

## The challenges of ecological transition - ETRE

Time: 2 hours. All documents forbidden - calculators authorised.

**The first page of the subject must be returned completed at the end of the examination,**  
with your exam sheets on which you will write the rest of the questions.

**For multiple-choice questions (MCQs), the following scale will be applied:**

0.5 points for a correct answer / -0.25 for an incorrect answer.

The rest of the scale is indicative only and might be used as a guide. Justified answers are expected.

Name	First name	Group

### **Exercise 1: Biodiversity and biogeochemical cycles** (indicative scale: /5 pts)

Answer the following questions.

**1.1) Which term refers to *all the living things in an ecosystem*? (check the box)**

- |                                     |                                       |                                  |
|-------------------------------------|---------------------------------------|----------------------------------|
| <input type="checkbox"/> Biotope    | <input type="checkbox"/> Biosphere    | <input type="checkbox"/> Biotic  |
| <input type="checkbox"/> Biocenosis | <input type="checkbox"/> Biodiversity | <input type="checkbox"/> Biology |

**1.2) Which term refers to the *study of the interactions of living organisms with each other and with their environment*?**

- |                                    |                                     |                                  |
|------------------------------------|-------------------------------------|----------------------------------|
| <input type="checkbox"/> Ecozone   | <input type="checkbox"/> Ecocomplex | <input type="checkbox"/> Climax  |
| <input type="checkbox"/> Ecosystem | <input type="checkbox"/> Ecozone    | <input type="checkbox"/> Ecology |

**1.3) In November 2022, the French Biodiversity Office, fr. *Office Français de la Biodiversité*, (OFB) produced a brochure entitled "*Invasive alien species: issues and impacts*" (fr. « *Les espèces exotiques envahissantes : enjeux et impacts* »), which contains the following extract:**

"France, one of the most affected countries in Europe. [...] Bordered by eight other countries and three different seas and oceans, France occupies a unique position within Europe. At the crossroads of Europe's climates and trade routes, our country is particularly vulnerable to invasions."

**a) How would you define an "invasive alien species" or just "*invasive species*"? Can you give an example of such a species?**

**b) Can you name two possible causes for the introduction of these species? Explain why France is "particularly vulnerable to invasions".**

**c) Using Figure 1, which deals with the problem of invasive alien species, and your own knowledge, criticise the choice of the term "*invasive species*".**

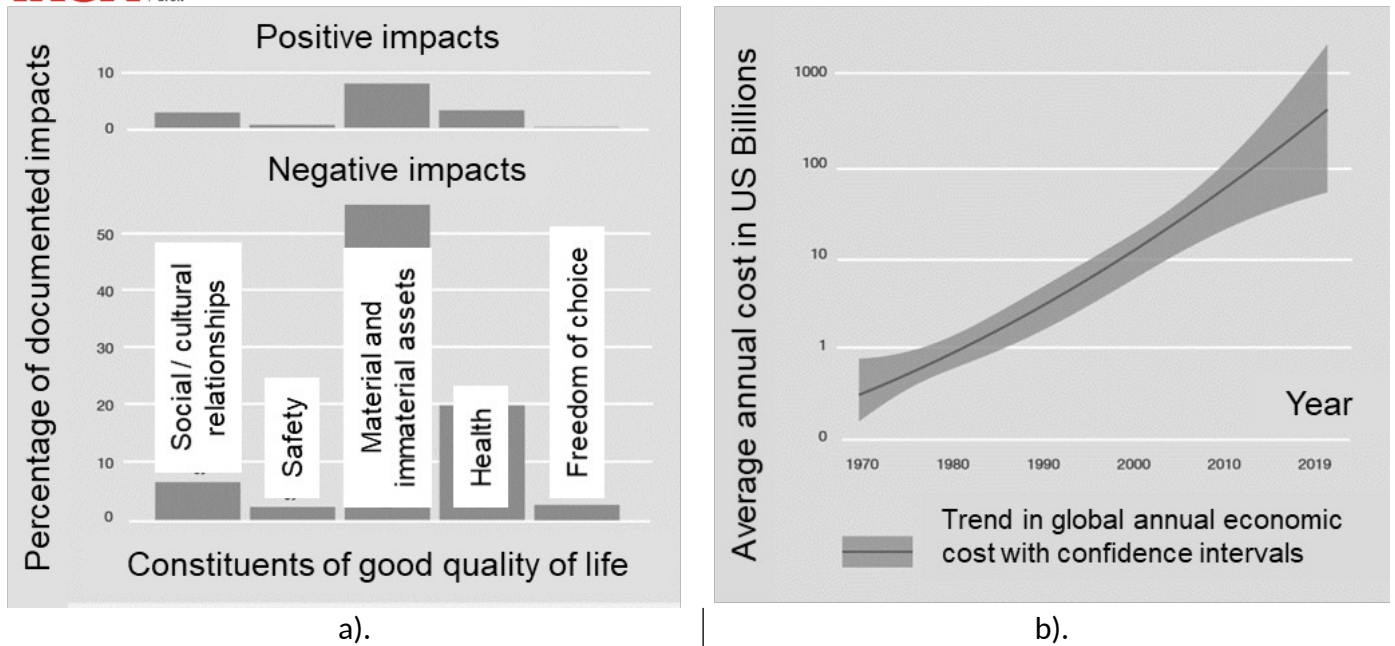


Figure 1 : a). Percentage of positive and negative impacts (of invasive alien species) on quality of life.

b). Increase in the average annual economic cost of biological invasions.

Source: Global Assessment of the Problem of Invasive Alien Species, IPBES<sup>1</sup>, 2023.

1.4) a). Complete figure 2 with the following five vocabulary words: **autotrophs**, **consumers**, **decomposers**, **heterotrophs**, **producers**.

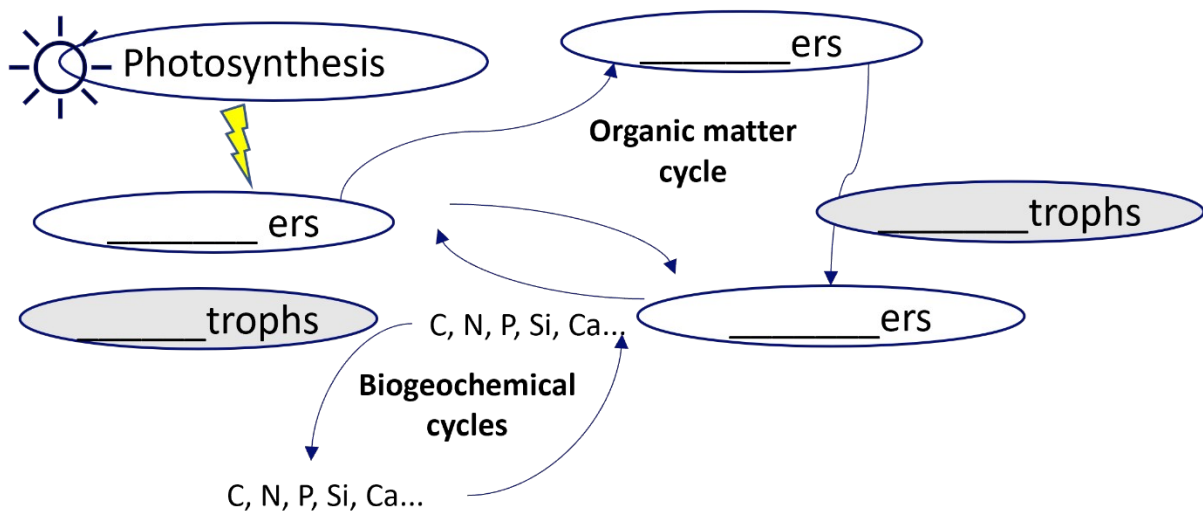


Figure 2: Simplified diagram of how biogeochemical cycles work

b). In the report entitled "The Limits to Growth (in a finite world)" by Dennis Meadows, Donella Meadows & Jorden Randers (1972, 50th anniversary special edition), we read the following extract:

"Separating and recycling materials after use is a step toward sustainability. It begins to move materials through the human economy the way they move through nature—in closed cycles. In nature the waste from one process becomes an input to another process. Whole sectors of ecosystems, particularly in

<sup>1</sup> intergovernmental science-policy platform on biodiversity and ecosystem services

the soils, work to take nature's waste materials apart, separate them into useable pieces, and send them back into living creatures again. The modern human economy is finally developing a recycling sector, too."

**What parallel can you draw between "materials through the human economy" and "[materials] through nature"? What are the limits of this parallel today? Use the example of metals and Figure 2.**

## Exercise 2: Impact of toilet paper on deforestation (indicative scale: /4 pts)

This exercise looks at the global production and consumption of toilet paper. 15% of deforestation is converted into raw materials for the production of this type of paper. The manufacture of toilet paper, like that of other types of paper, involves a number of chemical and physical processes.

The following two figures are taken from the **Lucart Group's Sustainability Report 2022**. This company produces 331,000 tonnes of tissue paper per year. Tissue products are single-use papers commonly used for personal hygiene and wiping, such as toilet paper, tissues, hand towels, etc. In this document, Lucart presents the results of a life cycle analysis of two toilet papers from its own production, comparable in terms of grammage, number of layers, number and length of tears, but manufactured one from virgin cellulose and the other from recycled fibres.

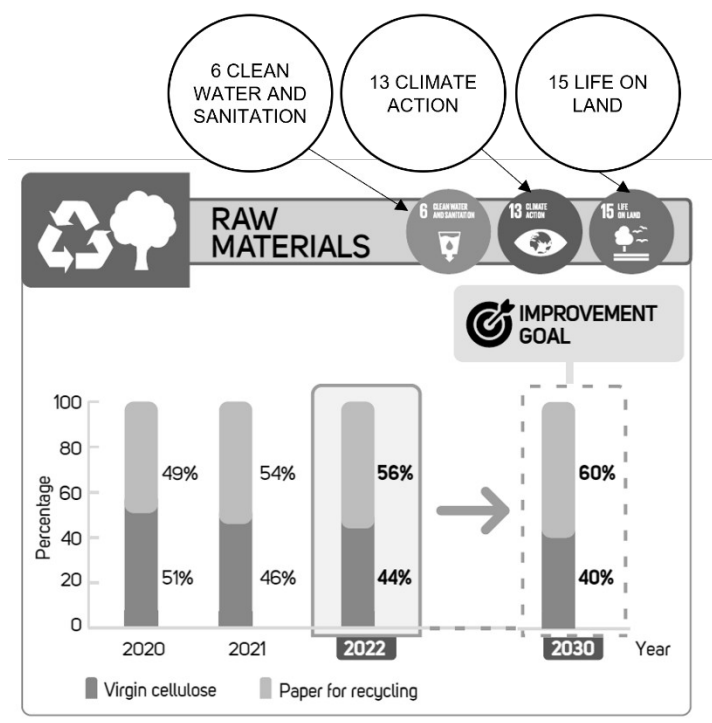


Figure 3: Proportion of virgin and recycled raw materials used by the Lucart in 2022

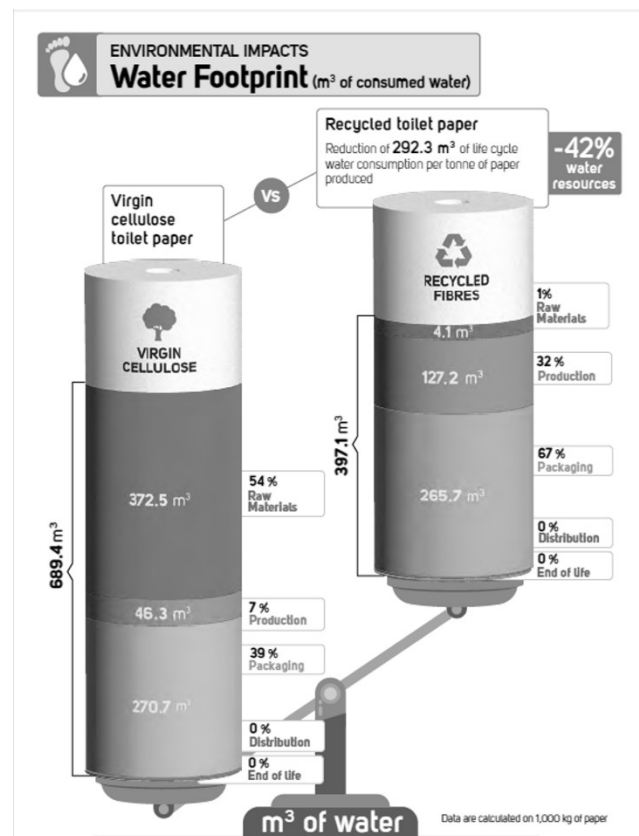


Figure 4: Water consumption at different stages of the life cycle for 1 tonne of toilet paper

**2.1) What can you tell us about Lucart's policy from Figure 3? What do the dots at the top right correspond to and why has the company chosen to show these three "labels" here?**

**2.2) How do you interpret Figure 4? You could suggest possible explanations for the difference in the quantity of water consumed for each phase identified (raw materials, production). What can you deduce from this?**

**2.3) Assuming that 100% of Lucart's production is toilet paper, and therefore using the percentages for this type of paper in Figure 3, give an estimate of the respective quantities of water used for the production of each type of toilet paper for Lucart in 2022.**

**Exercise 3: The challenges of lithium** (indicative scale: /6 pts)

*Lithium is a metal that is relatively scarce in the earth's crust, but it is widespread throughout the world. As an essential component in modern technologies, particularly batteries, it plays a crucial role in the energy transition to electrification. However, its extraction and use raise major environmental and ethical issues.*

**3.1) What are the two main axes used by the Bureau de Recherches Géologiques et Minières<sup>2</sup> (BRGM) to represent the criticality of a metal?**

**3.2) From Figure 5, calculate and justify the total global reserves of lithium in 2020. Compare with the data shown in Figure 6.**

**3.3) Figure 6 looks at cumulative lithium mine production. What is meant by the terms BAU and sustainable mobility, 4D and 2D scenarios? What do the dates 2005-2050 correspond to?**

**3.4) Compare the world's lithium resources and reserves calculated from Figures 5 and 6. Are they consistent? Explain the difference between resources and reserves.**

**3.5) Calculate the annual world production of lithium in 2020. Assuming constant production, in what year will lithium reserves be exhausted?**

**3.6) Discuss the validity of the constant production assumption made in the previous question. Justify this.**

**3.7) In the light of the previous results, what information do you think is important to take into account in order to qualify the criticality of lithium according to the two axes chosen in question 3.1?**

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<sup>2</sup> French Geological Survey

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GLOBAL LITHIUM PRODUCTION AND RESERVES IN 2020 (t)

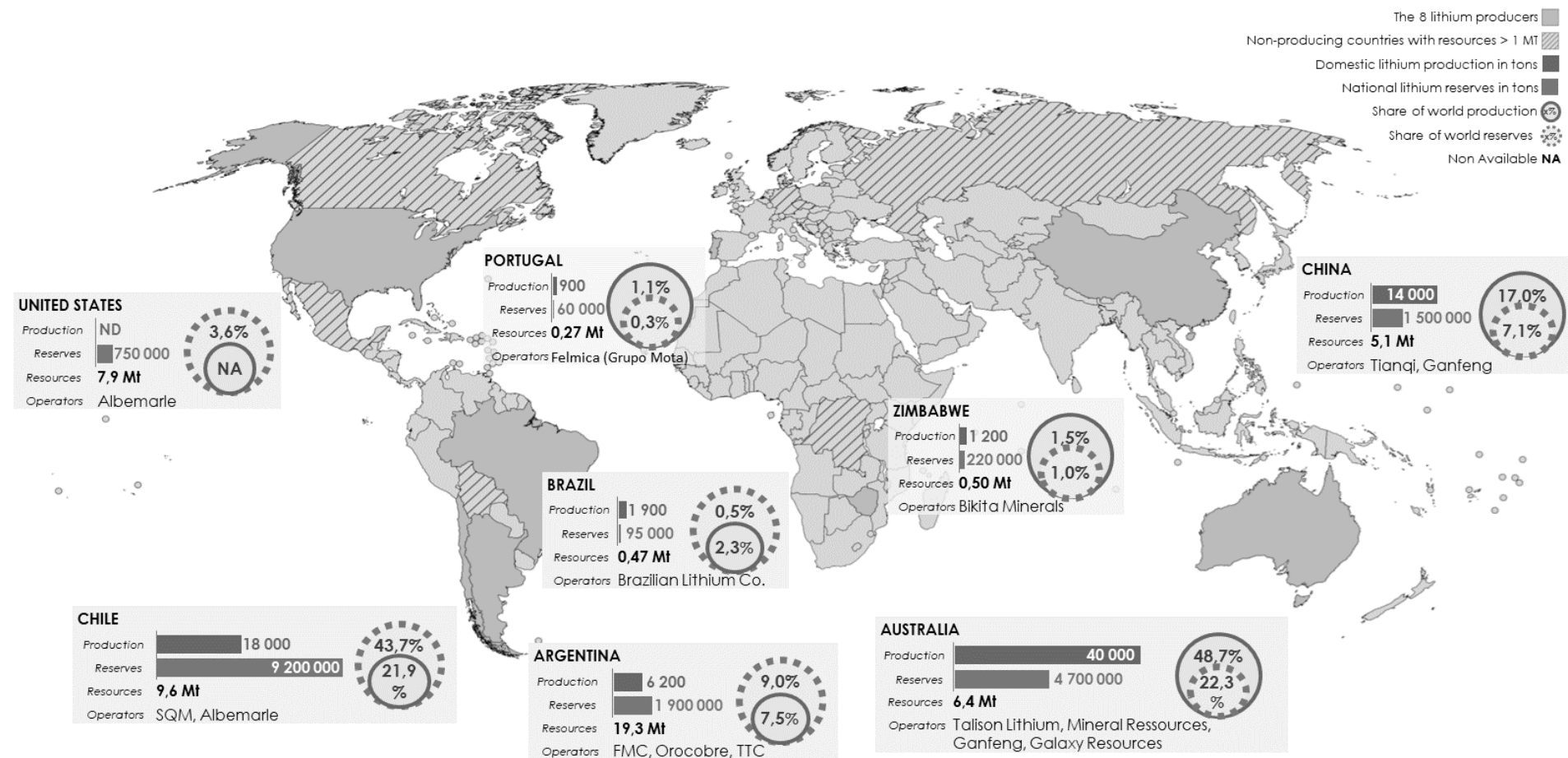


Figure 5: Annual production, world lithium reserves and resources in 2020 (map created by IFPEN using Mapchart.net based on USGS source data)

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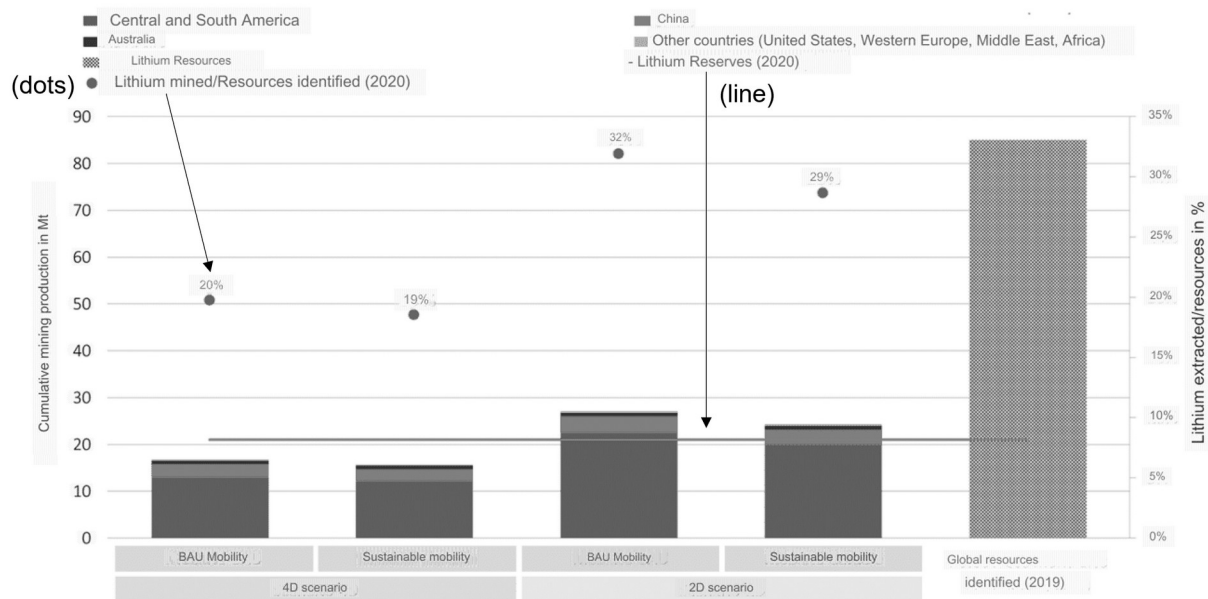
**COMPARISON BETWEEN CUMULATIVE LITHIUM MINING PRODUCTION  
(2005 – 2050) AND RESOURCES AND RESERVES IDENTIFIED IN 2020**

Figure 6: Comparison between cumulative lithium mine production (2005 - 2050) and identified resources (2019) and reserves (2020)

Source: <https://www.ifpennergiesnouvelles.com/article/lithium-energy-transition-more-resource-issue>, from IFPEN

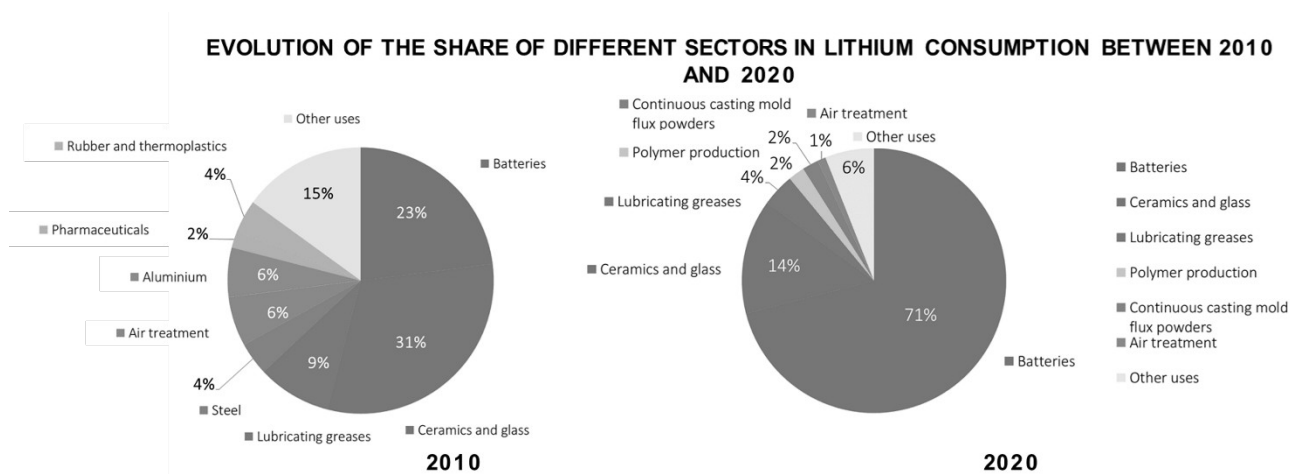


Figure 7: Change in the proportion of the various sectors linked to lithium consumption between 2010 and 2020

Source: <https://www.ifpennergiesnouvelles.com/article/lithium-energy-transition-more-resource-issue>, derived from USGS, 2010, 2021

**Exercise 4: France at +2°C - Life stories in the climate of the future** (indicative scale: /5 pts)

*BL évolution is a cooperative ecological transition consultancy working with public and private players on climate change mitigation and adaptation. With this in mind, BL évolution has published six forward-looking narratives that provide a better understanding of what France might look like in a world with +2°C warming compared to the pre-industrial era.*

**4.1) Give the definitions of utopia and dystopia. Then explain what a protopia is.**

Extracts from one of the stories are given at the end of the text (you can find more information, and the full story, on this website: <http://lafrancea2degres.fr/> ). Here we suggest you work on understanding and analysing the extract selected.

**4.2) Identify at least five environmental and societal issues in the extract** (quoting the relevant line(s)). **Explain each one in one or two sentences.****4.3) What do you think Valençonnette resort has been able to do to adapt?**

**4.4)** As with your work on the "What if?" project, this fiction is based on trends or events drawn from a wide range of scientific and technical resources. **By quoting the corresponding lines, clearly identify the parts of the text where each of the three groups of resources listed below may have been used to write the story** (if you think that the same resource may have fed into several sequences, identify them several times).

<b>Name of resources</b>	The <b>THI</b> (Temperature Humidity Index) is an indicator that takes into account the combined effect of temperature and air humidity, making it possible to estimate the conditions beyond which the survival of certain farm animals is threatened.	<b>IPCC (2022)</b> , "Chapter 13: Europe", WGII, Impacts, adaptation and vulnerability	Roudier et al (2015), "Projections of future floods and hydrological droughts in Europe under a +2°C global warming". Grillakis (2019), "Increase in severe and extreme soil moisture droughts for Europe under climate change".
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## It smells like Christmas tree

The weather today is magnificent. " It's going to be a nice weekend," says Charlie. (...) She can't remember the last time it snowed so much and so low, at 1,000 metres. (...) Charlie stretches, exhausted. It's been a busy week, with a number of unresolved problems at the Valençonette mountain resort, where she works as a water conservation officer. But the young woman doesn't want to think about it: tonight she's hosting her grandparents who are coming from Normandy. (...) Charlie leaves her house and decides to go to La Terrasse, a café-restaurant open all year round where one of her friends works. (...)

- "Hi Mia, how are you?" asks Charlie.

- Very well and you? Not too bad this week?

- "Tell me about it," grumbles Charlie. The mountain is full of tourists, it's hell to manage... I don't understand why the Hiver Bonheur resort keeps advertising the snow.

- It's not that surprising... They've got the last ski lifts in the region... 'They've got to make the most of it.

- Yes, but it's crazy that there are so many people despite the price of the lift pass! They've multiplied it by what, two? Three times? Given the drop in visitor numbers and the increase in energy costs...

Mia shakes her head, looking a bit overwhelmed.

- "So, what can I get you," she asks.

- A hot chocolate, please!

- All right... But I'm warning you, the milk doesn't come from here.

- What do you mean, it's not from here? Isn't it Gigi's milk?

- No, his herd took a big hit this summer. He lost three quarters of his herd despite Xena's advice... He's running out of milk (...)

"*Why is Isidore calling me?*" wondered Charlie, frowning. At the other end of the line, his colleague's voice sounds panicked.

- Hello, Charlie, how are you? Please tell me you're available! We've got a huge emergency!

- What the hell's going on?

- The whole village of La Haute is without water! Something must have gone wrong with the water pipes. I'll come and get you. We're off to Hiver Bonheur.

- What's that got to do with Hiver Bonheur?

- You know the connection they installed to the drinking water network last year? I think it failed because of the influx of tourists to the resort. They didn't install it properly and drew far too much water.... Including for the artificial snow.

- Right? And the two reservoirs<sup>1</sup> ?

- Dry! They kept the snow cannons running all through December... until the flakes at the beginning of this week! They're drawing down on their fair water quota. It's urgent, Charlie, not only has La Haute run out of water, but hundreds of litres of drinking water are being thrown away. We've got to go and give them a hand.

- OK, I'm at the terrace. Are you with your van?

- Yes! I'm on my way.



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Charlie has barely had time to drink her chocolate when Isidore's van appears around the corner (...) He sets off in the direction of the Hiver Bonheur station (...). Calocedar trees stand alongside downy oaks and exotic species that have been flourishing for the last ten years or so. The occasional spruce stands out, remnants of a species that was once endemic but has been swept away by drought, fires and increasingly severe episodes of bark beetle infestation.

In the streets of the Hiver Bonheur resort, Charlie is surprised to see so many people crowding the pavements. The big ski resort, in full decline, hasn't received so many holidaymakers for at least ten years. Deep down, even if Charlie is happy for some of her friends who run a business there, she can't help but feel a kind of bitterness. The model has run out of steam. It would have been entirely possible to rethink it, twenty years ago, taking inspiration from the approach taken by the Valençonette resort, which adapted very well to the end of the snow by completely rethinking its economic model in the 2020s. But by opting to focus entirely on skiing and artificial snow, Hiver Bonheur has doomed itself. An exceptional winter is not going to put it back on its feet (...)

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*[Charlie has now joined her grandparents for the evening meal; she tells them about the situation].*

Her grandfather dismisses the problem with a wave of his hand:

- With all the rain we've had, we shouldn't be short of water.

- "Think again," says Christelle, Charlie's grandmother. I read this morning that they're still in drought mode here. The poor things (...)

- We still have a deficit. Farming, agriculture, industry... Tourism! Everyone needs water.

- Do they still use water for the snow cannons at Hiver Bonheur? wonders Christelle.

- In the last few days, no, but in the last few months, yes, a lot. Luckily enough snow has fallen and it should hold for a while yet, otherwise it would be a disaster with all the tourists coming to ski (...)

- "It's true that we haven't had a winter, a real winter, for at least thirty years," she recalls. I remember when we were kids, in the 1980s, we sometimes had temperatures of -20, -30! And ten centimetres of snow on the plains! An exceptionally cold winter today was a mild winter fifty years ago.

(...)

- How long have you been an instructor again? asks Charlie of his grandmother.

- I did about thirty seasons! Right up until Valençonette's conversion. It was a heartbreaker...

- "It has to be said that we'd been feeling that skiing was running out of steam for a few years now," adds Olivier.

- It's true, it's true... And then it was no longer possible... We knew that the snow was falling less, and that it would fall even less in the years to come. Snowmaking isn't enough.

- "Especially when you're short of water," says Charlie.

- Especially when we're short of water, yes, and energy is expensive... And it has to be cold too. We used to have a lot of frosty days, but now... That's less true. It's good that Valençonette has managed to reinvent itself. There's still a bit of Nordic skiing in winter... I've also heard about tobogganing, but above all there are lots of activities in spring, summer and autumn. I really enjoyed skiing on wheels! It's another way of experiencing the mountains. But at the time, when they took the ski lifts down, it really did something to me.

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(...)

- And had you ever thought of working for another resort, Gran? Hiver Bonheur for example?

The old lady shakes her head.

- Going from a small family resort to a large complex managed by private investors didn't really appeal to me. Especially with their snow-at-all-costs model... They advertise four-season tourism, but when you see the amount of artificial snow they produce...

- "With the repeated water restrictions over the last few years, there's been a lot of grumbling in the area," confirms Charlie, shaking her head. The resort is drowning in debt. They didn't get emergency climate aid from the state last year, and it's too late to start making any fundamental changes. They're heading straight for disaster. The worst thing is that even when it snows like this year, things don't work out: they can't handle as many tourists as they used to. You can't recruit extra seasonal workers at the last minute. This could well be the resort's last season. It will have lasted as long as possible. The last ski resort in the region. (...)

i Hill reservoirs are water storage facilities in mountainous areas, filled with run-off water (snow melt, rain).

