacity of biochar and optimal application rates
   d. Build the evidence base and documentation of the results.

7.Development, support and incentives for the end use markets (both soil and non-soil), including investment into R&D to prove/establish emerging markets.
8.The CE MAG to consider granting funding to WSAA to develop industry estimates, as outlined above, about the treatment plant capacity thresholds where biochar is viable, the opportunities across Australia for regional agglomeration, and the likely yield of biochar and ACCUs, and address other opportunities for biosolids-derived biochar to support government circular economy, decarbonisation and climate adaptation policies/strategies.

State/territory actions:

- Re-designate biochar and its feedstocks as a product or 'non-waste' rather than a waste – for example, encourage establishment of End of Waste codes for biochar, charcoals and bio-carbons, that also redesignate feedstocks/co-feedstocks as 'resources' for making biochar. This will better enable biochar's role in the circular economy and unlock value streams (eg. through environmental regulation schedules [13]), in accordance with outcomes-based regulation.
- Revise existing state/territory-based biosolids guidelines to be applicable to biochar (eg. for heavy metals bioavailability and co-feedstocks) – see link for each state/territory guideline
- Partner with interested water utilities to promote regional scale governance models between local governments, private sector, and water utilities (eg. Colac RON) to enhance economies of scale in feedstock, multiple value streams, and capex/opex on production. Interest could be identified through a market sounding.
- Funding support and incentives, including through policy changes, for pilot projects, commercial demonstrations and large scale investment; testing systems for new innovations, such as a previous EPA mobile testing van. This should also include promoting outcomes-based regulatory frameworks over prescriptive ones wherever practicable, to minimise red tape delays.
- Supporting the development of consistent messaging across government, water and waste sectors to facilitate market confidence.
- Enhance and facilitate collaboration and knowledge sharing, especially between sectors & industries adjacent to the water industry: The collaboration and knowledge sharing among water utilities, research institutions, technology providers, biochar users, and other stakeholders should be enhanced to foster innovation, address technical challenges, demonstrate best practices and increase market awareness and acceptance of biochar products. The National Water Initiative would be a good vehicle to drive this.
- Where valuable potential schemes are identified, but are outside the core mandate of the water utility or not cost effective in their own right, identify and make use of levers in the regulatory framework to enable non-standard practices. For example, in NSW the government can require utilities such as Sydney Water to undertake an activity that is non-commercial or in the public interest, via a process defined in the State Owned Corporations Act.

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[13] The Victorian Environment Protection Regulations, Schedule 5, lists residues such as digestate, bottom ash and biochar as reportable priority waste

Downsides/risks/criticisms

- Environmental & health regulation re contaminants of emerging concern – unclear regulation threatens the scale up of biochar projects.
- Balance of nutrients and PFAS/contaminants – biosolids contain important soil nutrients in phosphorus and nitrogen. Biosolids-derived biochar can be enhanced by co-pyrolysis with other non-contaminated biomass such as crop and forestry residue. If biosolids-derived biochar is not used in agricultural applications because of perceived/real risks of contaminants, then these nutrients are lost from soils. Government resourcing to develop rate-based biochar application guidelines could assist this current constraint nationally.
- Potential commercial impacts from adjacent or competitive industries. For example the solid waste management industry includes many private players. Biochar can sometimes be improved in quality through combining food and garden solid organic waste with biosolids; there are competitive landscapes that need to be managed appropriately whilst exploring longer term circularity gains.

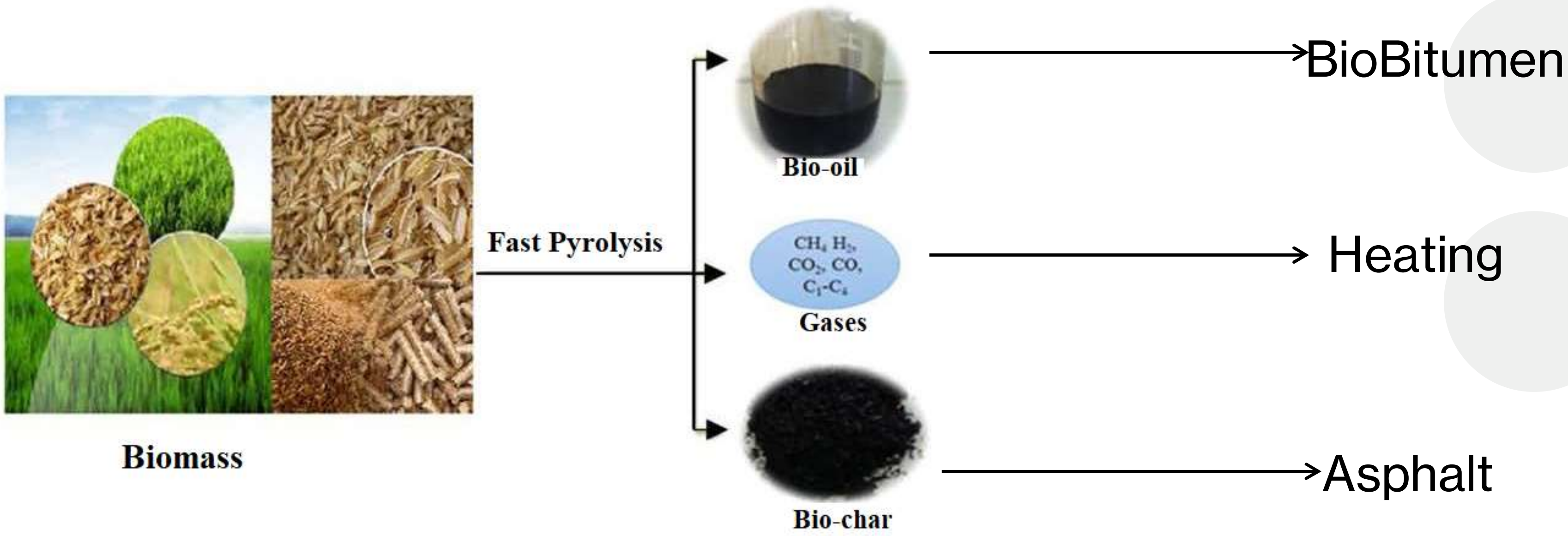
Media opportunities

- Combine announcement of a regulatory impact statement into the impacts of reviewing the classification of biosolids and/or biochar as 'waste'
- Multiple initiatives (eg 2. 4 and 9) and milestones of the Australian Biochar Industry 2030 Roadmap – particularly commercial scale demonstrations across the nation (Initiative 4).
- Market sounding in a regional area for opportunities to trial a combined waste to biochar scheme
- ·ABC have recently profiled the Logan Water gasification plant. Could be further opportunities to profile/launch other biochar projects eg Pyroco (Vic); and the Bega Group, which the biochar industry is currently engaging with, along with the NSW Decarbonisation Innovation Hub.
- Govt has given money to Bega Valley to establish national circular economy centre (of excellence?), headed by Bega Cheese Group, that wants to have a whole of community approach with a range of industries

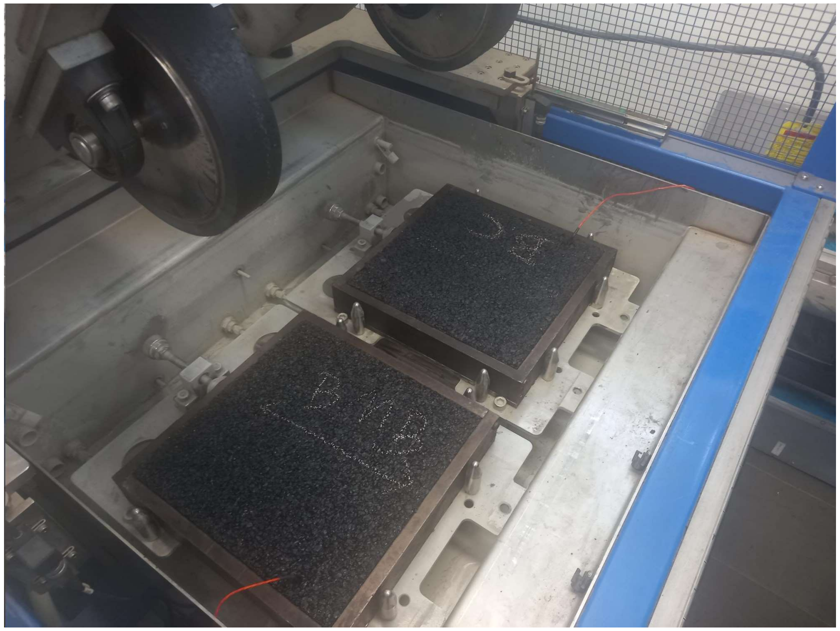
Capturing and storing CO_2 in Roads

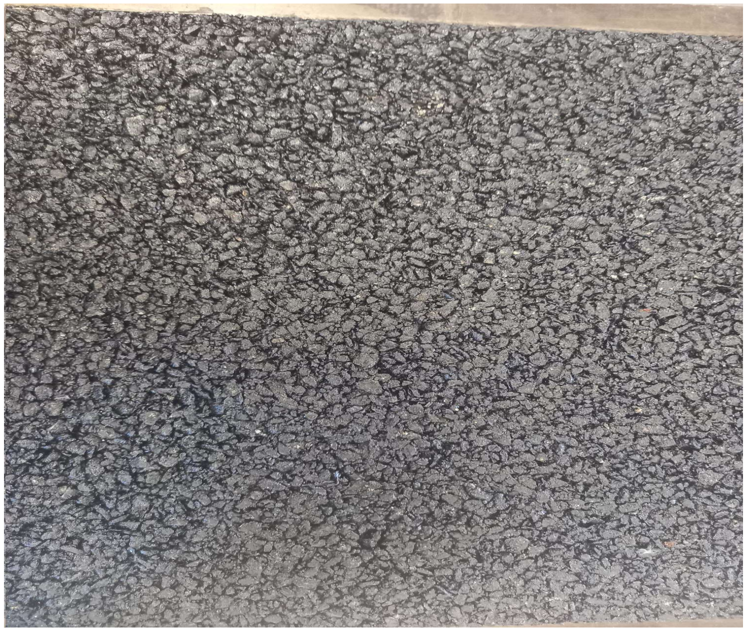
Dr. Alexandru Let
Technical Manager
State Asphalt NSW

Biomass valorisation toward sustainable asphalt pavements

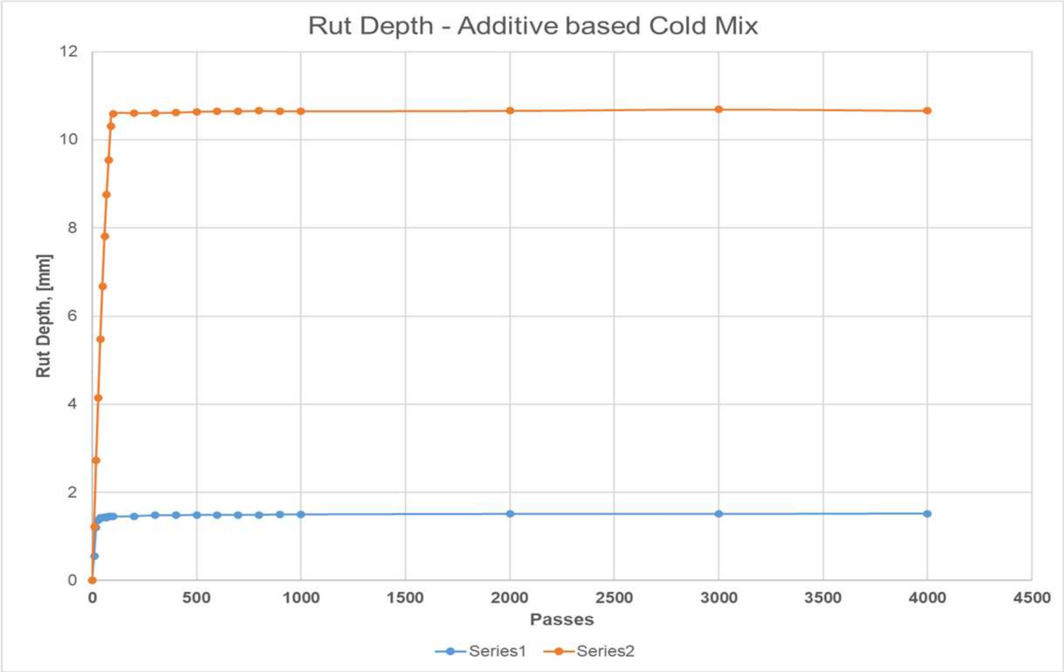


Additive based Biochar Cold Mix

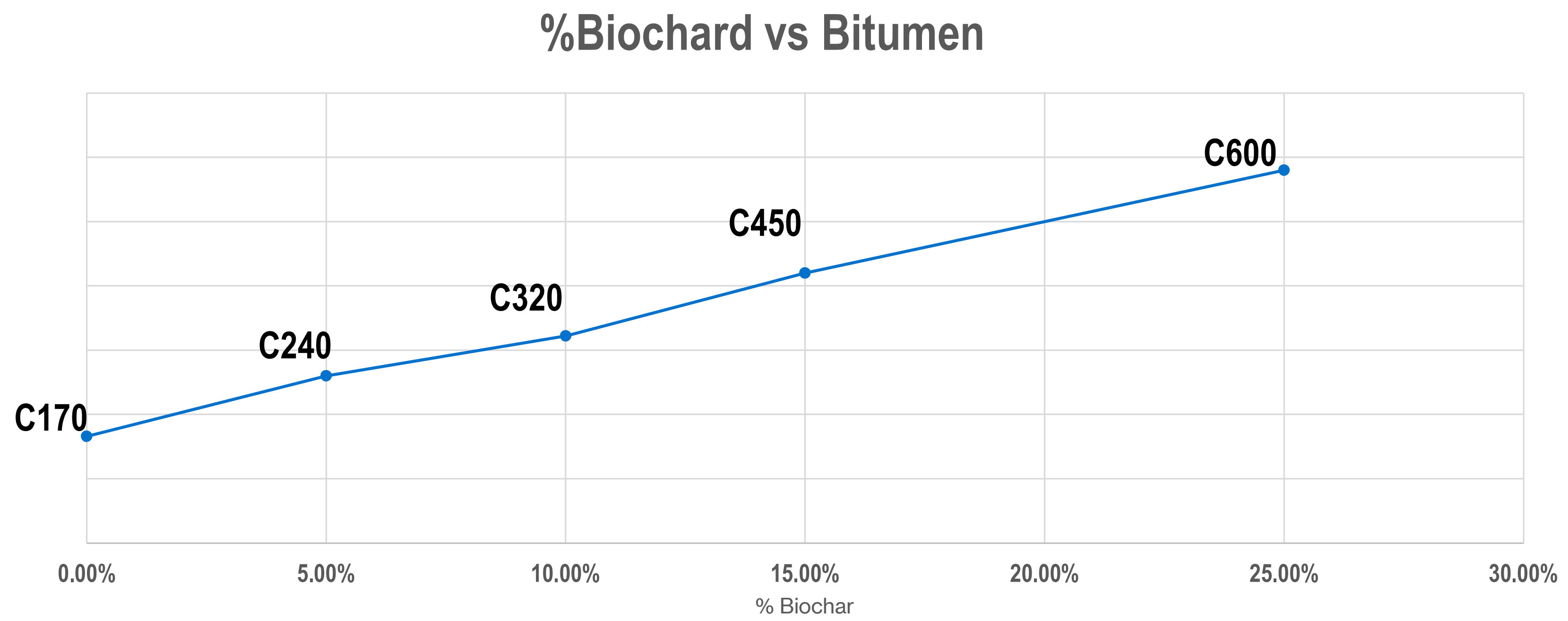




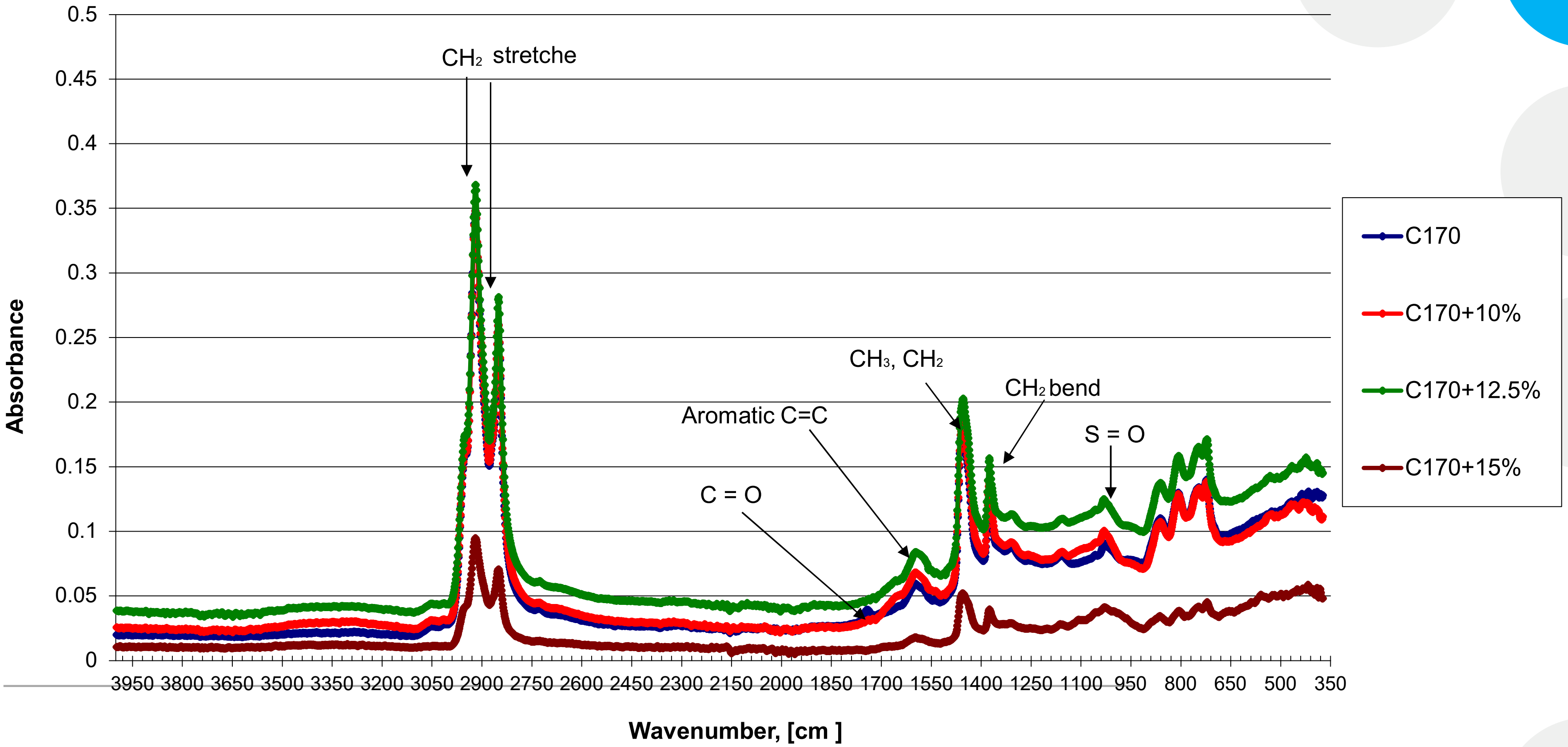
Additive based Biochar Cold Mix



Biochar Modified Asphalt

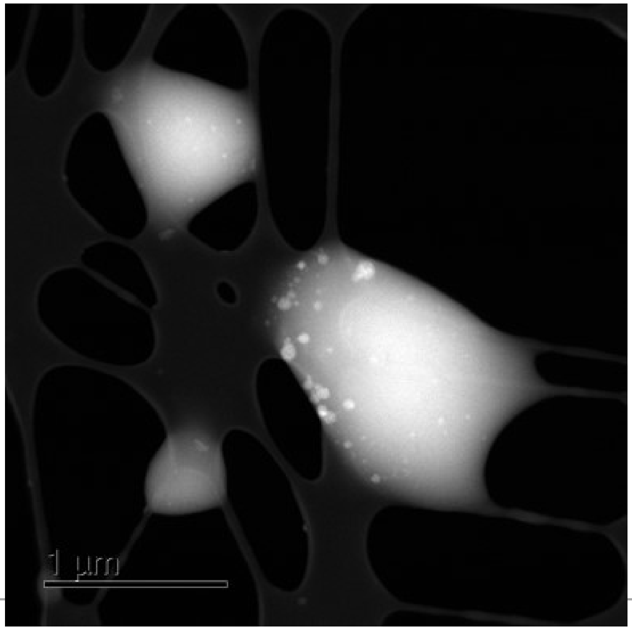


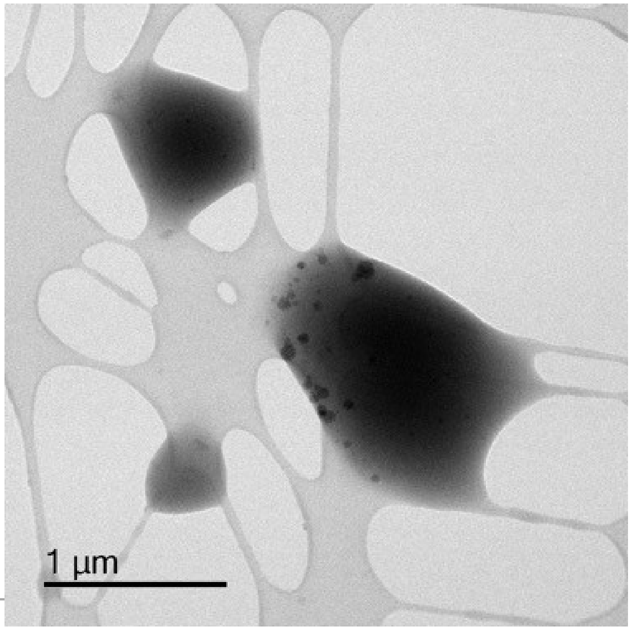
IR Spectra of BMB samples



Scanning Transmission Electronic Microscope

- STEM images show that there are biochar particles inside and on surface of the bitumen frgaments



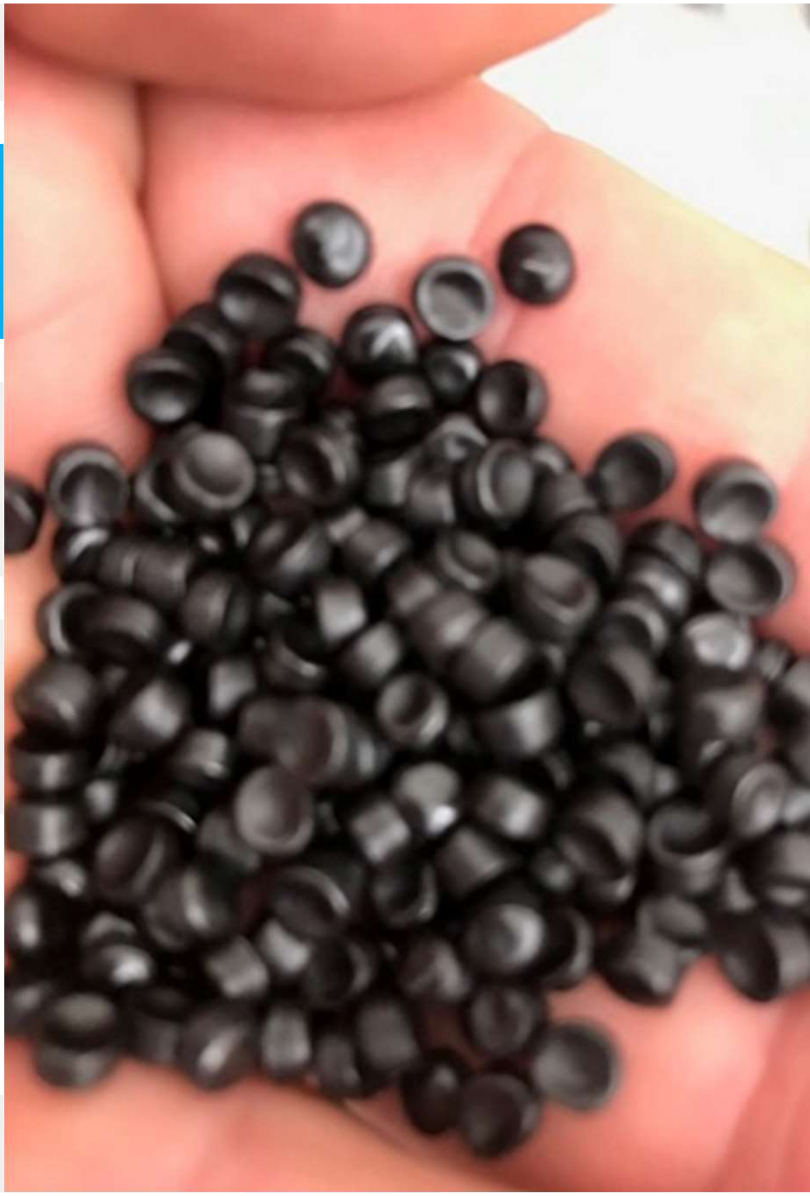


Plastic Encapsulated Biochhar

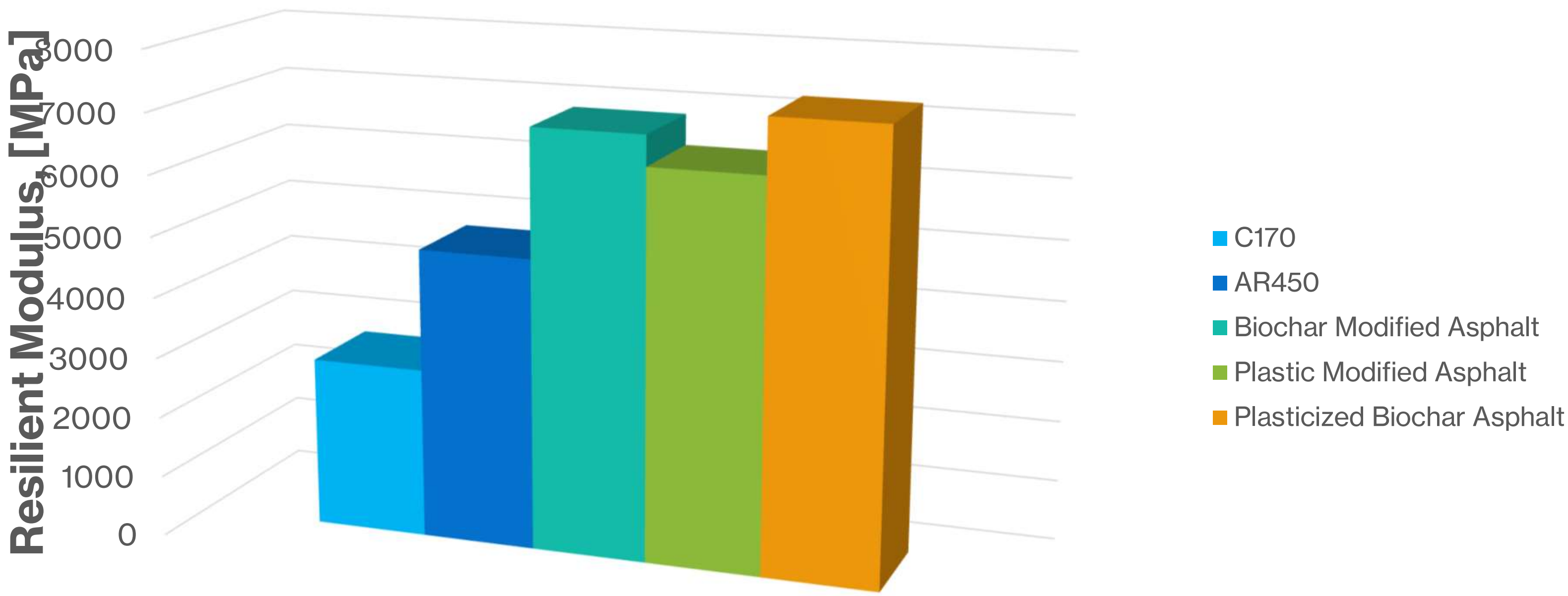
- To prevent any dust inhalation the biochar was encapsulated within recyclable plastic.

- Various amounts of biochar was encapsulated in recycle plastic.

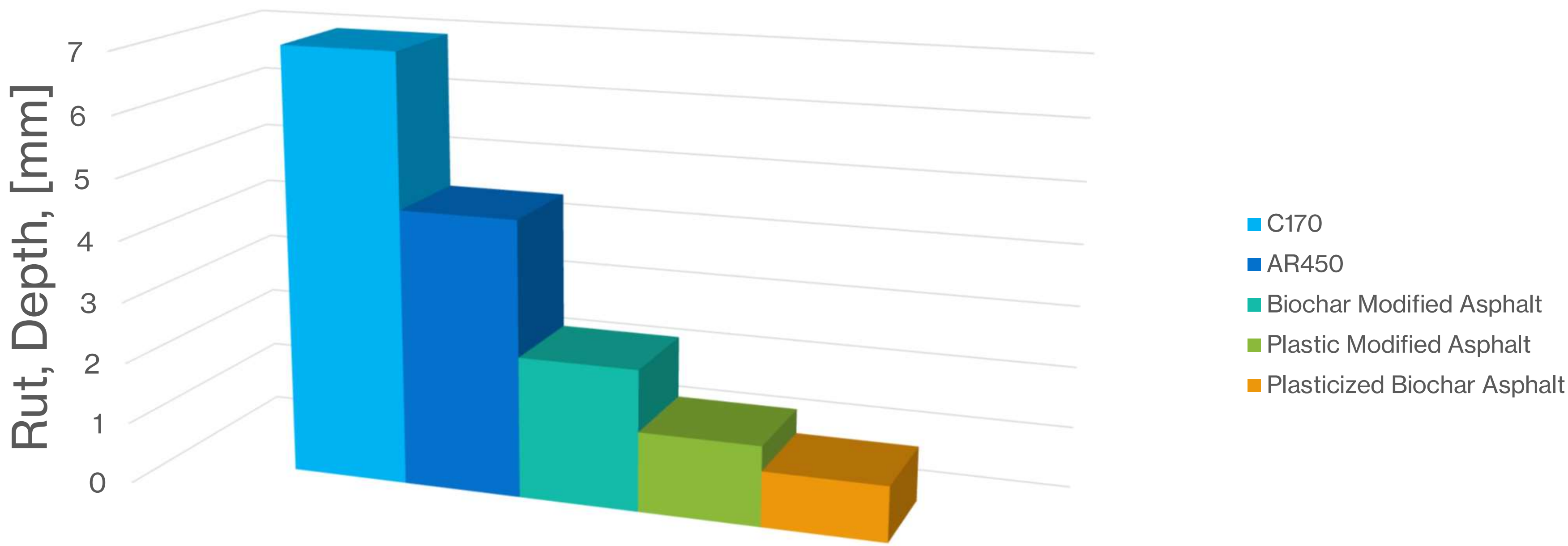
- Recycle plastic is propylene based.



Resilient Modulus



Ruth Depth at 60˚C after 10000 cycles



Bio-Bitumen

- 100% non fossil bitumen made using bio oil from bio-gas business
- Torsional Recovery – 50%
- Softening Point – 94.5 ˚C
- Viscosity @ 165˚C – 2.5 Pa*s
- Penetration – 32 uP

Thank You

FILTER POLLUTANTS WITH BIOCHAR

Cleaner water at less cost

Rain and snowmelt that flow over impervious surfaces are not absorbed into the ground. Referred to as stormwater runoff, it picks up pollutants like chemicals, oils, metals and dirt/sediment that can pollute rivers, streams, lakes, and coastal waters. Stormwater best management practices (BMPs) are used to protect these resources. Incorporating biochar into these practices can enhance their effectiveness and reduce costs.[1]

Engineered and in situ biofilters are increasingly used in urban environments to provide green space, alleviate flooding, and improve stormwater quality. These typically contain sand, soil, mulch or compost. In a meta-analysis of 84 studies, the addition of biochar was a low-cost option to remove various pollutants: heavy metals, microbial pollutants (like *E. coli* bacteria), and trace organics.[2]

Department of Transportation agencies that operate roadways must meet increasingly stringent regulations for stormwater runoff. Biochar

Research shows that adding biochar to stormwater media mixes can generate these benefits[4]:

- **Increases soil water holding capacity**
- **Improves soil aggregation in fine textured soils improving water infiltration**
- **Improves soil fertility in nutrient-poor soils improving nutrient availability for plants**
- **Filters metals**
- **Prevents the movement of bacteria into waterways, e.g. *E. coli***

Stormwater vault. *Photo by Sarah Burch*

Photo by Sarah Burch

Stand alone filter system to filter metals from industrial sites. *Photo by Ryan Holmann, Stormwater Biochar; filters by BioLogical Carbon* can also be effectively used in stormwater vaults, gabons, or stand alone filter systems.

Biochar offers a cost-effective option to existing carbon-based medias, such as activated carbon, that are used in stormwater filtration. Bulk biochar costs 20 – 100% less than activated carbon, which costs between $1,000 and $5,000 per ton. By comparison, bulk biochar costs can range from about $800 to $2,500 per ton.[3] Before using biochar, verify specifications: % carbon, surface area, particle size, and other characteristics.

How to use biochar in stormwater applications

Biochar effectiveness will vary by several factors including particle size, the surface area, pH, and the percentage of carbon in the material. The type of feedstock, as well as biochar production temperature, will influence media effectiveness.

Given all these variables, interested users of biochar can check with your local biochar producer to ensure the right biochar is selected for a specific project and application.

In general, biochar specifications vary by stormwater application type:

BMP Types	Objective	Specifications
Grass Swales **Vegetated Filter Strips** **Infiltration Basins**	Support healthy plants and increase soil infiltration	High quality biochar from wood or crop residues. Medium particle size: #20 - #60 sieve.
Bioretention	Support healthy plants and filter pollutants	High quality biochar from wood or crop residues. Medium particle size: #20 - #60 sieve.
Media Filtration	Filter pollutants at high flow rates	Wood-derived biochar. Coarse particle size: #8 - #20 sieve.

Environmental engineering firms can realize the following benefits from using biochar

- **Treat greater volumes of water with a smaller treatment footprint**[5]
- **Remove organic pollutants and bacteria**[5]
- **Filter dissolved metals not just metals in particulate form**[6]
- **Improve growing conditions for bioswale plants (particularly in urban environments)**[7]
- **Improve carbon footprint through use of a natural material**[8]

CASE HISTORY: BIOLOGICAL CARBON

CHALLENGE/OPPORTUNITY: John Miedema, founder of BioLogical Carbon, began working with biochar in 2008 after building his own pilot biochar machine. John makes customized biochar blends for his customers, particularly engineering firms installing stormwater vaults and other water treatment systems. He also constructs his own stormwater upflow and downflow systems for industrial customers.

His data sets demonstrate biochar's ability to remove metals and various other pollutants (including nutrients). BioLogical Carbon sees the opportunities and market applications for biochar are growing every year.

In 2021, BioLogical Carbon was contacted by one of his environmental engineering clients to supply a large volume of biochar for a major industrial company in Washington state. The company was building a large stormwater treatment system to manage and treat water for heavy metals produced during the construction of airplanes.

SOLUTION/APPROACH: John worked with Rexius company to sift and process nearly 1,500 yards of biochar into the appropriate particle and size class and arranged for delivery to the stormwater install location.

RESULTS: The biochar material was installed in the summer of 2021. The engineering company reports the material is working very well and is filtering copper and zinc at the required levels.

CASE HISTORY: CHESAPEAKE BAY

CHALLENGE/OPPORTUNITY: State highway agencies must meet increasingly stringent regulations for stormwater runoff. They are looking for low-cost options to avoid more expensive investments in infrastructure to handle rain events. In the Chesapeake Bay, a watershed collaborative between the University of Delaware, DelDOT, MDTA transportation agencies and Chuck Hegberg[9] tested biochar amendments for water infiltration and retention.[10]

SOLUTION/APPROACH: The group used laboratory column studies of soils collected by DOT's in California, Delaware, Maryland, and North Carolina. Lab tests assessed if adding 4% biochar (by mass) could increase rates of water infiltration and also remove nitrates.

RESULTS: For soils with poor water infiltration, the biochar amendment attenuated peak flow by 77% and runoff volumes by 53%.

As a result, researchers estimated that highway greenways could infiltrate 50% more water and remove 83% of sediment and nutrients. The biochar amended buffer could save $215,000 over standard treatments. That's because the biochar amended buffer needed only 0.12 acres compared to 3.7 acres required for standard treatments.

Economics

Save on material costs: Research and practical experience in the stormwater industry show that biochar can do as well or better than more expensive filter medias. Biochar can be made to a similar specification as activated carbon for 25% to 50% less (in some cases). Biochar also has a better carbon footprint than fossil-fuel based activated carbon.

Access to more markets: Biochar is superior to other filter medias because it can remove dissolved forms of heavy metals, which makes it unique among medias. Particulate-sized forms of metals can be removed with regular low-cost sand filters and activated carbon. Biochar can also remove dissolved forms of metals in water solution, allowing an expanded filtration media offering. It's a viable new tool for stormwater treatment.

Metal	Initial concentration ug/L	Post biochar filter ug/L	% removed
Total Copper	54.2	7.88	71.1%
Total Zinc	1,018	39.0	92.6%

Results from Biochar stormwater up flow filter tests to remove copper and zinc (biochar+ peat) in Washington State. *Data courtesy of Myles Gray, Geosyntec*

Non-economic benefits

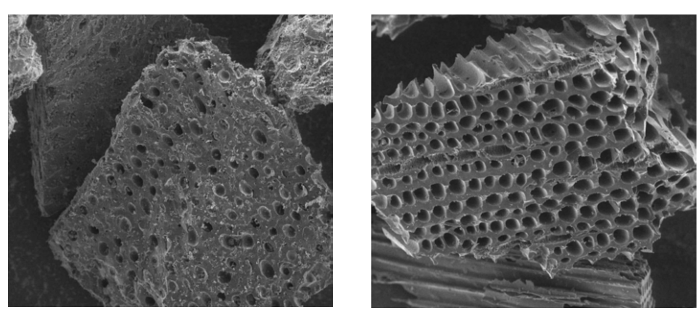
Biochar is made from a variety of biogenic biomass sources (leaves, wood chips, agricultural residues, orchard prunings, vineyard cuttings, and many others), which makes them natural and renewable.

Many locations across the United States have excess biomass with little or no market value. These materials are often either burned or sent to a landfill. Biochar applications, like stormwater management, provide a valuable mechanism to divert large-scale waste biomass resources and convert them into a product that can help clean up polluted stormwater and reduce runoff.

Right biochar for the right stormwater application

In most stormwater applications, biochar must be properly sized to ensure good complete contact with the water while not being too small as to clog up the filter or greenway. Biochar that is low in ash content (less than 5% ash is preferred) is typically needed for most metal filtration applications.

It is also usually helpful to conduct some initial lab tests of biochar's properties before using it in a field application.



Hazelnut shell **Douglas-Fir**

Electron microscope scans of biochar made from different feedstocks. *Photo courtesy of Myles Gray, Geosyntec*

CASE HISTORY: STORMWATER BIOCHAR

CHALLENGE/OPPORTUNITY: Ryan Holman is the CEO of Portland, Ore.-based Stormwater Biochar, which sells filtration systems to municipalities and private companies. Ryan specializes in navigating the permitting process to make sure customers meet water pollution controls required under the National Pollutant Discharge Elimination System (NPDES). He was particularly interested in biochar's ability to remove dissolved forms of metals and the materials low-cost compared to other media like peat and activated carbon.

SOLUTION/APPROACH: To explore biochar as a potential media for capturing metals, Ryan worked with John Miedema (BioLogical Carbon) and Myles Gray (Geosyntec) to conduct tests of the biochar performance in a laboratory over two years, Stormwater Biochar deployed filter systems with biochar media in 2017.

RESULTS: Stormwater Biochar reports solid performance of the systems in real world settings.[11] The filter systems consistently removed over 90% of dissolved copper and zinc, in addition to other problematic metals such as lead. In 2021, Stormwater Biochar installed a filter system at an Auto Parts Company near Los Angeles. Holman said biochar's main benefit is the lower cost and superior performance, particularly at removing dissolved forms of metals from stormwater. The biochar also performs consistently throughout the year in all seasons.

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BIOCHAR IN COMPOST

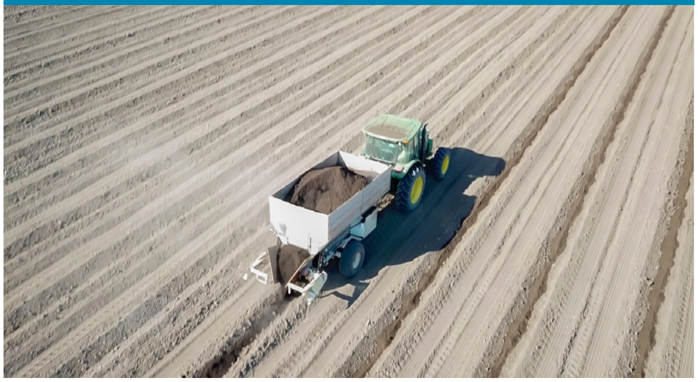
Adding biochar activates the composting process by enhancing the activity of microorganisms, which raises the temperature, reduces composting time and speeds up stabilization of the compost.[1]

> Research shows that that adding 5% to 10% by volume biochar at the start of the compost process can generate the following benefits:
>
> - **Speed up the composting process by 20% through better aeration of the pile and increasing microbial activity[5]**
> - **Capture odors[6]**
> - **Generate a compost with higher nutrient because biochar retains nitrogen[7]**

The use of biochar during the compost process yields a product comparable to those obtained with mineral fertilizer additions with a lower environmental impact.[2]

More recently, researchers found that benefits of co-composting with biochar far outweighed any drawbacks or side-effects when compared with other amendments. The quality of biochar-compost improves soil health and can boost crop yields.[3]

How to use biochar in the composting process



To use biochar in the composting process, the material should be added just like any other composting ingredient using existing equipment.

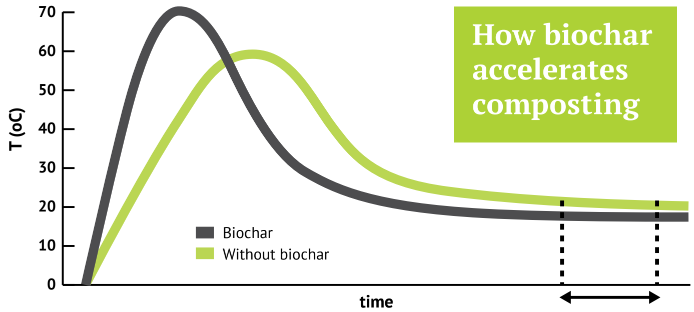
The scientific literature and experience of composters indicates that the best ratio of biochar to compost is in the range of 5% to 10% by volume. Adding more than 20% or 30% is not recommended as an excessive amount can interfere with biodegradation.[4]

Compost operators will realize these benefits

- **Accelerates compost process**
- **Reduces nutrient losses**
- **Reduces greenhouse gas emissions**
- **Acts as a bulking agent**
- **Increases microbial activity**
- **Reduces odor**

Economics

Increased production and savings: Composters who use biochar often see processing time reduced. More importantly, they report cost savings from turning piles less frequently. The fuel and labor savings is even more appealing than reducing compost time.



Biochar increases the temperature in the compost process, accelerating material decomposition

CASE HISTORY: REXIUS

CHALLENGE/OPPORTUNITY: Jack Hoeck is VP of Environmental Services at Rexius, a family-owned compost and soil producer in Oregon. Jack heard about the benefits of biochar through his conversations with John Miedema of BioLogical Carbon. He was intrigued by the material as a possible new amendment to help the company produce better compost.

SOLUTION/APPROACH: Rexius started out by creating two compost windrows, one with biochar and one without. In the windrow with 5% biochar by volume added, the compost-biochar had more moisture, nitrates and other nutrients than the pile without biochar. Overall, the quality was better in the biochar windrow.

RESULTS: Since starting to use biochar in the compost process, Rexius has continued to record higher nutrient values in their biochar-compost than compost without biochar. They also report higher beneficial plant bacteria and microbes compared to compost without biochar. Both the higher nutrients and more beneficial microbes create a higher value soil product that commands a better price for their home gardening potting and garden soils product lines.

Jordan Launch of Rexius said there are multiple benefits from incorporating biochar in their composting process. The two main ones are the labor and fuel savings from not having to turn the compost pile as often. That's in addition to having a higher value product at the end of the process. Biochar helps stabilize the soil whereas compost alone can degrade relatively quickly. Investing in adding biochar and biochar compost to soil offers long term benefits.

CONCLUSION: As Jordan mentioned, "The better your soil, the more productive your garden will be (whether that is better tomatoes, more colorful and vibrant flowers, or higher yields of lettuce or kale). Biochar and biochar-compost helps improve soil. Though the material costs more, it results in greater yields and makes it well worth the investment."

CASE HISTORY: PACIFIC BIOCHAR

CHALLENGE/OPPORTUNITY: The Oasis Vineyard located outside of King City, CA. was interested in trying different amendments to study how biochar and compost treatments effect soil water use, soil health, vine growth, harvest yields and grape quality.

The Oasis Vineyard had soils with low organic matter. In addition, the vineyard needed to conserve more water. Because biochar and compost can build soil organic matter and help retain moisture, the vineyard wanted to use them in a field trial.

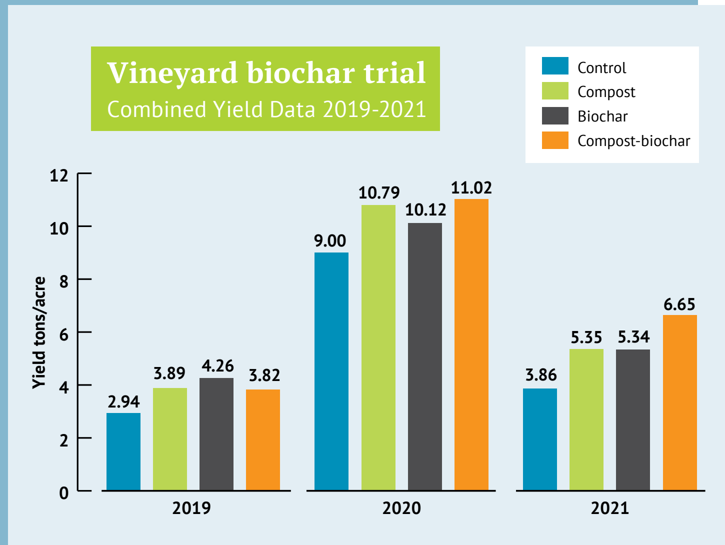
SOLUTION/APPROACH: Starting in 2016, the Sonoma Ecology Center, UC Riverside and Pacific Biochar worked with the Oasis Vineyard manager Monterey Pacific Inc. to develop a multi-year field trial with funding from the California Department of Water Resources. Treatments included biochar only, compost only, biochar-compost, and a control (no amendment).

New plantings of vines were prepared by ripping rows in the soil to a 30 inch depth, 2 feet wide by 2.5 feet deep (approximately 25 cubic feet of soil per vine). Biochar was applied in the planting row at 10 tons per acre wet weight, and compost was applied at 15 tons per acre wet weight.

RESULTS

Some of the reported findings include:

- The highest yield came from the biochar-compost treatment resulting in a 45% increase over the control.
- Increased pruning weight was observed for both the compost and the compost + biochar treatment. Higher cluster counts were observed for both the biochar and the compost + biochar treatments.
- All treatments received the same irrigation regimen throughout the trial, demonstrating improved water use efficiency where soil had been amended.



CONCLUSION: Results from the field research trial indicate that biochar and compost treatments can improve water use efficiency, vine growth, harvest yields and soil health for vineyards newly planted on low organic matter sandy soil.

The vineyard manager, Monterey Pacific, said the return on investment for adding biochar paid off in the first grape harvest with higher profit expected over the life of the vines.[8]

(Economics continued)

Higher quality material: Increased nitrogen in the final product gives biochar-compost a better nutrient profile than compost alone, making for a better soil amendment.

Interested in learning more about the economics of biochar? See the Biochar Atlas-Cost Benefit Analysis tool, which guides users to assess whether biochar is a good investment for your soil. **pnwbiochar.org/tools/cba**

Non-economic benefits

Biochar is made from a variety of biogenic biomass sources (leaves, wood chips, agricultural residues, orchard pruning, vineyard cuttings, and many others). As a biogenic resource, biochar feedstocks are natural and renewable.

Many locations across the United States have excess biomass with little or no market value. These materials are often either burned or sent to a landfill. Compost companies provide a valuable mechanism to divert large-scale waste biomass resources and make them into something that can help improve soils. Biochar is a new product made from low-value material that can help add value to compost.

In so many communities, excess biomass shows up at landfills for disposal. Every fall, when the leaves drop, the level of waste biomass that gets sent to the landfill is disturbing. This is also true for the debris from a strong windstorm or ice storm event. If we can develop new markets for low-value biomass (like biochar), we are helping to create natural, renewable, locally produced material that can benefit people and the environment.

Some tips for using biochar

- **Biochar compost products can be spread using the same type of equipment farmers use to spread compost.** It can either be worked into the soil using a plow or side-casting along rows, as in the case of biochar-compost vineyard applications
- **The amount of biochar-compost that you should apply to your soil will depend on a variety of factors**
- **To learn more about how biochar can help your soil, please view the Biochar Atlas pnwbiochar.org/tools**
- **The Biochar Selector tool can guide you on the amount of biochar for your soil. pnwbiochar.org/tools/selector**

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BIOCHAR REMOVES CARBON

The buildup of greenhouse gases in the atmosphere, including carbon dioxide (CO_2), contributes to climate change. As a result, governments, international agencies, and major corporations are prioritizing its removal from the atmosphere. There are two options for carbon removal: one uses technology (such as "direct air carbon capture") and the other method includes "nature-based strategies," which are the focus of this fact sheet.

Research shows that biochar, a nature-based strategy, has enormous potential to remove CO_2 from the atmosphere as part of an overall climate change mitigation strategy (Lehmann et al. 2006[1]). In 2022, the International Panel on Climate Change (IPCC) highlighted a variety of promising strategies to remove CO_2 from the atmosphere[2] with biochar cited as a very important pathway[3].

Made from waste biomass such as crop residues, sawdust, or forest slash piles, biochar removes carbon at a significantly lower cost than technology-based options.

Current interest in carbon markets

Though some governments are following a compliance model, investment through the voluntary market is on the rise, which is the focus of this document.

Companies like Microsoft[4] have ambitious goals to become "carbon negative" by 2030. In addition, the company has pledged to further offset all CO_2 emissions dating back to the organization's founding by 2050. To achieve this goal, Microsoft established a $1 billion dollar "Climate Innovation Fund"[5] to "accelerate technology development and deployment of new climate innovations through equity and debt capital."

Google, Facebook, Shopify, Stripe, and McKinsey recently created a joint venture called Frontier and committed nearly $1 billion to pay for carbon removal[6] through 2030.

Companies are also purchasing biochar carbon credits as part of their strategies to become carbon neutral. This relatively new interest in biochar carbon credits is driving new investments in biochar companies.

How are biochar carbon credits sold in the voluntary market?

Currently, biochar producers have two options to sell into the voluntary market: Puro.Earth[7] or Carbon Future[8]. Other voluntary carbon programs are under development through Verra and the Climate Action Reserve.

In general, voluntary carbon programs share some similarities with "organic certification." You may grow vegetables and not use any pesticides or herbicides during cultivation. At the end of the growing season, you may be 100% confident that you grew the crop organically. And you are probably correct.

However, if you want to sell your vegetables and use an organic label, you cannot get that stamp of approval unless you have followed rules, procedures and protocols established by an outside, third-party organic certification program.

To become organically certified, you must register your product with a recognized organic certification body and pay the required product listing and administrative costs of setting up an account. The next step in the organic certification process will involve paying for a third-party certifier to visit your farm to make sure you have followed all the rules and procedures of organic production.

When you can demonstrate that you meet all the organic certification requirements, you are given the approval to label your products as organic. Then you can sell your organic produce in the marketplace.

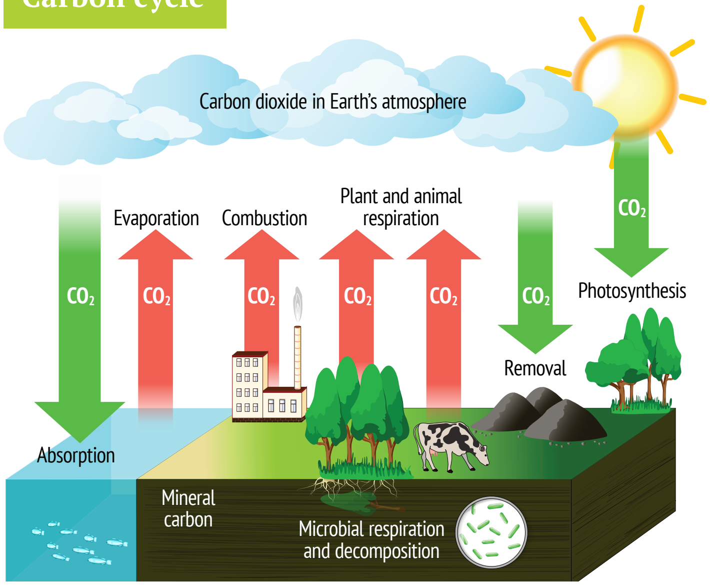
Carbon credit certification is very similar. To sell your biochar carbon removal credits to interested buyers in the voluntary carbon market, a biochar producer must enroll in a recognized third-party certification system.

Before investing time on biochar carbon revenue potential in voluntary carbon markets, consider the following:

- **Participating in the carbon market has fixed costs associated with the certification process. Biochar must be of sufficient scale to cover those ongoing costs. In general, an annual production of at least 100 tons of biochar makes the carbon market feasible.**
- **Current programs require biochar producers to report air emissions (including methane), operating temperature, and proof that up to 70% of the heat energy is for a productive use, e.g., displacing the need for fossil fuel. Hence small scale biochar production systems are typically not eligible.**
- **Most feedstocks used for biochar are eligible for carbon crediting. However, the raw feedstocks must be "biogenic" like forestry residues, wood chips, agricultural residues, and straw. Non-biogenic materials like tires, plastics, or municipal solid waste are not eligible.**

Photo by Marcus Kauffman, Oregon Dept. of Forestry

Carbon cycle



What is the value of biochar carbon credits in the marketplace?

Puro.Earth has various price indices for different types of carbon credits or "CORCs" on their web site[9].

Carbon Future does not currently have a publicly available price index for biochar carbon credits on their web site. However, they do provide individual project volumes available from biochar projects[10].

Puro.Earth has a price index instrument called "CORCHAR" (see graph below). The index provides up-to-date information on the price of biochar carbon removal credits. The Puro CORCHAR index is updated every 30 days. If interested, you can check the index periodically to understand the prices for CORCHAR.

As of May 1st, 2022, the CORCHAR index price was 100 Euros per ton of biochar (about $105 US Dollars).

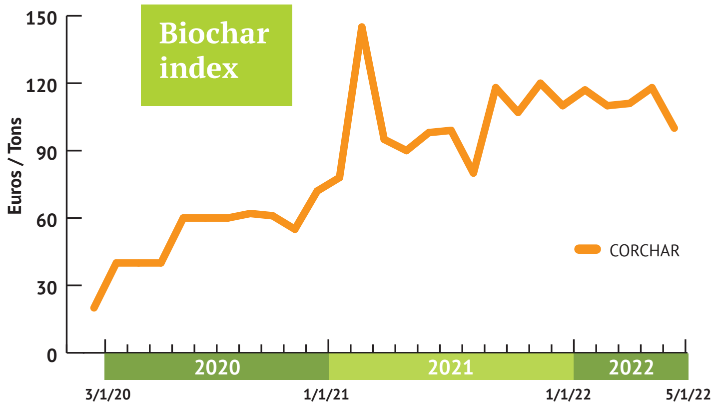



Photo by Marcus Kauffman, Oregon Dept. of Forestry

How many carbon credits can be generated from one ton of biochar?

According to Puro.Earth publicly available biochar project records[11], the number of CORCs per ton of biochar produced varies by biochar type and company. One CORC is equivalent to one ton of CO2. For wood feedstocks, the range of carbon credits per ton of biochar is 2.57 to 3.26, with an average of 2.83.

Other factors that influence the amount of carbon credits per ton of biochar are:

- **The gas or diesel used to process the biomass (e.g., woodchippers)**
- **Biochar composition: % carbon, % ash, bulk density, dry weight**
- **The amount of propane or other fossil fuels used during biochar machine start up and shut down**
- **How much fossil fuel-based electricity was used during biochar operation, for example running fans and augers and other equipment used during biochar production.**

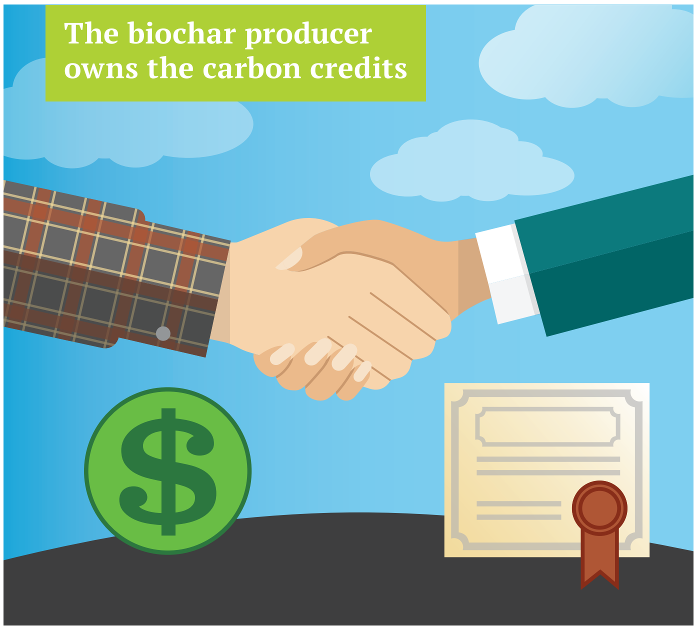
Various factors influence the carbon credits from one ton of biochar produced, including the amount of fossil fuel inputs via fertilizers used to grow the feedstocks. Fertilizer inputs are typically associated with agricultural residue feedstocks but are not typically a factor for forest or mill residues.

If a biochar producer listed on the Puro.Earth web site is credited with 2.5 tons of CORCS per ton of biochar produced, and each CORCHAR credit sells for $100 per ton, then a third party approved seller can generate $250 of CORC revenue per ton of biochar produced.

Carbon credits are in addition to revenue from selling the biochar

CORC buyers are purchasing the "carbon removal" benefit associated with the biochar product only. In other words, the CORC buyer is not physically taking possession of the biochar product itself. The biochar producer can still sell their product into the market (for example to a farmer as a soil amendment). So CORC sales are an additional source of revenue for biochar producers above revenue from selling the biochar product.

Certified biochar producers must provide documentation that the biochar they sell is going to an approved use (such as being added to compost or sold as an agricultural product). Biochar suppliers cannot sell CORCs if the biochar is diverted for use as a charcoal or other energy production purpose (fired in a biomass boiler).



Reference Guide

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2 UN climate report: Carbon removal is now "essential". 2022. MIT Technology Review. https://www.technologyreview.com/2022/04/04/1048832/un-climate-report-carbon-removal-is-now-essential/

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9 Puro.Earth CORC index. https://puro.earth/carbon-removal-index-price/

10 Carbon Future project portfolio. https://platform.carbonfuture.earth/balancer/portfolios

11 Puro marketplace project records. https://puro.earth/CORC-co2-removal-certificate/

For more information, please visit
US Biochar Initiative: **biochar-us.org**

Published by USBI in partnership with Nebraska Forest Service. The work upon which this project is based was funded in whole or in part through a grant awarded by USDA Forest Service Wood Innovations.

ONE DAY INTERACTIVE WORKSHOP

Biochar in NSW: Unifying Policy,Agriculture and Urban Development

ANZ BIOCHAR INDUSTRY GROUP

CATALYST Environmental Management

WESTERN SYDNEY UNIVERSITY
Hawkesbury Institute for the Environment

DECARB HUB New South Wales Decarbonisation Innovation Hub

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The development of the Australian Biochar Industry 2030 Roadmap has been supported by many organisations. We acknowledge and thank them for their support.

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- Southern Cross University
- energylink SERVICES
- CARBON FARMERS OF AUSTRALIA

Bronze

- MS2
- Carbon Drawdown Projects
- ECHO2 — sky carbon to earth
- Sustainability Plus Projects
- Melbourne Water
- Energy Farmers AUSTRALIA
- CINCH
- AET Advanced Energy Tech
- South East Water
- accend
- THE PENTARCH GROUP
- future energy
- kalsawmills
- GECA Environnement
- Barwon Water
- Kochii Australian Eucalyptus Oil
- BYRON BIOCHAR
- OPTIMAL — optimised energy solutions

BIOCHAR ADMIXTURES FOR THE ENHANCEMENT OF STRUCTURAL AND NONSTRUCTURAL CONCRETES

Sydney November 2023

John Saad

ANZ BIOCHAR INDUSTRY GROUP

CHT
SMART CHEMISTRY WITH CHARACTER.

John Saad Managing Director CHT Australia

WHAT TO EXPECT FROM THIS PRESENTATION

- ❑ WHY IS BIOCHAR IMPORTANT
- ❑ WHY THE PUSHBACK AGAINST BIOCHAR
- ❑ HOW GOOD ARE THE RESULTS FROM USING BIOCHAR
- ❑ HOW DOES BIOCHAR ACTUALLY WORKS
- ❑ THERE EXISTS NEW ADMIXTURE TECHNOLOGY
- ❑ OPTIMUM DOSE RESPONSE OF BIOCHAR IS SMALLER THAN YOU MIGHT THINK

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BIOCHAR ?!#@

- HISTORICAL NEGATIVE BIAS TO HIGH CARBON FLYASH
- DEPENDENCE NARROW STREAM OF ADMIXTURE CHEMISTRY
- CAPTIVE TO LIMITED SCM ALTERNATIVES
  - UNDERVALUING THE FUNCTION OF LOW CEMENT FORMULATION
- FEAR OF OHS CONTAMINANTS
  - PFAS
  - HEAVY METALS
- RESISTANCE TO PROCESS CHANGE
- SUPPLY CHAIN SCEPTICISM

REASONS FOR BIOCHAR

- DECARBONISATION
  - Real
  - Measurable
  - Sustainable
  - Rewardable
- LOWER COST
  - Real and deliverable
- HIGHER PERFORMANCE
  - Substantiated
  - Measurable
- ACADEMIA KNOWS
  - BUT STILL MORE TO FIND OUT

WHICH BIOCHAR

- ANY BIOCAHR IS GOOD.......>>>>>>NO, NOT REALLY........
- BIOCHARS WITH HIGH SiO2 CONTENT IS GOOD
- ***BIOCHAR CO PYROLISED WITH ALUMINA SILICATES IS BETTER***

- ANY SOURCE OF BIOSOLIDS IS GOOD......>>>>>NO, NOT REALLY........
- SOFTWOOD BIOSOLIDS ARE GOOD
- ***HARDWOOD BIOSOLIDS ARE BETTER***

- ***LOW TEMPERAURE PYROLYSIS IS BETTER***

- ANY PARTICLE SIZE OF BIOCHAR IS GOOD........>>>>>NO, NOT REALLY.......
- AGGREGATE SIZE SUBSTITUES ARE NOT SUITABLE
- SAND SIZE SUBSTITUTES ARE OK
- ***ULTRA FINE PARTICLES ARE BEST***

DOSE RESPONSE OF ADMIXTURES OF CARBON COATED MINERALS AKA "BIOCHAR"

SMART CHEMISTRY WITH CHARACTER.

WHAT CAN BE ACHIEVED

				Tod
Material	**Description**	**uom**	**Control**	**Recipe 1**
Cement	slag	kg/m³		
	fly ash	kg/m³		
	Type GP	kg/m³	450	450
Total Cementitous			450	450
Deer Park	14/7mm	kg/m³	1097	1097
Bacchus Marsh	C/Sand	kg/m³	661	661
Recycled aggregate				
CHT Cement Adjuvant		kg/m³		9.0
Additional Biochar				
Total water[kg/m3]		kg/m³	192	192
W/C		Ratio	**0.43**	**0.43**
Slump AS 1012.3.1 [mm]		mm	100	50
Biochar content		kg/m3		**3**
cement reduction		**%**		

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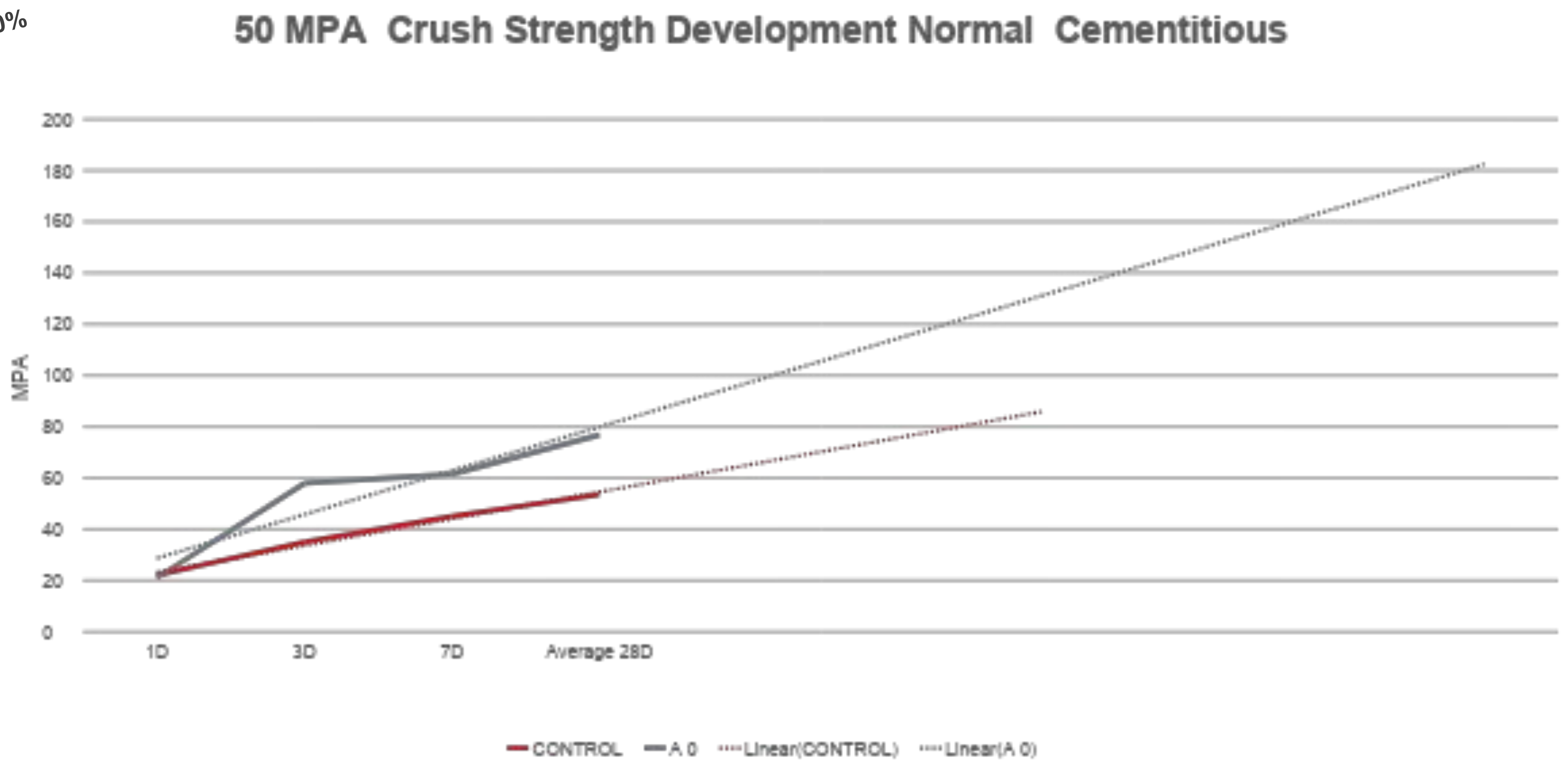
WITH CHARACTER.

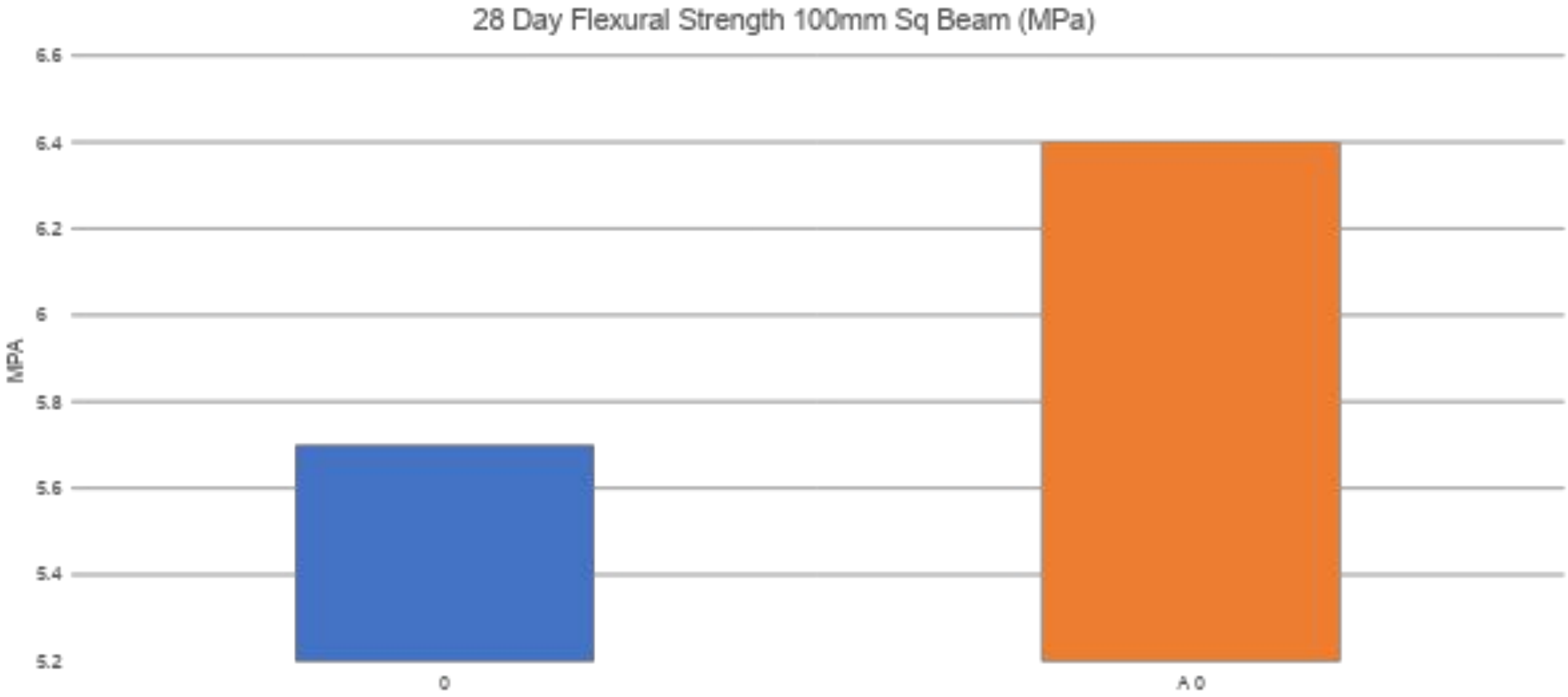
Compressive strength increase of 50%



John Saad Managing Director CHT Australia

SMART CHEMISTRY WITH CHARACTER.

Flexural Strength from 8% to 10%



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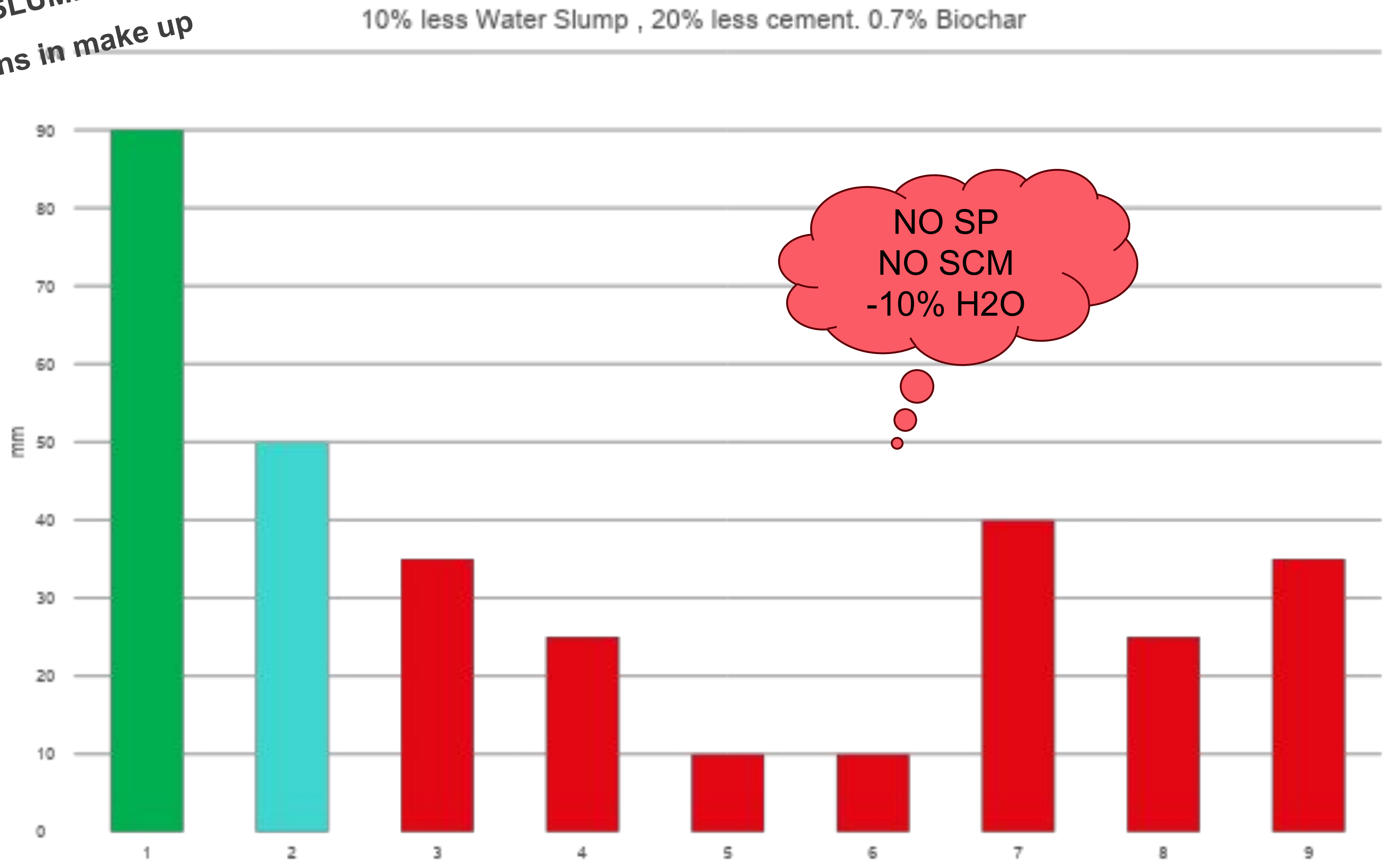
CHT SMART CHEMISTRY WITH CHARACTER.

STATIC SLUMP

Variations in make up

WHAT HAPPENS WITH 20% REDUCTION IN CEMENT



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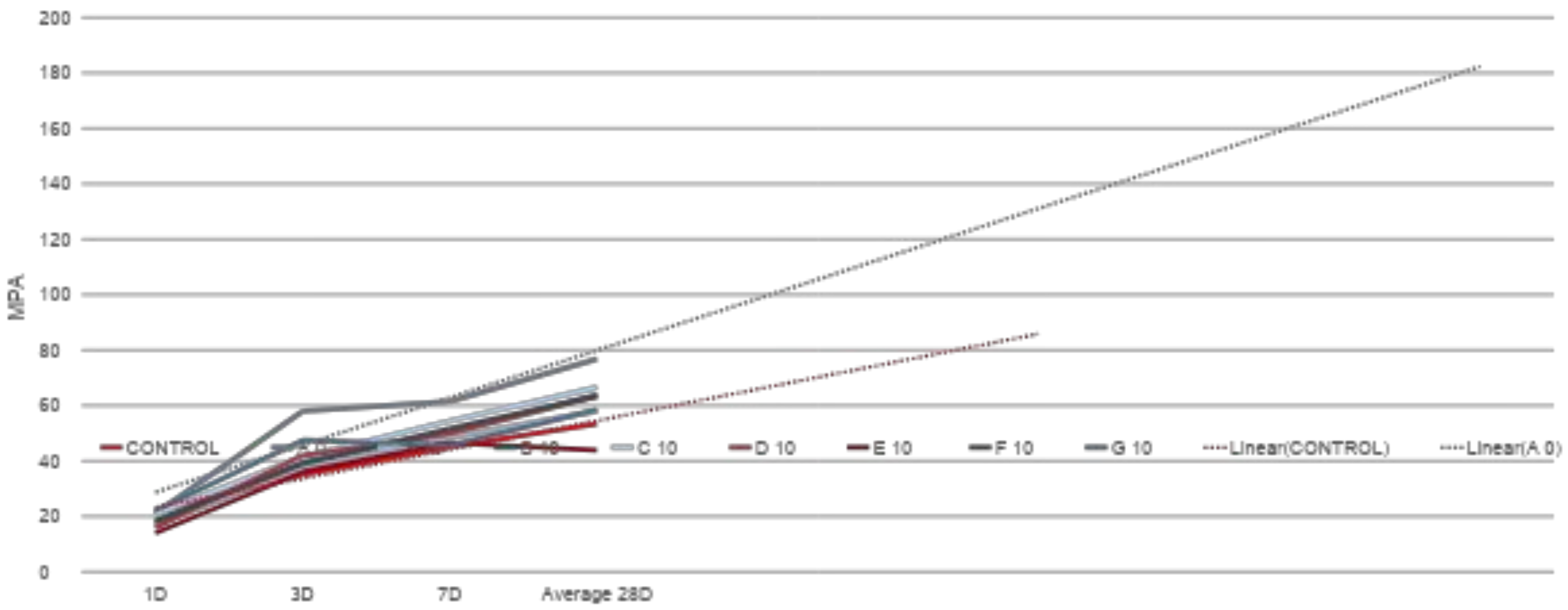
SMART CHEMISTRY WITH CHARACTER.

50 MPA Strength Development 10% less Water and 20% less Cement



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WHAT CAN BE ACHIEVED

				Today			
Material	**Description**	**uom**	**Control**	**Recipe 1**	**Recipe 2**	**Tomorrow**	**Soon**
Cement	slag	kg/m^3				100	100
	fly ash	kg/m^3					
	Type GP	kg/m^3	450	450	360	260	260
Total Cementitous			450	450	360	360	360
Deer Park	14/7mm	kg/m^3	1097	1097	1135	1135	
Bacchus Marsh	C/Sand	kg/m^3	661	661	732	732	732
Recycled aggregate							1035
CHT Cement Adjuvant		kg/m^3		9.0	7.2	10	10
Additional Biochar							100
Total water[kg/m3]		kg/m^3	192	192	172.8	180	180
W/C		Ratio	0.43	0.43	0.48	0.5	0.5
Slump AS 1012.3.1 [mm]		mm		50	35	50	50
Biochar content		kg/m3		3	2	3.3	103.3
cement reduction		%			20.00	42.00	42.00
total recycled		%					51.00
compressive strength gain		%		40	25	No less than control	
Flexural Strength gain		%		20	10		

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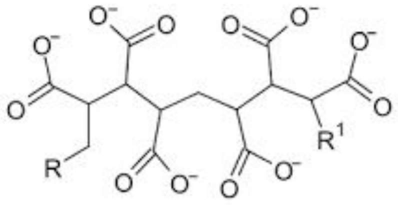
FUSING THE BIOCHAR

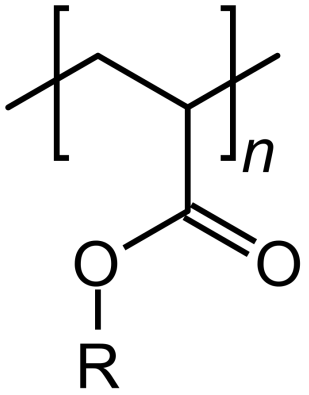
LOOK AT THE SUPERPLASTICIZER

PCE vs Polyether modified siloxanes

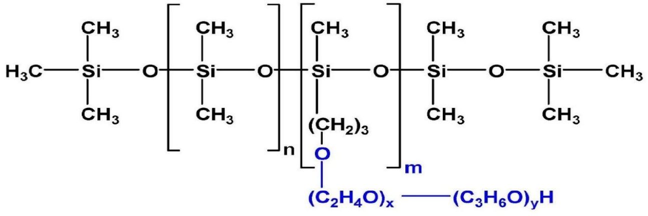
- PCE

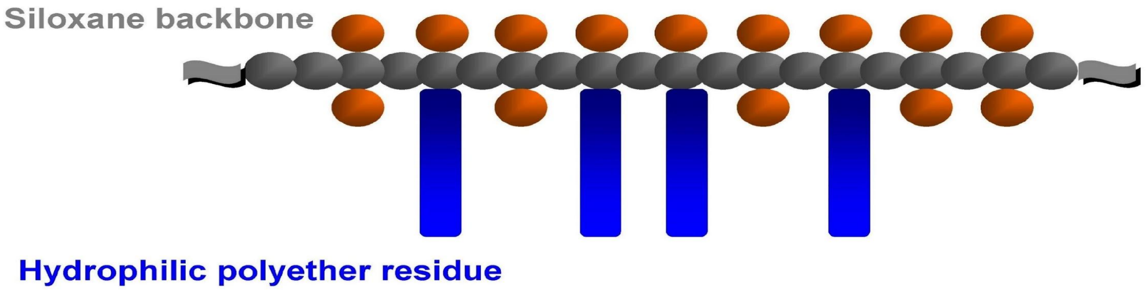


- Polyacrylate

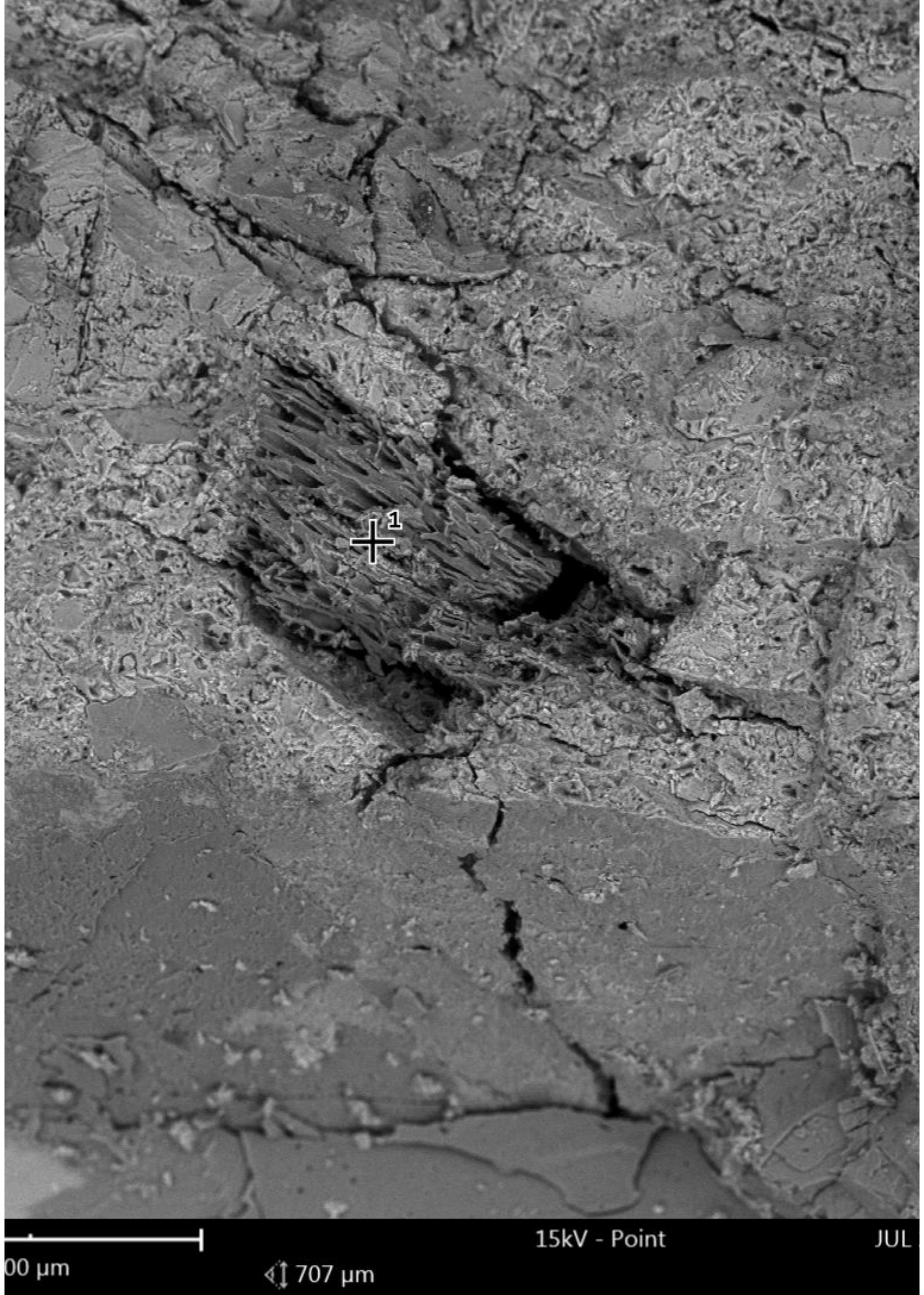


Silicone polyether copolymers





Sand and Cement Matrix – NO Coarse Aggregate

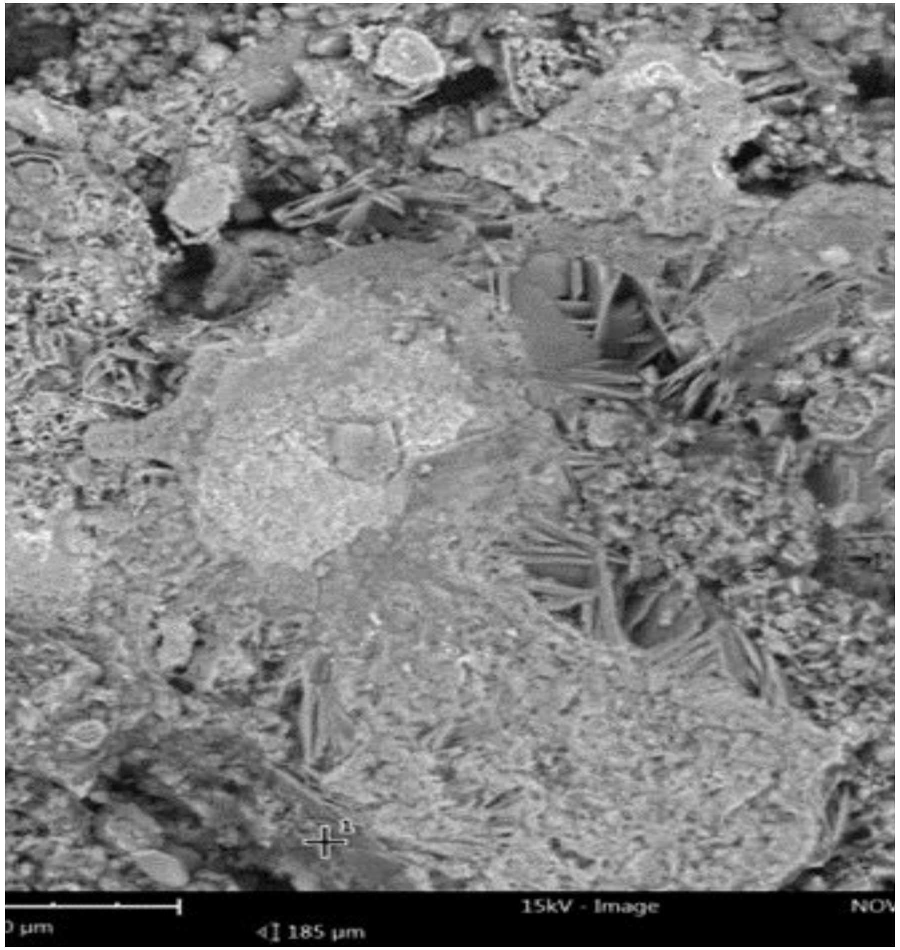


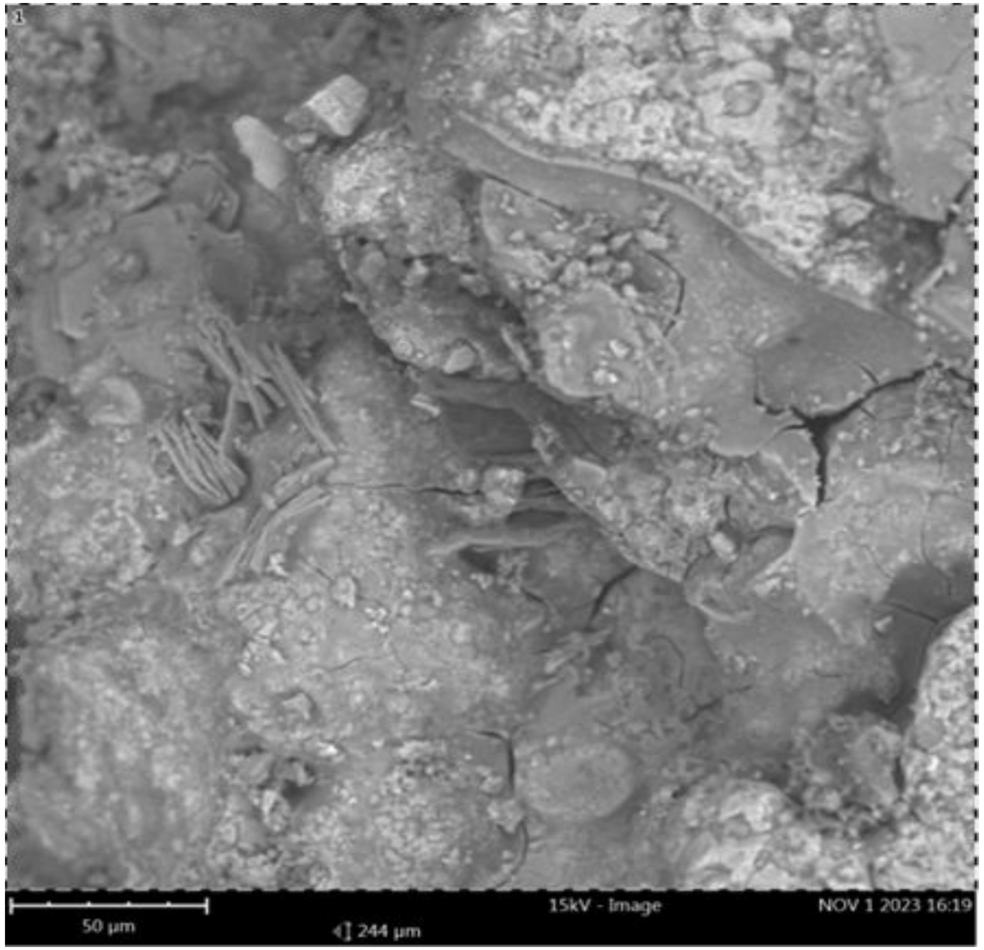
INTERRUPTING CRACK PROPAGATION

SMART CHEMISTRY WITH CHARACTER.

NO sand Complex

Biochar surrounded by aggregate and minerals and Cementitious material





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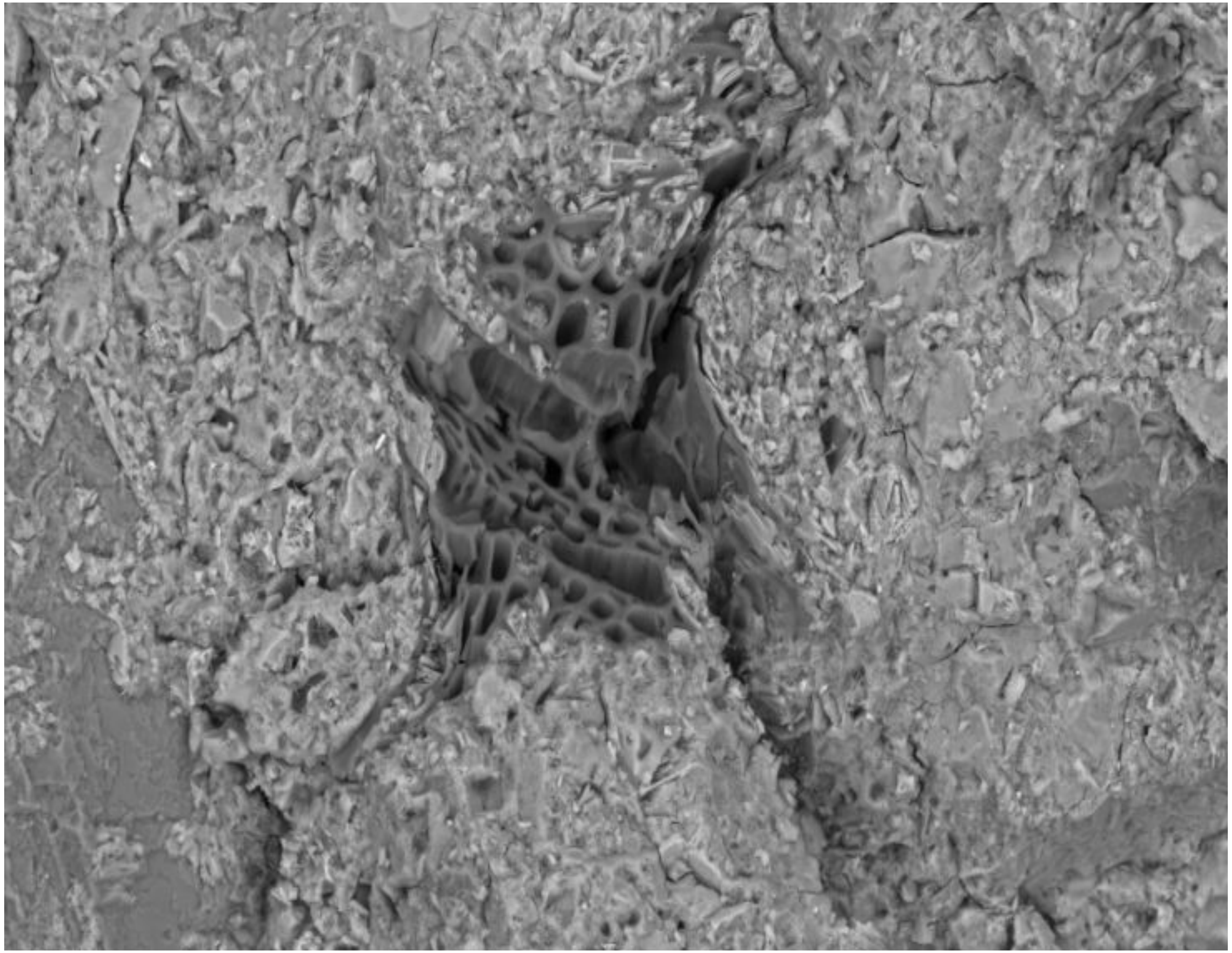
Graded Aggregate mix



BONUS INTERNAL WATER RESISTANCE

WITH A LITTLE IMAGINATION

The opportunities are huge

- Less cement
- Higher compressive strength
- Higher flexural strength
- Better water resistance
- Better corrosion resistance
- Reduced steel reinforcement
- Lower total weight
- Lower embedded carbon footprint
- Lower total Cost

SMART CHEMISTRY
WITH CHARACTER.

John Saad Managing Director CHT Australia

ITS UP TO YOU NOW TO TAKE UP THE CHALLENGE

- Thank you for your attention, and good luck to us all
- “some images Designed by macrovector / Freepik"

CHT
SMART CHEMISTRY
WITH CHARACTER.

THE FUTURE OF MORTAR ELEMENTS

Slag	Problematic	Limited Use	Desirable SCM	
Fly ash	diminishing resource	Increase its use in the short term	Decrease its use in the long term	
Cement	key materail Not Sustainable	Being reduced	Reduce Further	
Biochar	Sustainable renewal resource	Can be functionalized to SCM	Increase its use 0.7%	Increase further >10% as aggregate
Sand and Aggregate	finite resource	Replaced by recycled & pozzolanic materials	Will be more problematic	
ADMIXTURES	Need to be rethought	will need to be developed		

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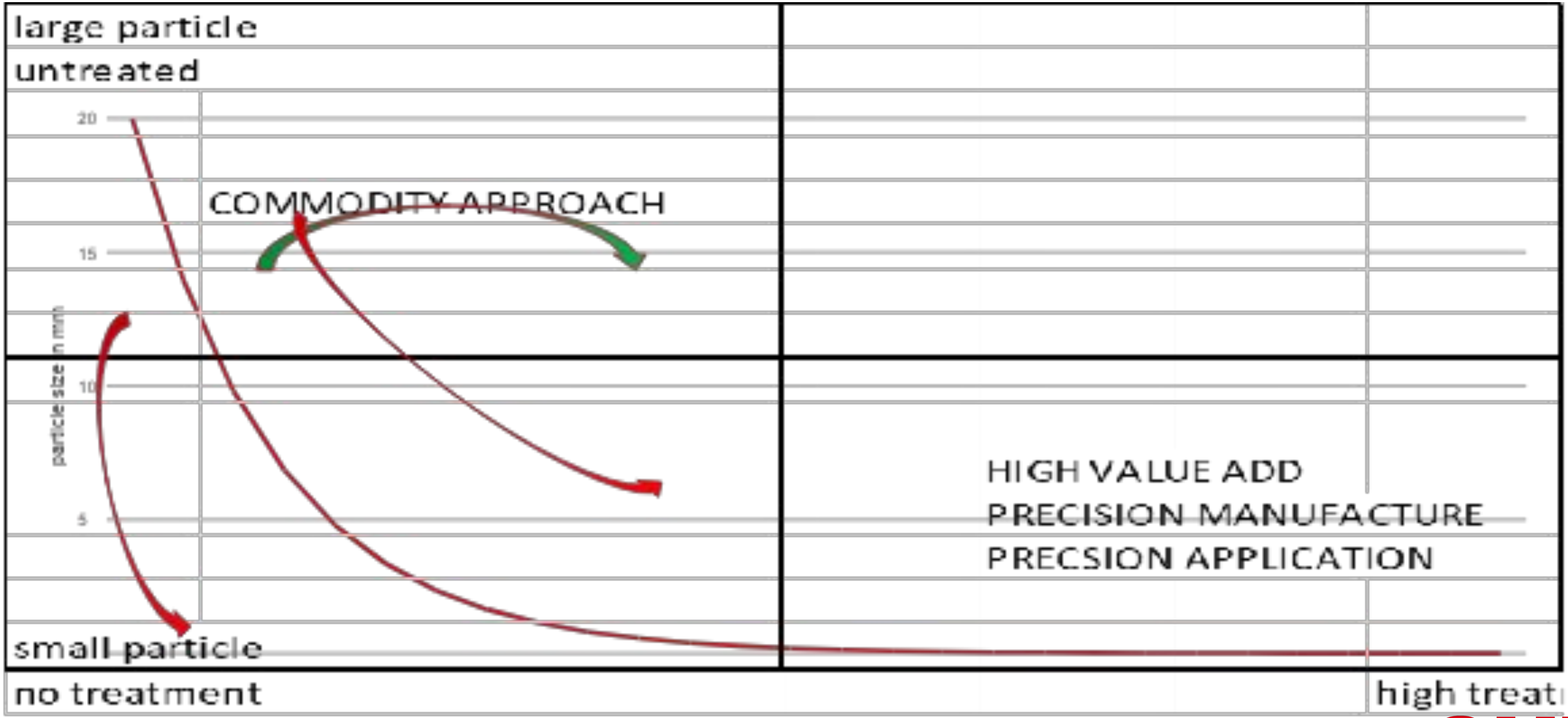
ADDING COST – CREATING BIGGER VALUE



NSW | ACT FORUM

AUSTRALIAN BIOCHAR INDUSTRY 2030 ROADMAP

ANZ BIOCHAR INDUSTRY GROUP

CATALYST Environmental Management

WESTERN SYDNEY UNIVERSITY
Hawkesbury Institute for the Environment

DECARB HUB New South Wales Decarbonisation Innovation Hub

HIWAY GROUP

Vital Chemical

B & K REVEGETATION & LANDSCAPING

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The development of the Australian Biochar Industry 2030 Roadmap has been supported by many organisations. We acknowledge and thank them for their support.

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- RegenerativeAg ALLIANCE – Resilience through farming together
- EAL Environmental Analysis Laboratory
- Southern Cross University
- energylink SERVICES
- CARBON FARMERS OF AUSTRALIA

Bronze

- MS2
- Carbon Drawdown Projects
- ECHO2 sky carbon to earth
- Sustainability Plus Projects
- Melbourne Water
- Energy Farmers AUSTRALIA
- CINCH
- AET Advanced Energy Tech
- South East Water
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- SOFT AGRICULTURE
- kalsawmills SPECIALISING IN PINE
- GECA Environment
- BarwonWater
- Kochii Australian Eucalyptus Oil
- BYRON BIOCHAR
- OPTIMAL optimised energy solutions

BlueScope

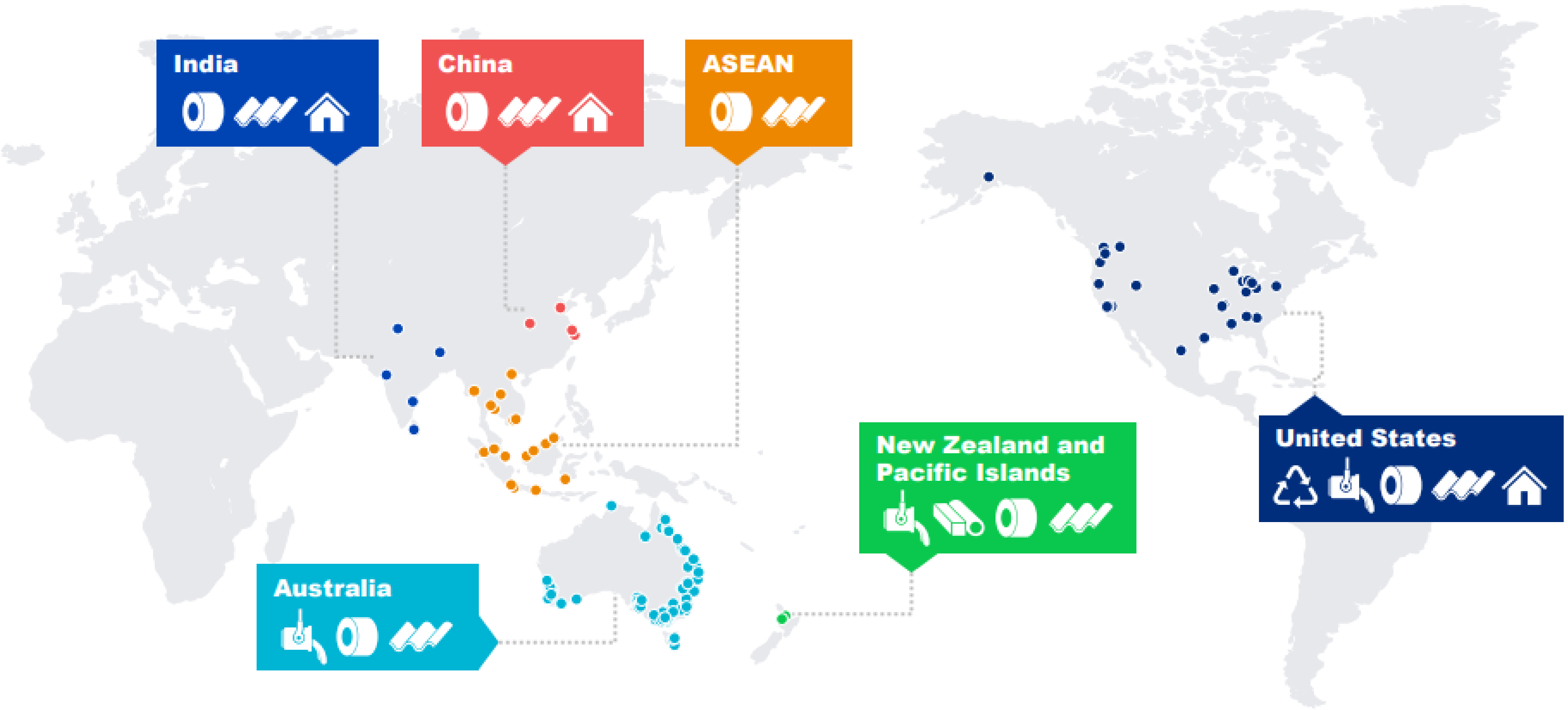
Steelmaking Decarbonisation: Opportunities for Biocarbon

November 2023

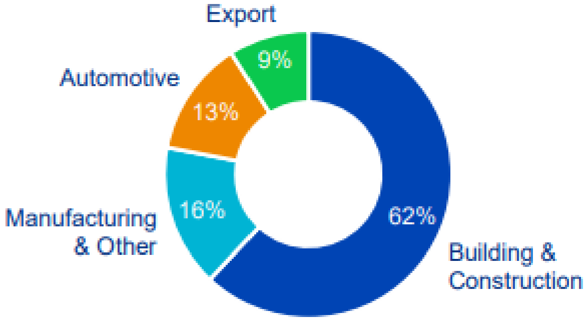
Pictured:
New lodges built along the Three Capes Track in Tasmania featuring COLORBOND steel
Photo: Brett Boardman

BlueScope Steel Limited. ASX Code: BSL
ABN: 16 000 011 058
Level 24, 181 Williams St, Melbourne, VIC, 3000

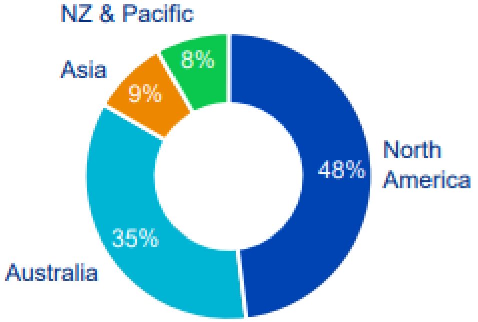
A HIGH-QUALITY ASSET PORTFOLIO



End-use segment exposure
(share of CY2022 despatch volume)



Earnings by region
(CY2022 Underlying EBITDA)



Key

- Recycling (scrap metal)
- Steelmaking (flat products)
- Metal coating and painting
- Long products (rebar, wire)
- Steel buildings and systems
- Steel building materials and components

CLIMATE ACTION

Key highlights

SET A GOAL FOR:

NET ZERO

GHG emissions across our operations by 2050[1]

SET TARGETS FOR:

12%

GHG emissions intensity reduction by 2030 for our steelmaking activities
(based on 2018 levels)

30%

GHG emission intensity reduction by 2030 for our non-steelmaking activities[2]
(based on 2018 levels)

INITIAL ALLOCATION UP TO

$150M

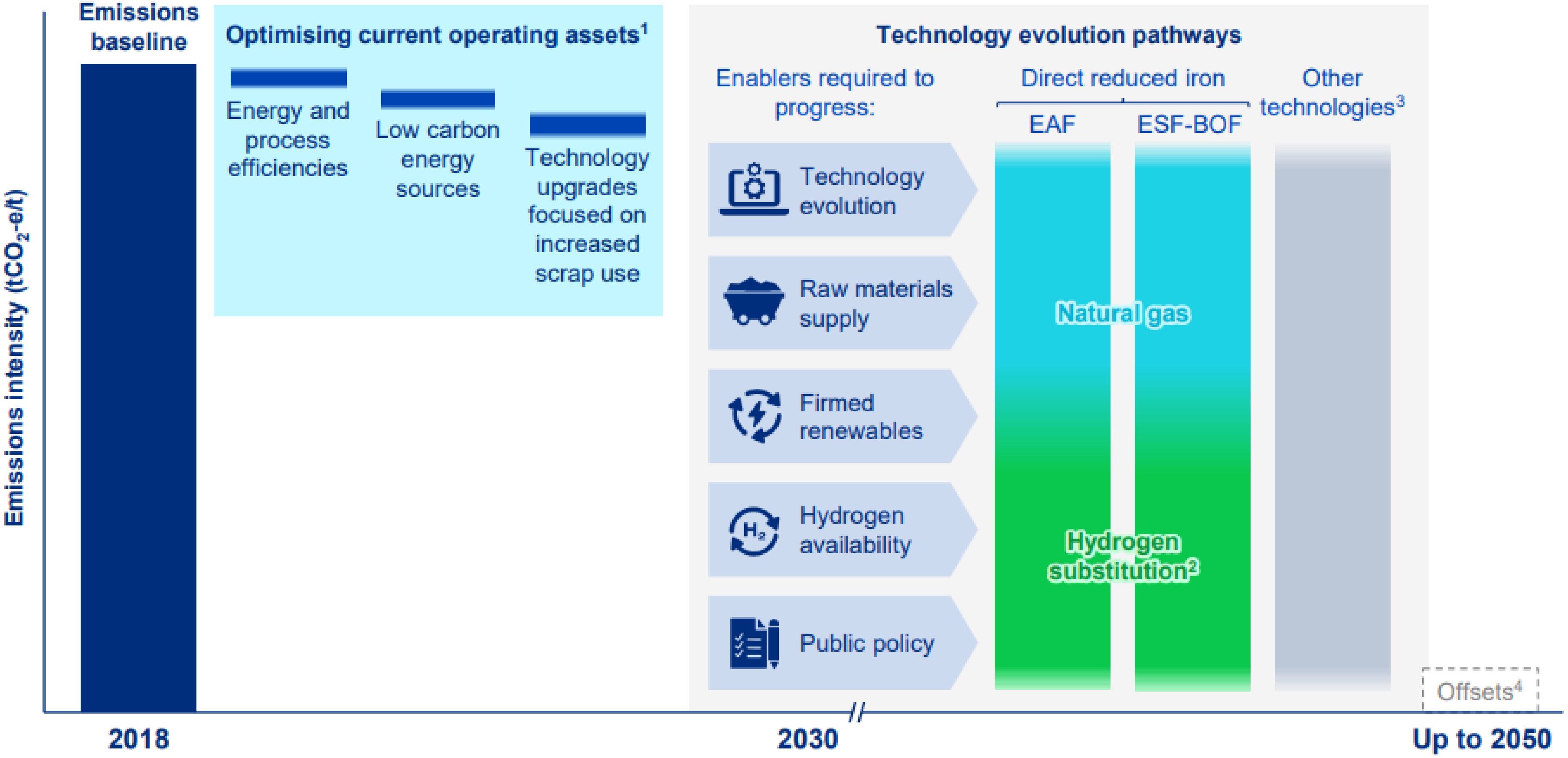
Capital for climate projects and initiatives over the next 5 years

- Appointed a Chief Executive Climate Change and established a corporate climate team
- Climate scenarios revised, including a 1.5ºC scenario
- Climate further integrated into Capital Allocation Framework
- Conducted a detailed climate physical risk assessment across >60 operational sites
- We are listening to our customers to create innovative and more sustainable products
- Our people are our strength – developing innovative, practical and efficient solutions
- Climate performance linked to executive remuneration
- Leading roles in key climate initiatives such as ResponsibleSteel™

1. Our 2050 net zero goal covers BlueScope's Scope 1 and 2 GHG emissions. Achieving the 2050 net zero goal is highly dependent on several enablers, including commerciality of emerging and breakthrough technologies, the availability of affordable and reliable renewable energy and hydrogen, availability of quality raw materials, and appropriate policy settings.
2. The Non-Steelmaking Target applies to our midstream activities that include our cold rolled, metal coating and painting lines and long and hollow products. It excludes our downstream activities.

INDICATIVE IRON AND STEELMAKING DECARBONISATION PATHWAY

Taking a dual-stream approach; focus on both near term process asset optimisation and longer-term technology evolution



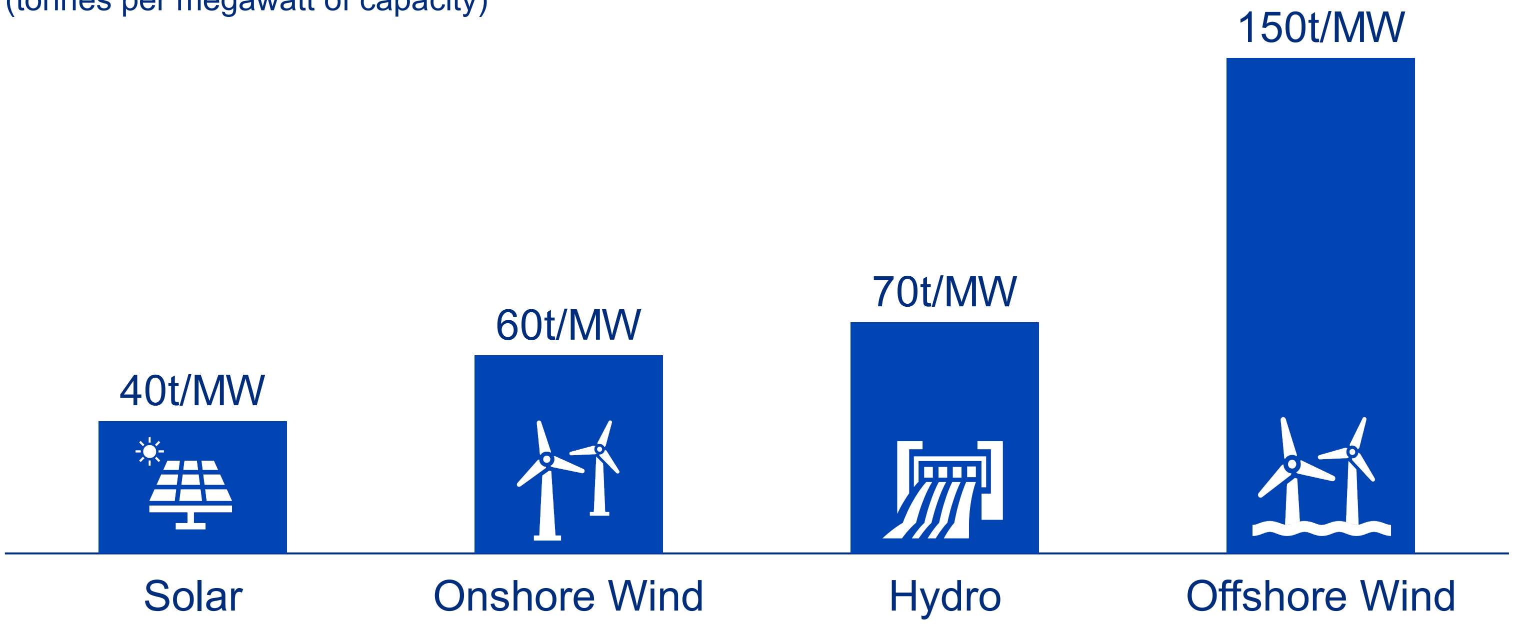
1. Optimising current assets involves working within currently available technology options to improve the efficiency of assets and processes, including upgrading technology where there are supportive enablers.
2. Contingent upon commercial supply of hydrogen from renewable sources.
3. Other technologies include electrolysis, CCUS and biocarbon, etc.
4. We retain the option to use offsets to meet our 2050 net zero goal where direct abatement is not technically or commercially feasible.

For more information, see page 41 of BlueScope's FY2023 Sustainability Report, available at www.bluescope.com/sustainability/reports

THE AGE OF STEEL:
CRITICAL TO THE WORLD’S FUTURE

A foundation for global decarbonisation; underpins renewable energy transition

Estimated steel required for renewable energy infrastructure[1]
(tonnes per megawatt of capacity)



The Blast Furnace Process at Port Kembla Steelworks - Bing video

~2 million tonnes of additional steel needed to meet Australia’s 2030 renewable energy targets; ~10 million tonnes to meet 2050 targets[2]

1. Source: BlueScope analysis
2. Source: BlueScope analysis, based on AEMO forecasting

For more information, see page 9 & 10 of BlueScope’s 2021/22 Sustainability Report, available at www.bluescope.com/sustainable-steel

The Australian Steel Industry CO2 breakthrough program

BlueScope

The CO2 breakthrough program was a collaboration between the CSIRO, BlueScope and Arrium and ran from 2006 to 2014.

The program identified that an integrated steelworks could use biochar to replace carbonaceous feedstocks in Ironmaking.

Two relevant outcomes were:

- A widely cited paper “Utilization of biomass as an alternative fuel in Ironmaking”
- Development of biochar pilot plant at CSIRO, Clayton Victoria.

Potential Applications of Biochar in Steelmaking

Application	Basis	Net emissions reduction: t-CO_2/t-crude steel	Net emissions reduction: % of CO_2 emissions
Sintering solid fuel	50–100% replacement of coke breeze or anthracite at 45–60 kg-coke or anthracite/t-sinter (and 1.7 t-sinter/t-HM)	0.12–0.32	5–15
Cokemaking blend component	2–10% of coking coal blend, with coke used at 300–350 kg-coke/t-HM	0.02–0.11	1–5
BF lump charcoal charge	Replace 2–10% of coke lump charge with coke used at 300–350 kg-coke/t-HM	0.02–0.11	1–5
BF nut coke replacement	50–100% replacement of 45 kg-nut coke/t-HM	0.08–0.16	3–7
BF carbon/ore composites (unreduced)	Replace 5–10% of iron charged to the BF by unreduced charcoal/ore briquettes	0.08–0.15	3–7
BF prereduced feed	Replace 5–10% of iron charged to the BF by prereduced charcoal/ore briquettes	0.09–0.18	4–8
BF tuyere fuel injectant	Full replacement of injected coal (PCI) at 150–200 kg-coal/t-HM	0.41–0.55	19–25
Totals		0.82–1.58	36–72

PKSW BIOCHAR TRIAL

ARENA partially funded a PKSW Emissions reduction study in partnership with UOW.

The main outcomes for the project are:

- Deliver a report considering the economic and technical viability of decarbonisation options
- Pneumatic testing of pulverised coal and biochar blends
- Trial of a partial replacement of pulverised coal with biochar for use in the blast furnace tuyeres.

The trial used up to a 30% biochar blend for 24 hours with no significant adverse effects on the process (~1000T dry consumed).

Biocarbon use at PKSW

BlueScope

Potential realistic applications of biomass derived biocarbon in Ironmaking and Steelmaking operations at PKSW

Application	Basis	Biochar (t p.a.)
Blast furnace pulverised coal replacement	Up to 100% replacement at 150kg/t-HM and 7900t-HM/day	425,000
Sintering solid fuel	Up to 30% replacement of solid fuel	70,000
Coking coal replacement	Up to 3% replacement without impact on coke properties	68, 000
Steelmaking re-carburizer	Full replacement of calcined anthracite or petroleum coke	1000
	Total	**564,000**

Typical PCI quality

Property	Range
Ash	< 10% db
Volatile Matter	< 20% db
Fixed Carbon	> 74% db
Alkalies (Na_2O + K_2O)	< 0.7% db (in ash)
Moisture	<15% wet mass basis
Size	<50mm
Arsenic	< 4mg/kg
Chrome	< 25mg/kg
Lead	< 8mg/kg
Zinc	<50mg/kg

Safeguard mechanism -Overarching Principles

BlueScope

1.) The Safeguard Mechanism is the vehicle to achieve the Labour Policy of "Repowering Australia" with a stated aim of a 43% reduction in GHG emissions by 2030 from 2005.

2.) The Mechanism covers 215 facilities (28% of Australia's total emissions) with scope 1 GHG emissions above 100,000T pa.

3.) The scheme aims to cap emissions to 100MT by 2030 from the current 143MT

4.) Deviation from baseline require an adjustment (credit or liability) via ACCU's (Australian Carbon Credit Units) although capped to $75/TCO2eq + CPI +2% per year.

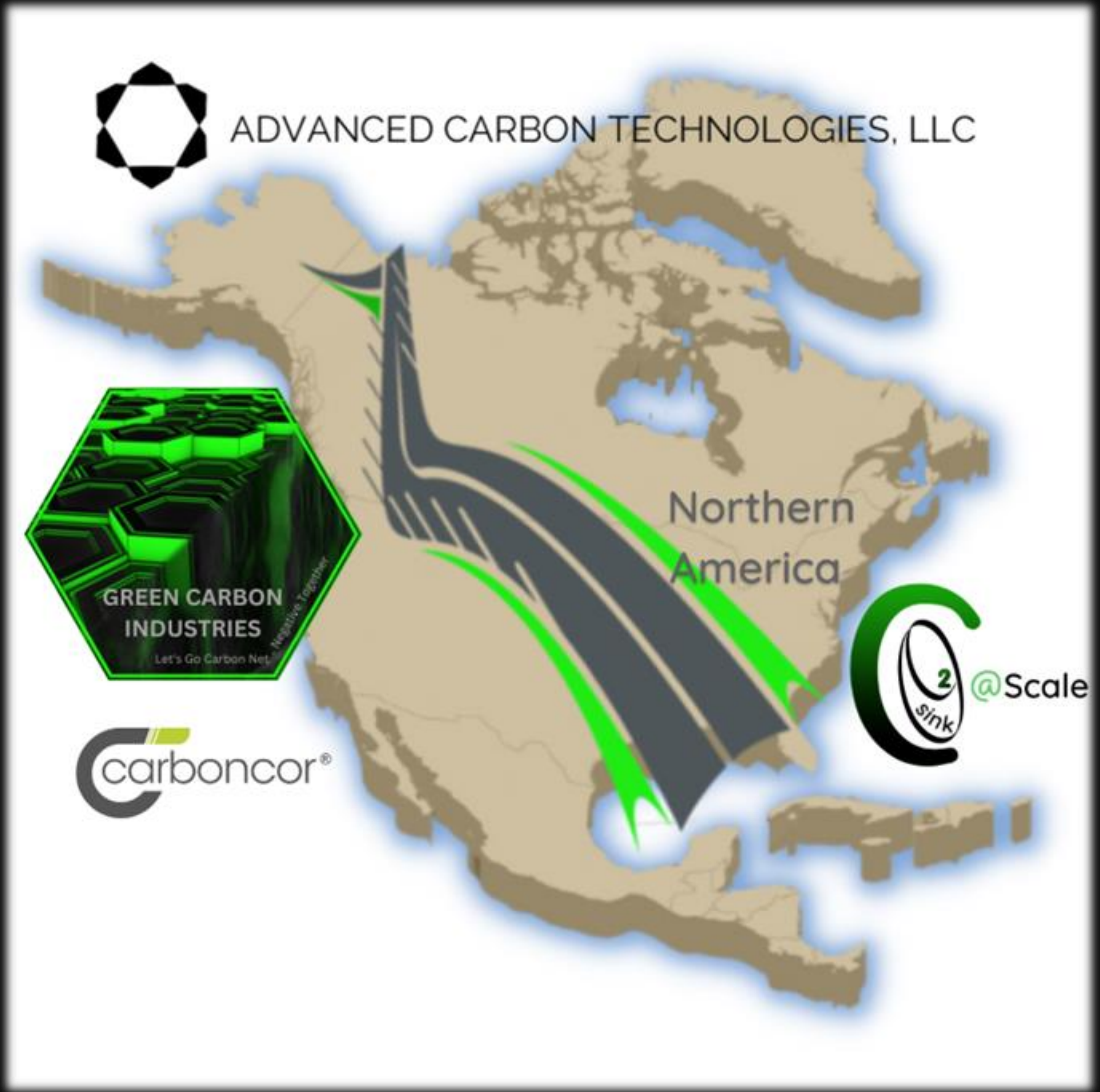
PROPOSAL FOR A BIOCHAR PLANT AT PKSW

- Collaborated with a Pentarch to develop a proposal to produce biochar using woodchips as a feedstock.
- The project utilised European Technology similar to Arcelor Mittal's Steelworks in Ghent, Belgium.
- The CAPEX required to produce ~ 30,000T biochar was 90-110M AUD and was deemed uneconomic.
- Focus has moved to potential Biocarbon supplies local to available feedstocks.

Questions?

Carbon Capture and Sequestration (CCS) at scale utilizing Biochar in:

- Construction
- Soil Stabilization
- Pavements & Roads



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Let's Go Carbon Net - Negative Together

Utilizing Technology from

carboncor

Nov 2022

Let's Go Carbon Net-Negative Together

CONSTRUCTION BIOCHAR WILL BE THE *BRAKE* AGAINST CLIMATE WARMING!

Agenda

- Introduction
- Mission
- Timeline
- Specifications
- Why Green Carbon Technology

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ADVANCED CARBON TECHNOLOGIES, LLC

Bringing unique environment safe technology to Northern America to establish high Carbon Sink & Storage "Biochar" based roads and construction

A diverse array of Biochars can be used (photo credit Sanjai Parikh)

ADVANCED CARBON TECHNOLOGIES, LLC

GREEN CARBON INDUSTRIES

Introduction

Green Carbon Industries are further developing Environment Safe Technologies @ Scale for applications around circular economic carbon drawdown and storage in a variety of industries centred around both Construction, and Renewable Energy Technologies.

Carbon Sink & Storage (CCS) @ Scale

We have unique capabilities, utilizing natural and environment safe cold emulsion bonding technologies, with high Biochar content across a wide range of construction applications. Our superior penetration bonding mechanisms enable our product installations to achieve "carbon net negative" status due to carbon sequestration at scale (high Biochar content), as well as Green House Gas Emission Avoidance savings towards true carbon drawdown status.

ADVANCED CARBON TECHNOLOGIES, LLC

High Permanence and Longer Lasting

Carbon sequestered is stored near indefinitely within an inert road base and various general construction applications, making our products and installations more cost effective per m^2, easier to use, stronger by an order of magnitude and far safer for the environment if compared to conventional hot asphalt and cement applications.

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Negative Together

Let's Go Carbon Net

Our Mission

We invite you to join us in our ongoing mission towards making our world Carbon Net-Negative by 2030 and beyond.

We will be a Carbon Capture and Storage (CCS) World Leader

We use sustainable sourced Biochar from biomass and reclaimed waste, our unique emulsions and a wide range of quarry aggregates, soils, gravels and recycled building waste that to produce high performance materials containing high concentrations of Biochar towards Carbon Sink at scale.

These higher performance cold mix alternatives to concrete and standard warm or hot mix asphalt pavements are being used as road base, wearing course, and road maintenance applications.

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Carbon Net-Zero vs Carbon Net-Negative vs Emission Avoidance and Carbon Abatement Explained

Carbon Net Zero is similar in principle to carbon neutrality but is expanded in scale. To achieve net zero means to go beyond the removal of just carbon emissions. Net zero refers to all greenhouse gases being emitted into the atmosphere, such as methane (CH_4), nitrous oxide (N_2O) and other hydrofluorocarbons.

Being **Carbon Net Negative** means we offset or remove more carbon from the atmosphere than we emit.

Emissions Avoidance or emissions reduction projects are when an activity or project results in future greenhouse gas emissions being avoided or reduced.

Carbon Abatement simply means curbing emissions in order to reduce the concentration of certain gases and contaminants in our environment.

What have we Done? What's Next?

What have we done? We have demonstrated and proved the use of high Biochar concentrations in both urban and rural construction materials worldwide. High performance pavements for heavy duty mine feeder & haul road applications, general road maintenance, overlay repairs and new road installations

What's next? New soil stabilizing applications throughout a wide industry is also in progress, utilizing in-situ soils and gravels, mixed with our unique environment safe emulsion and high concentration of Biochar.

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American Alliance in Development

GCI/Carboncor

- Emulsion Technology
- Modified Biochar Technology
- Process R&D
- Pyrolysis Technology

- Pyrolysis Partners
- Renewable Energy Partners
- Emulsion Plant & mixing Equipment Supply
- Production Site Operation Partners
- Carbon Sink & Trading Platforms
- EIA & EPA Partners or Consultants
- Technology Licensing SPV

ACT

- Key Raw Materials Control
- Production Site Management
- Carbon Sink Accreditation
- Calciner Technology
- Renewable Energy Technology
- Business Development
- Specialized Packaging Technology

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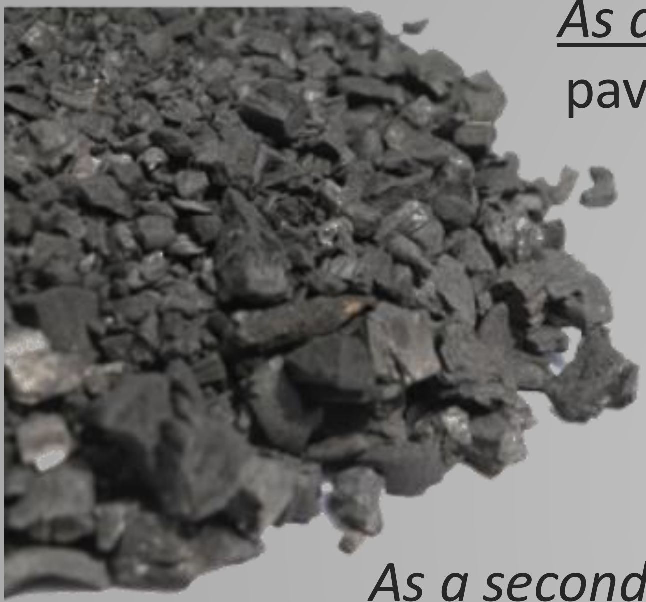
Biochar for Construction - Specifications



As a first phase, most types of Biochar can be used for the pavement products with general specifications as follows:

Minimum Carbon Content -	**40% and higher**
Maximum particle size -	**6 mm preferred**
Maximum moisture content -	**35%**

As a second phase, further modified Biochar applications will be introduced to include specific PSD mix designs, as well as special products that may include contaminated and partially pyrolyzed char waste and other exotic Biochars by mid 2023 onwards

By 3rd quarter 2023, there will also be a demand for higher grade fine grinded Biochar

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Biochar Supply Timeline

While the new Biochar rich pavement material undergoes certification test work, moderate quantities will be required by Spring of 2023 for private and mining haul road installations.

The <6mm fraction of Biochar will be used in the initial roll-out of the standard cold bio asphalt wearing course material, as well as addition to bulk soil stabilization starting spring 2023.

For 2023, the estimated Biochar demand is expected to be ca 25 000 to 40 000 Metric tons.
Follow-on demand is estimated to more than double each year for the next 2 - 5 years.

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Detailed Preliminary Biochar Specifications

- Minimum 40% fixed carbon content. (Biochar will generally have a higher value)
- Particle size max 6 mm.
- Moisture content of no more than 35%.
- “Rest” for a period of no less than 5 days before transport.
- Pass a self heating test at a certified laboratory.
- Biochar that fails the self heating test must be carried in Specialized bulk packaging.
- All pyrolysis feedstock must originate no farther than 250 miles from the pyrolysis plant.
- Most types of waste biomass feedstocks are acceptable.
- Treated or construction & demolition wood feedstock is acceptable.
- High ash content is generally not a problem.
- All efforts to maximize CO_2 avoidance and carbon removal credits should be taken to enhance value.
- Biochar for construction value will be determined by a formula which calculates fixed carbon content permanence, carbon credit value, logistics and Pyrolysis CO_2 footprint.

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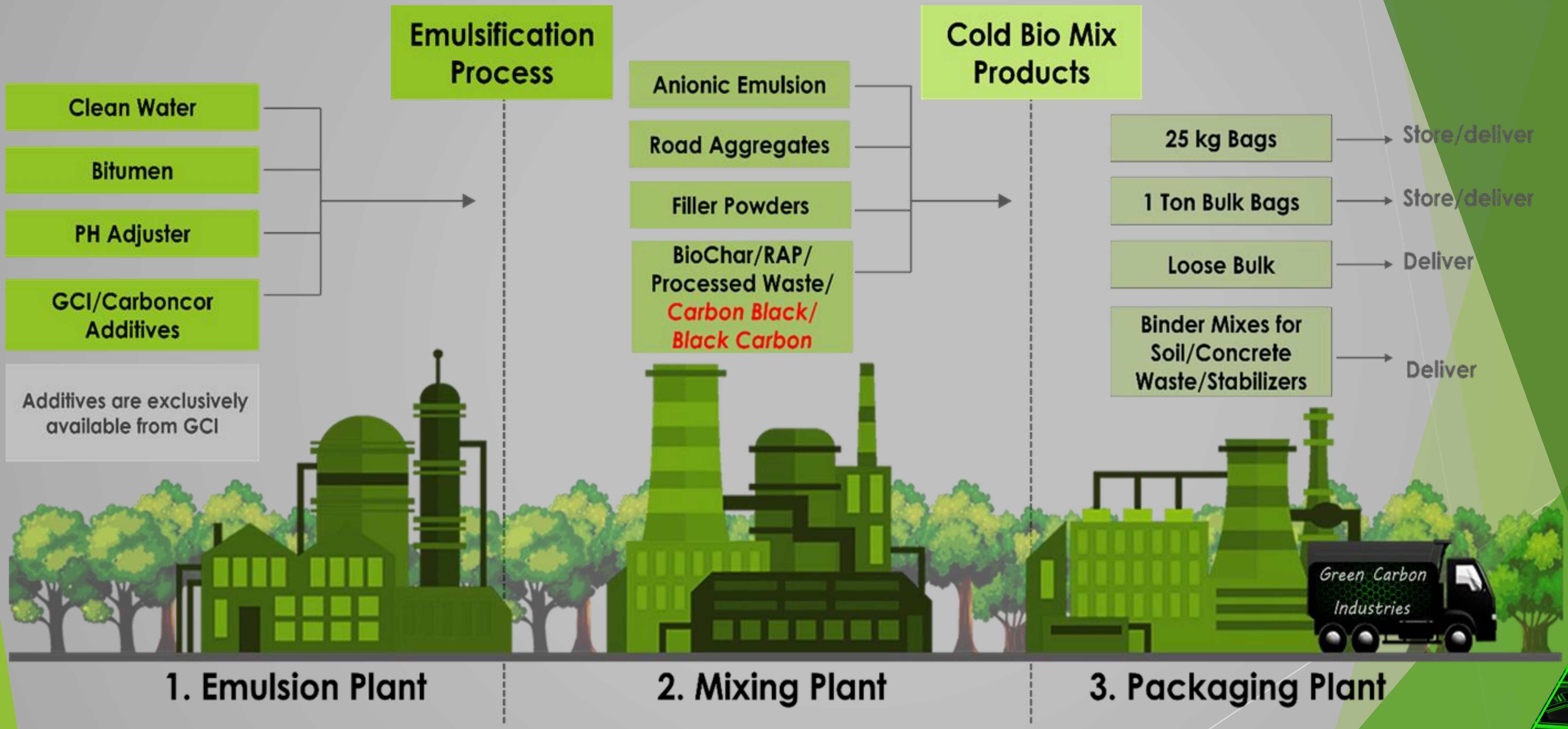
THE PROCESS

Basic production is completed in a ***3 stage*** process with between 80 – 99% of the final product sourced from the local market area in the production territory. More than 30% processed waste can be used as raw materials. Even larger quantities of RAP (Reclaimed Road Pavement) can be used.



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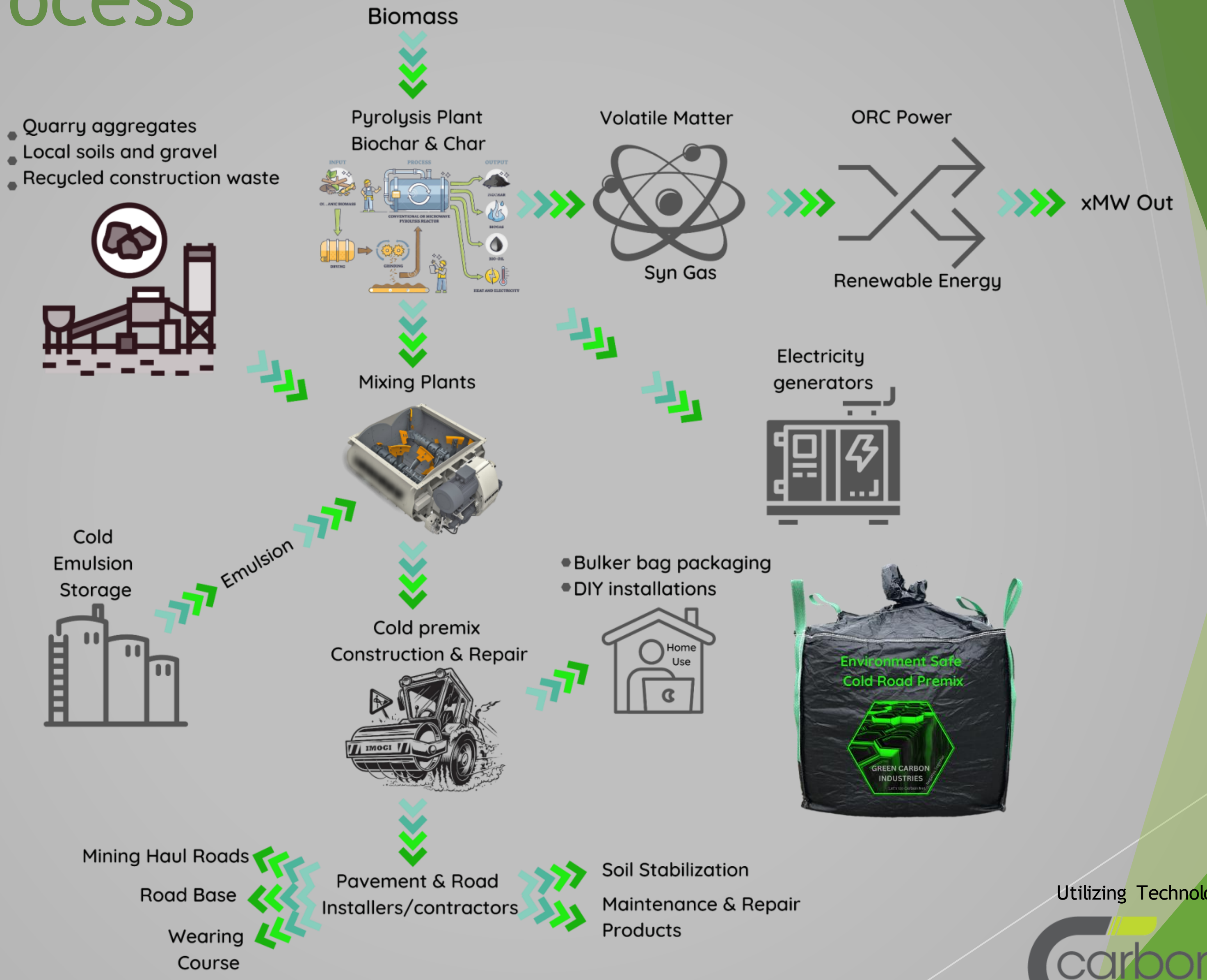
Project Process

What is Biomass?

Biomass is a term for all organic material that stems from plants (including algae, trees and crops). **Biomass is produced by green plants converting sunlight into plant material through photosynthesis** and includes all land- and water-based vegetation, as well as all organic wastes.



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What's next?

Our road to a Climate Target by 2030 and Beyond

2022

- Introduce high Biochar Content Environmentally Safe Cold Asphalt to all of America
- Further educate partners & customers on the use of Biochar in construction & roads

2023

- Establish relevant lab analysis, certification and endorsement process for America

Scale-up of Biochar production on the continent, including awareness of "Waste Material to construction Biochar"

Support & Establish Carbon Sink & Carbon Credit Systems for American producers and consumers

2024

- Onwards – Continue scale-up of Biochar production, and Pavement Carbon Net- Negative applications
- Further develop & Introduce larger scale renewable energy recovery technologies from waste materials

2025

- Further develop and introduce non-biomass waste types to pyrolyzed Biochar applications, as well as integrating renewable energy recovery technology on all the site operations

2026 and Beyond

- Supersize renewable energy recovery from waste to construction char worldwide
- Supersize Biochar use throughout all construction applications
- Supersize waste recycling and for optimum circular economy systems

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Projects Completed

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2 THE PRODUCT

2.1 Carboncor Technology

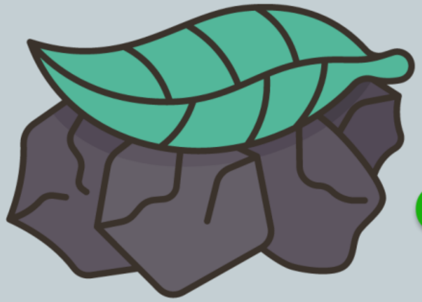
Uses local road aggregates, carbon-based materials and specifically formulated anionic bituminous emulsion to form a permanent solution for all road use. Its benefits include:

- No Cracking ✓
- No "Creeping" ✓
- No Heat ✓
- No Leaching ✓
- No Solvents ✓
- No Tack Coat ✓
- No Waste ✓

Questions

What is Green Carbon?

The colour of carbon matters. Green Carbon is the carbon stored in the plants and soil of natural ecosystems and is a vital part of the global carbon cycle



Why use Biochar and Green Carbon?

Use of biochar, sustainably derived from Green Carbon char significantly enhances permanence and superior high duty pavements are proven

If you would you like to know more, please do not hesitate to contact us

ADVANCED CARBON TECHNOLOGIES, LLC

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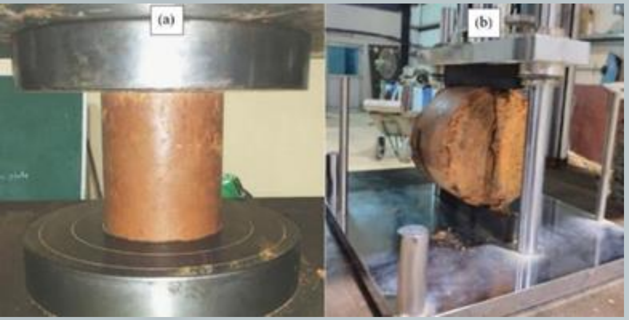
GREEN CARBON INDUSTRIES



THE ROAD TO CERTIFICATION

Resilient Indirect Tensile Modulus (ITM)

Resilient Modulus on Unbound Granular Material

Flexural Beam Modulus

Flexural Beam Fatigue

Wheel tracking (Rut Resistance)

MnROAD

Safer, Smarter, Sustainable Pavements Through Innovative Research

Minnesota Department of Transportation's Road Research Facility (MnROAD)
National Center for Asphalt Technologies (NCAT)

Measuring the Benefits of Pavement Preservation
and
Quantifying the Impact of Premium Mix Additives

Partnership Vision

This partnership between MnROAD and NCAT facilitates high-value pavement research that addresses national needs using full-scale pavement testing facilities in both warm and cold climates on flexible, rigid, and composite pavement structures

National Center for Asphalt Technology NCAT at AUBURN UNIVERSITY

CAPRI CONSORTIUM FOR ASPHALT PAVEMENT RESEARCH AND IMPLEMENTATION

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TAKE AWAY:

Africa and Asia on route

- Use of Biochar sustainably derived from Green Carbon char significantly enhances performance and superior high duty pavements are proven in Africa and ASEAN countries.
- Using GCI and Carboncor technology, up to 300 tons of Biochar or char sequestrated per mile of 2 lane road.
- The binder + Biochar products are also used for military and rural road maintenance (pothole, stabilization, overlays) with high Biochar content.

For America

- Great opportunity to use Biochar and carbonaceous chars to enhance durability for pavement construction and road repairs.
- We need to validate its efficacy using local Biochars, bio-coals and chars.
- Carbon sink certification for the Biochar rich pavement is on route in America already.

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THE POSITIVE IMPACT ON CLIMATE

- 70 Mil to 100 Mil tons of Biochar material needed to make environment safe char-based asphalt road mixes for the asphalt roads constructed every year…greatly increased Biochar sales value.
- Biochar from forest clean-up, residuals and from fire damaged wood resources, insect damaged wood and construction and demolition wood can be safely used.
- Carbon is sequestered in the pavements and provides a superior bonding mechanism.
- More conductive and with less layer thickness, this will reduce heat sink effects.
- Reduced installation related emissions and simpler road construction.
- Existing infrastructure and equipment can be used.
- Renewable Energy Recovery during production and converted to sensible heat and converted to power using ORC turbines.
- When technology is verified by NCAT and MNROAD, state adoption can proceed.
- Biochars & chars can also be used in various industries as carbon sink alternatives to reach Global Climate Targets.

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EASY TO USE TECHNOLOGY

Road Wearing Course Installations

Step 1: A small % (less than 1% of final mix) Carboncor and GCI additives are used to manufacture a cold anionic emulsion.

Step 2: Standard quarry aggregates are mixed with Biochar and emulsion and has a "on tipper truck" shelf life of up to 2 weeks.

Step 3: Standard road paving equipment is used, with no heat or solvents required.

- Compaction is by way of light weight equipment only, while total time of installation is reduced due to reduced wearing course thickness required. All surfaces must be damp before installation commences, so no extended drying times for road base required.

Step 4: Curing within a few hours, depending on weather conditions.

- For low volume roads in a straight line, roads can be opened immediately after compaction.

Road base, Soil Stabilization and Hardstands

Step 1: Use of standard mechanized soil stabilization equipment or mobile twin screw pugmill mixer to mix emulsion + Biochar and local soils and gravels, or recycled waste to create a "Weatherproof" base or subbase layer for roads, factory hardstands, airport runways, slope stabilization and various other applications.

- With the addition of slightly higher concentrates of emulsion, the soil stabilizer layer also serves as a dust and skid free wearing course on remote and rural roads.

Utilizing Technology from

USE OF CHARS AS ASPHALT MODIFIER

- Reduce temperature susceptibility (Cooler Pavement)
- Improve Resilient Modulus (Higher Strength)
- Improve binder performance (Effective Binding)
- Better resistance against oxidative aging (Less Binder Breakdown)
- Develop self-healing/fixing properties in pavement
- Sequester carbon long term in pavement installations (Char stays in mix)
- Obtain environmental credits for emission avoidance, energy savings and long-term carbon sinks

Net Benefit: Stronger pavement, less expensive, longer lasting, and easier installation

TRULY CARBON NET NEGATIVE INSTALLATIONS

ADVANCED CARBON TECHNOLOGIES, LLC

Utilizing Technology from

carboncor®

GREEN CARBON INDUSTRIES

Let's Go Carbon Net Negative Together

Meet Our GCI Team

Andre van Zyl

Founder and Director

Wanda Kasselman

Business Development Manager

Anrich van Zyl

Technical Manager

Kay van Zyl

Founder and Director

Ashvin Konasagaran

Operations Manager

Sue Martine

HR Manager

GREEN CARBON INDUSTRIES

Meet the Team in Northern America

- Dr. Donald R. Fosnacht / CTO GSS

  Cell: (773-315-4880)

  Email: drfosn@prodigy.net
- Larry Amick / CEO ACT

  Cell: (919-949-4822)

  Email: tlamick@advancedcarbontek.com
- Tom Nelson / Dir. Biochar Resources

  Cell: (440-897-9118)

  Email: tom@torresak.com
- Link Schumaker / CEO / Global Biosystems

  Cell: (919-444-2191)

  Email: Link@gobiosystems.com
- Jeff Morris / CTO ACT

  Cell: (412-389-5299)

  Email: jeffreywardmorris@gmail.com

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THANK YOU

GREEN CARBON INDUSTRIES

Let's Go Carbon Net - Negative Together

- **Andre van Zyl**
  - Founder and Director
  - andre@greencarbon.world

Green Carbon Industries

WhatsApp Business Account

Scan this code to start a WhatsApp chat with Green Carbon Industries.

- **www.greencarbon.world**

CO_2 sink @Scale

Biochar for Erosion Control, Revegetation & Rehabilitation

Vital Chemical

- B & K -
REVEGETATION & LANDSCAPING

Ben Hough

Chief Commercial Officer

Vital Chemical

Cameron Darby

Sydney District Manager

B&K Revegetation & Landscaping

Vital Chemical

Vital Chemical assists clients overcome challenges by formulating, manufacturing, and providing environmentally sound products and services to manage erosion, dust, revegetation, concrete cleaning and removal and specialised heat exchange corrosion inhibition.

B & K are a commercial landscaping and revegetation specialist contractor with three areas of expertise and service – Landscaping, Revegetation, and Bush Regeneration.

- B & K -
REVEGETATION & LANDSCAPING

Vital Biochar

Vital Biochar meets the growing demand for reliable, at scale supply of biochar across a range of sectors:

- Revegetation
- Amelioration
- Water Treatment
- Contamination Isolation and Remediation

Feed Stock

Vital Biochar is sustainably sourced and produced in Australia from thermally treated organic forest residues and waste timber.

- Clean Green
- Quality Control
- Constant Supply

Our Process

Utilising a mobile solution that can reduce wood residue down by up to 90%. The remaining is sequestered Carbon which, can be repurposed for water and soil remediation.

Source: Sustainable Queensland timber plantations (mainly root structure/debris)

Synthesis: Pyrolysis up to 500 – 1000°C

Output: 100% Organic Carbon & up to 84% Total Carbon

National Arboretum Revegetation Growth Study

Vital Biochar Availability

Vital Biochar is available in three grades, 1-3mm, 4-7mm and 7-25mm within various pack sizes including 30L bags and bulk-a-bags.

Vital Chemical and B&K Revegetation & Landscaping are incorporating Vital Biochar at a dose rate of 10-20% within turnkey applications of VE Gro-Matt and VE Organic Matt.

1-3mm **4-7mm** **7-25mm**

Objective

Investigate addition of recycled carbon back into soil under varying formulations and environmental exposure.

Scope

- Carbon measured quarterly in soil
- Carbon measurement in soil and vegetation after 12 months

Materials

Vital Biochar & Vital VCell dosed into range of soil binders and hydromulch

Location

- Canberra, ACT Australia
- 20 plots of varying formulation incorporating different carbon amendments, microbes & fibres (wood/straw)
- Temperature challenges (-5°C to 45°C)


Vital Chemical


Vital Chemical

Vital Biochar Applications

Albert Hall (ACT)

Albert Hall (ACT)

3 months post application

Sunshine Coast Waste Disposal (QLD)

Warringah Freeway Upgrade (NSW)

Canberra Arboretum (ACT)


Pullenvale (QLD)
14 days post application
Vital Chemical

Vital Chemical

- B & K -
REVEGETATION & LANDSCAPING

ONE DAY INTERACTIVE WORKSHOP

Biochar in NSW: Unifying Policy,Agriculture and Urban Development

ANZ BIOCHAR INDUSTRY GROUP · CATALYST Environmental Management · WESTERN SYDNEY UNIVERSITY Hawkesbury Institute for the Environment · DECARB HUB New South Wales Decarbonisation Innovation Hub · HIWAY GROUP · Vital Chemical · B & K REVEGETATION & LANDSCAPING

Supporters and Sponsors

The development of the Australian Biochar Industry 2030 Roadmap has been supported by many organisations. We acknowledge and thank them for their support.

Diamond

- EARTH SYSTEMS – Environment | Water | Sustainability
- CARBON STANDARDS international
- WASTE CIRCOLOGY – Sustainable Carbon Technology
- NewWorld – CLIMATE & AGRICULTURE
- C-TWELVE
- SYNDICATION GROUP

Silver

- CATALYST Environmental Management
- RegenerativeAg ALLIANCE – Resilience through farming together
- EAL Environmental Analysis Laboratory
- Southern Cross University
- energylink SERVICES
- CARBON FARMERS OF AUSTRALIA

Bronze

- MS2
- Carbon Drawdown Projects
- ECHO2 – sky carbon to earth
- Sustainability Plus Projects
- Melbourne Water – Enhancing Life and Liveability
- Energy Farmers AUSTRALIA
- CINCH
- AET Advanced Energy Tech
- South East Water
- accend
- THE PENTARCH GROUP
- future energy
- kalsawmills
- GECA Environnement
- Barwon Water
- Köchii Australian EUCALYPTUS OIL
- BYRON BIOCHAR
- OPTIMAL – optimised energy solutions

HIWAY GROUP

ANZBIG Workshop

Peter Metcalfe
Group CEO

November 2023

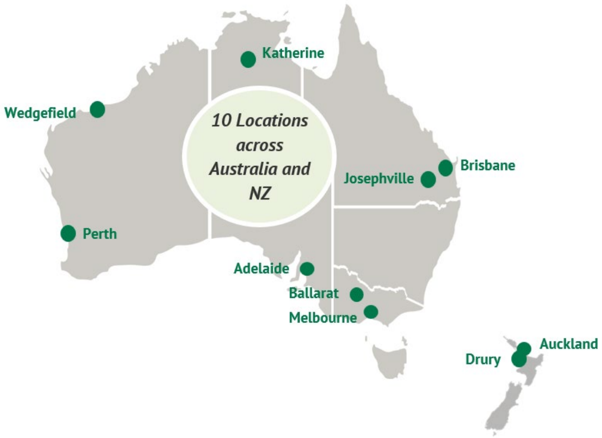
www.hiways.co.nz

SNAPSHOT OF HIWAY GROUP

Business Overview

- Hiway Group is Australasia's largest, leading provider of specialist insitu recycling and ground improvement solutions, with over 35 years' experience in the construction of road, rail, renewables, defence, ports & airports infrastructure
- A strong track record of growth averaging an annual 29.3% year on year since 2016
- Hiway Group's key differentiator - Technical & innovative delivery capabilities. Focused on advanced technical solutions, working with clients on design optimisation and alternative recycling treatment options that provide - improved end performance outcomes, and a reduced carbon footprint while delivering significant cost savings

Geographic Presence



Carbon Focus

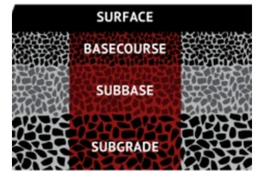
- Hiway Group solutions generally provide for a 30-50% reduction in carbon emissions over traditional methods of road construction
- Hiway Group solutions provide for a 40-50% reduction in time to construct
- Hiway Group is active in lobbying and shaping a political focus towards decarbonisation of the transport infrastructure sector
- Since 1986, Hiway has saved its clients, 3,0323,574,077 KG's of Carbon

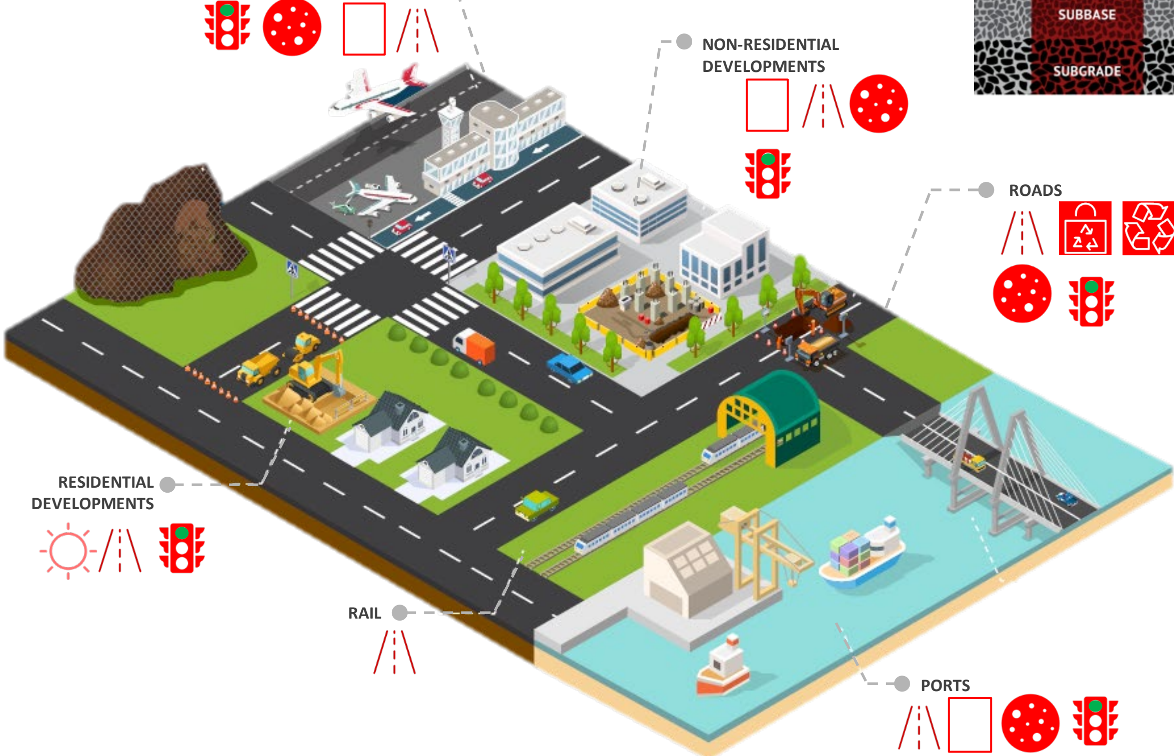
HIWAY'S SANDIT WE PLAY IN

HIWAY GROUP

Hiway's innovative ground improvement solutions are used in a range of infrastructure maintenance and construction Insitu recycling applications

Composition of a road





Pavement Recycling

Basecourse, subbase & subgrade recycling (inc MasterCarb CR & LR)
Involves addition of binders, polymers and agents to new and existing soil and construction materials to improve pavement performance

MasterTex
Process which re-texturises flushed surface courses without removing bitumen

MasterCarb A
Insitu cold recycled asphalt

Foamed bitumen recycling (MasterPave)
Pavement rehabilitation process involving the mixing of foamed bitumen with either new or existing materials

Fill drying
A variety of specialist binders (e.g. lime) are applied to soil to achieve instant drying and conditioning, allowing earthwork projects to continue without weather delay

Ex-Situ
Manufacture CTB or foamed bitumen utilising new or recycled materials. The ex-situ process is a production plant with the material produced off site transported and then paver laid, in-situ

Heavy Duty Pavements
Specialist designed heavy duty pavements for high loading applications

HIWAY'S CORE SERVICES

Hiway Group's innovative ground improvement solutions have a broad range of infrastructure maintenance and construction applications, and significant long-term performance benefits

HIWAY GROUP

Subsurface Recycling & Reuse (MasterCarb CR & LR)

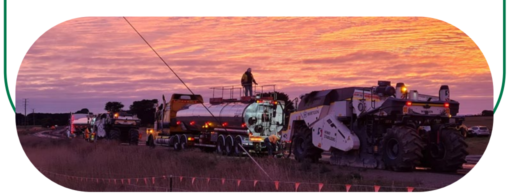
Description

Improves performance of subgrade, subbase and basecourse layers

Existing subsurface materials is combined with binders then is re-laid to optimise groundwork structure – Biochar addition at this point

Benefits

- ✓ Improved performance of subsurface layers providing for reduced pavement depth design requirements
- ✓ Recycles existing materials, reducing aggregate requirements
- ✓ Faster construction time



Fill drying

Description

Chemical alteration of soil structures, converting into a useable and controlled engineering fill

Specialist binders incorporated into existing ground soil to remove water and strengthen subsurface soils

Benefits

- ✓ Instant drying and soil conditioning
- ✓ Substantially increases subsurface strength
- ✓ Can remove water up to 3x binder weight
- ✓ Extends earthworks season

Aggregate modification

Description

Enhances marginal aggregates to exhibit structural and performance properties equal or better than premium quality aggregates

Special blended binders incorporated into marginal aggregates to improve performance

Benefits

- ✓ Much lower cost than traditional methods
- ✓ Reduces reliance on premium aggregate
- ✓ Applicable to both subbase and basecourse

HIWAY'S CORE SERVICES (CONT.)

Hiway Group's innovative ground improvement solutions have a broad range of infrastructure maintenance and construction applications, and significant long-term performance and functional benefits

HIWAY GROUP

Foamed Bitumen Recycling (MasterPave)

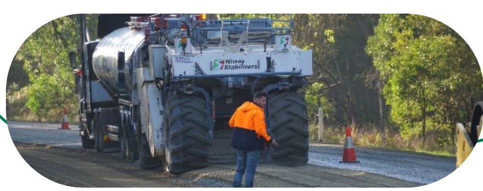
Description

Bitumen is foamed with specialist additives and rejuvenators and incorporated into existing asphalt. This is then picked up with specialist plant and re-laid through a paving operation

Provides long-term rehabilitation and 100% recycling of existing asphalt roads that have reached the end of their useful life

Benefits

- ✓ Performance equivalent to asphalt
- ✓ Surface can be trafficked almost immediately
- ✓ Eliminates the need for new aggregates



MasterCarb A

Description

A cold in-situ recycled asphalt providing an alternative to existing hot produced asphalt. MasterCarb utilisises existing in-situ roading materials incorporates a specialised binder developed by our partners C12 and includes Biochar at 5% and other powdered binders.

Benefits

- ✓ Equivalent or better performance to asphalt
- ✓ Eliminates the need for new materials
- ✓ Reduced cost to new asphalt
- ✓ Carbon negative

MasterTex

Description

Alternative solution to asphalt flushing in wheel tracks that retexturizes the road surface without requiring water blasting

Involves reheating the asphalt and adding chip aggregate to the heated bitumen to retexturize the surface

Benefits

- ✓ maintains pavement integrity rather than damaging it through the removal of bitumen
- ✓ Corrects the volumetrics & restores texture
- ✓ Lower environmental impact

A CASE STUDY

	SH2 WAIHIERE STRAIGHT	SH2 POTENTIAL SITE	SH2 CLARKES CORNER II	SH2 RAILWAY TUNNEL	SH2 KORTES BROWN I & II	SH2 MANGATU & DYMOCKS I
THE TRADITIONAL APPROACH	Chinseal Surface 160mm AP40 Overlay Cement Modified to 200mm 190mm Stabilised Basecourse	Chinseal Surface 160mm AP40 Overlay Cement Modified to 200mm 210mm Granulated Layer	Chinseal Surface 150mm AP40 Overlay Cement Modified to 200mm 200mm Granulated Layer	Chinseal Surface 150mm AP40 Overlay Cement Modified to 200mm 200mm Granulated Layer	Chinseal Surface 175mm AP40 Replacement Cement Modified to 200mm 40mm Old Base 40mm Old Seal 200mm GAP65 Subbase	Chinseal Surface 150mm AP40 Overlay Cement Modified to 200mm 170mm Old Basecourse
CONSTRUCTION TIME	14 DAYS	6 DAYS	6 DAYS	6 DAYS	15 DAYS	7 DAYS
TOTAL PAVEMENT COST	$573,259	$204,309	$207,026	$163,289	$675,411	$269,565
WHOLE OF LIFE CO2e	378,988kg	111,256kg	117,547kg	86,747kg	423,242kg	183,761kg
ALTERNATIVE DESIGN FOAMED BITUMEN RECYCLED	Chinseal Surface 230mm Foamed Bitumen Basecourse 240mm Existing Pavement	Chinseal Surface Overlay 75mm & 230mm Foamed Bitumen Basecourse 15mm Existing Basecourse 40mm Old Seal 40mm Old Base 65mm Subbase 30mm Old Seal 250mm Subbase	Chinseal Surface 100mm Ovlerlay and 230mm Foamed Bitumen Basecourse 160mm Bound Subbase I 40mm Subbase II 50mm Old Seal	Chinseal Surface 230mm Foamed Bitumen Basecourse 40mm Old Seal 200mm GAP65 Subbase	Chinseal Surface 240mm Foamed Bitumen Basecourse 280mm Existing Pavement	Chinseal Surface 230mm Foamed Bitumen Basecourse 120mm Existing Pavement Subgrade CBR = 4 CDF = 1.78
CONSTRUCTION TIME	5 DAYS	3 DAYS	2 DAYS	2 DAYS	4 DAYS	3 DAYS
TOTAL PAVEMENT COST	$581,135	$255,963	$277,364	$185,126	$604,414	$365,451
WHOLE OF LIFE CO2e	188,149kg	56,932kg	60,440kg	43,875kg	199,230kg	93,712kg
CLIENT VALUE	9 DAYS 190.8T CO2e 378.9T CO2e inc BC	3 DAYS 54.3T CO2e 111.2T CO2e inc BC	4 DAYS 57.1T CO2e 117.5T CO2e inc BC	4 DAYS 42.9T CO2e 86.7T CO2e inc BC	11 DAYS 224.0T CO2e 423.2T CO2e inc BC	4 DAYS 90.0T CO2e 183.7T CO2e inc BC

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CLIENT VALUE – PROGRAMME ASSESSMENT

THE TRADITIONAL APPROACH	158 CONSTRUCTION DAYS $6.64M TOTAL INVESTMENT 3.786M kgCO2e
OPTIMISED DESIGN UTILISING FOAMED BITUMEN RECYCLING	64 CONSTRUCTION DAYS $6.4M TOTAL INVESTMENT 1.869M kgCO2e 0.00M kgCO2e if we include 1% BC

THE SAVINGS & IMPROVEMENT

94 CONSTRUCTION DAYS SAVED
1.917M kgCO2e SAVED
Or 3.786M kgCO2e with Biochar

23.42 LANE KM
REMEDIATED
IMPROVED
PERFORMANCE
LONG-TERM RESILIENCE

HIWAY GROUP

THE MARKET OPPORTUNITY FOR BIOCHAR

Biochar Use in Transport Infrastructure

- 1% addition of biochar specially blended prior to deliver to site & incorporated into Hiway's traditional core products provides for a carbon neutral outcome
- The biochar addition provides for a 5% improvement in strength performance
- All Hiways products can utilise bio-char for both carbon reduction benefits (work progressing on PSD & Pyrolysis temperatures and their effect)
- Hiway are unique in its ability to incorporate bio-char into the pavement rather than try to incorporate char into liquid bitumen i.e. asphalt

Carbon Benefit

- Recycling processes reduce demand for virgin aggregate supply (NZ alone utilises 21m tonnes of aggregate which travels from quarries to site damaging the very road they are building)
- No heat required – safer and less fuel usage
- For road construction, based on the median average, a carbon emissions baseline of 2,231 tCO_2e/lane km is considered as the baseline. NZ Roading network is 94,000km while Australia's Roading network is 810,000 km

Potential Opportunity

- 20,000 tonnes of Biochar p.a. in Hiways core products
- An additional 10-15,000 tonnes p.a. in Hiways asphaltic and new innovation product portfolio roll out (Masters Range).
- Key area is the need to pass through the carbon benefit to the end client – they will not pay extra unless there is some ability to recognise the carbon benefit.
- Clients won't pay $800 per tonne for bio-char
- Hiway could also use a bio-binder in products as a bitumen replacement or extender

THE INFRASTRUCTURE PIE IS BIG

CURRENTLY INSITU RECYCLING IS BETWEEN
6-8% PENETRATED
OUR GOAL IS TO GET TO 20%

QUESTIONS

NSW | ACT FORUM

AUSTRALIAN BIOCHAR INDUSTRY
2030 ROADMAP

ANZ BIOCHAR INDUSTRY GROUP

CATALYST Environmental Management

WESTERN SYDNEY UNIVERSITY
Hawkesbury Institute for the Environment

DECARB HUB New South Wales Decarbonisation Innovation Hub

HIWAY GROUP

Vital Chemical

B & K REVEGETATION & LANDSCAPING

Supporters and Sponsors

The development of the Australian Biochar Industry 2030 Roadmap has been supported by many organisations. We acknowledge and thank them for their support.

Diamond

- Earth Systems – Environment | Water | Sustainability
- Carbon Standards International
- Waste Circology – Sustainable Carbon Technology
- NewWorld Climate & Agriculture
- C-Twelve
- Syndication Group

Silver

- Catalyst Environmental Management
- RegenerativeAg Alliance – Resilience through farming together
- EAL Environmental Analysis Laboratory
- Southern Cross University
- energylink Services
- Carbon Farmers of Australia

Bronze

- MS2
- Carbon Drawdown Projects
- ECHO2 – sky carbon to earth
- Sustainability Plus Projects
- Melbourne Water
- Energy Farmers Australia
- CINCH
- AET Advanced Energy Tech
- South East Water
- accend
- The Pentarch Group
- future energy
- Soft Agriculture
- Kel Sawmills – Specialising in Pine
- GECA Environnement
- Barwon Water
- Kochii Australian Eucalyptus Oil
- Byron Biochar
- Optimal – optimised energy solutions

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ANZBIG Forum

Biochar for Insitu Recycling in Infrastructure Pavement Construction

David Simmons

GM – INNOVATION and CLIENT SOLUTIONS

November 2023

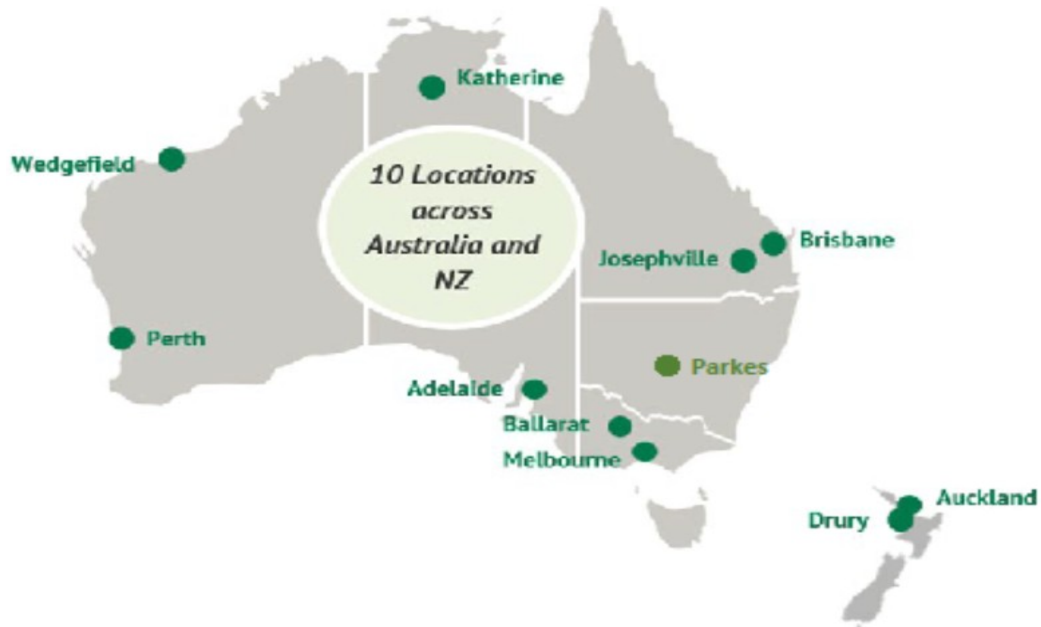
SNAPSHOT OF HIWAY GROUP

Hiway Group is the largest, leading Australasian provider of specialist in-situ & plant-mixed recycling & reuse solutions with a strategic focus on Australian and

Business Overview

- **over 35 years' experience and boasting over 250 dedicated staff.**
- **Delivers road, rail, renewables, defence, ports & airports infrastructure projects including private ventures.**
- **A strong track record of growth year on year.**
- **Industry leading zero harm performance.**
- **Our reuse and recycling solutions reduce carbon emissions, saves time and minimises the use of new virgin materials**

Geographic Presence



TECHNICAL EXPERTISE AND DEDICATED INNOVATION TEAM

Hiway Group has an extensive team of over 250 employees, with dedicated in-house design and technical capabilities to ensure the business remains an Australasian market leader and continues to innovate.

Significant growth in personnel

- Grown to a market leader over 3 decades
- Investment in staff personal and professional development
- Provides clients with leading technologies and solutions

Dedicated in-house design & technical team

- Dedicated in-house design and technical team
- Project design optimisation
- Technical involvement in industry working groups to shape technical specifications that develop reuse and recycling technologies

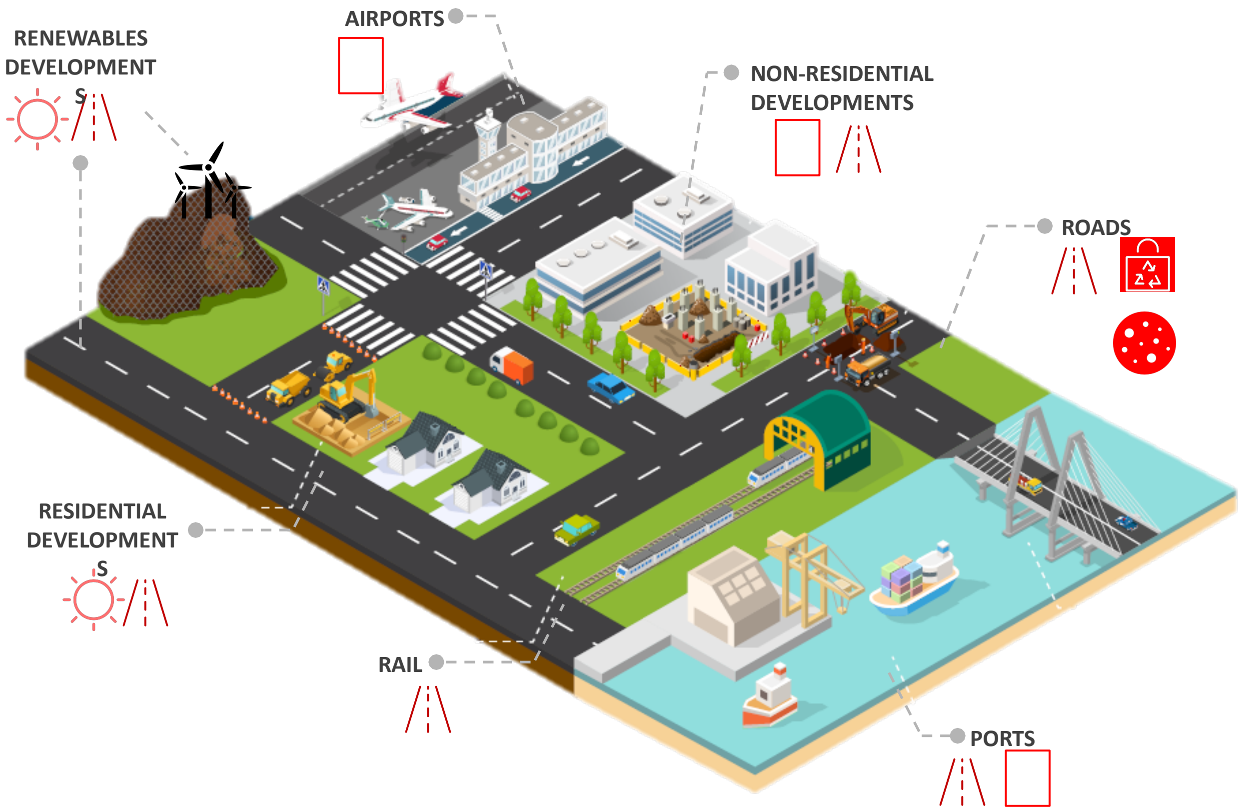
Focus on innovation and product development

- Consistent focus on innovation and product development
- Track record of developing new solutions and bringing these to market.
- A number of alternative innovative technologies are active in the pipeline

HIWAY GROUP

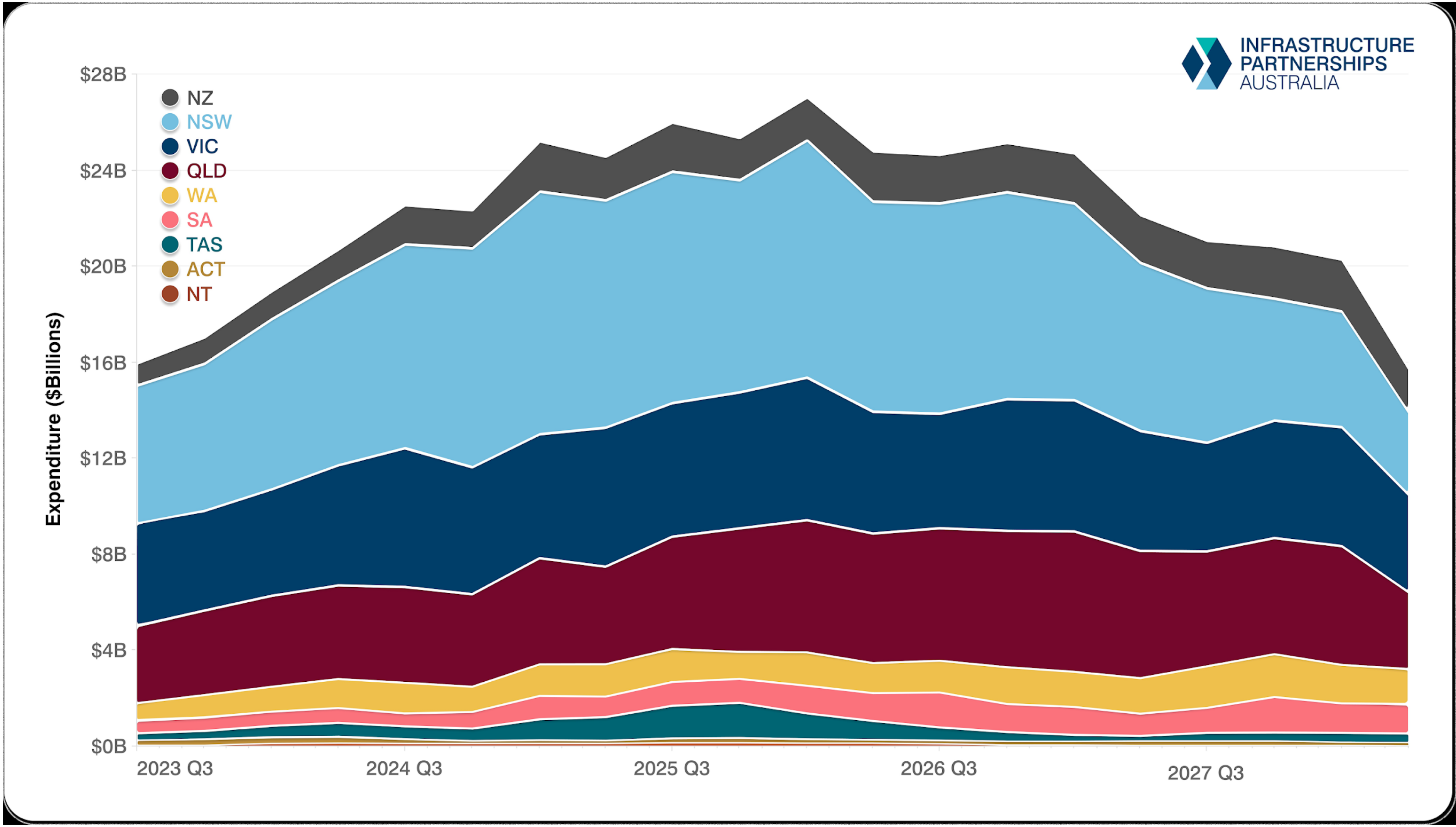
INFRASTRUCTURE SECTORS WE WORK WITHIN

Hiway's innovative ground improvement solutions are used in a range of infrastructure maintenance and construction Insitu recycling applications



Solutions	
	Basecourse, subbase & subgrade stabilisation
	Foamed bitumen recycling
	Fill drying
	Plant mixed
	Heavy Duty Pavements

RECORD LEVELS OF INFRASTRUCTURE ACTIVITY



HIWAY GROUP

THE MARKET OPPORTUNITY FOR BIOCHAR

Biochar Use in Infrastructure

- The addition of bio-char may provide a carbon neutral outcome
- The biochar addition provides an improvement in strength and reduction in pavement fatigue.
- Utilise bio-char for both carbon reduction and pavement improvement
- Minimising virgin materials used in key projects

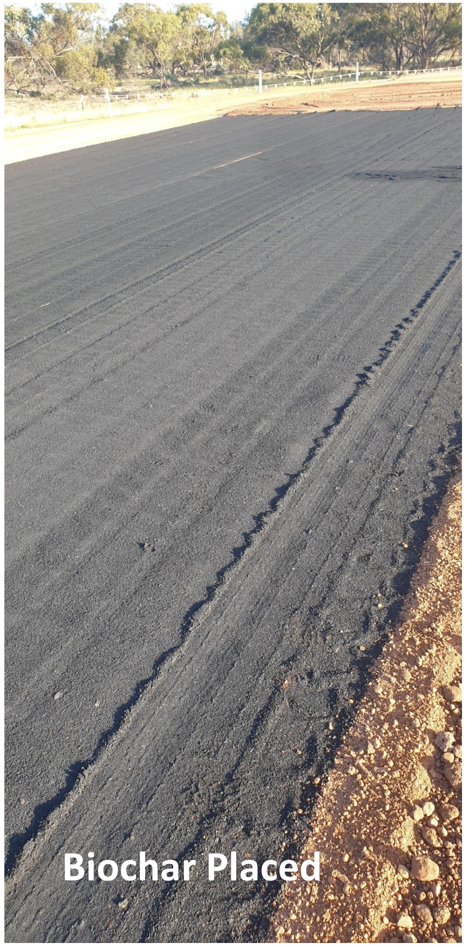
Carbon Benefit

- Hiway are unique in our ability to incorporate biochar into pavements
- No heat required – safer and less fuel usage
- Less impact on the environment – lower emissions
- Competitive edge with clients wanting better environmental outcomes

Potential Opportunity

- Potential 20,000 tonnes of Biochar p.a. in Hiways core products
- An additional 10-15,000 tonnes p.a. in our new innovation product portfolio roll out in 2024.
- Price of Biochar and the benefit to the client will be the key to the products success

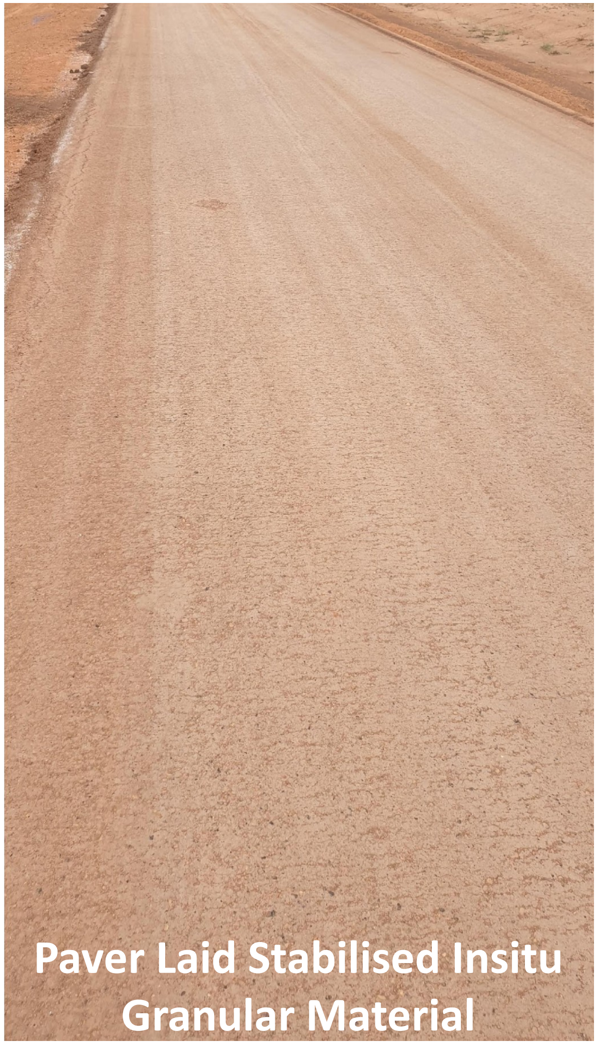
Case Study Watheroo – CBH- WA Sept 2023 -Introducing Hiways MasterCarb.



Project challenges

- Premature pavement failure when exposed to high stress from the DOG. (Drive over grid – very heavily loaded)
- Distance from quality aggregate sources a problem
- Existing unbound local material was marginal
- Birds damage the asphalt where grain fills the voids

Case Study Watheroo WA- Continued



Contracted Scope of Works

Grain Bunker 7

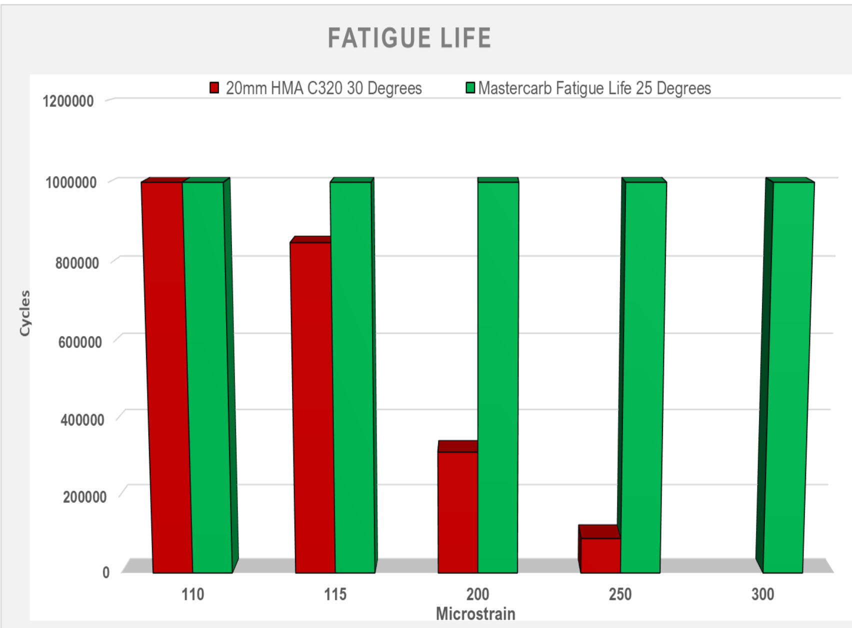
- Total Area – 8,246m^2
- Biochar – 63 tonnes
- Emulsion - 105 Tonnes
- Stabilised Depth – 120mm

DOG Road (Heavily loaded pavement)

- Total Area – 3,000m^2
- Biochar – 30 tonnes
- Emulsion - 51 Tonnes
- Stabilised Depth – 160mm

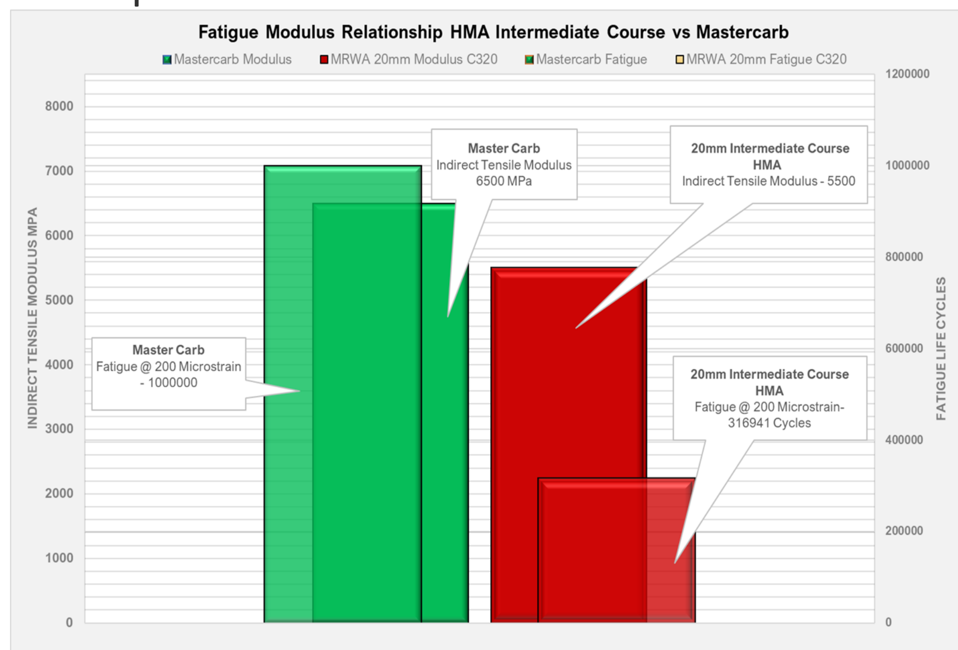
MasterCarb Performance Data from Watheroo Trial

HIWAY GROUP



Fatigue Life

- Compared with MRWA Asphalt data
- Superior Fatigue when compared against asphalt.



Fatigue vs Modulus Comparison

- Testing of the stabilised material shows a High Modulus and High Fatigue.
- Enhanced asphalt generally has higher Modulus but Lower Fatigue.

Case Study Watheroo WA

Outcomes

- More resilient pavement
- sustainably strengthened
- Minimised imported materials
- Maximum environmental benefits

QUESTIONS