Critical Raw Materials for Electric Vehicles

Bert Witkamp – Operating Agent Task 40

Task 40: Introduction, objectives and developments 2017 – 2022

29th April 2022 - webinar

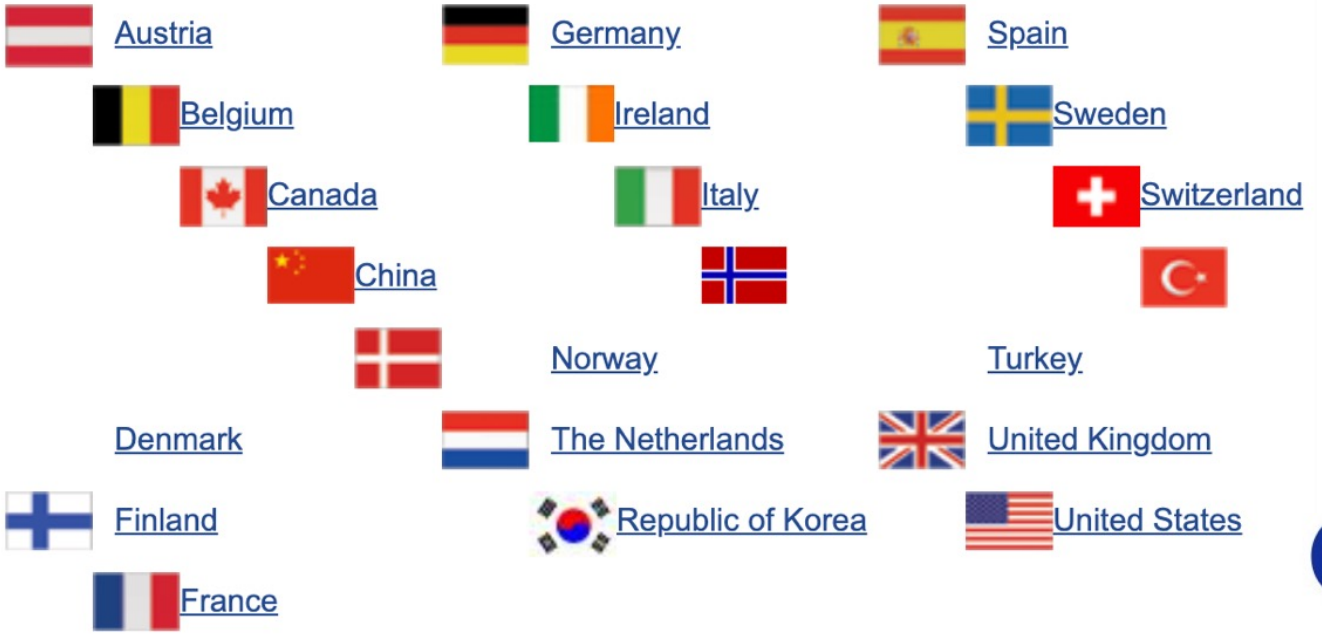
Disclaimer

- ***The IEA HEV TCP is part of a network of autonomous collaborative partnerships focused on a wide range of energy technologies known as Technology Collaboration Programmes or TCPs. The TCPs are organised under the auspices of the International Energy Agency (IEA), but the TCPs are functionally and legally autonomous. Views, findings and publications of the HEV TCP do not necessarily represent the views or policies of the IEA Secretariat or its individual member countries.***

- ***Views, findings and publications of the Task 40 CRM4EV (HEV TCP) do not necessarily represent the views or policies of the HEV Secretariat, HEV TCP or its individual member countries. Nor does it necessarily represent the individual Task 40 participants.***

The Hybrid Electric Vehicle Technology Cooperation Programme

An independent 19 country initiative in cooperation with the IEA and started in 1993



HEV TCP has started Task 40 CRM4EV in April 2018

CRM4EV
CRITICAL RAW MATERIALS ELECTRIC VEHICLES

CRM4V participating countries and organisations 2018 - 2022

IEA HEV Members

Agencies

British Geological Survey

ivl Svenska Miljöinstitutet

Geological Survey of Norway - NGU -

mriwa Minerals Research Institute of Western Australia

Office for Low Emission Vehicles

Rijkswaterstaat Ministry of Infrastructure and Water Management

Research

Argonne National Laboratory

Birmingham Centre for Strategic Elements and Critical Materials

Institute of Process Engineering, Chinese Academy of Sciences

DLR Deutsches Zentrum für Luft- und Raumfahrt German Aerospace Center Institute of Vehicle Concepts

IFP Energies nouvelles

IREC

JOANNEUM RESEARCH LIFE

The Faraday Institution | ReLiB Reuse & Recycling of Lithium Ion Batteries

울산대학교 University of Ulsan

Other participants

AVERE The European Association for Electromobility

BOTREE 博萃循环

Cu Copper Alliance®

VALUAD Sustainable Future

Industry participants 4/2018 – 4/2021

AngloAmerican

Cobalt Institute

Nickel Institute knowledge for a brighter future

igo

umicore materials for a better life

VALE

hevtcp

CRM4EV Critical Raw Materials Electric Vehicles

IEA HEV Task 40 CRM4EV

Connecting the raw material industry with electromobility

- **Mission**
  - To supply objective information to the **Task 40 participants** & to **governmental policy makers** and agencies, industry decision makers and research institutes
  - To facilitate international collaboration involving shared resources from multiple countries and organisations
- **Scope**
  - Raising awareness (on the topic): expert networks, workshops, publications, and communication.
  - Define supply and demand scenarios for EV deployment, battery technologies and key EV raw material requirements

hevtcp

CRM4EV
Critical Raw Materials Electric Vehicles

EVs and Critical Raw Materials:

Stakeholders need reliable, transparent & up to date information

Critical Raw Materials - Supply

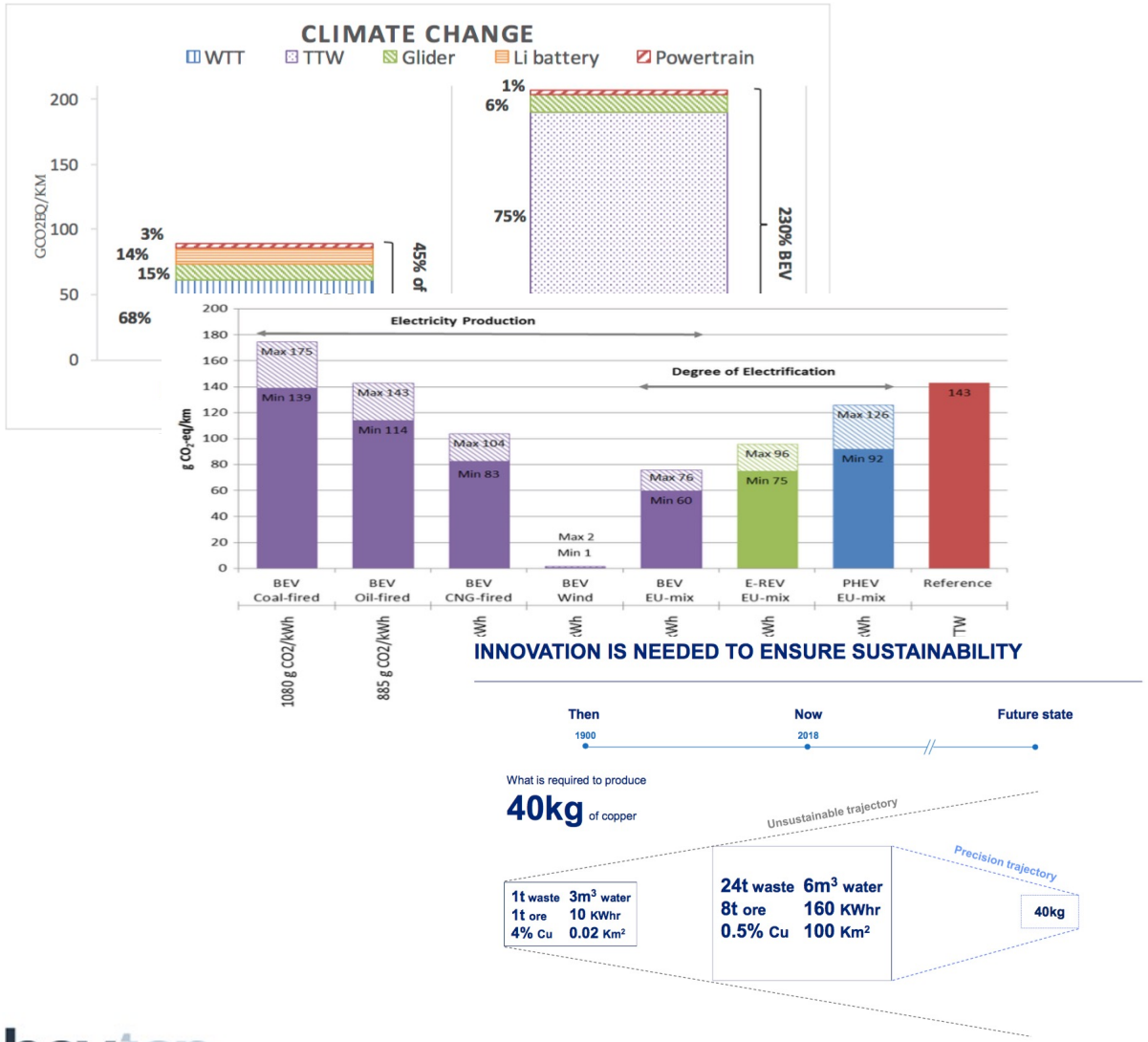
- Supply risks at short and long term?
- Environmental impacts?
- Social impacts?
- Recycling and the circular economy?
- *Li-Ni-Co-Cu-Graphite-Rare Earths*

Electric Vehicles - Demand

- How many, when, which type?
- When and to what extend will mass deployment happen
- How are EV technologies evolving which impact the type and quantity of CRMs required (per unit)?

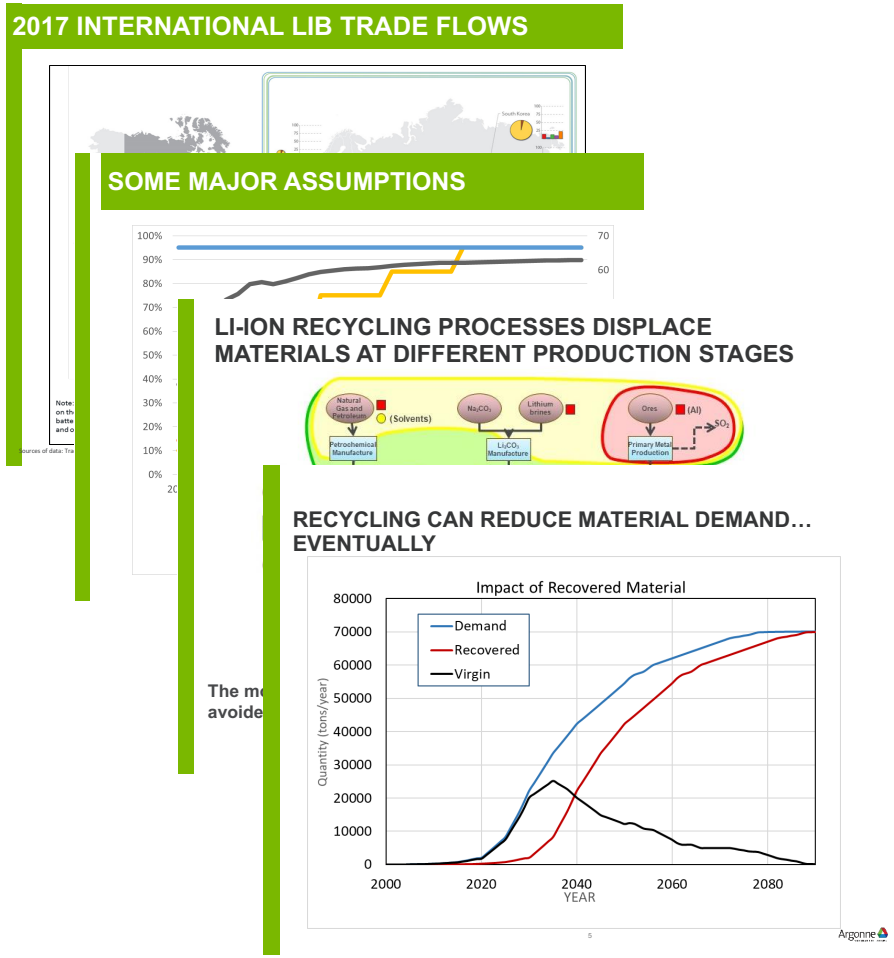
Geo-political risks were not specifically part of the scope

Reducing the Life Cycle impacts of EV batteries



- Entire EV lifecycle, raw materials key
- Focus GWP & primary energy demand
- Leveraging existing LCA studies and expertise of Task partners
- Harmonization of methodologies in existing CRM-LCA studies
- Current / future battery chemistries to consider in LCA

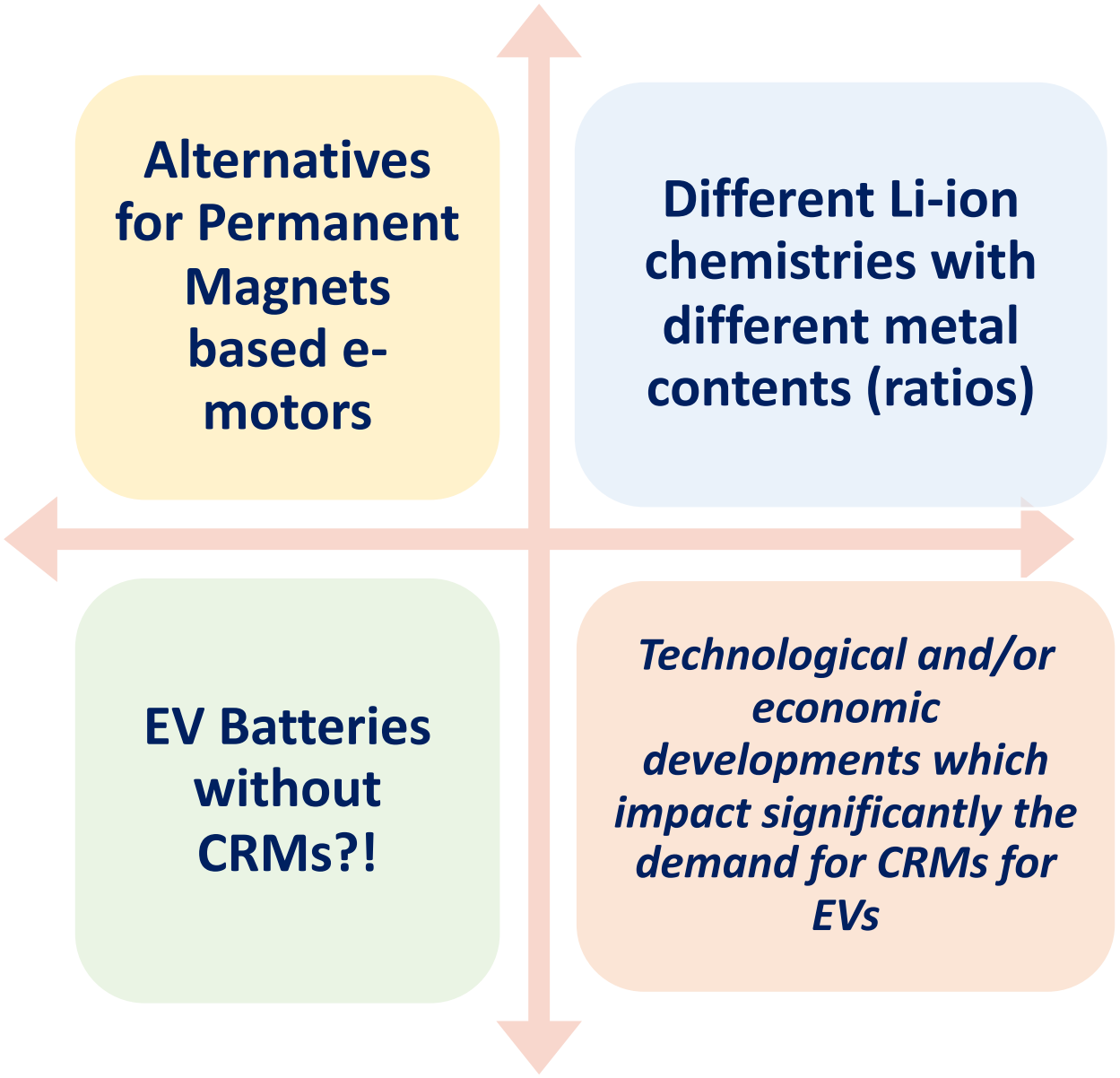
Recycling in task 40 CRM4EV



- Recycling as future source of raw materials (mass flow model, economics)
- Environmental impacts of recycling (input to Task 40 LCA model) versus use of virgin raw materials
- Evaluation of existing and future recycling processes (material yields, energy efficiency)

Also in scope:

Alternatives for Critical Raw Materials (applications)



Task 40 CRM4EV: examples of outputs

- **Electric vehicle deployment, battery demand and raw material requirements scenarios (update every year)**
  - Passenger cars (Global, Fast movers, Rapid shift to zero/low-Cobalt battery chemistries)
  - Scenarios for all road vehicles and other battery applications
  - Impact of recycling, contained minerals stock (battery materials)
  - Passenger cars use of rare earth elements for electric drive and recycle potential
  - Avoided PGM mineral consumption scenario
- **Battery technologies paper (peer-reviewed by external experts)**
- **Meta study of (50+) EV and raw material forecasts**

- **3 Task 40 CRM4EV Workshops and site visits, virtual events as of 2020**
- **About 100 internal presentations by Task 40 pariticpants and external experts and 15 presentations at external events**

CRM4EV
Critical Raw Materials Electric Vehicles

CRM4EV outputs

Electric Vehicle transition scenarios

EV penetration 2030 likely to be (much) higher than forecasted

- **Battery chemistry development (into commercial applications) has proven to be much faster than forecasted:**
  - High nickel NMC into 622, 811 chemistries (or even 955)
  - LFP storage density at cell and pack level (+ cell-to-pack design)

Facts & Assumptions on batteries technology

Assumptions on key mineral availabilities and potential supply issues

2019 of 14 million ton, resources 62 million ton; 2021: 21 million ton reserves and resources of 86 million ton)

External scenarios for (B)EV growth and sale

(IEA, GBA-WEI EV30@30, BNEF most consultancies

- **Assume a strong domination of high nickel battery chemistries (2030 horizon)**; this concluded from the scenario details provided and CRM4EV analysis.

BEVs are lower in purchase cost than conventional cars around 2025, combined with lower fuel and maintenance cost this should accelerate growth

- In many cases BEVs are already lower in TCO at present, lower taxes can be a deciding element

Assumptions on BEVs deployment

CRM4EV scenarios

cover external scenarios, ...litical ...ferent ...tries, ...state ...on-Li

November 2021

Battery market (GWh): Global scenarios, forecasts & targets 2030 for EV, ESS & CE

Scenario:	30% growth CRM4EV	40% growth CRM4EV	50% growth CRM4EV	GBA base	GBA target	EV30@30 midpoint	IEA STEPS	IEA SDS	BNEF	Road transport 100% electric "COP 21"
	8905	2332	3389	2651	1490	2980	1322		10230
	9195	2622	3679	2941	1687	3305	1612		10520
	97	*89*	*92*	*90*	*88*	*90*	*82*		*97*
	4400	1003	1398	1365	767	1463	706		4924
		1061	1584		657	1584			
	2920								3444
	1401								1487
	719	191	274	220	129	251	111		805
		214	290		109	263			
	820								918
	411								427
	1039	243	330	332	177	346	182		1189
		164	378		164	378			

RM4EV scenarios "High NiCo Li-ion battery demand" 2030 for EV

30% growth CRM4EV	40% growth CRM4EV	50% growth CRM4EV	GBA base	GBA target	EV30@30 midpoint	IEA STEPS	IEA SDS	BNEF	Road transport 100% electric "COP 21"

Nickel demand (kton): CRM4EV scenarios "High LFP and High Mn Li-ion battery demand 2030" for EV

Weighted Average Ni content in application kgNi/kWh	30% growth CRM4EV	40% growth CRM4EV	50% growth CRM4EV	GBA base	GBA target	EV30@30 midpoint	IEA STEPS	IEA SDS	BNEF	Road transport 100% electric "COP 21"
	387	754	1198	267	386	338	211	429	150	1198
	42	21	0	45	65	48	31	51	32	0
						14	0	0	6	10

- **CRM4EV scenarios developed to date:**
  - Cover the external scenarios, both in BEV growth rate as well as battery chemistry mixes: CRM4EV "High NiCo Li-ion demand" scenario at 30% YoY growth
  - Cover (much) higher BEV growth rates, in line with current trends and OEM/country ambitions (40% and 50%)
  - Cover 3000 – 9000 GWh battery demand by 2030
  - **Cover the current trends in battery chemistries for commercial applications (LFP, high-Mn) as well as announced developments (High-Mn and LFP scenarios)**
  - Cover a higher penetration of electrification for heavy duty vehicles

- **CRM4EV scenarios to be developed:**
  - Non-lithium based battery chemistries for commercial EV applications
  - Faster than "expected" growth of Solid State Batteries
  - Trends to reduce significantly (average) battery sizes of EVs

Battery and mineral demand scenarios

...cenarios and external global scenarios

CRM4EV Critical Raw Materials Electric Vehicles

April 2021: To execute additional work on new battery chemistries and technologies

- Significant developments in “zero/low” nickel/cobalt chemistries are on the horizon, we will evaluate status and potential impact
- Update of EV deployment scenarios, inclusion of commercial vehicles and buses
- Overall Li-ion battery demand (all apllications): update
- Evaluation of 2021 studies and scenarios (IEA, BNEF)

CRM4EV participants: 2018 – 2021: inclusion of industrial partners; final phase 2021 – 2022 focus on academic, expert and research stakeholders & avoid potential conflict of interest

Electric Vehicles & Policies 2015 - 2022

180° turnaround

2015: 500k PEV

2019: 2.3 mio PEV

2021: 6.7 mio PEV

2022: > 10 mio PEV

- **Up to 2015 considered to be a fantasy by (almost all) policymakers, industry & experts**
  - *Focus on Hydrogen, Natural Gas, ICE optimization…..*
- **In 2017 considered to be a nice but expensive niche solution with never more than a modest impact**
- **In 2019 industry and policymakers starting to accept it as short-term option to decarbonize transport**
- **In 2021: EV are the most important element to transition road transport to zero emission transport**
- **In 2022: War in Ukraine has / will further accelerate the transition from fossil fuels to renewables (= electricity) especially in Europe**