Bioeconomy & Low Carbon Technology Overview for November 2023

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This summary of low carbon technology developments for November 2023 is based on the data and information collated by Gifford Consulting and presented on our website: Gifford Consulting

Highlights: November 2023

More information on these articles can be found on our website dashboards.

Ammonia

1. Ammonia Production in Norway (Aker Horizons ASA): Aker Horizons ASA secured grid capacity for its green ammonia plants in Kvandal and Berlevåg, Norway, enhancing the country's renewable energy infrastructure.
2. Ammonia Production in Malaysia (Gentari Sdn Bhd): Gentari Sdn Bhd entered an agreement with AM Green for a joint investment in a green ammonia platform, advancing Malaysia's renewable energy sector.
3. Ammonia Production in India (Gentari International Renewables): Gentari and AM Green announced agreements to produce 5 MTPA of green ammonia by 2030 in India.
4. Ammonia Production in the Netherlands (OCI Global): OCI Global supplies bio-ammonia to Röhm for producing methyl methacrylate, an essential precursor for PLEXIGLAS, demonstrating innovative use of renewable chemicals.

Biobased Chemicals

5. Biobased Chemicals in Minnesota, USA (Solugen and ADM): Solugen and ADM partner to build a biobased specialty chemicals plant, utilizing ADM's dextrose to develop lower-carbon organic acids and new molecules.
6. Biobased Chemicals in Thailand (Circa Group AS): Circa Group AS and Thailand's National PowerSupply sign a MoU for evaluating sites for Circa's green solvent and platform chemical production plant.
7. Biobased Chemicals in Thailand (NatureWorks): NatureWorks makes significant progress in constructing a fully integrated Ingeo PLA biopolymer manufacturing facility, enhancing the biobased materials market.
8. Biobased Chemicals in South Korea (LG Chem and GS Caltex): LG Chem and GS Caltex plan to start a plant producing biobased 3-hydroxypropionic acid, potentially used for biodegradable plastics, in Yeosu, South Korea.
9. Biobased Chemicals in Sweden (Perstorp): Perstorp launches a new 2-Ethylhexanol grade with 100% renewable carbon content, achieving a negative carbon footprint from production to gate.

10. Biobased Chemicals in USA (Lummus Technology and Citroniq Chemicals): Lummus Technology and Citroniq Chemicals sign agreements for green polypropylene plants in the U.S., pioneering bio-polypropylene production.

11. Biobased Chemicals Collaboration in USA (Goodyear and Visolis): Goodyear and Visolis collaborate to produce isoprene from biobased materials, aiming to enhance the sustainability of tire manufacturing.

12. Biobased Chemicals Technology in USA (Lummus Technology): Lummus Technology acquires rights to license and market ester grade acrylic acid technology, expanding its portfolio in propylene production and derivatives.

13. Biobased Chemicals Technology Trend (IDTechEx): IDTechEx discusses technology trends that drive sustainable polymers for a circular economy, highlighting advancements in eco-friendly materials.

14. Biobased Chemicals Shipment in USA (PureCycle Technologies): PureCycle Technologies sends a commercial shipment of Ultra-Pure Recycled resin to Milliken & Company, showcasing fully sustainable polypropylene concentrate.

Biobased Plastics

15. Biobased Plastics Acquisition in Italy (Versalis): Versalis completes the acquisition of Novamont, now holding its entire share capital, strengthening its position in the biobased plastics market.

16. Biobased Plastics Facility in Indiana, USA (AgroRenew LLC): AgroRenew LLC launched a facility in Indiana to convert food waste into bioplastics, leveraging local agricultural produce for eco-friendly materials.

Biodiesel

17. Biodiesel in India: Universal Biofuels has been selected by India's government-controlled oil marketing companies to supply about $150 million worth of biodiesel. This contract, for the period starting October 2023, aims to supply approximately 40 million gallons of biodiesel, marking a significant move in India's renewable energy initiatives.

18. Biodiesel in Brazil: JBS in Brazil is pioneering the use of 100% biodiesel (B100) in its truck fleet. This project aligns with JBS’s environmental commitments, especially in transportation, aiming to showcase the ecological benefits of biodiesel over traditional diesel.

19. Biodiesel in South Korea: HD Hyundai Oilbank in South Korea signed contracts to purchase 80,000 tons of palm fatty acid distillate (PFAD) from Indonesia's Korindo Group and Korea's LX International for biodiesel production. PFAD, a byproduct of palm oil, is used in selected biodiesel plants globally.

Bioeconomy

20. Bioeconomy in the USA: Origin Materials, facing extended timelines and rising costs for its OM2 project, announced a 30% workforce reduction. This restructuring reflects the company's need for a leaner organization and a revised near-term strategy.

Biofuels

21. Biofuels Trend: A noticeable trend in the biofuels industry is the emergence of smaller, local sustainable aviation fuel refineries complementing larger-scale renewable diesel retrofits of major refineries.
22. Biofuels in the USA: CVR Renewables in Illinois plans to use Honeywell's Ecofining technology for a potential project to produce sustainable aviation fuel (SAF), renewable diesel, and other products from feedstocks like distillers corn oil.
23. Biofuels in Spain: Spain witnessed its first test of renewable fuels in rail transport by Cepsa, Maersk, and Renfe. Over 15 weeks, Renfe locomotives used over 130 tons of renewable diesel, transporting over 4,700 containers.

Biogas

24. Biogas in Brazil: São Martinho in Brazil is set to build its first biomethane plant, using ethanol production residue vinasse. This plant aims to produce 15 million cubic meters of biomethane annually.
25. Biogas in the USA: Ammongas installed a pioneering biogas upgrading facility in New York, part of a series developed by Cayuga RNG Holdings. This marks a significant step in biomethane production in the state.
26. Biogas in Canada: Hydron Energy received a grant for its INTRUPTor technology, a groundbreaking gas upgrader producing renewable natural gas and clean hydrogen from biogas, indicating a significant advancement in renewable fuel technology.

Biojet/Sustainable Aviation Fuel

27. Biojet Market Growth in the USA: The global market for Sustainable Aviation Fuel (SAF) is expected to skyrocket from $219 million in 2021 to $15.7 billion by 2030, expanding at a CAGR of 60.8%, signifying a booming industry shift towards sustainable aviation.
28. Biojet in Saudi Arabia: SATORP, a joint venture of Aramco and TotalEnergies, successfully converted used cooking oil into Sustainable Aviation Fuel (SAF), becoming a regional pioneer in this sustainable fuel production.
29. Biojet in the USA: Southwest Airlines announced a significant offtake agreement with USA BioEnergy for up to 680 million gallons of sustainable aviation fuel (SAF).
30. Biojet in Italy: Eni and Saipem in Italy have embarked on developing biorefining, transforming traditional refineries and creating new biorefineries, marking a significant shift towards sustainable energy production.
31. Biojet in the UAE: Emirates received 315,000 gallons of blended Sustainable Aviation Fuel (SAF) from Shell for use in Dubai.
32. Biojet Collaboration in the UAE: Boeing and Zero Petroleum are collaborating in the UAE to develop and test next-generation technologies for sustainable aviation fuels (SAF), aiming to reduce aviation's lifecycle emissions.
33. Biojet Investment in the Netherlands: Macquarie Asset Management announced an investment of up to €175 million in SkyNRG, supporting its goal to become a major

Sustainable Aviation Fuel (SAF) producer, with plans to build dedicated SAF facilities in Europe and the US.

34. Biojet Funding in the USA: Project Speedbird, a collaboration between LanzaJet, British Airways, and Nova Pangaea Technologies, secured $11.2 million funding for sustainable aviation fuel development, showcasing significant governmental support in renewable energy.

35. Biojet in the Netherlands: Shell and Rotterdam The Hague Airport signed an agreement to blend sustainable aviation fuel at the airport, aiming to exceed the European blending mandate and reduce emissions from international aviation.

36. * Biojet in UAE: Emirates became the world's first airline to operate a demonstration flight of an A380 using 100% Sustainable Aviation Fuel (SAF). This historic flight demonstrates SAF's viability as a sustainable alternative to conventional jet fuel, potentially reducing carbon emissions by up to 85%.

Biotechnology

37. Biotechnology in Denmark: Novozymes A/S in Denmark introduced Quara LowP, a revolutionary enzymatic solution for renewable diesel and SAF production. This innovation enables efficient processing of diverse feedstocks, enhancing profitability without compromising environmental benefits.

CO2 Removal

38. CO2 Removal in Saudi Arabia: LanzaTech Global, Inc. and Olayan Financing Company formed a joint venture in Saudi Arabia to accelerate the deployment of LanzaTech's carbon recycling technology. This venture will focus on reducing emissions in hard-to-abate industries within the Kingdom and selectively across the Middle East.

39. CO2 Removal by Renewable Carbon Initiative (EU): The Renewable Carbon Initiative released an updated version of its guide on sustainable carbon cycles, emphasizing the use of renewable carbon for a sustainable future. This revision reflects the evolving landscape of sustainable carbon initiatives.

40. CO2 Removal in Illinois, USA: In Illinois, the push for using ethanol in Sustainable Aviation Fuel is hindered by local resistance to CO2 pipelines. Without carbon sequestration, current US ethanol production methods struggle to meet the environmental standards necessary for SAF supply chain inclusion.

41. CO2 Removal in Belgium: ArcelorMittal announces the first industrial production of ethanol at its Steelanol plant in Belgium, marking Europe's first carbon capture and utilization project. This significant milestone is a step towards the full commissioning of the Steelanol plant.

Deforestation

42. Global Deforestation Trends: Global deforestation increased by 4% in 2022, with a loss of 6.6 million hectares. This indicates the world is off track to eliminate deforestation by 2030, with a need for significant reduction efforts to meet future goals.

E-Fuels

43. E-fuels in Saudi Arabia: thyssenkrupp Uhde has been contracted by ENOWA and Aramco for a CO2-to-methanol and methanol-to-gasoline plant in Saudi Arabia. This plant, producing methanol and gasoline, showcases innovative processes in sustainable fuel production.
44. E-fuels by Liquidwind (Sweden): Liquidwind aims to establish 80 standardized eMethanol units by 2030, potentially reducing CO2 emissions by 14 million tons annually. This project demonstrates a commitment to large-scale production of sustainable eMethanol.

Ethanol

45. Ethanol Production in India: Hindustan Petroleum Corporation Limited is setting up a $168 million 2G bio-refinery in Bathinda, Punjab, to produce ethanol from paddy straw for petrol blending. This project is monitored by the Commission for Air Quality Management, signifying its environmental significance.
46. Ethanol Innovation in the UK: Ingenza and Phibro Ethanol collaborate to engineer a yeast strain for increased bioethanol yield under various conditions. This innovation aims to enhance bioethanol availability for sustainable fuel production across industries.

Feedstock

47. Feedstock Innovation in the USA: Yield10 Bioscience and BioMar Group intend to commercialize engineered Camelina for omega-3 oil production, offering a land-based solution for aquafeed supplement, addressing the scarcity of marine long-chain fatty acids.
48. Feedstock Research Project CAFIPLA (Germany): The CAFIPLA research project, involving the DBFZ, focuses on using biogenic waste from households for producing chemicals and recovering fibers. This approach aims to reduce environmental costs associated with traditional biomass feedstocks.
49. Feedstock in North Carolina, USA: VISION Bioenergy Oilseeds and ADAMA partnered to develop new crop protection solutions for Camelina growers, expanding the range of products available for this emerging crop in the renewable fuels market.
50. Feedstock in Brazil: Petrobras' Research Centre achieved a milestone by successfully processing 100% soybean oil in a Fluid Catalytic Cracking Unit, marking a first in renewable petrochemical production.
51. Feedstock in Massachusetts, USA: Yield10 Bioscience received USDA-APHIS approval for its glufosinate tolerant Camelina sativa, allowing its cultivation and breeding in the U.S., enhancing the agricultural prospects for renewable fuels.
52. Feedstock in North Dakota, USA: ADM and Marathon Petroleum inaugurated Green Bison Soy Processing, North Dakota's first dedicated soybean processing complex, significantly boosting the supply chain for renewable green diesel.

Hydrogen

53. Hydrogen in France: The Lorraine region in eastern France is estimated to contain 46 million tons of naturally produced hydrogen, potentially making it one of the largest known hydrogen deposits worldwide.

54. Hydrogen in Australia: Ampol, Hyundai Australia, Pacific Energy, and Toyota Australia signed a MoU to develop hydrogen refuelling infrastructure, supporting the growth of fuel cell electric vehicles in the country.
55. Hydrogen in Denmark: The Åland Energy Island project, a collaboration between CIP, Lhyfe, and Flexens, will integrate large-scale offshore wind generation and hydrogen production, supporting energy security and decarbonization in Åland and the EU.
56. Hydrogen in California, USA: H2B2 Electrolysis Technologies unveiled SoHyCal, North America's largest operational green hydrogen production plant powered entirely by renewable energy.
57. Hydrogen in Missouri, USA: BayoTech Inc. announced the availability of sustainable hydrogen fuel from its newly completed hub in Wentzville, producing 350 tons of hydrogen annually for various applications.
58. Hydrogen in Germany: Ceres's first-of-its-kind solid oxide electrolyzer is producing hydrogen at AVL's site in Germany, nearing factory acceptance testing, signifying advancements in hydrogen production technologies.
59. Hydrogen Production Study: A study in Solar Energy Journal presents a design for a system that produces solar thermochemical hydrogen, offering a clean fuel alternative for transportation with no greenhouse gas emissions.
60. Hydrogen in the UK: Lhyfe expanded its UK operation to Sheffield, South Yorkshire, aiming to accelerate the roll-out of green hydrogen and contribute significantly to the region's clean energy transition.
61. Hydrogen in Morocco: Falcon Capital Dakhla and French company HDF Energy are partnering to build a $2 billion green hydrogen production plant in Dakhla, Morocco, with substantial wind and photovoltaic energy capacity.
62. Hydrogen in Illinois, USA: Caterpillar announced a three-year program to demonstrate an advanced hydrogen-hybrid power solution built on its new Cat C13D engine platform, showcasing innovative uses of hydrogen in power systems.
63. Hydrogen by Siemens Energy, Germany: Siemens Energy is set to mass-produce electrolyzers, a move essential for the ramp-up of the hydrogen economy, aiming to make hydrogen widely available and cost-effective.
64. Hydrogen in Japan: Asahi Kasei, Gentari Hydrogen Sdn Bhd, and JGC completed a feasibility study for producing green hydrogen using a large-scale electrolyser system and signed an MoU for further project development, backed by Japan's NEDO.
65. Hydrogen in Spain: H2SITE successfully validated the first ammonia cracker for high-purity hydrogen production, installed on the BERTHA B supply ship, demonstrating innovative onboard power generation using PEM fuel cells.
66. New Hydrogen Report in UK: RenewableUK published a guide explaining the UK Government's Hydrogen Production Business Model, aimed at investors and policymakers, to support the deployment of green hydrogen projects.

Marine Fuels

67. Marine Fuels in Sweden: Stena Oil conducted a biofuel bunkering for Dalaro Shipping's Oslo Wave 3, using B25 fuel composed of rapeseed methyl ester and Marine Gasoil, highlighting the shipping industry's sustainability efforts.
68. Marine Fuels in Denmark: Green Marine Copenhagen and Stamford Ship Management formed a joint venture in Singapore to manage methanol dual fuel propulsion vessels, diversifying across the marine methanol spectrum.
69. Marine Fuels in the Netherlands: VETUS received approval for using Hydrotreated Vegetable Oil in its marine diesel engines, following extensive testing, enhancing sustainable fuel options in marine transportation.
70. Marine Fuels in UAE: Dockendale Ship Management and Green Marine established a joint venture focusing on the management of methanol-powered ships, aiding the maritime industry's transition to methanol fuel.
71. Marine Fuels in Denmark: Maersk signed a groundbreaking green methanol offtake agreement with Goldwind, significantly de-risking its low-emission operations for the next decade.

Market Development

72. Market Development in Canada: Azure Sustainable Fuels Corp. partnered with Savage and Bartlett to accelerate plans for Sustainable Aviation Fuel (SAF) production, marking progress in renewable energy initiatives.
73. Market Development in Kenya: The International Finance Corporation plans a $210 million investment in Eni Kenya's agribusiness project, showcasing significant economic development in sustainable agriculture.
74. Market Development Debate: A key infrastructure debate emerges focusing on whether supporting grid expansion or maintaining current grid reliability and affordability is more crucial, considering climate change and adaptation.

Methanol

75. Methanol Research in EU: AIMPLAS is working on projects like LAURELIN to obtain green methanol, focusing on advanced synthesis technologies and developing a new reactor for efficient production.
76. Methanol Development in Spain: C2X, aiming to establish large-scale green methanol production, advances in developing their second production site, indicating growth in renewable methanol sector.

Packaging

77. Packaging in Japan: Neste, Mitsui Chemicals, and Prime Polymer are collaborating to provide sustainable food packaging solutions for JCCU's CO-OP brand, initially focusing on bio-based materials for seaweed snack packaging.

Plastic Recycling

78. Plastic Recycling in France: Carbios announced the construction of the world's first PET biorecycling plant in Longlaville, France, an industrial-scale enzymatic recycling solution for PET waste.

79. Plastic Recycling in Germany: OMV announced the final investment decision to build an innovative sorting plant in Walldürn, Germany, for producing feedstock for chemical recycling, in partnership with Interzero.

80. Recycling Plastic Study: A study led by Carney Almroth found that plastic pellets from recycling plants in 13 countries contain hundreds of chemicals, including toxic pesticides, totalling 491 organic compounds and an additional 170 compounds tentatively annotated.

Reduction of Emissions

81. Emission Reduction Policy in New Zealand: Fonterra targets a 30% reduction in on-farm emissions intensity by 2030, aiming to lower the emissions profile of its products significantly.

82. Renewable Carbon Initiative (EU) Policy: The RCI emphasizes comprehensive carbon management beyond CO2 emissions, advocating for decoupling industries from fossil feedstocks and efficient use of renewable carbon.

Renewable Diesel

83. Renewable Diesel in California, USA (Neste and PTL Marine): Neste partners with PTL Marine to supply Neste MY Renewable Diesel™ to California's marine sector, facilitating access to renewable diesel for maritime fuel and lubricants.

84. Renewable Diesel in California, USA (Chevron Lummus Global LLC): Chevron Lummus Global LLC announced the successful startup of an ISOTERRA unit at Chevron's El Segundo Refinery, marking significant progress in renewable fuel conversion.

85. Renewable Diesel in Canada (Tidewater Renewables): Tidewater Renewables' HDRD Complex in Canada has commenced commercial operations of renewable diesel, producing 1,500 bbl/d and aiming for 3,000 bbl/d design capacity.

86. Renewable Diesel in Spain (Cepsa): Cepsa starts supplying 100% renewable diesel (HVO) to professional customers, aiming to decarbonize activities and plans to expand this offering to 20 stations by 2024.

87. Renewable Diesel in Canada (Braya Renewable Fuels): Braya Renewable Fuels secured two transactions supporting its refinery conversion for renewable diesel production, including a Supply and Offtake Agreement and a $75 million loan.

88. Renewable Diesel in Indiana, USA (Neste and Hightowers Petroleum): Neste and Hightowers Petroleum form a strategic partnership to offer Neste MY Renewable Diesel, the first TOP TIER certified renewable diesel fuel in the Midwest U.S.

89. Renewable Diesel in France (Neste): Neste partners with two distributors to introduce Neste MY Renewable Diesel in France, contributing to the reduction of greenhouse gas emissions in transportation.

90. Renewable Diesel in Sweden (Preem): Preem's Board of Directors approves a $527.5 million investment to repurpose the Lysekil refinery, shifting from fossil to renewable fuel production.
91. Renewable Diesel in Romania (OMV Petrom): OMV Petrom agrees to purchase 50% of "Respiră Verde" shares, supporting its renewable diesel initiatives with a focus on used cooking oil collection.
92. Renewable Diesel in Texas, USA (Topsoe and Santa Maria): Topsoe signs agreements with Santa Maria to develop a project focused on producing renewable fuels from various feedstocks.

Technology Development

93. Technology Development in Brazil (Mahle): Mahle develops a Global Bio-mobility Center in Jundiaí, Brazil, integrating expertise from its U.S. and India tech centers to advance biofuel and internal combustion engine development.

Overview –November 2023 (based on the above bullet points):

For ammonia production, key developments are taking place in Norway, Malaysia, India, and the Netherlands. Aker Horizons ASA in Norway is enhancing the country's renewable energy infrastructure with large-scale green ammonia plants in Kvandal and Berlevåg. Similarly, Malaysia's Gentari Sdn Bhd's collaboration with AM Green is advancing the nation's renewable ammonia sector. In India, Gentari International Renewables and AM Green aim to produce 5 million tons per annum (MTPA) of green ammonia by 2030, signifying a major step in green hydrogen production. Furthermore, OCI Global in the Netherlands is pioneering the use of bio-ammonia for the production of methyl methacrylate, an important precursor for PLEXIGLAS. These initiatives are vital as ammonia production is traditionally energy-intensive and a significant source of CO2 emissions. Transitioning to green ammonia could therefore have a substantial impact on reducing industrial carbon emissions.

The biobased chemicals industry is also witnessing significant progress. In the USA, Solugen and ADM's partnership to build a biobased specialty chemicals plant in Minnesota is a notable development. This plant will utilize renewable resources to produce lower-carbon organic acids and new molecules, replacing fossil fuel-based materials. This transition to biobased chemicals is crucial for reducing the carbon footprint in the chemical industry, which is traditionally reliant on petrochemicals.

Another major stride in this sector is the collaboration between Goodyear and Visolis in the USA to produce isoprene from biobased materials. This is particularly impactful as isoprene is essential for synthetic rubber production, a key component in tire manufacturing. Shifting to biobased isoprene aligns with the broader goal of reducing reliance on fossil fuels in industrial processes.

In the renewable diesel sector, several countries including the USA, Canada, Spain, France, Sweden, and Romania are making significant contributions. Neste's multiple partnerships across the globe to supply renewable diesel are noteworthy, as they represent a move towards cleaner, alternative fuels in the transport sector. The use of renewable diesel is essential for reducing greenhouse gas emissions from transportation, one of the major contributors to global CO2 emissions.

Plastics recycling and biobased plastics, developments such as Carbios' PET biorecycling plant in France and AgroRenew LLC's bioplastics facility in the USA highlight the shift towards sustainable

materials. These developments are crucial for reducing the environmental impact of plastic waste and promoting a circular economy.

Companies: Significant Contributions – November – 2023

1. **Aker Horizons ASA (Norway)**: Developing large-scale green ammonia plants in Kvandal and Berlevåg, enhancing Norway's renewable energy infrastructure significantly.
2. **Gentari Sdn Bhd (Malaysia)**: Partnering with AM Green for a joint investment in a green ammonia platform, advancing Malaysia's renewable energy sector.
3. **OCI Global (Netherlands)**: Supplying bio-ammonia for the production of methyl methacrylate, an important precursor for PLEXIGLAS, showcasing innovation in renewable chemicals.
4. **Neste (Multiple Locations - USA, France, Sweden)**: Forming several partnerships globally to supply renewable diesel, contributing significantly to cleaner fuels in the transport sector.
5. **Solugen (USA)**: In partnership with ADM, building a biobased specialty chemicals plant in Minnesota to produce lower-carbon organic acids and new molecules.
6. **Goodyear Tire & Rubber Company (USA)**: Collaborating with Visolis to produce isoprene from biobased materials, reducing reliance on fossil fuels in tire manufacturing.
7. **Carbios (France)**: Announced the construction of the world’s first PET biorecycling plant, offering an industrial-scale enzymatic recycling solution for PET waste.
8. **Lummus Technology (USA)**: Signing agreements for green polypropylene plants and acquiring rights to license and market ester grade acrylic acid technology.
9. **Preem (Sweden)**: Investing approximately $527.5 million to repurpose the existing refinery in Lysekil, transitioning from fossil to renewable fuel production.
10. **Chevron Lummus Global LLC (USA)**: Announcing the successful startup of an ISOTERRA unit as part of a renewable fuel conversion project at their El Segundo Refinery.
11. **Tidewater Renewables (Canada)**: Commencing commercial operations of renewable diesel, producing 1,500 bbl/d and aiming for a 3,000 bbl/d design capacity.
12. **Cepsa (Spain)**: Started supplying 100% renewable diesel (HVO) to professional customers, aiming to decarbonize activities and planning to expand this offering.
13. **Braya Renewable Fuels (Canada)**: Secured transactions supporting its refinery conversion for renewable diesel production, including a Supply and Offtake Agreement and a $75 million loan.
14. **Hightowers Petroleum (USA)**: Forming a strategic partnership with Neste to offer Neste MY Renewable Diesel in the Midwest U.S.
15. **OMV Petrom (Romania)**: Agreed to purchase 50% of “Respiră Verde” shares, supporting renewable diesel initiatives with a focus on used cooking oil collection.
16. **Santa Maria (USA)**: Collaborated with Topsoe to develop a project focusing on producing renewable fuels from various feedstocks.

17. **Mahle (Brazil)**: Developed a Global Bio-mobility Center in Jundiaí to further biofuels and internal combustion engine development.
18. **NatureWorks (Thailand)**: Made significant progress in constructing a fully integrated Ingeo PLA biopolymer manufacturing facility, enhancing biobased materials market.
19. **Circa Group AS (Thailand)**: Signed a MoU with Thailand's National PowerSupply for evaluating sites for a green solvent and platform chemical production plant.
20. **LG Chem (South Korea)**: Plans to start a plant producing biobased 3-hydroxypropionic acid, potentially used for biodegradable plastics, in Yeosu.

Company Ranking – November 2023

Rank	Company	Frequency	Achievements Summary
1	Renewable Carbon Initiative	3	Renewable Carbon Initiative, involved in policy and sustainable carbon cycles.
2	Gentari, India	2	Involved in green ammonia production in Malaysia and India, signifying a major contribution to green hydrogen production.
3	Solugen	2	Partnered with ADM to build a biobased chemicals plant in Minnesota, USA, advancing sustainable chemical manufacturing.
4	NatureWorks	2	Significant progress in constructing a biopolymer manufacturing facility in Thailand.
5	Lummus 7	2	Engaged in the creation of green polypropylene plants and chemical production technologies in the USA.
6	Cespa	2	Started supplying 100% renewable diesel (HVO) to professional customers in Spain, supporting the decarbonization of transport.
7	Emirates	2	Participated in expanding the use of sustainable aviation fuels and demonstrated flights using 100% SAF.
8	LanzaTech	2	Carbon recycling technology for hard-to-abate industries.
9	Yield 10	2	Yield10 Bioscience, received USDA-APHIS approval for cultivation of a genetically engineered crop.
10	Lhyfe	2	Engaged in developing hydrogen production projects, contributing to energy security and decarbonization in Europe.
11	Neste	2	Formed partnerships globally to supply renewable diesel, contributing to cleaner fuels in the transport sector.
12	Aker Horizons	1	Aker Horizons, developing large-scale green ammonia plants in Norway.
13	OCL Global	1	Provided bio-ammonia for manufacturing of important industrial chemicals in the Netherlands.

Rank	Company	Frequency	Achievements Summary
14	Circa Group	1	Signed an MoU for evaluating sites for a green solvent production plant in Thailand.
15	LG Chem	1	Plans to start a plant producing biobased 3-hydroxypropionic acid in South Korea, potentially for biodegradable plastics.

Topic & Theme Ranking – November 2023

Topic	Frequency
Hydrogen	13
Biobased chemicals	12
Biojet/Sustainable Aviation Fuel	10
CO2 Removal	7
Renewable Diesel	7
Feedstock	6
Marine fuels	5
Ammonia production	4
Policy	4
Biodiesel	3
Biofuels	3
Biogas	3
Market Development	3
Renewable diesel	3
Biobased plastics	2
Ethanol	2
Methanol	2
Plastic recycling	2
Recycling plastic	2

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