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Life Cycle of Products, Processes and Services

Metal circularity opportunities & challenges

François Saunier, Senior Analyst

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Metals and circular economy in Quebec

https://mern.gouv.qc.ca/mines/publications/analyses-projets-recherche/

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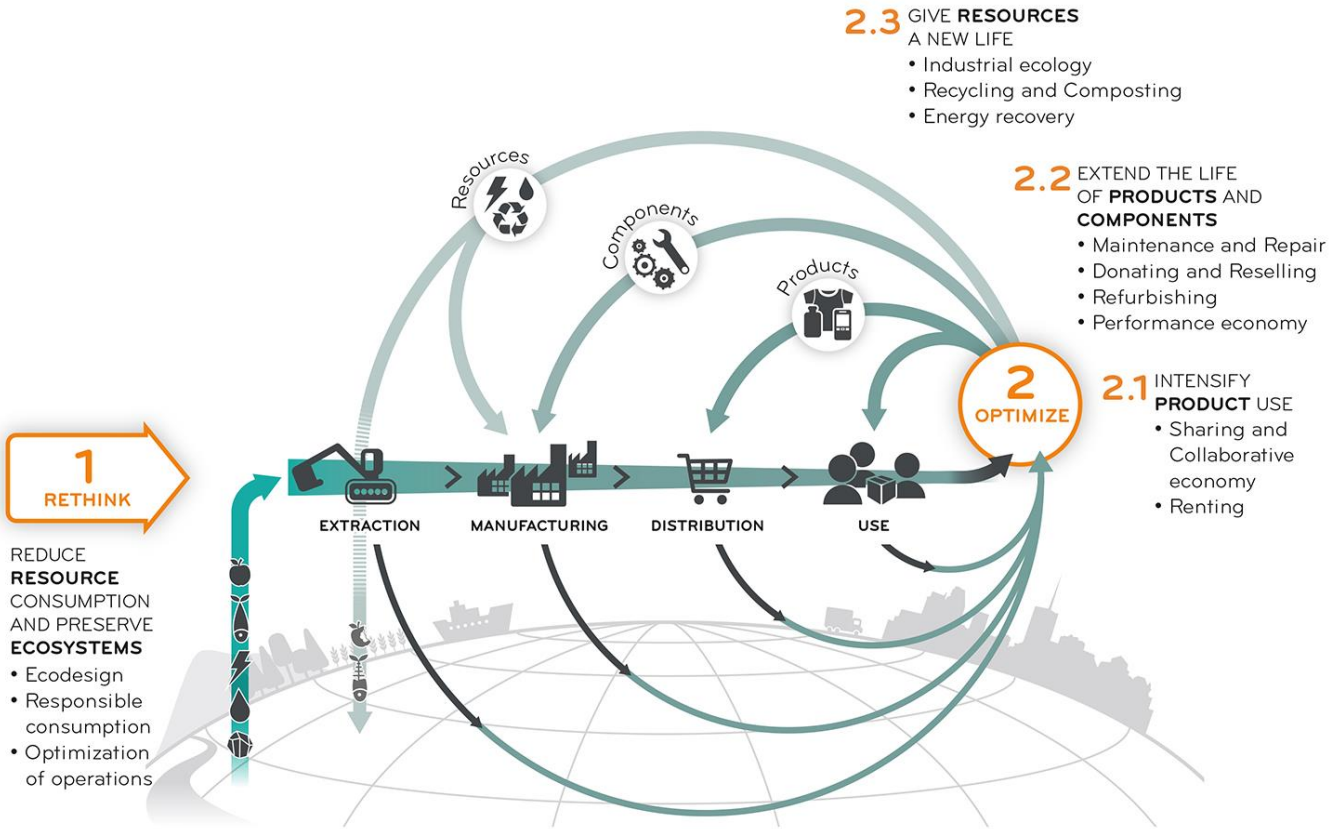
Metals and circular economy in Quebec - MERN

- Two objectives
  - Evaluation of the circularity potential of 3 strategic metals in Quebec
  - Documentation of their environmental impacts over their life cycle

- Funded by MERN – Ministère de l'Énergie et des Ressources Naturelles (2016-2018, 900k$), as part of the "Vision stratégique du développement minier" policy

- Multidisciplinary team : Polytechnique, HEC, University of Montreal

Circular economy



Objective of the study

To evaluate the circularity potential of 3 strategic metals in Quebec

Copper

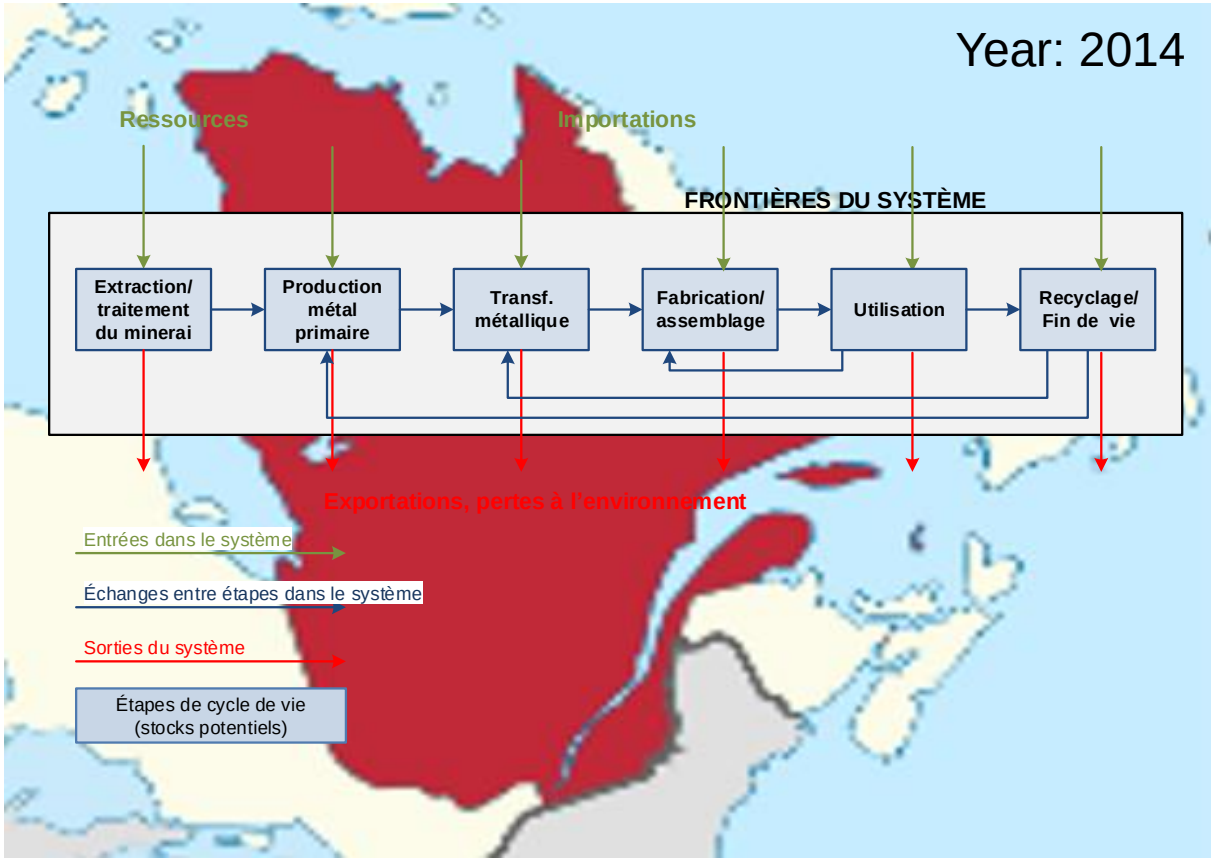
Iron

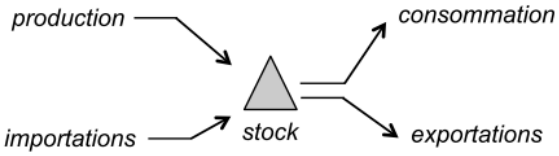
Lithium

Project stages

1. Selection of the 3 metals
2. Diagnostic
   - Material flow analysis
   - LCA
3. Review of relevant circularity strategies
4. Analysis of circularity strategies
   - Incentives and obstacles
   - Circularity potential, economic faisability and risk to burden shifting

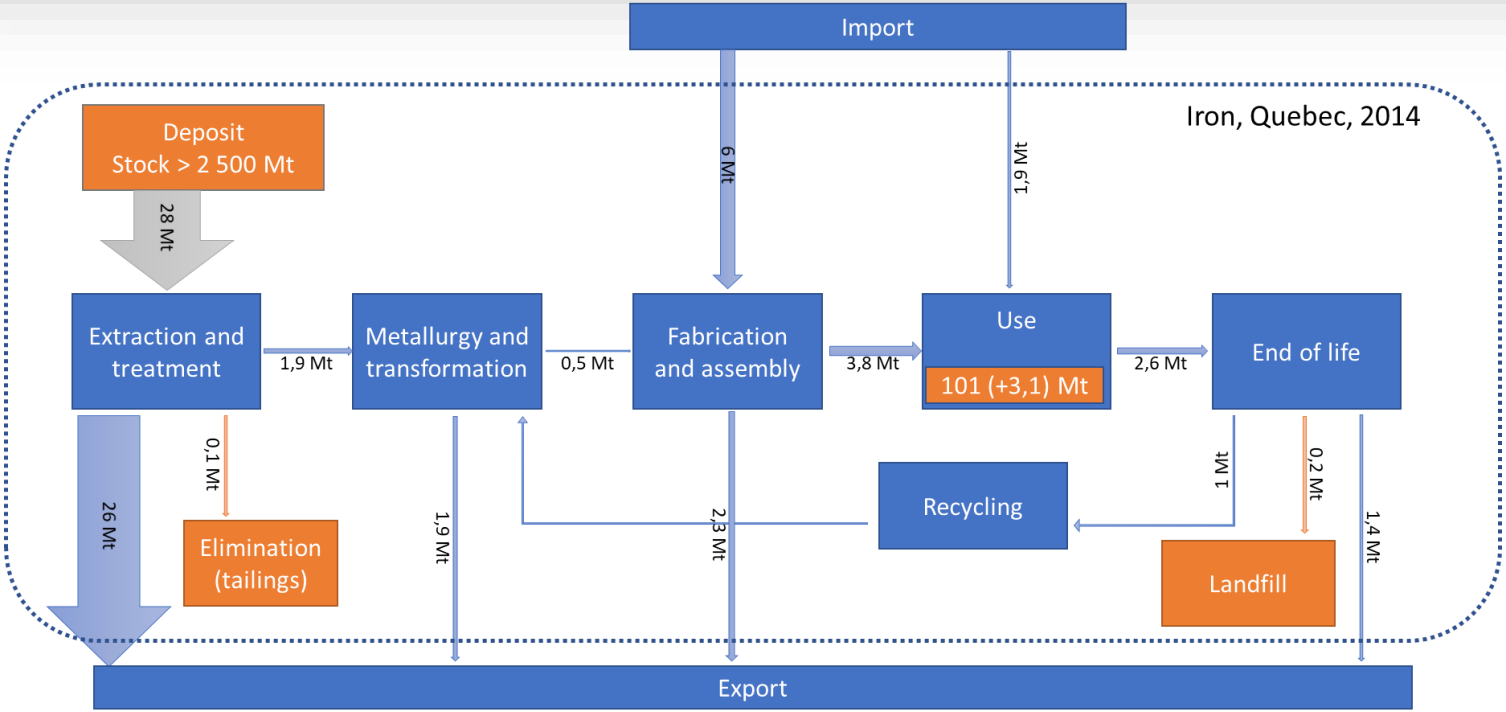
Diagnostic – Material Flow Analysis





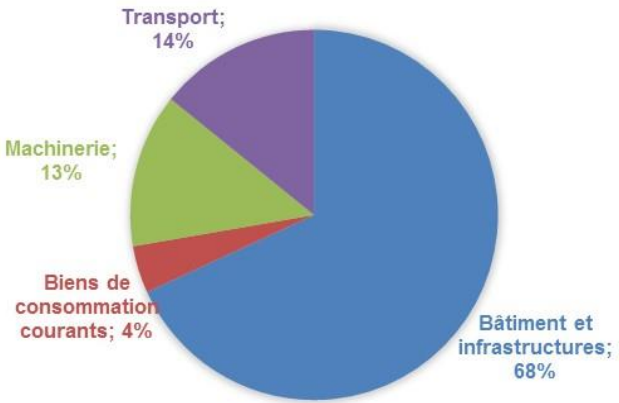
$$I + P = C + \Delta S + E$$

Diagnostic - MFA - Iron in Quebec

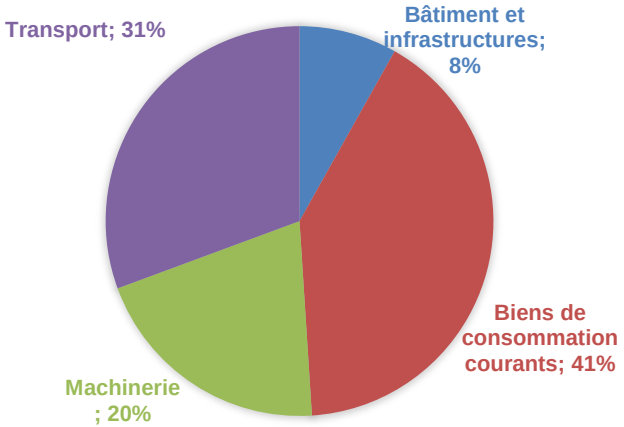


Diagnostic - MFA - Iron in Quebec

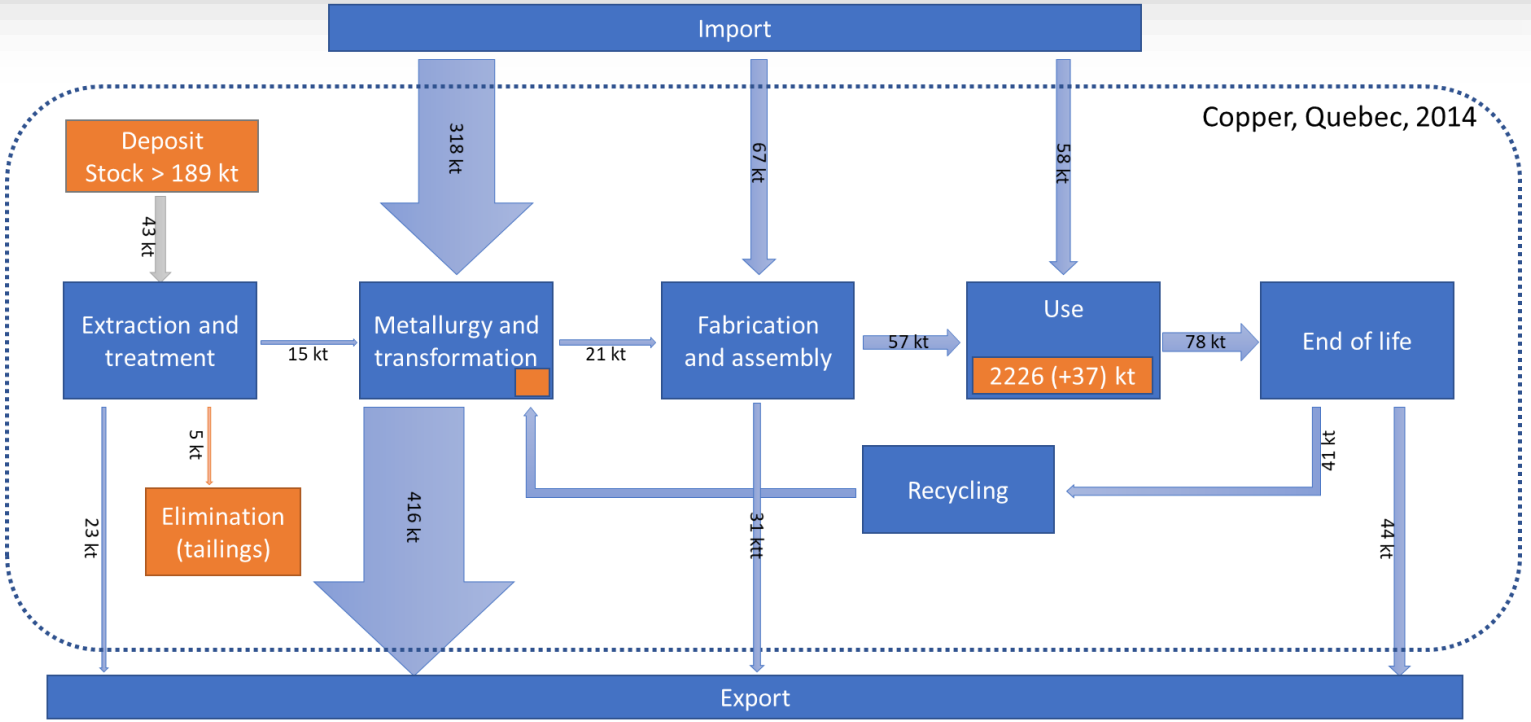
Composition of stock in use (100 Mt)



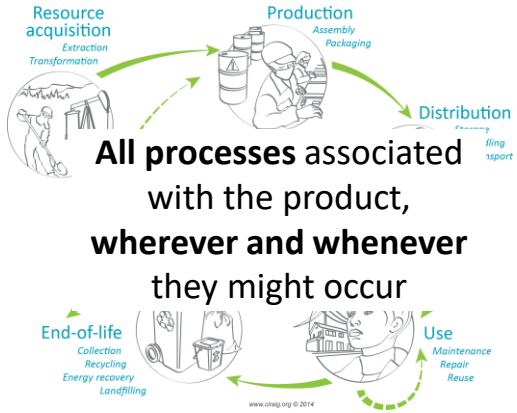
End of Life flow (2,6 Mt/an)



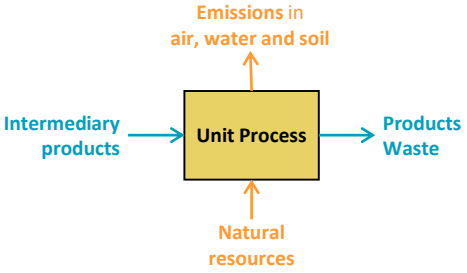
Diagnostic - MFA - Copper in Quebec



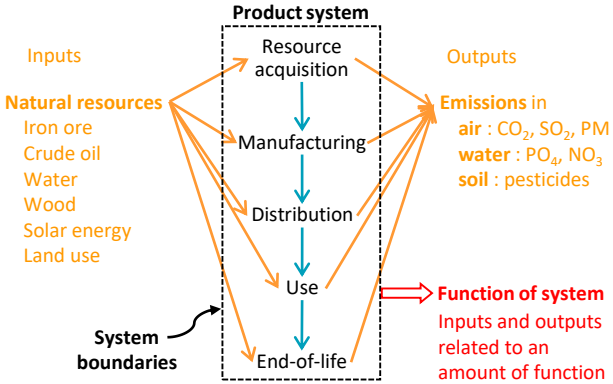
Diagnostic – Life Cycle Assessment (LCA)

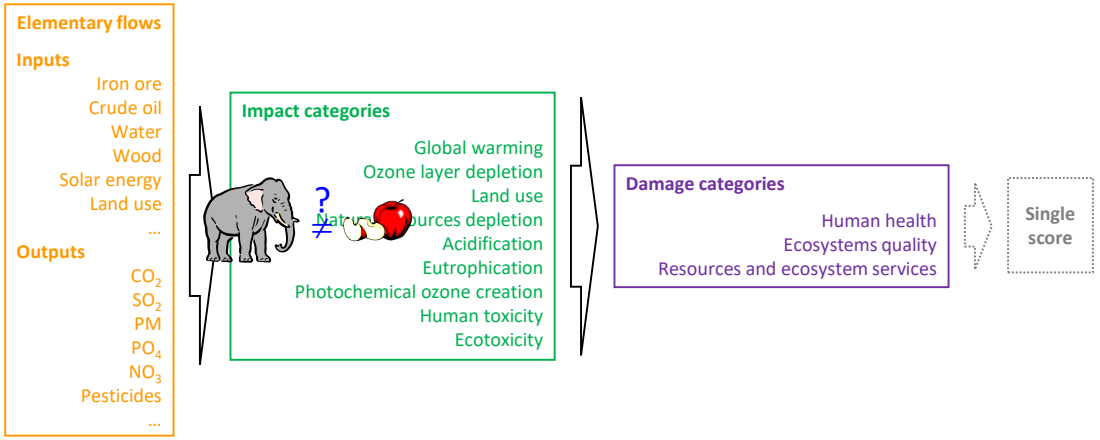


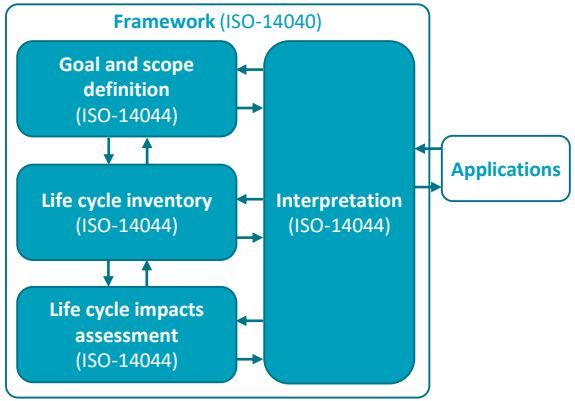
All processes associated with the product, **wherever and whenever** they might occur



The inputs and outputs of processes, exchanged between processes or with the environment, can be quantified, compared and aggregated



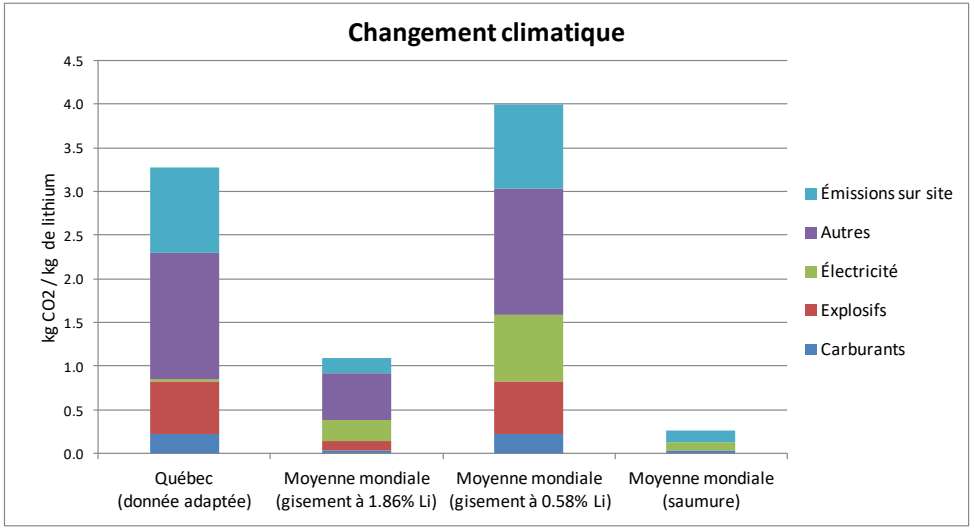




Diagnostic - LCA – Lithium in Quebec

Comparison of GHG emissions for lithium extraction and concentration (from spodumene or brine)

- Lower spodumene concentration in Quebec (0.56% Li vs 1.86% Li in world average data)
- Solar energy for brine evaporation



41 identified circularity strategies

18 common strategies among the 3 metals and products including them

- Extraction – ex. better storage of mine tailings
- Metallurgy – ex. industrial symbiosis of slag residues
- Metallic transformation – ex. ecodesign, functional economy .
- Use phase – ex . Repair workshops
- End of Life– ex. metal recycling, development on desalloy processes

23 specific on products including the metals

- wires, home appliances, construction, vehicles, batteries, mechanical and industrial equipment

-> Selection of 13 strategies based on several criteria (feasibility, utility, amount of metal, environmental and social potential…)

Analysis of the circularity strategies

1. Incentives and obstacles
   - Interview of industrial and governmental actors

2. Evaluation of the 13 selected circularity strategies from a technico-economical and long term perspective
   - Circularity potential
     - Amount of re-used or recycled metal
     - Avoided amount of primary metal (non-extracted)
   - Technico-economical faisability
     - Is the strategy profitable for a company
     - Does the strategy comes out being optimal for the society?

3. Evaluation of the risk of burden shifting due to the implementation of such circularity strategies (LCA)

Analysis of the circularity strategies

Potentiel de circularité (quantité)	Faisabilité technico-économique (coût) – Fort	Faisabilité technico-économique (coût) – Moyen	Faisabilité technico-économique (coût) – Faible
Fort	Fabrication additive **Recyclage de la ferraille** **Recyclage du lithium des batteries** Écoconception des véhicules – Matériaux plus légers	Stockage d'énergie photovoltaïque avec des batteries lithium-ion usagées	Mines urbaines **Recyclage du fer des trains** Déconstruction sélective des bâtiments et infrastructures Récupération des métaux précieux des boues anodiques
Moyen	Séquestration du CO_2 à partir de laitiers	Entreposage adéquat des résidus miniers pour une extraction ultérieure **Recyclage du cuivre des câbles**	Écoconception des poutres en acier
Faible	Développement technologique pour une extraction plus efficace **Recyclage du fer des voitures**	Récupération d'énergie thermique des laitiers **Recyclage du cuivre des circuits imprimés** Autopartage **Modularité des équipements mécaniques et industriels**	**Recyclage du fer des avions** **Recyclage du cuivre des ordinateurs** **Recyclage du cuivre des cellulaires** Recyclage du lithium du verre

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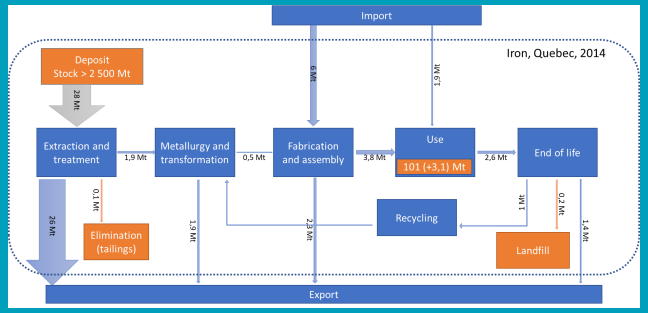
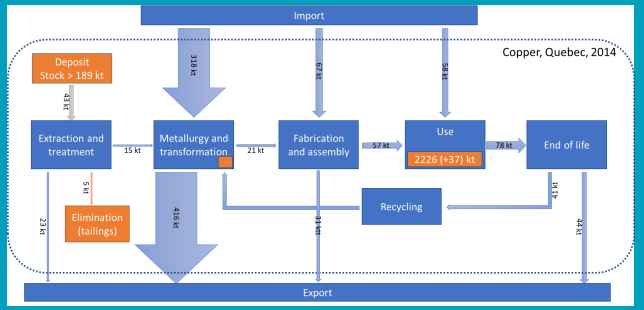
Conclusions

- Some strategies are well implemented and have a good performance (steel recycling, …)
- Some strategies need compromise (car sharing, used batteries for energy storage, …)
- Importance to evaluate circularity consequences (LCA, technico-economic approches, …)
- Opportunities to develop lithium activities in Quebec in a more circular way.

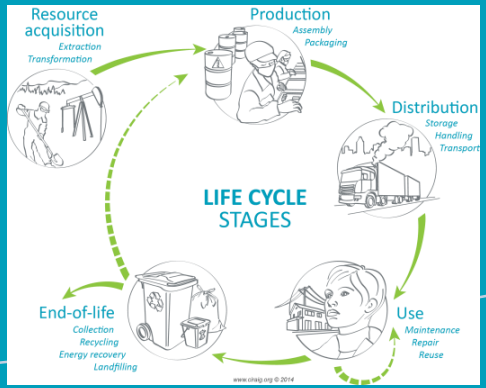
Recommendations for policy development

- Build on existing successes to promote circularity and reduction of raw material extraction.
- A systemic view is needed in the assessment of strategies.
- Local context is important and could influence the potential of circularity strategies.
- Without a global approach addressing both production and consumption, we won't be able to tackle the preservation of resources and natural environment in the long term.





QUESTIONS ?



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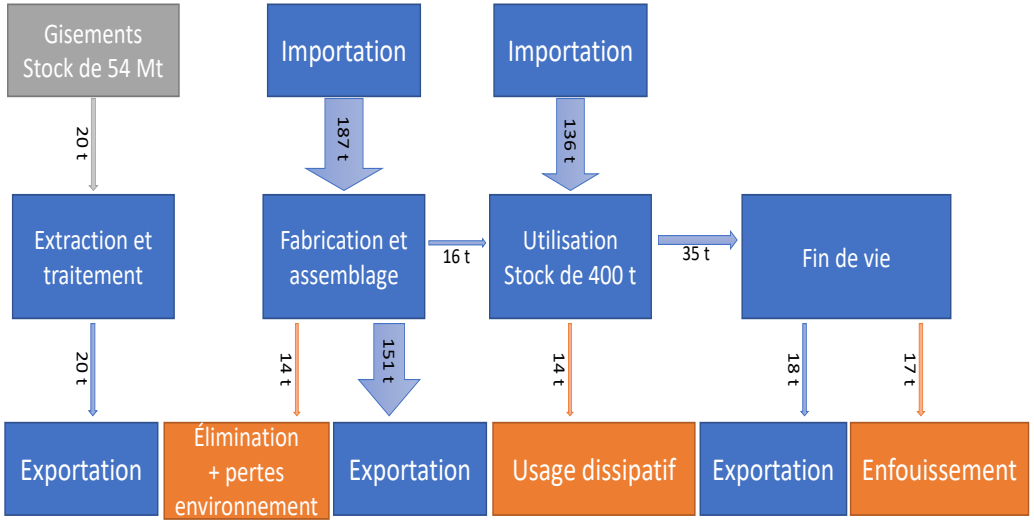
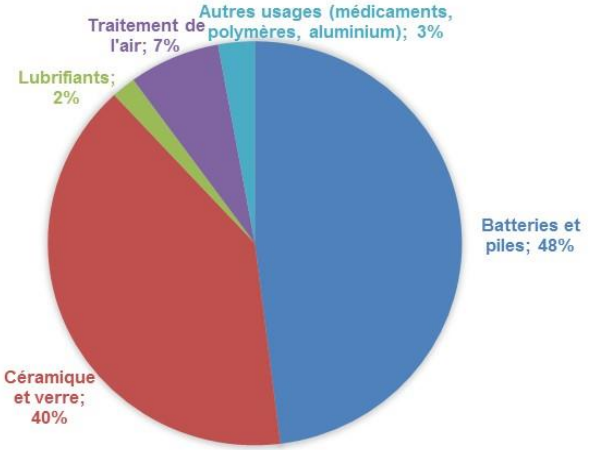
MFA of Lithium in Quebec





CIRAIG study on electric vs conventional vehicles

Hydro-Québec mandated the CIRAIG for an in depth analysis of electric and conventional vehicles based on the characteristics of currently (2013) available vehicles

http://www.hydroquebec.com/developpement-durable/centre-documentation/acv-vehicule-electrique.html.

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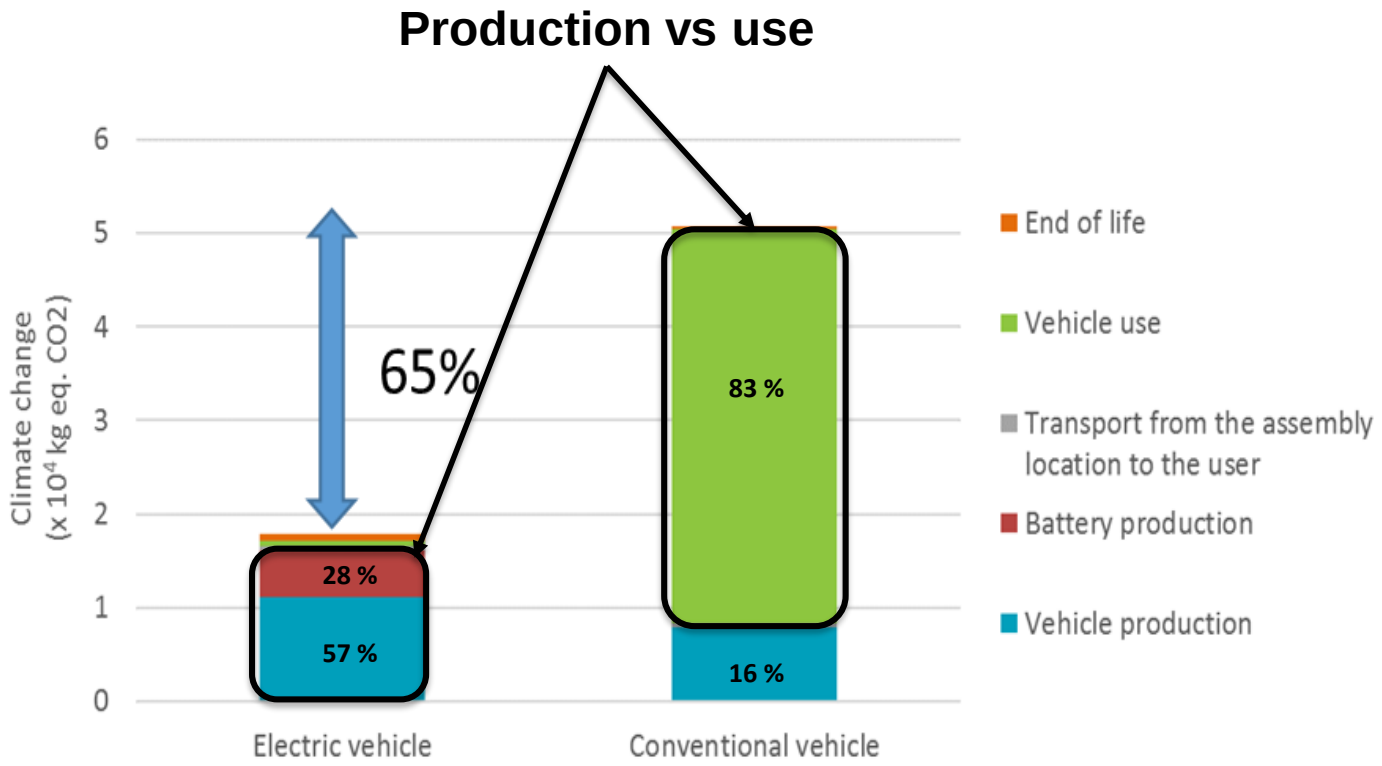
Comparison of electric vs conventional vehicles



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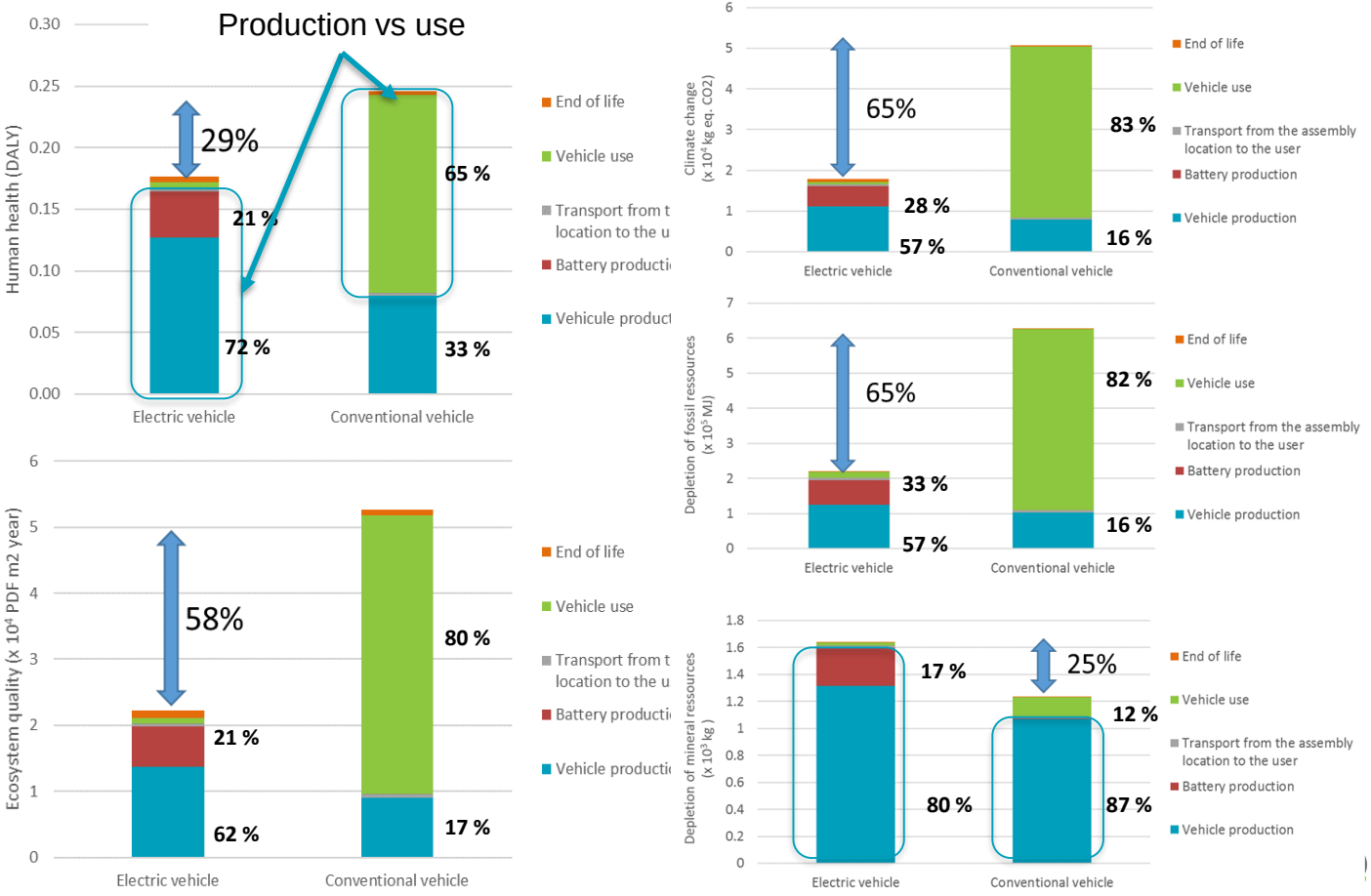

The importance of the production step

Componants (kg)	Steel	Iron	Aluminum	Copper
Common components: doors, brakes, etc.	770,9	18,2	21,8	15,8
Specific to the conventional vehicle	110,4	97,5	49,5	6,5
Specific to the electric vehicle	33,1	13,2	184,5	110
Total Conventional vehicle	**881,3**	**115,7**	**71,3**	**22,3**
Total Electric vehicle	**804,0**	**31,4**	**206,3**	**125,8**
Impact factor associated with the production of materials (per kg of produced materials)				
Human health (DALY/kg)	$3,4\times10^{-5}$	$4,6\times10^{-5}$	$1,17\times10^{-4}$	$2,8\times10^{-4}$
Ecosystem quality (PDF m^2 an/kg)	2,1	2,2	16,8	18,5
Global warming (kg $CO_{2\ eq.}$ /kg)	1,8	2,0	15,6	5,5
Fossil resource depletion (MJ /kg)	14,9	16,2	120,1	74,1
Mineral resource depletion (kg/kg)	0,7	0,9	1,3	1,3

Conclusion

Main scenario and sensitivity analysis	Observations
• Main scenario	EV shows 29 to 65% less impacts than CV (except for Mineral resource depletion)
• Vehicles mass	Mineral resource depletion: smaller EV equivalent to bigger CV
• Vehicles lifetime (km)	Increases the advantage of EV
• Energy consumption	Marginal consequences on EV
• Driving pattern	Marginal consequences on EV
• Battery change	Increases the EV impact by 17 to 30%
• Recharging efficiency	Little to no influence on the overall results
• Vehicle origin	Little to no influence on the overall results
• Road inclusion	No influence on the overall results
• Battery type	Little to no influence on the overall results
• Battery end-of-life	Little to no influence on the overall results