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NEW ENERGY FINANCE

MOVING TOWARDS A NEXT-GENERATION ETHANOL ECONOMY

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EXECUTIVE SUMMARY

The world has a unique opportunity to develop a next-generation bioproduct industry in the next two decades. There could be major benefits in terms of job creation, the economy, reduction of greenhouse gases and energy security. The regular supply of agricultural residue can underpin the development of this industry. It is a resource that can be sustainably harvested without altering current agricultural land use patterns. In supplementing food production, this resource theoretically can be turned into a variety of bioproducts from transport fuels to chemicals and plastics.

In this study Bloomberg New Energy Finance explores how establishing a next-generation ethanol value chain in the next two decades could contribute towards building a bio-based economy in eight select regions: Argentina, Australia, Brazil, China, EU-27, India, Mexico and the US. We have used next-generation ethanol – manufactured from an enzymatic hydrolysis technology – as a proxy output for other bioproducts.

OUTCOMES

Next-generation ethanol can be used as a proxy output for other bioproducts like biobutanol, bio-succinic acid or farnesene.

The study uses two scenarios to illustrate the potential of a bioproduct industry. In the "fuel demand" scenario, we project what it will take to replace 10% of forecast gasoline demand with next-generation ethanol. It is important to note, these volume projections represent an addition to existing first-generation ethanol supply: the intention is to illustrate a reasonable but achievable penetration that does not rely on significant changes to the existing vehicle fleet. In our "residue potential" scenario, we project how much gasoline could be replaced with next-generation ethanol if 17.5% of the available agricultural residues were used. Both scenarios could have various positive knock-on effects in our selected regions.

- *Using a sustainable and renewable feedstock*: In our 8 select regions, we project that 780m dry tonnes – 17.5% of total agricultural residue produced – could be available today as feedstock for next-generation ethanol production, without altering current land use patterns. This annual availability figure rises to 945m dry tonnes by 2030. Residues from wheat, sugarcane, maize, rice and soybean crops make up the bulk of this resource. Agricultural residues can be harvested with existing techniques and grown again and again each year in perpetuity.
- *Diversifying farmers' income:* Harvesting a sustainable amount of agricultural residue will not interfere with the food chain, but it will provide rural economies with an additional revenue source that will help diversify farmers' income.
- *Creating job opportunities:* In the "fuel demand" scenario, 2.40m man-years of employment are generated in the next two decades. If 17.5% of the agricultural residues available are converted into next-generation ethanol, then up to 8.15m man-years of employment could be created from today until 2030. Jobs will come from constructing the necessary biorefining capacity, operating these biorefineries and delivering agricultural residues to these plants.
- *Lowering crude imports bill:* Under the "fuel demand" scenario conditions, our 8 select regions could produce an aggregate of 115bn litres of next-generation ethanol each year by 2030 – using only 5% of the agricultural residue supply. In the "residue potential" scenario, these regions could produce up to 351bn litres each year – enough to replace around 50% of the forecast 2030 gasoline demand, which will provide an important step towards energy independence.
- *Generating additional revenues:* These 8 regions have the potential to generate revenues of $1 trillion between today and 2050 in the "fuel demand" scenario, resulting from the production

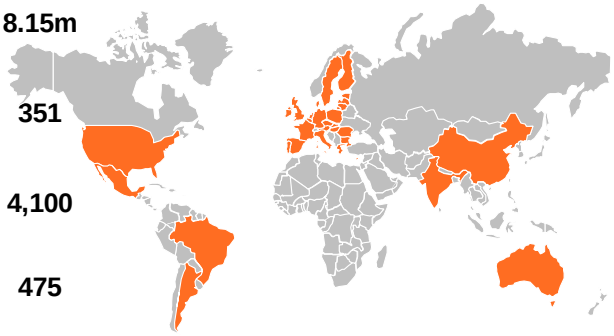
of next-generation ethanol when assuming oil is at $100 per barrel. Revenues, under "residue potential" scenario conditions, climb to approximately $4.1 trillion in the same period.

- *Reducing greenhouse gas emissions:* 155m tonnes of greenhouse gases (GHG) would not be emitted between today and 2030 in the "fuel demand" scenario, which equates to not burning 850,000 railcars of coal. In the "residue potential" scenario, there are approximately 25% less GHG emissions.
- *Towards a bio-based economy*: the development of a bioproduct industry in rural areas could constitute the first step away from a petroleum dependent economy. It will lead towards a more diversified future where renewable agricultural residues become a significant feedstock for both fuel and chemical production.

These regions could replace 10% of its gasoline demand in 2030 by converting 5% of its agricultural residues to next-generation ethanol.

Figure 1: Key metrics

	FUEL DEMAND	RESIDUE POTENTIAL
JOB OPPORTUNITIES, 2011-30 (man-years of employment)	2.40m	8.15m
NEXT-GENERATION ETHANOL POTENTIAL, 2030 (billion litres per annum)	115	351
REVENUE, 2011-2050 ($ bn)	1,000	4,100
POTENTIAL GHG SAVING, 2011–2030 (mtCO2e)	155	475
MAJOR RESIDUE SOURCES	Maize stover, sugarcane residues, wheat straw	



Source: Bloomberg New Energy Finance Note: The "Job opportunities" metric is man-years of employment, which represents one man-year of fulltime employment. The "Next-generation ethanol potential" metric is billion litres per annum; with $bn for "Revenues"; and million tonnes of carbon dioxide equivalent (mtCO2e) for "Potential GHG savings". We assume plant costs will be $1.50 per litre of annual capacity and revenues will be generated from oil at $100 barrel. Following the EU-27 Renewable Energy Directive, the study assumes next-generation ethanol reduces GHG emissions by 80%. The "fuel demand" scenario assumes 10% of gasoline demand will be met with next-generation ethanol by 2030 – in addition to existing first-generation ethanol supply. The "residue potential' scenario assumes all 17.5% of the agricultural residues supply is converted into next-generation ethanol. The manufacturing of next-generation ethanol – via an enzymatic hydrolysis technology – can be used as a proxy for other bioproduct production.

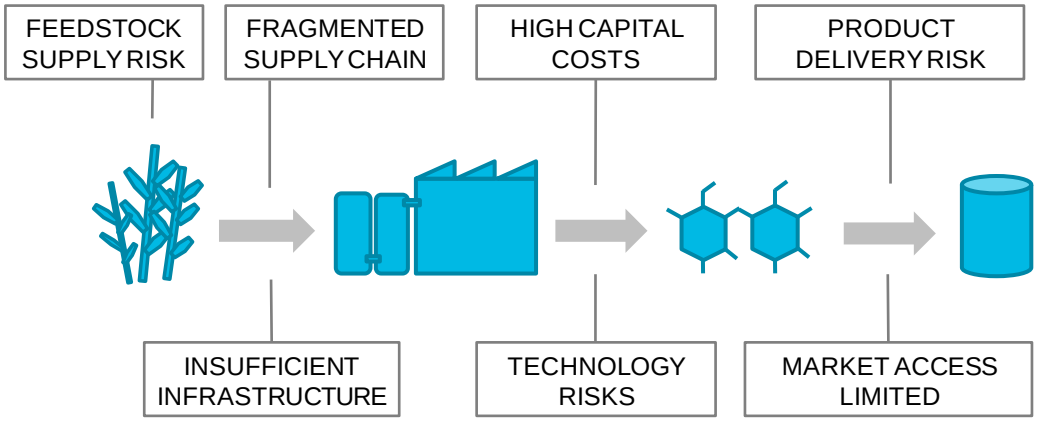
BARRIERS AND POLICY SUGGESTIONS

There are however barriers preventing the industry from unlocking the value of this agricultural residue resource. Bloomberg New Energy Finance has outlined some actions that could be taken by policymakers and other stakeholders to address risks and unlock this potential. Some of the 8 regions have however already taken steps to promote a next-generation ethanol industry – the US particularly stands out.

- *Feedstock supply risk*: Temporary incentives for farmers to collect agricultural residue could facilitate the development of a next-generation ethanol value chain.
- *Fragmented supply chain*: Helping to create a framework for large agricultural residue suppliers, that can aggregate different feedstock streams, will reduce some of the supply risk and instil greater confidence in the eyes of the capital providers.
- *Insufficient infrastructure:* Investment in rural roads, from the fields and orchards, will facilitate efficient agricultural residue transport and reduce costs.

- *High capital costs*: Government support in the form of loan guaranties and R&D grants is vital to reduce the capital costs associated with constructing next-generation biorefineries.
- *Technology risks*: Incentives must be locked in for the lifetime of the plant, giving a premium to the first-movers. Investors will then become more comfortable with the project risks, which will mitigate any wait-and-see strategies.
- *Product delivery risk*: It is imperative to provide stable demand to attract capital to the farming and next-generation bioproduct sectors. It will also give the financial community a long-term market, which will considerably ease raising debt and equity capital.
- *Market access limitations*: Allow ethanol, both first and next-generation, to replace more than 10% of the fossil gasoline supply, which will help remove a "blend wall" that is impeding industry growth, promote flexible fuel vehicles and encourage long-term offtake agreements.

Figure 2: Risks along the next-generation bioproduct value chain



Source: Bloomberg New Energy Finance

STUDY CONDITIONS

Bloomberg New Energy Finance's study is designed to show how much agricultural residue will be available between now and 2030 and how this could be used for bioproducts, under certain conditions.

- It assumes that 75% of total agricultural residues will be returned to the field to protect soil quality; while 7.5% will go towards biopower production and animal husbandry; with the remaining 17.5% being made available for bioproduct conversion, under the appropriate economic circumstances. In addition, 30% of the bagasse produced in sugar mills is directed towards ethanol production.
- Agricultural land-use patterns have deliberately been held constant up to 2030 to negate any indirect land-use change concerns. Energy crops have likewise been excluded. One of the primary intentions of the study is to show what resources are available with little or no ecological change.
- EU sustainable transport group data shows a litre of gasoline has a well-to-wheel emissions footprint of 2.42kg/CO2e. Following RED indications, the study assumes next-generation ethanol, using the enzymatic hydrolysis technology, reduces GHG emissions by 80%. While overall transport fuel demand is rising, gasoline demand in these regions is declining. We assume, however, that gasoline market share will not fall below 20% compared to diesel fuels in any of the regions.
- Bloomberg New Energy Finance was commissioned by Novozymes to write this report. The content and conclusions are those of Bloomberg New Energy Finance alone, based on its own independent analysis.

- The scenarios assume that the industry responds very rapidly in building up the necessary capacity in response to the opportunity of a next-generation bioproducts industry and any delay would defer revenues into future years. The study is a representation of how a next-generation bioproduct could evolve in the next two decades, but it is not an industry development forecast.

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