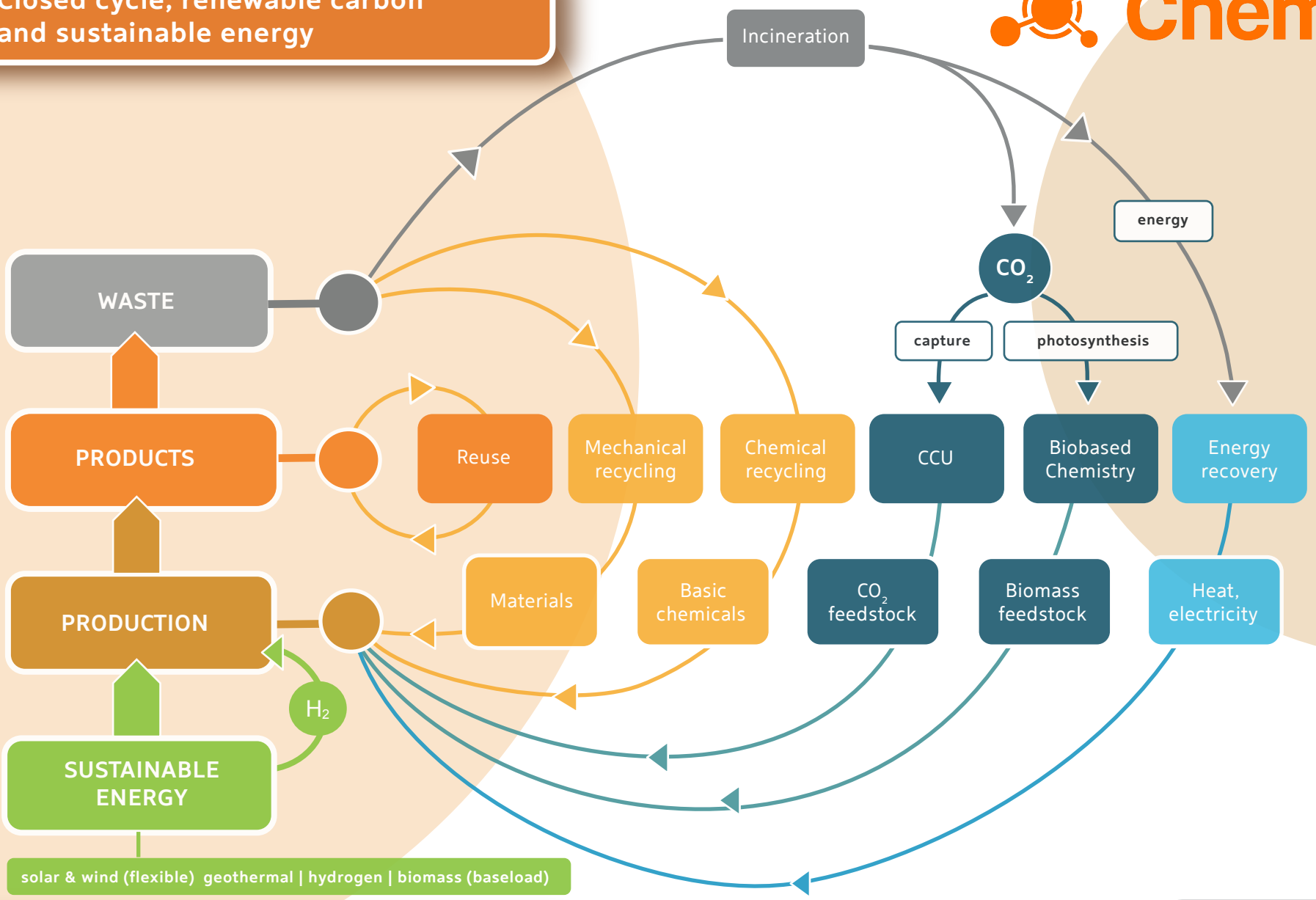
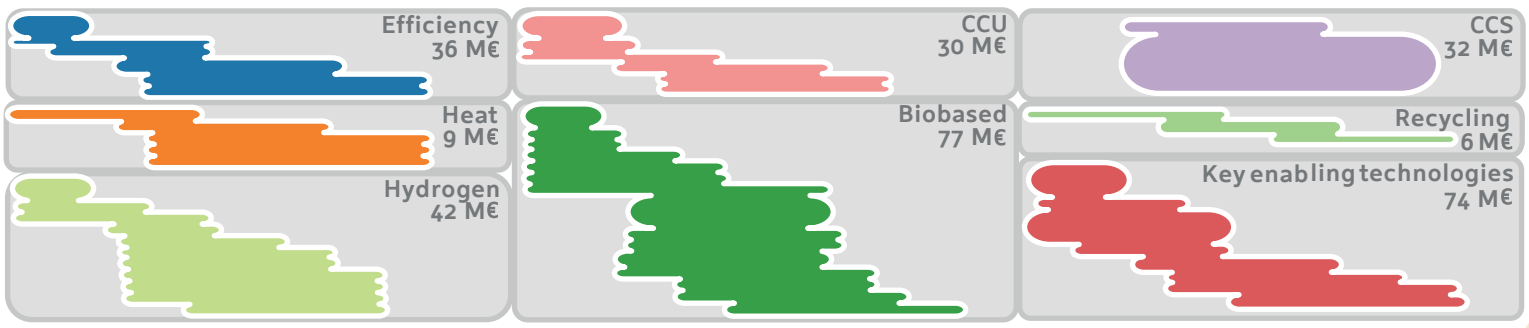
Innovation portfolio for climate, energy and sustainability

Closed cycle, renewable carbon and sustainable energy



Research and innovation programmes

The horizontal axis runs from TRL 1 to TRL9. Every "pill" stands for a programme line.
The amounts represent the sum of the estimated deployment of current projects. These are, per theme, the total accumulated project funds with public funding. Reference year: 2018.



Overall picture

	R&D - effort necessary	Upscaling - effort necessary	Execution - effort necessary
Focus areas	Design for recycling combined with advanced separation technology	Chemical recycling; Biobased plastics and single-use products	Improving quality and impact recycling system combined with biobased
	High temperature heat based on renewable electricity	Renewable low temperature heat; heat pump,geothermal	Energy efficiency
	Direct H_2 and CO_2 routes (photocatalysis, solar fuels, CCU)	Hydrogen from methane or residual stream; gasification technology; power to products	Hydrogen electolysis
general pre-conditions	Improving connection to higher TRLs	KET: Advanced processes & advanced materials	Market conditions (raw material-, CO_2- and energy prices)
	Insight in carbon efficiency in recycling	Improving climate impact	Infrastructure (storage and distribution)
		Public-private investments	Private investments

In 2018, TKI Chemistry, together with the business community and knowledge institutions, made an analysis of the innovation portfolio of the top sector chemistry: Climate-PITCH. The study has mapped out all technologies that can contribute to a climate-neutral chemical sector. For each theme it has made visible which R&D efforts are now being made in public-private partnerships. Subsequently, with the help of experts, an estimate was made of the maturity of the relevant technologies (TRL levels). In three rounds a total of around 40 substantive experts were involved: ao scientists, innovation managers and business developers. They have assessed the extent to which these technologies can contribute to the replacement of fossil resources and what the effect is on the energy system. The climate impact is qualitatively estimated for both the direct emissions (scope 1) and for the end-of-life emissions (scope 3) of greenhouse gases.

The analysis shows that with the technologies currently under development, the climate goals of the chemical industry - as formulated in "Chemistry for Climate" (VNCI) and the Climate Agreement are achievable. The following recommendations follow from this:

1. Meeting the 2030 objective requires technologies with a minimum of TRL 6. The pipeline is sufficiently filled, but realization depends on upscaling to TRL 9 and rollout. This requires considerable efforts.

2. Recycling and energy emissions must be optimized in conjunction. This requires system innovation. The contribution from the chemical industry is essential for a circular economy.

3. Connection between research on low TRLs and implementation in higher TRLs within and between technology groups requires more attention.

With the Climate-PITCH, TKI Chemistry has a clear overview of the innovation challenges that lie ahead fand a practical structure to monitor and manage this critical portfolio.

Download the Climate-PITCH via www.chemistrynl.com/theme/climate/

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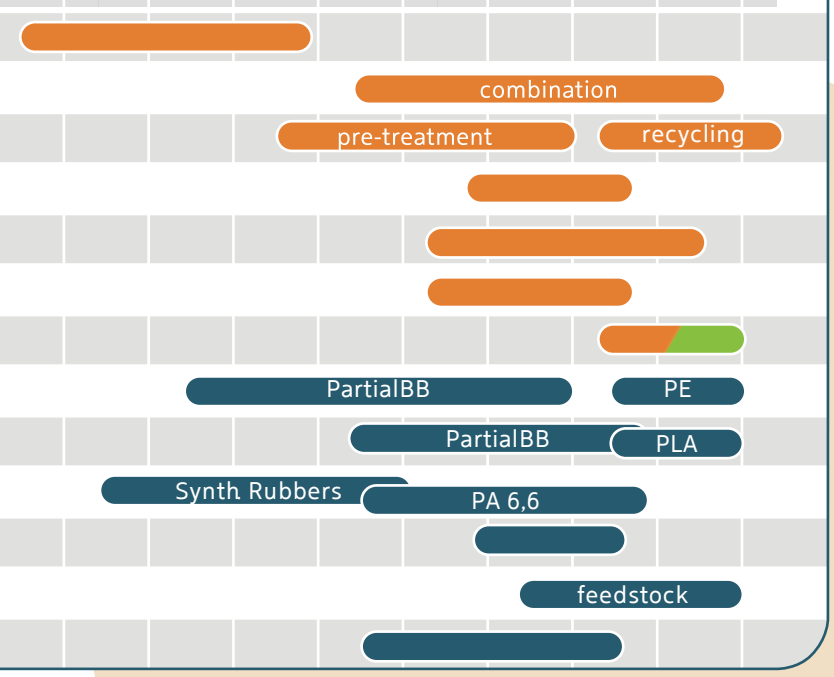
Circular economy

ChemistryNL

Expert assessment maturity and impact of renewable feedstocks

	MMIP	Technology group	Impact: Energy demand reduction	Impact: Fossil substitution	Impact: Climate CO_2 reduction	TRL
Circular mplastics	6.1	1. Design for circularity	++	++	++	
	6.1	2. Waste detection and separation	++	++	++	
	6.1	3. Mechanical recycling	++	+	++	
	6.1	4. Solvolysis(dissolve)	?	+	+	
	6.1	5. Depolymerisation	?	+	+	
	6.1	6. Pyrolysis	0/+	0/+	+/?	
	6.1	7. Gasification (syngas)	0/+	0/+	+/?	
Biobased raw material	6.2	8. Biobased vinyl polymers	0/?	0/+	0/?	
	6.2	9. Biobased polyesters	0/?	+	+/?	
	6.2	10. Bioplastics polyamides and rubbers	0/?	+	+/?	
	6.2	11. Biobased single use products	0/?	+	+	
	6.2	12. Bio fuel 1st generation	0/?	0/+/?	0/+/?	
	6.2	13. Bio fuel 2nd generation	0/?	+/?	+/?	

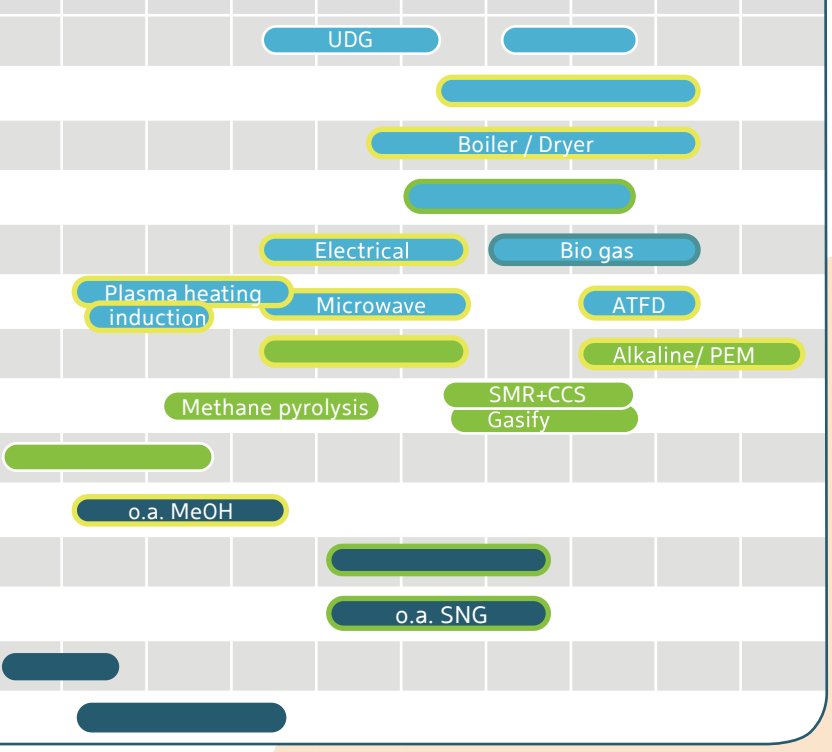


Effect: ++ very positive; + positive; 0 neutral; - negative; ? uncertain
Effect on the entire chain, assessed in relation to the current system
It is assumed that all non-technical conditions can be met

Renewable energy (carriers)

Expert assessment maturity and impact of heat, hydrogen and electrification

	MMIP	Technology group	Impact: Energy demand reduction	Impact: Fossil substitution	Impact: Climate CO_2 reduction	TRL
Heat	7.3	14. Geothermal energy / residual heat	0/?	++	+	
	7.2/8.1	15. Heat pump	++	++	++	
	7.2/8.1	16. Electrical heating	+/?	++	+	
HT Heat	7.4	17. Hydrogen Boiler	0	+/?	+/?	
	7.4/8.1	18. Stove	0	++	+/?	
	7.4/8.1	19. Other	0	+/?	+/?	
Hydrogen	8.1	20. H_2 via elecrolysis	--	++	++	
	6.2/8.1	21. H_2 from methane or residual power	-	-	+/?	
	6.3	22. Photocatalytical	+/?	++	++/?	
Power-to-Products	6.3	23. Electrochemical CO_2 activation	-	+/?	+	
	8.1	24. Low carbon fuels*	0	0	+	
	8.1	25. Low carbon chemicals*	0	0	+	
	6.3	26. Solar fuels	+/?	+/?	+/?	
	6.3	27. CCU†	--	++	+	



Effect: ++ very positive; + positive 0 neutral; -negative; ? uncertain
*cconventional routes with low carbon H2 † The use of CO2 from the air or from flue gas as raw material. This partly overlaps with 25-27
Effect on the entire chain, assessed in relation to the current system
It is assumed that all non-technical conditions can be met.

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Colofon:
Execution: MSG Sustainable Strategies
Advice: TNO
Design: HENS Concept & Motion Graphic Design