



Collaborative actions to bring novel **BIO**fuels **THE**rmochemical  
**RO**utes into industrial **Scale**

# Production of sustainable transport biofuels via pyrolysis upgrading

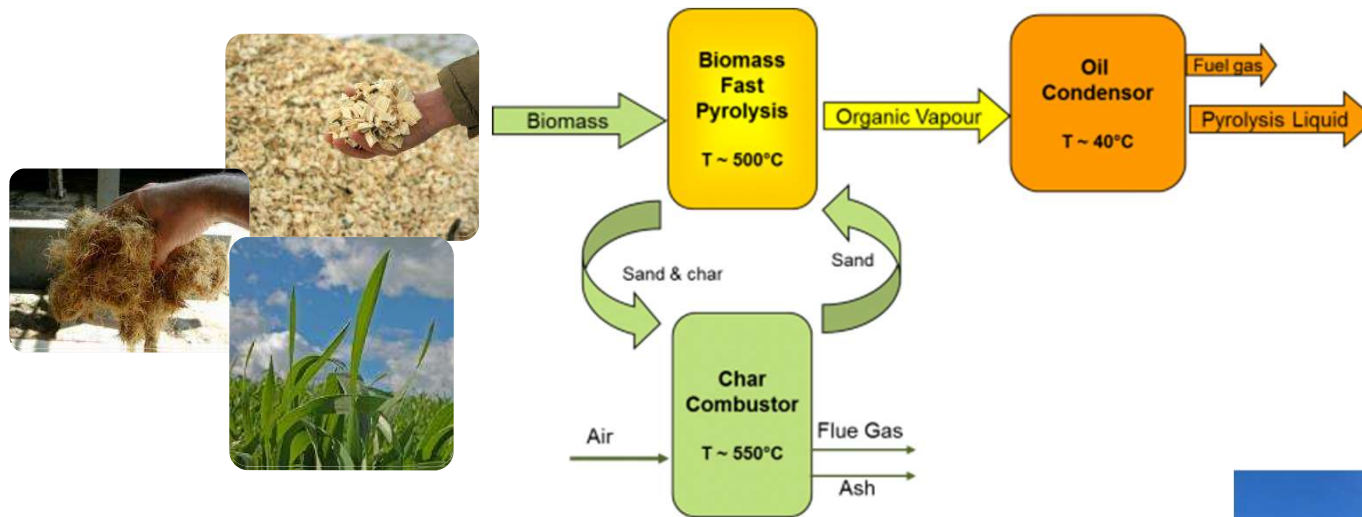
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# Pyrolysis technology



Pyrolysis oil

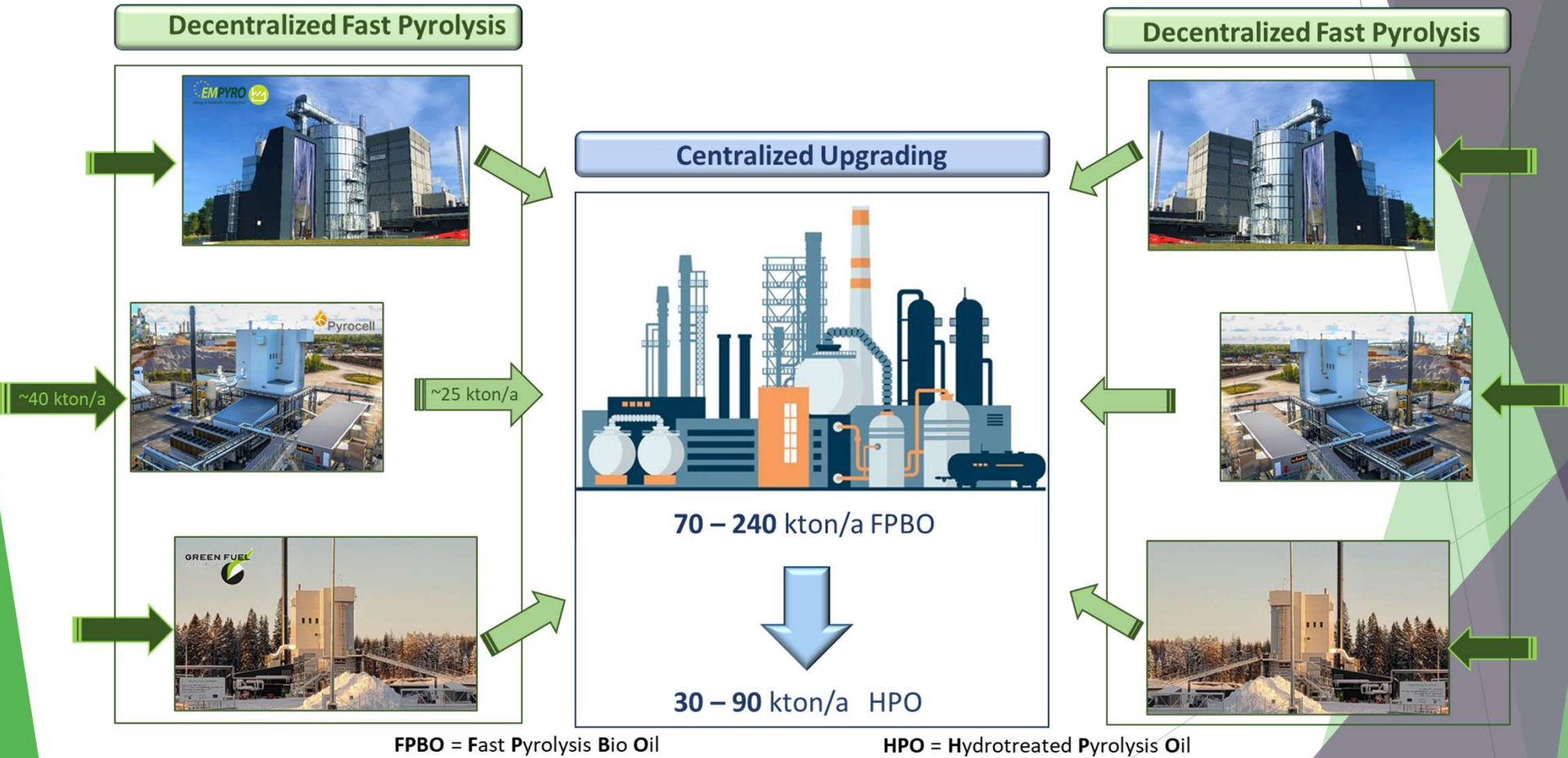


- ▶ Efficient, sustainable process using non-food biomass
- ▶ Proven technology: three 24.000 tonne/year plants have been implemented, in the Netherlands, Finland and Sweden
- ▶ Upgrading of pyrolysis oil is required to produce advanced transport fuels



The Empyro Pyrolysis plant in Hengelo (est. 2015)

# Pyrolysis – Advanced biofuels value chain





# The Challenge

## Fast Pyrolysis Bio-Oil

Water content	25	wt%
Density	1,170	kg/m <sup>3</sup>
LHV	16	MJ/kg
Acid Number	70	mg <sub>KOH</sub> /g
Sulfur	< 500	ppm
FlashPoint	?	°C
Cetane Number	< 20	-
MCRT	> 15	wt%

Components: Acids, carbohydrates, ketones, aldehydes, water, phenolic,...



Fast Pyrolysis Oil - FPBO



## Drop-in Fuels

Water content	< 0.008	wt%
Density	< 840	kg/m <sup>3</sup>
LHV	> 42.8	MJ/kg
Acid Number	< 0.015	mg <sub>KOH</sub> /g
Sulfur	< 15	ppm
FlashPoint	> 38	°C
Cetane Number	> 35	-
MCRT	<< 1	wt%

Components: hydrocarbons



Aviation Fuel – JET A/A1

Water content		wt%
Density	< 890	kg/m <sup>3</sup>
LHV	~42	MJ/kg
Acid Number	< 0.5	mg <sub>KOH</sub> /g
Sulfur	< 1,000	ppm
FlashPoint	> 60	°C
Cetane Number	> 40	-
MCRT	< 0.3	wt%

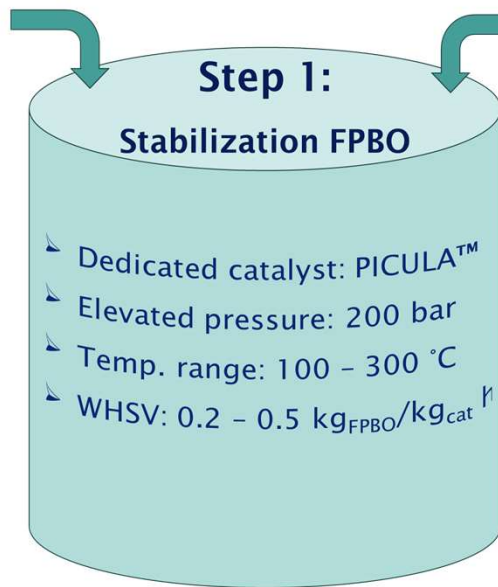
Components: hydrocarbons



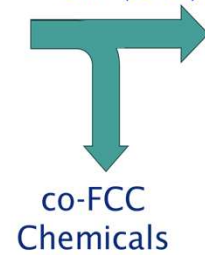
Distillate Marine Fuel – DMA

# Approach

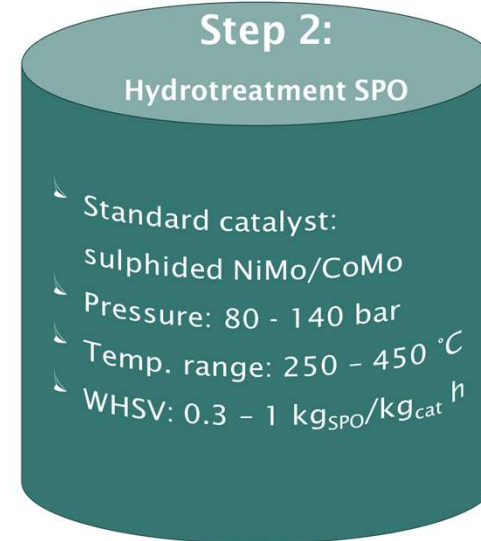
Fast Pyrolysis Bio-Oil  
(FPBO)



Stabilized Pyrolysis  
Oil (SPO)

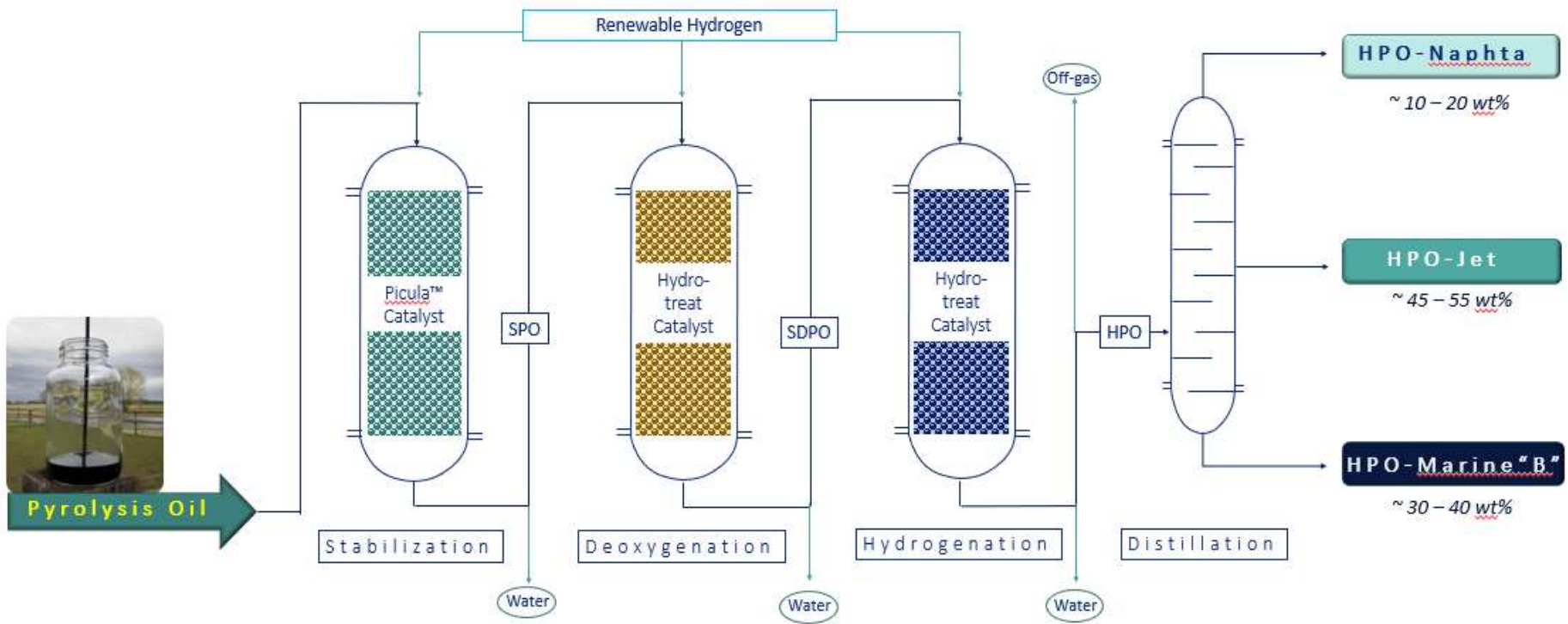


Renewable Hydrogen



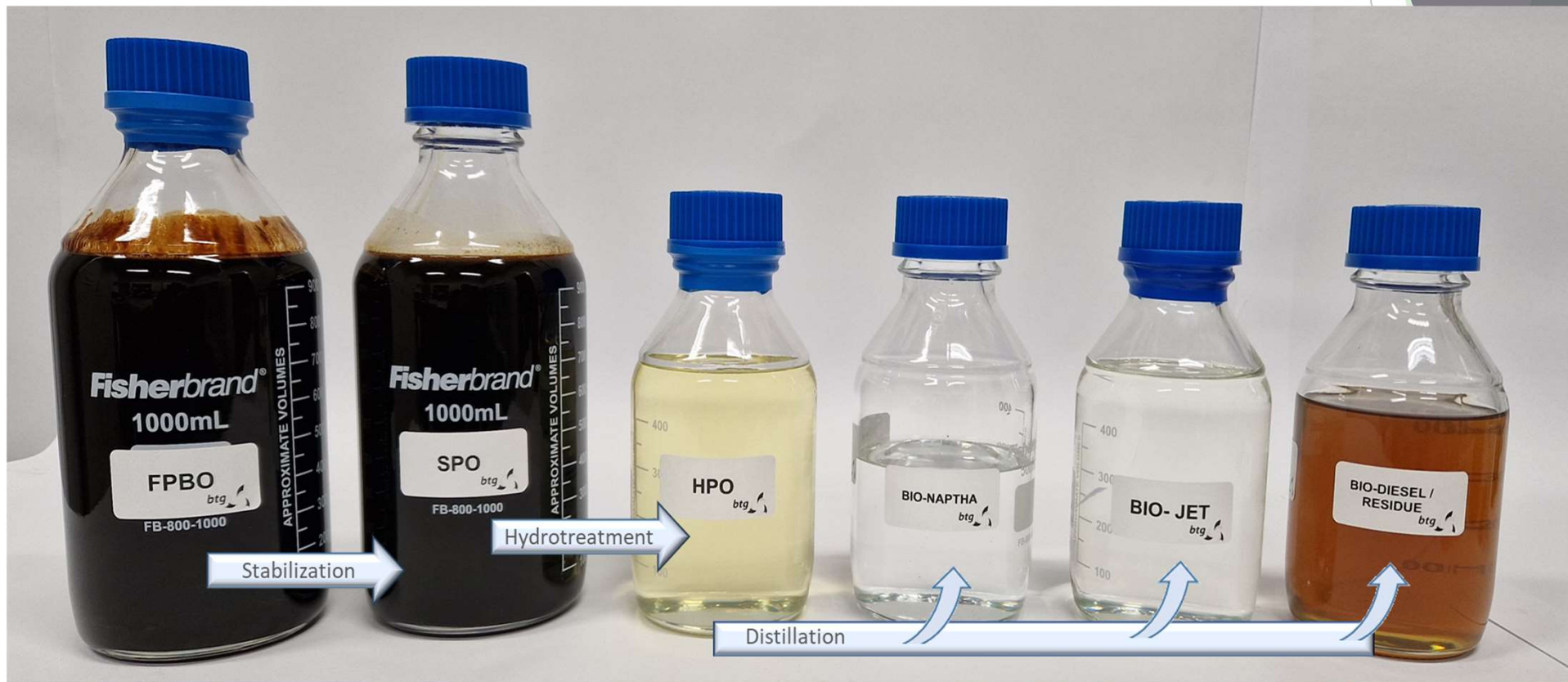
Hydrotreated  
Pyrolysis Oil (HPO)

# Process



**FPBO** = Fast Pyrolysis Bio-Oil    **SPO** = Stabilized Fast Pyrolysis Oil    **SDPO** = Stabilized Deoxygenated Pyrolysis Oil    **HPO** = Hydrotreated Pyrolysis Oil


# Pyrolysis – Advanced biofuels value chain





# Fuel properties

Parameter	Unit	FPBO	SPO	SDPO	HPO
Water content	wt.%	20 - 23	≤ 10	< 2	<0.1
Density	kg/l	1.2	1.1	0.90	0.85
Viscosity (40° C)	cSt	32	100	10	2
Acid number (carboxylic)	mg KOH/g	60 - 70	60 - 70	< 5	<0.03
Carbonyl content	mmol/g	4.5	< 2	< 1	<0.1
MCRT	wt.%	17 -20	≤ 10	< 0.5	0
Carbon content	wt.%	42-44	53 - 58	78 - 83	85.3 - 87.6
Hydrogen content	wt.%	7 - 8	8 - 9	10.5 - 11.5	12.4 -14.7
Oxygen (by difference)	wt.%	47 - 50	30 - 40	4 - 8	< 0.1
Lower Heating Value	MJ/kg	16 - 18	23 - 25	37 - 39	42 - 43
H/C	mole/mole	1.3 - 1.5	1.5 - 1.7	1.6 - 1.7	1.7 - 2
O/C	mole/mole	0.45 - 0.52	0.3 - 0.45	0.03 - 0.05	< 0.01

 *Indicative values*



# Fuel properties

Parameter	Unit	HPO-Naptha	HPO-Jet	HPO-Marine
Density (T=20 °C)	kg/l	0.74 - 0.78	0.82 - 0.84	0.87 - 0.92
Viscosity (40 °C)	cSt	0.6 - 1	1.3 - 1.6	11 - 14
Acid number	mg KOH/g	< 0.02	< 0.02	< 0.05
Carbonyl content	mmol/g	<0.1	<0.1	<0.1
MCRT	wt.%	0	0	0
Flash point	°C	-15 - 0	39 - 47	> 120
ICN	-	-	36 - 42	40 - 58
Net heat of combustion	MJ/kg	42.8 - 44	42.7 - 43.0	42 - 43
	MJ/L	32 - 35	35 - 36	37 - 39



*Indicative values*

# Summary

- ▶ Fast Pyrolysis Bio-Oil (FPBO) can be upgraded to Hydrotreated Pyrolysis Oil (HPO).
- ▶ HPO is fractionated into Naptha, Sustainable Aviation Fuel (SAF) and Renewable Marine Diesel.
- ▶ In the BioTheRos project the value chain will be demonstrated using forestry residues and Barley straw as feedstock for pyrolysis.



HPO-Naptha: 10-20 wt%

HPO-Jet: 45-55 wt%

HPO-Marine: 30-40 wt%

# Project Partners



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RESEARCH & TECHNOLOGY  
HELLAS



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**BEST**

Bioenergy and  
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# Thank you!

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