

Government Assignment – Infrastructure for Test/Pilot Facilities for Critical Raw Materials

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The Government assignment

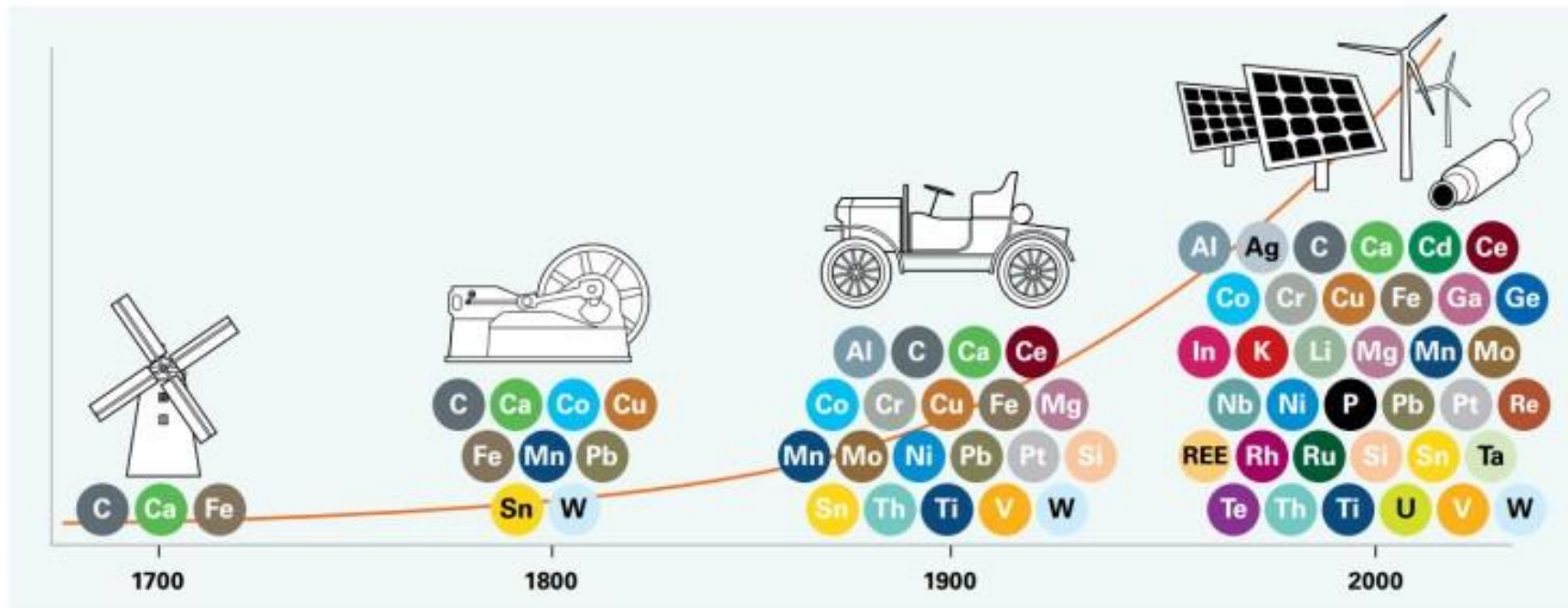
- **Time frame:** 2025–2026
- **Purpose/Aim:**
 - To analyse and propose what infrastructure needs to be established in Sweden to meet future needs for test and demonstration facilities for extraction technologies—complementing the infrastructure already available in the Nordic region and accessible to Swedish universities/companies.

The assignment also includes proposing how such a test and demonstration infrastructure should be organised.

- **Budget:**
 - Year 1: 1,5 million (2025)
 - Year 2: 3,6 million (2026)
- Cooperation with Luleå University of Technology (LTU)

Increasing product complexity

- making use of almost the entire periodic table of elements



Elements widely used in energy pathways

Achzet et al., Materials critical to the energy industry, Augsburg, 2011

Energy-Critical Elements (APS, 2010)

Legend:

- Platinum Group Elements (Blue)
- Other ECEs (Orange)
- Rare Earth Elements (Purple)
- Photovoltaic ECEs (Green)

Callouts:

- Varuträsk: Li
- Österlen: V
- Vittangi: B, C, N, O, F, Ne
- Bottenbäcken: Pt, Au, Hg, Tl, Pb, Bi, Po, At, Rn

1 H Hydrogen 1.01																	2 He Helium 4.00										
3 Li Lithium 6.94	4 Be Beryllium 9.01																	10 Ne Neon 20.18									
11 Na Sodium 22.99	12 Mg Magnesium 24.31																	17 Cl Chlorine 35.45	18 Ar Argon 39.95								
19 K Potassium 39.10	20 Ca Calcium 40.08	21 Sc Scandium 44.96	22 Ti Titanium 47.87	23 V Vanadium 50.94	24 Cr Chromium 52.00	25 Mn Manganese 54.94	26 Fe Iron 55.85	27 Co Cobalt 58.93	28 Ni Nickel 58.69	29 Cu Copper 63.55	30 Zn Zinc 65.39	31 Ga Gallium 69.72	32 Ge Germanium 72.61	33 As Arsenic 74.92	34 Se Selenium 78.96	35 Br Bromine 79.90	36 Kr Krypton 83.80										
37 Rb Rubidium 85.47	38 Sr Strontium 87.62	39 Y Yttrium 88.91	40 Zr Zirconium 91.22	41 Nb Niobium 92.91	42 Mo Molybdenum 95.94	43 Tc Technetium (98)	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.91	46 Pd Palladium 106.42	47 Ag Silver 107.87	48 Cd Cadmium 112.41	49 In Indium 114.82	50 Sn Tin 118.71	51 Sb Antimony 121.76	52 Te Tellurium 127.60	53 I Iodine 126.90	54 Xe Xenon 131.29										
55 Cs Cesium 132.91	56 Ba Barium 137.33	57 La Lanthanum 138.91	72 Hf Hafnium 178.49	73 Ta Tantalum 180.95	74 W Tungsten 183.84	75 Re Rhenium 186.21	76 Os Osmium 190.23	77 Ir Iridium 192.22	78 Pt Platinum 195.08	79 Au Gold 196.97	80 Hg Mercury 200.59	81 Tl Thallium 204.38	82 Pb Lead 207.2	83 Bi Bismuth 208.98	84 Po Polonium (209)	85 At Astatine (210)	86 Rn Radon (222)										
87 Fr Francium (223)	88 Ra Radium (226)	89 Ac Actinium (227)	101 Rf Rutherfordium (261)	105 Db Dubnium (262)	106 Sg Seaborgium (266)	107 Bh Bohrium (264)	108 Hs Hassium (269)	109 Mt Meitnerium (268)																			
														LREE				HREE + Y									
														58 Ce Cerium 140.12	59 Pr Praseodymium 140.91	60 Nd Neodymium 144.24	61 Pm Promethium (145)	62 Sm Samarium 150.36	63 Eu Europium 151.96	64 Gd Gadolinium 157.25	65 Tb Terbium 158.93	66 Dy Dysprosium 162.50	67 Ho Holmium 164.93	68 Er Erbium 167.26	69 Tm Thulium 168.93	70 Yb Ytterbium 173.04	71 Lu Lutetium 174.97
														90 Th Thorium 232.04	91 Pa Protactinium 231.04	92 U Uranium 238.03	93 Np Neptunium (237)	94 Pu Plutonium (244)	95 Am Americium (243)	96 Cm Curium (247)	97 Bk Berkelium (247)	98 Cf Californium (251)	99 Es Einsteinium (252)	100 Fm Fermium (257)	101 Md Mendelevium (258)	102 No Nobelium (259)	103 Lr Lawrencium (262)

Varuträsk

Österlen

Vittangi

Skellefte field
gold and
sulphide ores

Bottenbäcken

Kiruna type apatite iron ores, Norra Kärr

Critical/Strategic Raw materials

- EU Critical Raw Materials list of 2023 (32+2)

2023 Critical Raw Materials (Strategic Raw Materials in blue)

aluminium/bauxite	coking coal	lithium	phosphorus
antimony	feldspar	LREE	scandium
arsenic	fluorspar	magnesium	silicon metal
baryte	gallium	manganese	strontium
beryllium	germanium	natural graphite	tantalum
bismuth	hafnium	niobium	titanium metal
boron/borate	helium	PGM	tungsten
cobalt	HREE	phosphate rock	vanadium
		copper	nickel

Assignment Restrictions

- Assignment deals mostly with primary resources, since there is little mass of critical secondary resources as yet.
- Work investigates up to and including metal production. Further treatment falls under material science, and that is beyond the scope of the assignment.
- Major interest is to map open lab, test, and pilot resources.
- Only test and pilot facilities in Nordic countries are investigated. European sites might be visited at a later stage.

Expected Deliverables

Interim Report 1 (March 2026): Mapping of existing Nordic infrastructure. Scenario analysis delivered to the Government Office

Workshop in Luleå 21st April with Swedish stakeholders

Interim Report 2 (October 2026): Summary of proposals (from industry, research institutes, etc.) for new Swedish infrastructure (model, organisation, financing)

Final Report (December 2026): Consolidated analysis, conclusions and recommendations

Other workshops and meetings:

Sector dialogues with Swedish/Norwegian and Finnish industry stakeholders, and research funders.

Performed/Planned Visits – Inventory

Sweden

Facility	Type	P/S/Both	Process step	Materials
KTH (I)	LAB	Secondary	H–SX	CRM
Chalmers (I)	LAB	Secondary	H–SX–P	REE, Li, Co, Ni, PGE
LTU (I)	LAB/Bench	Both	E–H–P	CRM, Fe, Base metals, Graphite
SWERIM (I)	Pilot	Both	P	Fe, Ni, Mn
Boliden R&D (Boliden) (I)	Pilot	Both	E–H	Te, Ni, Cu, Zn
Boliden (I) Rönnskär	IND	Both	P–R	Cu, Ni, ZnO, PGE
Boliden Bergsöe	IND	Secondary	P–R	Pb
LKAB Malmberget (I)	IND	Primary	G–E	Fe, P
LKAB Minerals (I)	DEM	Secondary	H–SX–R	REE, P
Talga	DEM/IND	Primary	R	Graphite
IVL	LAB	Sekondary	H	P, REE
RISE (I)	LAB/Pilot	Secondary	H–SX	Li, Co, Ni, Graphite

G: Grinding; **E:** Enrichment; **H:** Hydrometallurgy; **SX:** Solvent Extraction; **R:** Refinement, **P:** Pyrometallurgy; **I:** Interviewed;
FIN: Finland; **NO:** Norway; **DK:** Denmark; **IND:** Industry scale; **LAB:** Laboratory scale; **Bench:** Bench scale

Performed/Planned Visits – Inventory, ctd.

Nordic Countries

Facility	Country	Type	P/S Both	Process step	Materials
GTK Mintec (I)	FIN	Bench/Pilot	Primary	G–E–H	Li, Co, Ni, Cu etc.
VTT (I)	FIN	Bench/Pilot	Secondary	E–H–SX	Li, Co, Ni, Mg etc.
Oulu University (I)	FIN	LAB/Bench	Primary	G–E	Ni, Cu, etc.
Metso Test Center Pori	FIN	Bench/Pilot	Primary	G–E–H	Ni, Ti, Cu, Cg
Yara Siilinjärvi	FIN	IND	Primary	G–E–H	P, Mg etc.
Boliden Harjavalta	FIN	IND	Both	P–R	Cu, Ni, Au, Ag etc.
REEttec (I)	NO	DEM/IND	Secondary	H–SX–R	REE
Boliden Odda	NO	IND	Both	R	Zn, Pb, Au, Ag etc.
NTNU–SINTEF (I)	NO	Pilot/DEM	Both	P	Mn, Ti, Si etc.
DTU	DK	LAB	Secondary	H	Li, Co, Ni etc.

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Experiences from industry, academy and institutes

• Industry:

- Development of in-house pilot and demonstration facilities (own capacity, internal funding)
- Challenges related to small production volumes (“good price / no volume”)
- Production of intermediate products for strategic applications
- Gap: the productization stage; limited collaboration with universities (regulatory constraints, difficulties in sharing R&D activities)
- Test equipment suppliers (limited availability, often non-customised, off-the-shelf solutions)

• Universities:

- High level of expertise along the value chain
- Limited capacity in the final productization stage
- Shortcomings: Long-term financing, capacity/opportunity for commercial projects

• Research institutes:

- Key: Flexibility in personnel and pilot equipment,
- Shortage of metallurgists and pilot technicians,
- Financing models not adapted for pilot operations, often not available to SMEs (no customers)

Scenario analysis

- Illustrate alternative ways to organise and dimension infrastructure for testing, pilot, and demonstration
- Analytical tool to compare capacity, costs, organisational consequences, and degree of national availability for different directions/scenarios
- Swedish cost estimates: Based on mining and metallurgical processes' specific technical demands, experience from industry/academy/institute
- Finnish cost estimates: Costs for Scenario D and E are based on disclosed CAPEX and OPEX for GTK Mintec and VTT Espoo, adjusted to Swedish conditions, and concerns establishment and operation of test and pilot for mineral processing and hydrometallurgy.
- **A** – Swedish universities
- **B** – Swedish research institutes
- **C** – Combination Swedish universities–research institutes
- **D** – Nordic co-operation
- **E** – A Swedish GTK Mintec

Analysis of scenarios A – C

Aspect/Scenario→ ↓	A – University	B – Institute	C – University+ Institute
Initial physical processing	Good (Lab+Bench)	Limited (not core business)	Good (University)
Later process stages (H, SX/IX, P, R)	Good (Lab+Bench)	Very good Pyro, some Hydro	Very good (Bench+Pyro)
Productization and market relevance	Limited	Good	Good
Secrecy and industrial co-operation	Limited	Very good	Very good
Investment (CAPEX)	~ 20 MSEK	~ 400 MSEK	
Annual extra operating cost (OPEX)	~ 5 MSEK/year	~ 80 MSEK/year	
General assessment	Strong R&D/low pilot capacity	Strong metallurgic pilot	Best national balance
Implementation time	2 years	2 – 3 years	3 – 5 years

H = hydrometallurgy, SX/IX = solvent extraction/ion exchange, P = pyro metallurgy, R = refining, L: Laboratory, B: Bench, PI: pilot.

- A. Universities** – good capacity in bench scale throughout nearly the whole value chain, productization missing. Limitations in pilot scale, and implementation of commercial projects.
- B. Institutes** have strong capacity in metallurgic (pyro and hydro) pilot scale and good industrial coupling, but do not cover early process stages. May run commercial projects.
- C. Combination** universities' wide bench scale capacity in early and late process stages with research institutes' pilot scale and industrial work.

Analysis of scenarios D – E

Aspekt / Scenario → ↓	D – Nordic co-operation	E – Swedish centre like GTK Mintec
Initial physical processing	Very good (GTK Mintec, Metso Test Centre and others)	Very good (national pilot capacity)
Later process stages (H, SX/IX, P, R)	Very good (VTT, SINTEF, REEtec and others.)	Good (hydro metallurgy in lab and pilot)
Productization and market relevance	Good (depending on external access)	Good (intermediate products, not full refining)
Secrecy and industrial co-operation	Varying (different regulations)	Good (national structure)
Investment (CAPEX)	Limited national investment (~ 30–70 MSEK)	High initial investment (~ 1000 MSEK)
Annual extra operating cost (OPEX)	Moderate (~ 20–40 MSEK/year)	High (~ 100–120 MSEK/year)
General assessment	Strong technical capacity, but dependent on external settings	Full national resourcefulness, high cost, large fixed personnel cost
Implementation time	2–3 years	10 years

H = hydrometallurgy, SX/IX = solvent extraction/ion exchange, P = pyro metallurgy, R = refining, L: Laboratory, B: Bench, PI: pilot

D. Nordic co-operation. Swedish supplementary investments and ongoing access to Nordic facilities. Small investments, but requires more planning, and willingness to co-operate (less availability).

E. Swedish GTK Mintec. Construction and operation of a national Swedish centre with corresponding functional width as GTK Mintec. High costs OPEX/CAPEX, long time for environmental permit, construction time, recruitment of competent personnel. Does not answer to the need for immediate access to lab and test capacity for critical materials.

Experiences from Workshop

- Sweden shall collect, present, and coordinate what is already existing as infrastructure – not try to build another GTK Mintec.
- The needs of large and small companies may differ.
- The creation of a small scale (drill-core scale) pilot facility is called for.
- Test facilities for separation, cleaning, and productization of critical materials is needed.
- There is a need for continuous government funding of infrastructure, not just for building lab and test facilities, but for maintaining capacity and for training and retaining technical personnel.

Overall analysis and ways forward

Largest challenges

- Sweden is missing a cohesive, open, and flexible pilot infra structure
- Largest deficiency in late, value critical process stages

Recommendations based on the analysis

- National coordination among academy, institutes and industry. How?
- Modular structure – coherent pilot chains are only established where it is technically motivated, while other process stages can be handled in bench scale or as detached pilot stages.
- Long-term government support – initial investment and operating cost (since customers may not line up from the beginning)