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Decarbonising the energy intensive basic materials industry

UNFCCC-TEC Thematic Dialogue, Bonn, 29 mars 2017

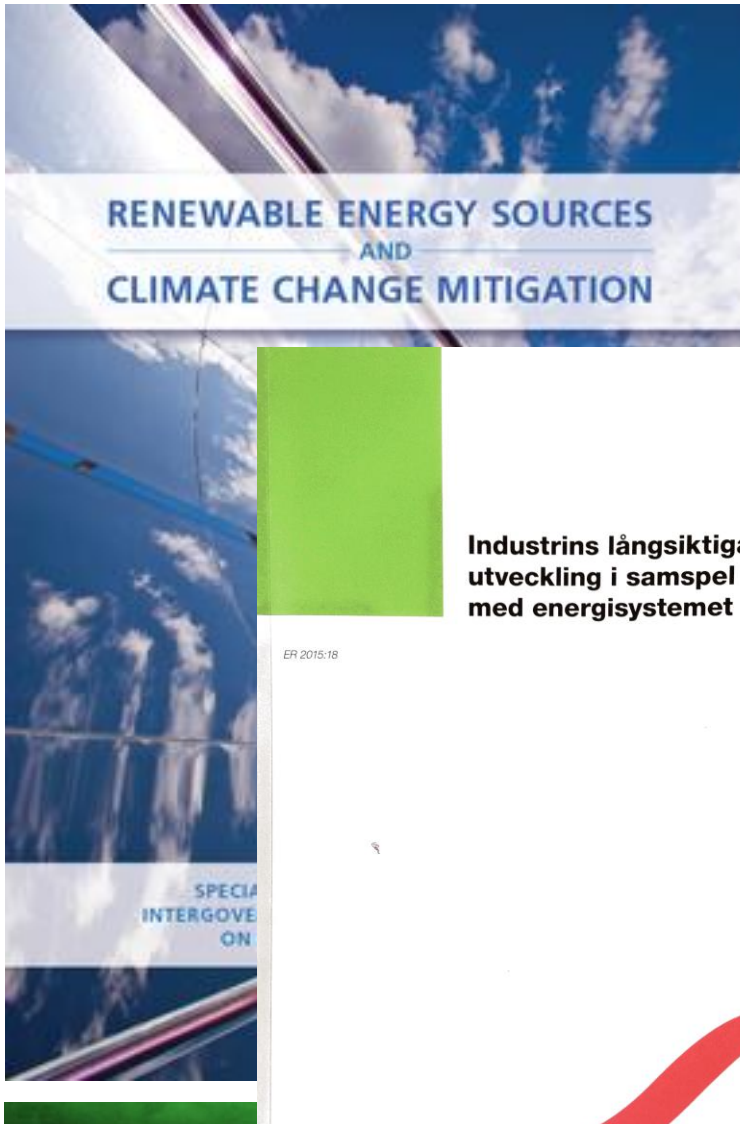
LARS J. NILSSON



GHG mitigation option categories for industry and materials

- Service demand reduction (e.g., switching from private to public transport, new product design with longer life)
- Product-Service efficiency (e.g., through car sharing, or higher building occupancy)
- Material efficiency in (a) manufacturing (e.g., through reducing losses, recycling, re-using) and (b) in product design (e.g., through extended product life or light-weight design)
- Energy efficiency (e.g., through furnace insulation, process integration, variable speed drives)
- Emissions efficiency (e.g., from switching to non-fossil fuel electricity supply, renewable feedstock, or CCS)



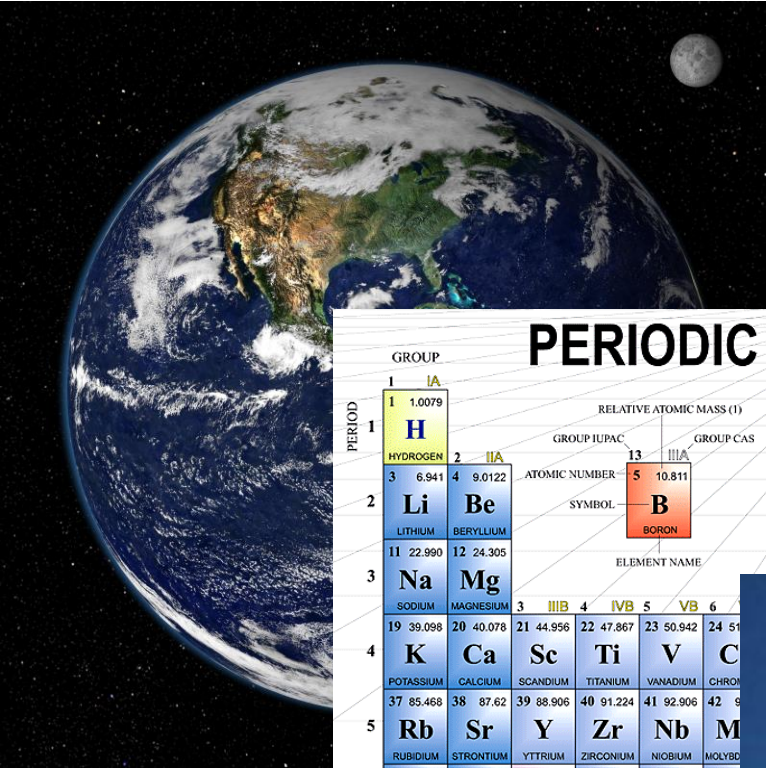


VARIOUS PUBLICATIONS

- SRREN 2011, Ch 8 on Integration
- Decarbonising industry in Sweden (2012 for EPA roadmap); Electrofuels – a review (2013 for FFF); Industry and net-zero emissions 2050, (in Swedish, 2013 for M-Env)
- Decarbonising industry in the EU - climate, trade and industrial policy strategies (2015, book chapter)
- Decarbonising the energy intensive basic materials industry through electrification – implications for future EU electricity demand (2016, Energy)
- Industrins långsiktiga utveckling i samspel med energisystemet (ER 2015:18, for SEA)
- Global climate policy and deep decarbonization of energy-intensive industries (2016, Climate Policy)
- Electricity-based plastics and their potential demand for electricity and carbon dioxide (2016, JCP)
- The characteristics of energy intensive processing industries towards deep decarbonization: implications for transitions research (2016, submitted)

With Åhman, Nikoleris, Palm, Lechtenböhmer, Wesseling, Ericsson, Johansson, Coenen, Worrell etc.

What do we have to work with?



PERIODIC TABLE OF THE ELEMENTS

<http://www.ktf-split.hr/periodni/en/>

PERIOD	GROUP I		GROUP IIA		GROUP IIIA										GROUP IVA		GROUP VA		GROUP VIA		GROUP VIIA		GROUP VIIIA		
1	1 1.0079 H HYDROGEN		2 4.0026 He HELIUM																						
2	3 6.941 Li LITHIUM		4 9.0122 Be BERYLLIUM												5 10.811 B BORON		6 12.011 C CARBON		7 14.007 N NITROGEN		8 15.999 O OXYGEN		9 18.998 F FLUORINE		10 20.180 Ne NEON
3	11 22.990 Na SODIUM		12 24.305 Mg MAGNESIUM												13 26.982 Al ALUMINUM		14 28.086 Si SILICON		15 30.974 P PHOSPHORUS		16 32.065 S SULFUR		17 35.453 Cl CHLORINE		18 39.948 Ar ARGON
4	19 39.098 K POTASSIUM		20 40.078 Ca CALCIUM												21 44.956 Sc SCANDIUM		22 47.867 Ti TITANIUM		23 50.942 V VANADIUM		24 58.933 Cr CHROMIUM		25 58.933 Mn MANGANESE		26 58.933 Fe IRON
5	37 85.468 Rb RUBIDIUM		38 87.62 Sr STRONTIUM												39 88.906 Y YTTORIUM		40 91.224 Zr ZIRCONIUM		41 92.906 Nb NIOBIUM		42 95.94 Mo MOLYBDENUM		43 95.94 Tc TECHNETIUM		44 95.94 Ru RHENIUM
6	55 132.91 Cs CAESIUM		56 137.33 Ba BARIUM												57-71 La-Lu Lanthanide		72 178.49 Hf HAFNIUM		73 180.95 Ta TANTALUM		74 188.91 W TUNGSTEN		75 188.91 Re RHENIUM		76 188.91 Os OSMIUM
7	87 (223) Fr FRANCIUM		88 (226) Ra RADIUM												89-103 Ac-Lr Actinide		104 (261) Rf RUFORNIUM		105 (262) Db DUBNIUM		106 (263) Sg SEABORGIUM		107 (268) Bh BOHRIUM		108 (269) Hs HASSIUM

Legend:

- Metal
- Semimetal
- Nonmetal

Classification:

- 1 Alkali metal
- 2 Alkaline earth metal
- Transition metals
- Lanthanide
- Actinide
- 16 Chalcogens element
- 17 Halogens element
- 18 Noble gas

Standard State (25 °C; 101 kPa):

- Ne - gas
- Fe - solid
- Ga - liquid
- ☞ - synthetic

LANTHANIDE

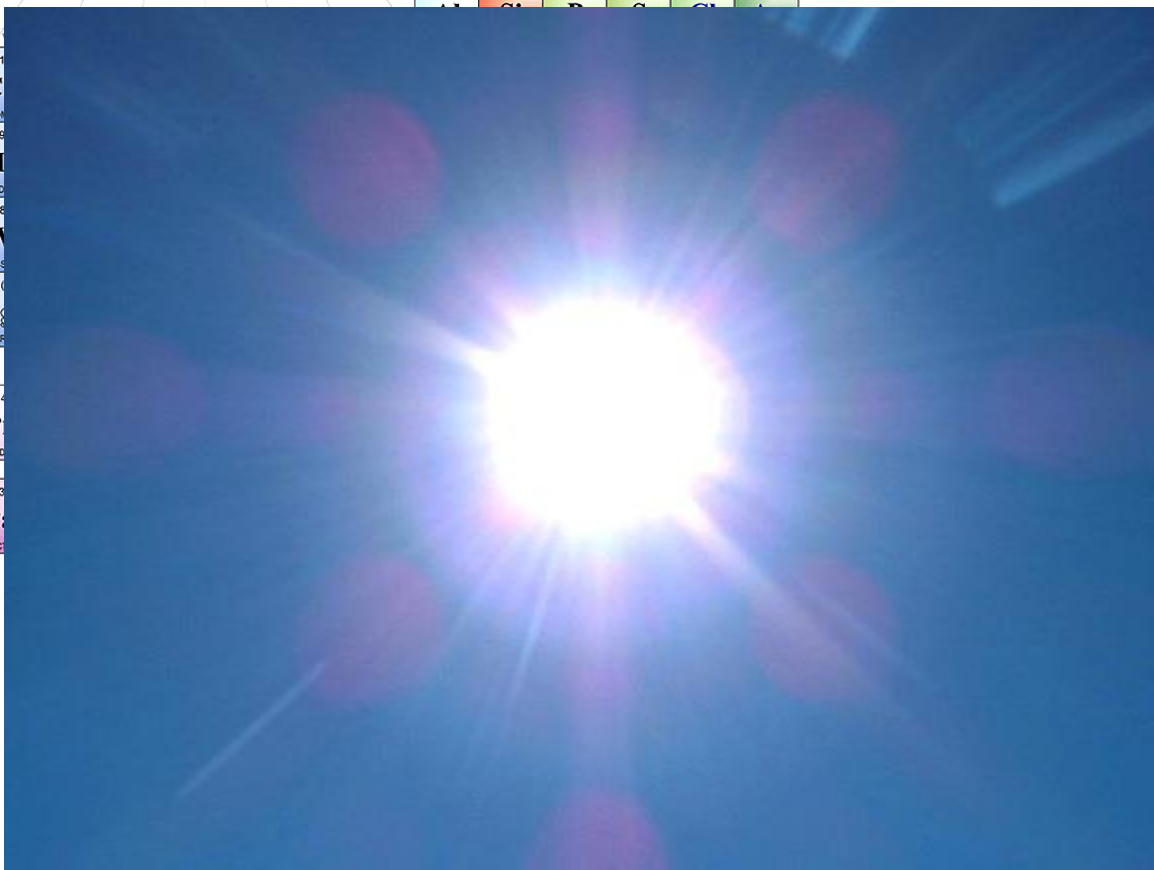
57 138.91 La LANTHANUM	58 140.12 Ce CERIUM	59 140.91 Pr PRASEODYMIUM
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ACTINIDE

89 (227) Ac ACTINIUM	90 232.04 Th THORIUM	91 232 Pa PROTACTINIUM
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(1) Pure Appl. Chem., 73, No. 4, 667-683 (2001)
Relative atomic mass is shown with five significant figures. For elements having no stable nuclides, the value enclosed in brackets indicates the mass number of the longest-lived isotope of the element.
However three such elements (Th, Pa, and U) do have a characteristic terrestrial isotopic composition, and for these an atomic weight is tabulated.

Editor: Aditya Vardhan (advard@netlinx.com)

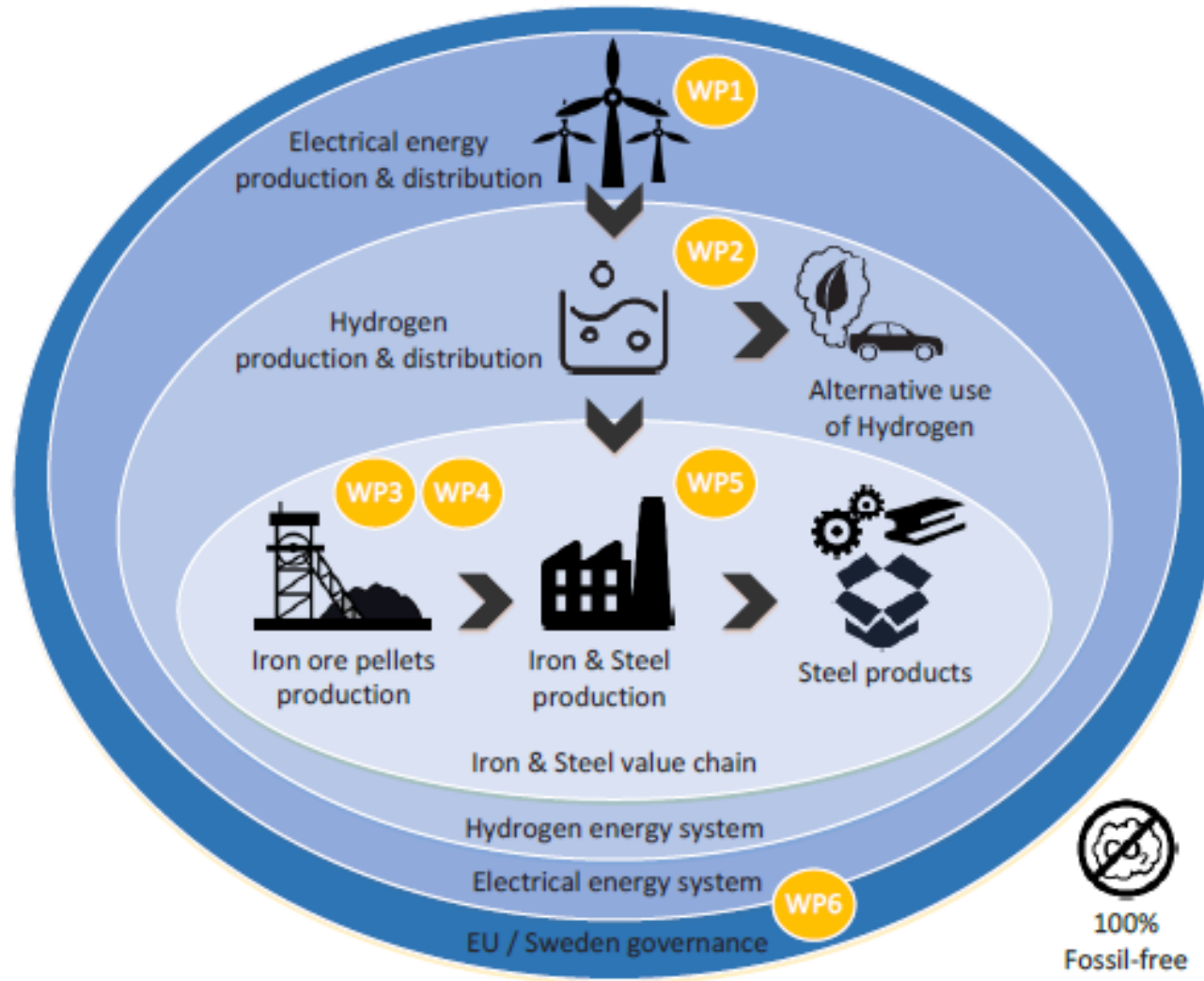


Energy intensive basic materials

- Metals (e.g., copper and steel), minerals (e.g., lime and silicon) and various organic compounds (e.g., cellulose fibers and plastics) in a circular economy
- Mitigation through emissions efficiency:
 - Carbon Capture and Storage
 - Biobased feedstock and fuels (biogas, charcoal, wood chips, etc.)
 - Electricity and hydrogen/hydrocarbons for fuel and feedstock
- Few, if any, co-benefits but more expensive (from 30 % for bulk steel to +300 % for plastics?)
- Potentially large electricity user (e.g., +1500 TWh in EU)



Opinion: This is how we make the steel industry fossil free



Hydrogen Breakthrough Iron-making Technology (HYBRIT)

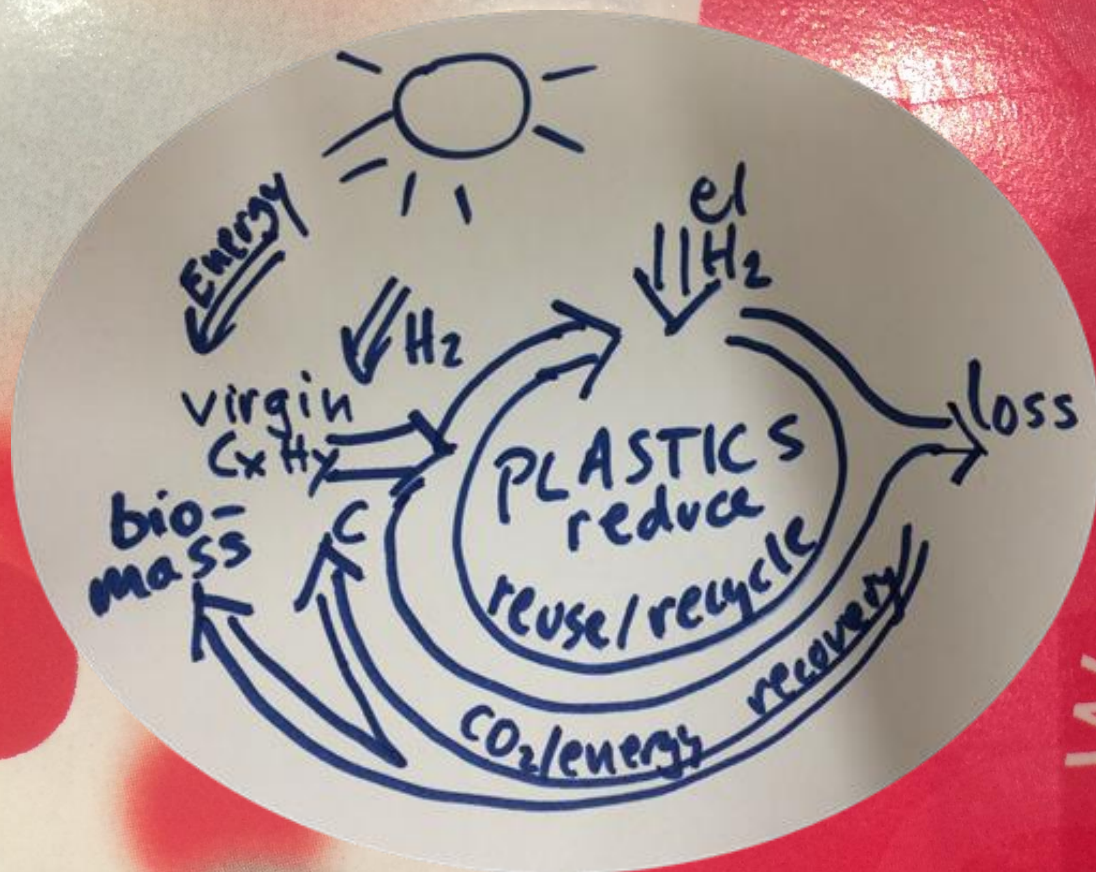


6 - 7 December 2016,
Maternushaus, Cologne,
Germany

5th Conference on

CO₂

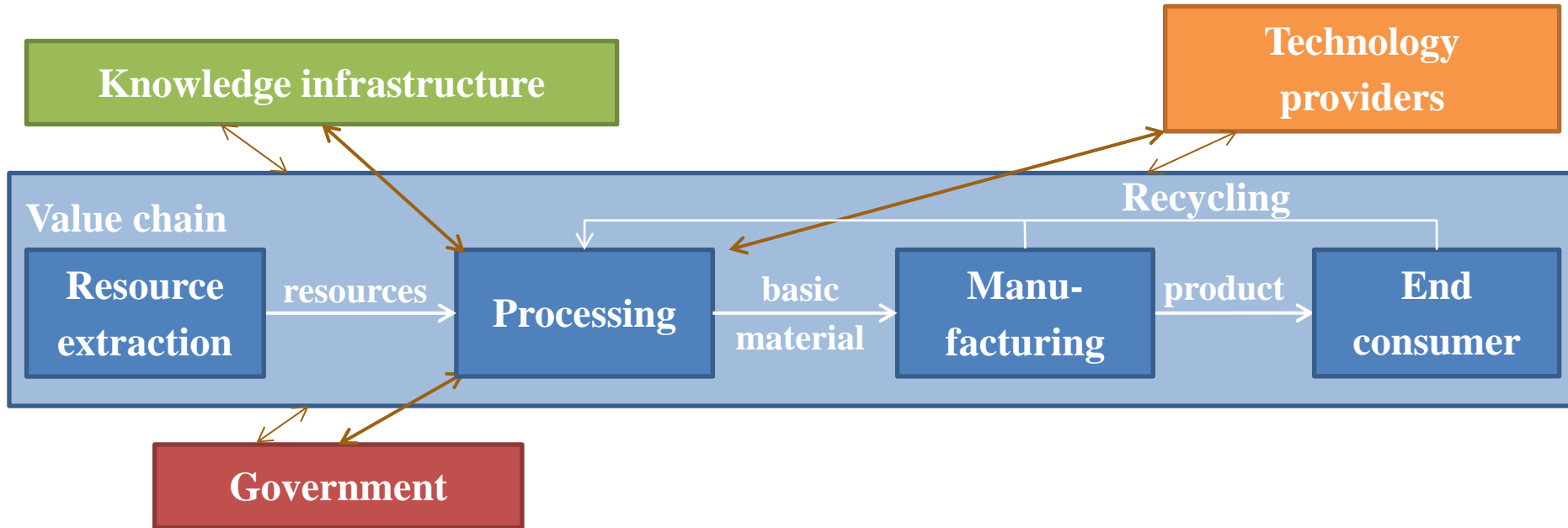
Carbon Dioxide
as Feedstock for
Fuels, Chemistry
and Polymers



We love CO₂

STEPS - Sustainable Plastics and Transition Pathways

Industry characteristics and innovation systems



- **Industry structure:** capital intensive, investment cycles, scale economies
- **Innovation strategies:** incremental process improvements, some products
- **Markets:** bulk commodities, cyclic, small margins (but some nichés)
- **Public policy:** safety, pollution, efficiency and shelter against disadvantages
- **Systemic lock-in:** incumbents, no markets, no push-pull, CO₂-leakage



Policy and governance implications

- **Direction**
 - Roadmaps, strategies, etc.
- **System innovation**
 - Technology push and market pull, co-evolution with energy system
- **Deployment**
 - Risk sharing and financing
- **Institutional capacity**
 - Government expertise and ability to manage decarbonisation
- **International policy coherence**
 - Revisit CBDR, sectoral approaches, trade



The future cannot be predicted,
but futures can be invented.

D. Gabor, 1963

“It was man's ability to invent which has made human society what it is.”

**“Überall geht ein frühes Ahnen dem
späteren Wissen voraus.”**

(Later knowledge is always preceded by an early instinctive idea)

Alexander von Humboldt (1769 – 1859)



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