



IEA Bioenergy

Technology Collaboration Programme



IEA Bioenergy Task 44 WP1 Technologies for flexible bioenergy

Webinar IEA Bioenergy “Flexible Bioenergy in Renewable Energy Systems”

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Technology Collaboration Programme

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Flexibility in biomass related energy conversions

Feedstocks	Intermediates (limited spatial and temporal flexibility)	Energy carrier (storable, large spatial and temporal flexibility)	Application (variable)
Renewable electricity (variable)			Chemical Industry
	H ₂	Liquid Fuels (MeOH, FT, ...)	Transport & Mobility
Dry biomass (storable)		Stabil. Pyrolysis oil	CO ₂ for BECCS
	Pyrolysis oil		
	Producer gas	Methane, LNG, Methane & CO ₂	
	Biogas		Heat (storage) & electricity (FCs, ICE, mGT)
Wet biomass (usually not storable)		Pellets, Chips	Heat

	Long term flexibility service	Short term flexibility service	
	Storage as chem. energy/Upgrading	Back-up/Peak generation	Negative ancillary service
Existing (technically and economically feasible)			
Emerging (technically demonstrated, but no business case yet)			
Under development (i.e. TRL < 6)			

Flexibility around biogas

Feedstocks

Wet biomass
(usually not storable)

Intermediates

(limited spatial and
temporal flexibility)

Energy carrier

(large spatial and temporal
flexibility)

Application

Transport &
Mobility

CO₂ for BECCS

Heat (storage)
& electricity
(FCs, ICE, mGT)

Heat

Flexibility around biogas

Feedstocks



Anaerobic digestion: state of the art, > 10000 plants;
Storage capacity for hours

Wet biomass
(usually not storable)

Intermediates

(limited spatial and temporal flexibility)

Energy carrier

(large spatial and temporal flexibility)

Methane, LNG,
Methane & CO₂



Application

Transport & Mobility

CO₂ for BECCS

Heat (storage) & electricity
(FCs, ICE, mGT)

Heat

Biogas

Flexibility around biogas

Feedstocks



*Biogas-upgrading: state of the art, >> 100 plants (pressurised water scrubber, amine scrubber, PSA, membranes; **Fast ramp up/down**)*

*Anaerobic digestion: state of the art, > 10000 plants; **Storage capacity for hours***

Wet biomass
(usually not storable)

Intermediates

(limited spatial and temporal flexibility)

Biogas

*Biogas-CHP: state of the art, >>1000 plants (mostly engines); **ramp up/down < 5 min, 0-100% load***

Energy carrier

(large spatial and temporal flexibility)

Methane, LNG,
Methane & CO₂

Application



Transport & Mobility



CO₂ for BECCS

Heat (storage) & electricity
(ICE,

Heat



Flexibility around biogas

Feedstocks

Intermediates

(limited spatial and temporal flexibility)

Energy carrier

(large spatial and temporal flexibility)

Application

Renewable electricity
(not used otherwise)

H₂

Biogas based Power-to-Gas: at demo scale TRL 7-8; < 20 plants (biological/catalytic methanation); warm start < 20 min, 0/20 - 100% load

Biogas-upgrading: state of the art, pressurised water scrubber, PSA, ramp up/down

Methane, LNG,
Methane & CO₂

Transport & Mobility

CO₂ for BECCS

Biogas

Heat (storage) & electricity (FCs, ICE, mGT)

Heat

state of the art, >>1000 (mostly engines); ramp < 5 min, 0-100% load



Etogas/HZI



regioenergie.ch

Flexibility around biogas

Feedstocks

Intermediates

(limited spatial and temporal flexibility)

Energy carrier

(large spatial and temporal flexibility)

Application

Renewable electricity
(not used otherwise)

H₂

Biogas based Power-to-Gas: at demo scale TRL 7-8; <20 plants (biological/catalytic methanation); warm start < 20 min, 0/20 - 100% load

Biogas-upgrading: state of the art, >> 100 plants (pressurised water scrubber, amine scrubber, PSA, membranes; Fast ramp up/down

Methane, LNG,
Methane & CO₂

Transport & Mobility

CO₂ for BECCS
Sequestration of biogenic CO₂: in research (TRL 2-3)

Anaerobic digestion: state of the art, > 10000 plants; storage capacity for hours

Biogas

Heat (storage) & electricity
(FCs, ICE, mGT)

Wet biomass
(usually not storable)

Biogas-CHP: state of the art, >>1000 plants (mostly engines); ramp up/down < 5 min, 0-100% load

Heat

Flexibility around wood

Feedstocks

Renewable electricity
(variable)

Dry biomass
(storable)

Intermediates

(limited spatial and
temporal flexibility)

Energy carrier

(large spatial and temporal
flexibility)

Application

Chemical
Industry

Transport &
Mobility

CO₂ for BECCS

Heat (storage)
& electricity
(FCs, ICE, mGT)

Heat

Flexibility around wood

Feedstocks

Renewable electricity
(variable)

Dry biomass
(storable)

Intermediates

(limited spatial and temporal flexibility)



Energy carrier

(large spatial and temporal flexibility)



Application

Chemical Industry

Transport & Mobility

CO₂ for BECCS

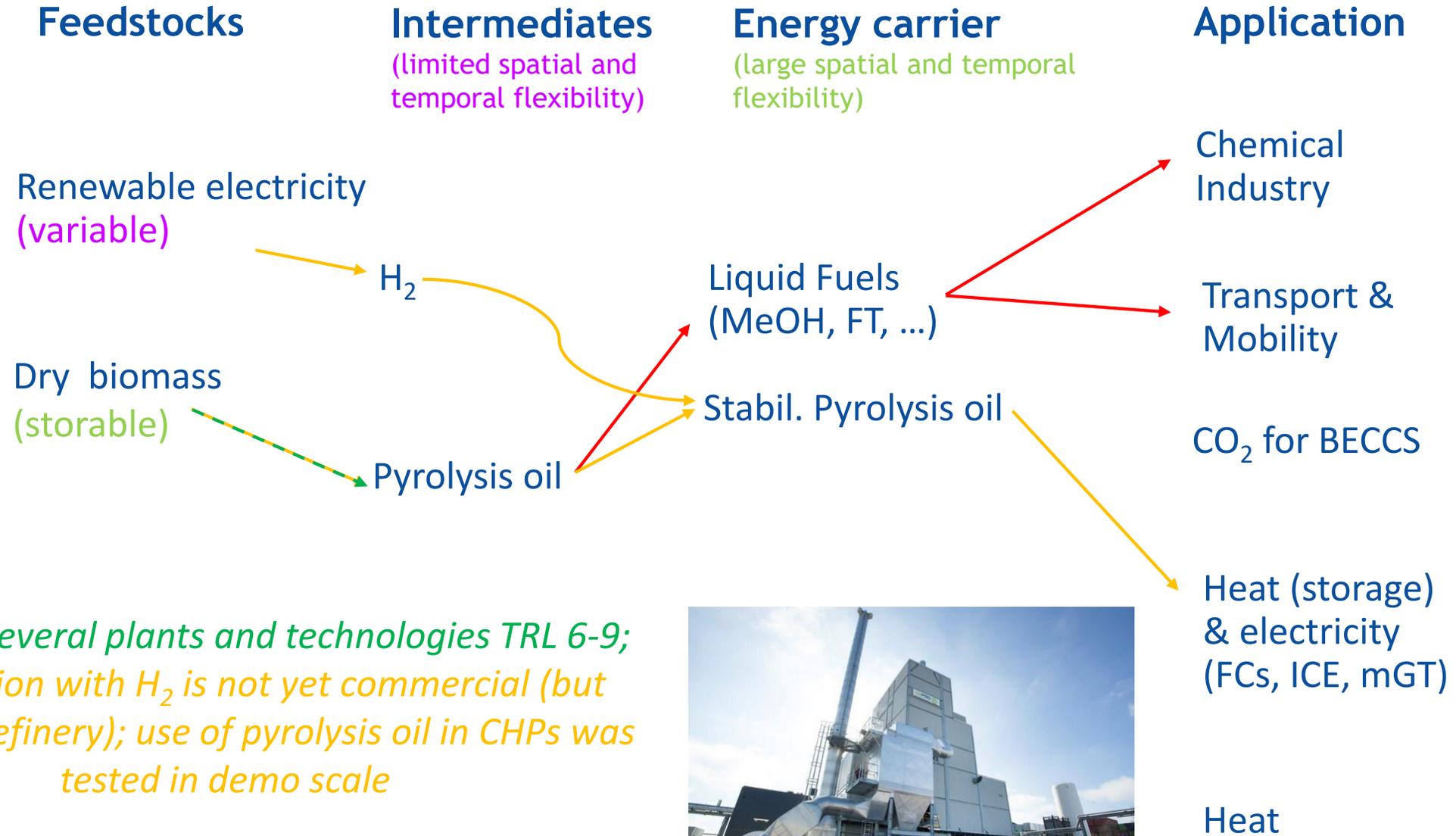
Heat (storage) & electricity (FCs, ICE, mGT)

*Wood CHP: many plants combustion/steam turbine/ORC;
less plants small gasification/gas engine (ICE);
ramp up/down combustion 1h-1d, 30/50-100% load;
ramp up/down turbines/ORC/ICE < 5 min, 0-100% load*

Pellets,
Chips

Heat

Flexibility around wood



*Pyrolysis: several plants and technologies TRL 6-9;
Stabilisation with H₂ is not yet commercial (but similar to refinery); use of pyrolysis oil in CHPs was tested in demo scale*



Flexibility around wood

Feedstocks

Renewable electricity
(variable)

Dry biomass
(storable)

Intermediates

(limited spatial and
temporal flexibility)

Producer gas

Energy carrier

(large spatial and temporal
flexibility)



Application

Chemical
Industry

Transport &
Mobility

CO₂ for BECCS

Heat (storage)
& electricity
(FCs, ICE, mGT)

Heat

*Wood CHP: few plants large scale gasification/gas engine;
ramp up/down gasification 1d;
ramp up/down gas engine < 5 min, 0-100% load*

Flexibility around wood

Feedstocks



Dry biomass
(storable)

Intermediates

(limited spatial and temporal flexibility)

Producer gas

*Fuel synthesis to CH₄, Diesel: TRL 7-8;
ramp up/down gasification 1d;
warm start methanation ca. 30 min*

Energy carrier

(large spatial and temporal flexibility)

Liquid Fuels
(MeOH, FT, ...)

Methane, LNG,
Methane & CO₂

Application

Chemical Industry

Transport & Mobility

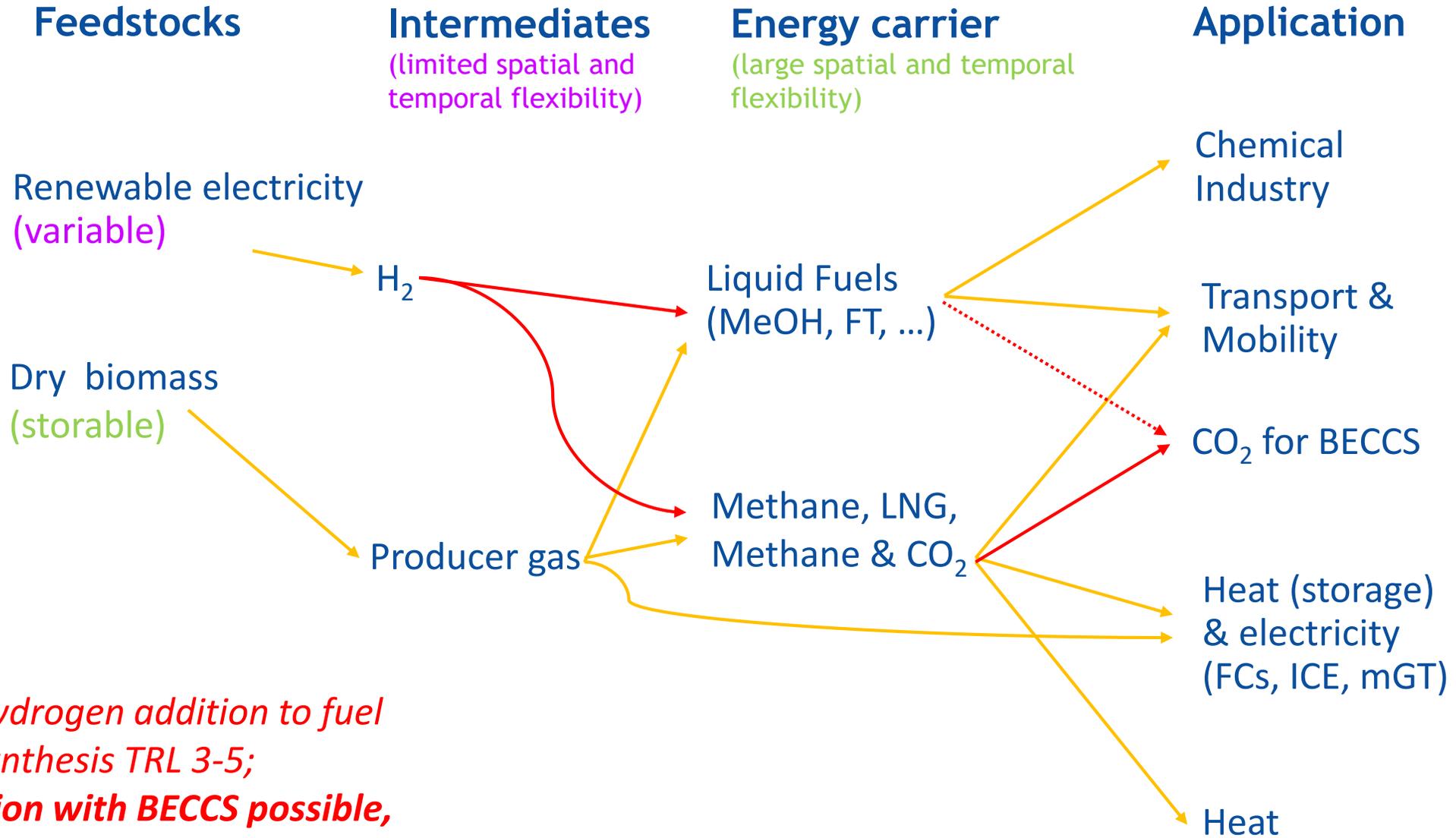
CO₂ for BECCS

Heat (storage) & electricity
(FCs, ICE, mGT)

Heat

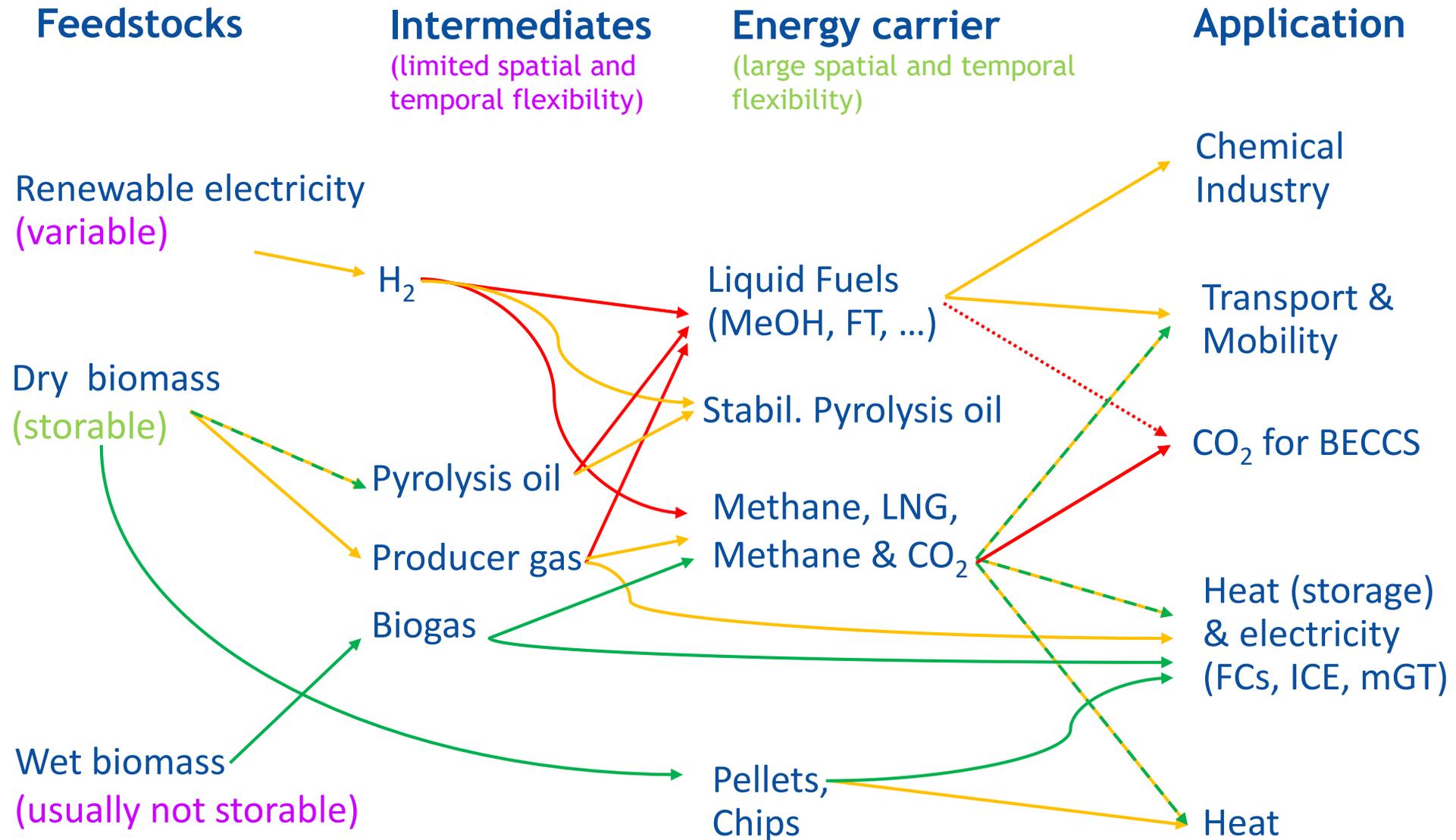


Flexibility around wood



Flexible hydrogen addition to fuel synthesis TRL 3-5; Combination with BECCS possible, when no H₂ available

Flexibility bioenergy is a complete network!



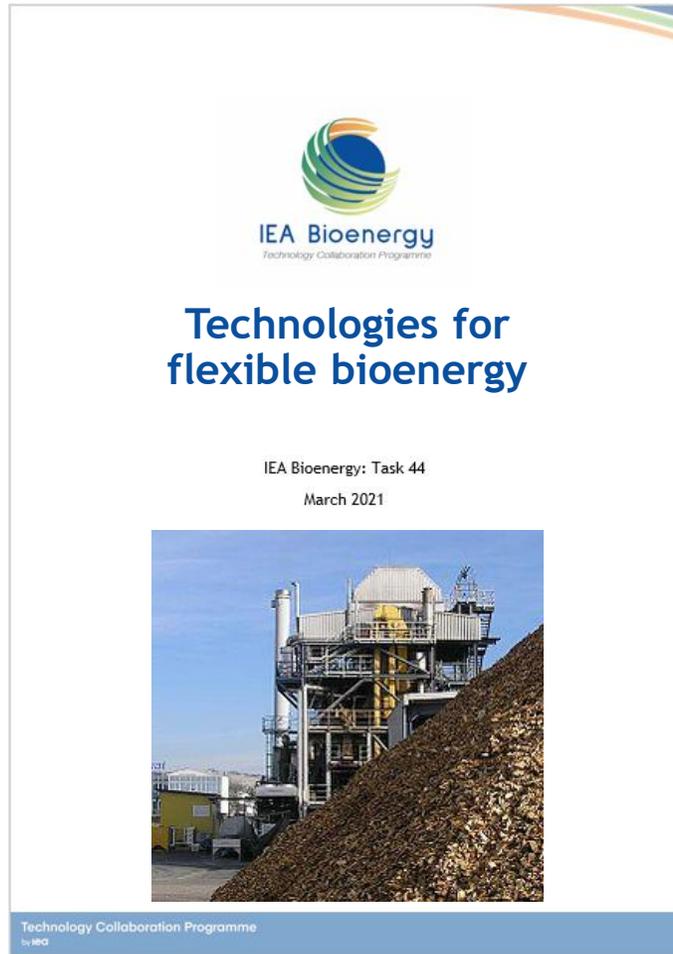
	Long term flexibility service	Short term flexibility service	
	Storage as chem. Energy/Upgrading	Back-up/Peak generation	Negative ancillary service
Existing (technically and economically feasible)	<ul style="list-style-type: none"> - Biogas upgrading 	<ul style="list-style-type: none"> - Biogas-CHP - Wood combustion with steam turbine 	
Emerging (technically demonstrated, but no business case yet)	<ul style="list-style-type: none"> - Pyrolysis oil (stabilisation) - Torrefaction - Wood to SNG, FT-Diesel 	<ul style="list-style-type: none"> - flex. heat from biomass - Wood gasif./engine - Polygeneration 	<ul style="list-style-type: none"> - Biogas upgrading with H₂ (biological & catalytic) - (Pyrolysis) oil stabilisation
Under development (i.e. TRL < 6)	<ul style="list-style-type: none"> - HTC, HTL, HTG+Methanation - Chemicals from biomass 	<ul style="list-style-type: none"> - Biomass CHP with SOFC - Bio-CHP with flexible power to heat ratio - Microbial fuel cell 	<ul style="list-style-type: none"> - Flexible H₂ addition to biofuel synthesis - Fuels from CO₂ and H₂ (biological process) - Electrons in fermentation

Learnings technologies for flexible bioenergy

- Many well developed technologies exist and have been demonstrated successfully
- Some business cases work (besides combustion):
 - Starting with waste streams that do not burn (biogas production)
 - Producing electricity if support scheme in place; flexible use however only with additional support!
- Wood: combustion as alternative use, fossils as alternative feedstocks make the business cases difficult up to now.
- Flexible hydrogen addition to fuel synthesis still under development
- Flexible peak electricity production, CO₂ mitigation and negative balancing power are important building blocks for a future energy system that bioenergy can deliver
- But the advantage of these features is under-valued today

IEA Bioenergy Task 44

WP1 Technologies for flexible bioenergy



- Report coming soon
- Many thanks to the colleagues in the IEA Bioenergy Tasks 32, 33, 37, 39, 44
- Many thanks for your attention!