Land-Use Competition between Biodiversity and Net Zero Goals

A case study of Canada

International Energy Agency

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Abstract

Meeting global targets for energy, climate, and biodiversity conservation has major implications for land use. To ensure that the tripling of renewable energy capacity by 2030 aligns with the goal of protecting 30% of the planet's land and water by the same date, robust mechanisms that direct solar and wind projects away from the world's most biodiverse areas are needed. To address the potential impacts of renewable development on biodiversity, the IEA developed the Renewable Energy and Land-Use Model (REALM), which identifies areas of overlap between renewable projects, critical mineral mining, and conservation priorities. Using Canada as a case study, this report highlights areas of potential land-use conflict and shows how the country can reach its 30% by 2030 target without significantly hindering the wind and solar development needed to achieve its net zero targets.

Key points

Achieving global energy, climate and biodiversity conservation targets simultaneously has significant implications for land use. At the 28th United Nations Climate Change conference (COP28) in 2023, nearly 200 countries set a target to triple renewable energy capacity by 2030. Based on an assessment by the International Energy Agency (IEA), tripling the capacity of renewables globally requires allocating up to an additional 600 000 km² of land – an area the size of France – to utility-scale solar PV and onshore wind power by 2030, and 2 million km² by 2050. In parallel, the IEA estimates that demand for key energy transition minerals – cobalt, copper, graphite, lithium, nickel and rare earth elements (REEs) – is projected to increase at least fivefold by 2030, requiring more land for mining and processing these minerals. At the same time, the Kunming-Montreal Global Biodiversity Framework aims to protect 30% of the world's land by 2030, requiring an additional 20 million km² of land – an area slightly larger than South America – to be set aside for conservation.

The IEA Renewable Energy and Land-Use Model (REALM) identifies potential overlaps between renewables development, energy transition minerals mining and biodiversity conservation. Natural Resources Canada and the IEA partnered to develop this analytical framework capable of highlighting where solar, wind and critical mineral development risk overlapping with important areas for biodiversity conservation around the world, building on Canada's leadership in providing open-source geospatial information on land use, resource distribution and ecosystems at risk. The new tool compiles 15 global geospatial datasets covering the resource distribution for solar, wind and mineral deposits with datasets on biodiversity and other land-use designations to help resolve competition between various land uses. This analysis is not intended to provide specific recommendations on which lands to protect and which to develop, nor does it reflect an endorsement from the Government of Canada on the metrics and definitions chosen. It rather serves as an example to highlight areas of potential conflict based on the resources and physical attributes of the land. This model can inform a wide array of actors – such as developers searching for sites with high potential away from biodiversity hotspots, or governments and utilities looking to pre-screen that align with land-use objectives and auction them to developers – and was designed to be applicable in regions around the world.

The amount of land required for renewables and critical mineral mining en route to meeting Canada's net zero by 2050 target is small relative to the total resource potential. By 2050, Canada will need over 50 GW of solar and nearly 80 GW of wind, together requiring up to 15 000 km^2 of land, an area that is only 1% of the country's more than 1 200 000 km² of land that is economic and suitable for utility-scale wind and solar development. Canada also hosts over 200 Mt of known key energy transition mineral resources, which would occupy a direct footprint of approximately 7 000 km² if all deposits were to be developed. IEA's latest high-side projections of Canada's production indicate that roughly 20% of this known resource would have mining operations ongoing in 2040.

Canada can reach its 30% by 2030 target by protecting its prime biodiversity areas without significantly hindering the wind and solar development needed to reach its net zero targets. Canada would need to conserve an additional 16% of its landmass – an area totalling 1 300 000 km² – by 2030 to meet its 30 by 30 target. If this target was met by prioritising currently unprotected lands most important for global biodiversity, around 1 million km² of these lands would not overlap with Canada's best wind, solar or mineral resources. This is equivalent to around 14% of Canada's total land mass.

However, without directing new solar and wind projects away from biodiversity hotpots, new development could conflict with biodiversity conservation efforts. Over 25% of the top-tier solar and wind resources in Canada overlap with unprotected areas important for global biodiversity conservation, and 40% of solar PV and onshore wind power capacity currently under development exhibit the same overlap. Proactive measures, such as environmental pre-screening or designating renewable development zones away from biodiversity hotspots, can redirect future development with minimal impacts on project costs and feasibility. Solar projects have also been competing with Canada's croplands in recent years, with today's croplands overlapping with half of the country's top solar resources. Co-location of wind and solar together or alongside agriculture, as well as incentivising brownfield development, could help reduce the direct land-use conflict.

Several known critical mineral resources overlap or are near lands rich in biodiversity. Around 35% of Canada's mineral resources key to the energy transition are located in unprotected lands important for global biodiversity conservation, including two of the largest known resources for cobalt and graphite. Mitigating the environmental impacts associated with developing new mining operations depends on diligent site selection, robust environmental assessment of impacts, and taking measures to minimise the risk of any incidents. Over 30% of Canada's known critical mineral occurrences – indicative of potential resources – do not intersect with top biodiversity lands. These occurrences, if explored, could uncover new resources that fall beyond the most biodiverse areas.

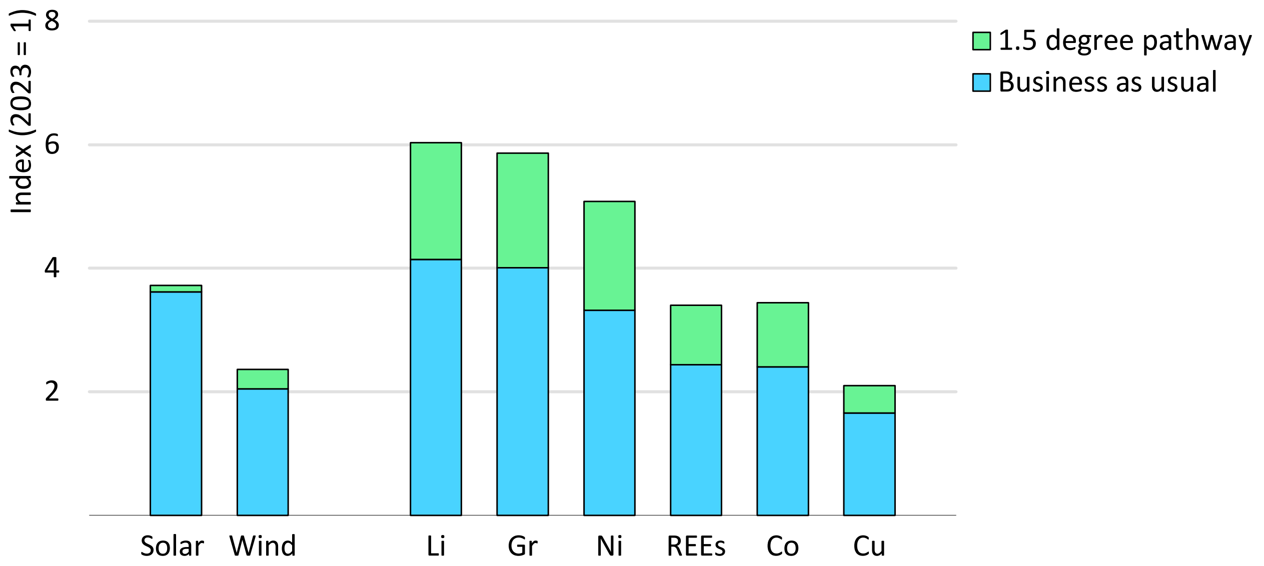
Integrating land-use considerations into energy system planning can reduce negative biodiversity impacts and enhance co-ordination across land-use priorities. Upfront planning to avoid the most biodiverse areas tends to be the most effective and least expensive way to reduce potential negative impacts and create a more coherent network of protected areas. Land-use planning practices are less mature in other parts of the world – some of which face more acute challenges in balancing conservation targets and other land uses, including energy. Other land-use considerations could be added to this analysis over time, including overlap with areas prone to natural hazard risks, shipping lanes or migratory pathways, lands important for natural carbon sequestration, and lands that may be sensitive for various political or national security reasons. The IEA will continue to advance this modelling in partnership with other countries, including those in developing regions where such planning procedures may not exist today.

Context: The land-use implications of international renewable energy and land conservation targets

Meeting global targets for biodiversity conservation and renewable energy development simultaneously presents potential complications for land-use allocation. At the 16th Conference of the Parties to the Convention on Biological Diversity (COP16), global leaders reaffirmed the goal of protecting 30% of the planet's land and water by 2030 – enshrined in Target 3 of the Kunming-Montreal Global Biodiversity Framework. At the same time, meeting climate objectives requires a rapid expansion of renewable energy capacity, with the UAE Consensus agreed upon at 28th Conference of the Parties to the Framework Convention on Climate Change (COP28) calling for a tripling of renewable energy capacity by 2030. The accelerating deployment of solar PV and wind, which together accounted for over half of the growth in global power generation in 2024, has substantial implications for land use. Even under today's policies, the growth of renewables will require a signification amount of land, with global solar PV capacity set to nearly triple by 2030, and wind capacity to double over the same timeframe. With just over 17% of global land area conserved, protecting 30% of the world's land area while also tripling renewable energy capacity by 2030 requires nuanced strategies to ensure that renewable energy development aligns with the conservation of the most important areas for global biodiversity.

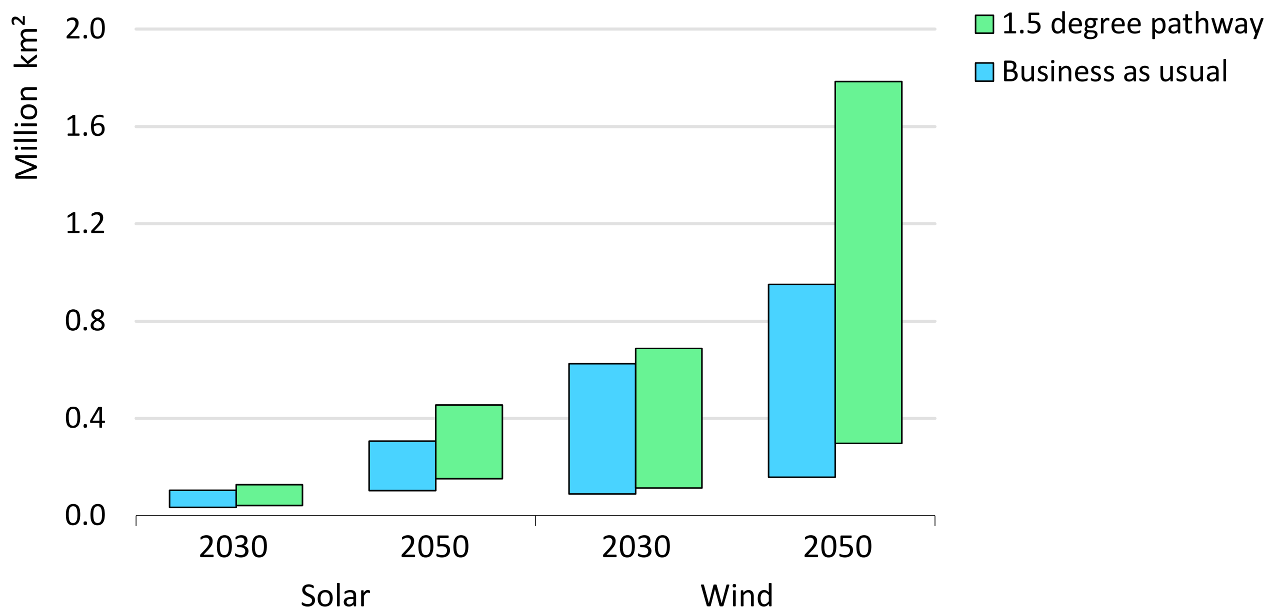
Climate change and biodiversity loss have historically been addressed independently, but these crises are fundamentally linked. Biodiversity – defined not only in terms of the number of species, but also their genetic diversity and the variety of ecosystems they inhabit – supports the provision of food and fresh water, the natural regulation of the climate and sequestration of carbon, and the preservation of cultural and social heritage. Biodiversity loss has primarily resulted from the direct conversion of natural land; however, climate change is becoming a major driver of biodiversity loss. Decarbonising electricity generation is critical to addressing climate change, especially given the rapid electrification taking hold across all sectors of the economy, but the expansion of renewable power generation presents a new driver of land-use change that can affect biodiversity in various and compounding ways. Thoughtful consideration of where renewable infrastructure is sited and how it affects species' habitats, movement and behaviour is crucial for delivering better outcomes for both climate and nature.

Global projected increase in installed solar PV and onshore wind capacity alongside key energy transition mineral demand by scenario, 2023-2030



Notes: Co = cobalt; Cu = copper; Gr = graphite; Li = lithium; Ni = nickel; REEs = rare earth elements.
Sources: IEA (2024), World Energy Outlook 2024; IEA (2024), Critical Minerals Data Explorer, accessed August 2024.

Global projected increase in wind and solar land use, by scenario, 2030 and 2050



Note: These bars show the upper and lower bound of the total land area required for solar PV and onshore wind power globally under a 1.5 degree pathway versus a business-as-usual pathway, based on high and low estimates of the square kilometres required per MW produced.
Source: IEA (2024), Net Zero Roadmap: A Global Pathway to Keep the 1.5 °C Goal in Reach.

The land-use implications of expanding solar, wind and critical mineral mining will be substantial. Utility-scale solar PV projects generally require 1-3 km² per 100 MW, while onshore wind projects occupy 5-30 km² per 100 MW due to the need for turbine spacing, although only around 10% of that land is occupied by the direct footprint of the turbine. Tripling the capacity of renewables globally requires allocating up to an additional 600 000 km² of land – an area the size of France – to utility-scale solar PV and onshore wind by 2030. By 2050, the land required for these projects could increase tenfold from today, totalling up to 2 million km².

While the projected land area required for solar PV and onshore wind power is significant, the permanent impacts that they have on the land are markedly lower than those of fossil fuel-based power plants. Life-cycle assessments indicate that the total land-use intensity – in terms of both the direct and indirect area occupied per unit of energy produced – of utility-scale, ground-mounted solar PV and onshore wind is respectively comparable to coal and natural gas power. However, the fact that solar PV and wind do not consume a fuel during operation means their overall mining intensity – in terms of kilogrammes of rock excavated per unit of energy produced – is far lower than coal- or natural gas-fired facilities. The total land required for solar PV and wind power is primarily due to the installation.

Nevertheless, a rapid expansion of solar PV and wind power implies an increased demand for the key energy transition minerals crucial for clean energy technologies, notably for powerlines and batteries. In a 1.5° C-aligned scenario, demand for minerals such as lithium, graphite and nickel is projected to rise sharply, with each increasing approximately sixfold by 2030 to meet the needs of clean energy technologies. Estimating the future land-use requirements for key energy transition mineral extraction is complicated by the fact that land use varies substantially according to the type of resource, the extraction method employed and the co-production of minerals. However, developing an average-sized mine[1] atop all the known key energy transition mineral resources globally would require around 40 000 km². This estimate accounts for just the direct footprint of the mine – the environmental impacts of mineral extraction can extend far beyond the mine gate.

Despite the scale of this expansion, the land needed for renewable projects and the requisite minerals is relatively small compared to the area allocated to agriculture or the area to be protected by 2030. The 2 million km² of land required for renewable energy in a net zero emissions world by 2050 is 4% of the nearly 50 million km² of global land used for agriculture and is only 10% of the 20 million km² needed to reach the 30 by 30 target globally. While the world has more than enough suitable land to scale up wind and solar capacity, the challenge lies in quickly deploying them in a way that avoids compromising biodiversity or placing undue pressure on agricultural production.

Mainstreaming biodiversity conservation into the development of renewable energy policies can serve not only to mitigate the impact of solar, wind and mining projects on biodiversity, but it can also help maximise synergies, minimise trade-offs and offer

[1] An average mine footprint of 15 km² was derived from Maus et al. (2022), An update on global mining land use after clustering polygon features within 10 km of each other. Therefore this is likely to be an overestimate as it does not distinguish adjacent mines, is positively skewed by the extraction of bulk commodities, and assumes future mines will use the same techniques at the same level as today.

greater certainty to stakeholders. Pre-screening areas for environmental impacts as part of a strategic environmental assessment (SEA) can identify high-resource, low-risk areas suitable for expedited permitting. Offering incentives for brownfield or mixed-use development can incentivise efficient land use and increasing compliance monitoring and enforcement in relation to development near biodiversity hotspots can provide certainty that conservation efforts are enduring.

To address this, the IEA partnered with Natural Resources Canada to develop a new geospatial Renewable Energy and Land-Use Model (REALM) that assesses where the best resources for utility-scale solar PV and onshore wind projects intersect three other land-use categories: 1) unprotected areas important for global biodiversity conservation, 2) the current network of protected areas, and 3) croplands. The model delineates prime wind and solar resources as areas with a resource potential that is above the average of project sites already developed and excludes areas too rugged for development, areas beyond 20 km from the existing grid, built-up areas and inland water bodies. The model also evaluates the potential overlap of identified mineral resources and known occurrences of six key energy transition minerals: cobalt, copper, graphite, lithium, nickel and rare earth elements (REEs). Finally, the model measures the proximity of solar PV and onshore wind capacity under development, as well as known occurrences and measured resources of key energy transition minerals, to the three specified land-use categories.

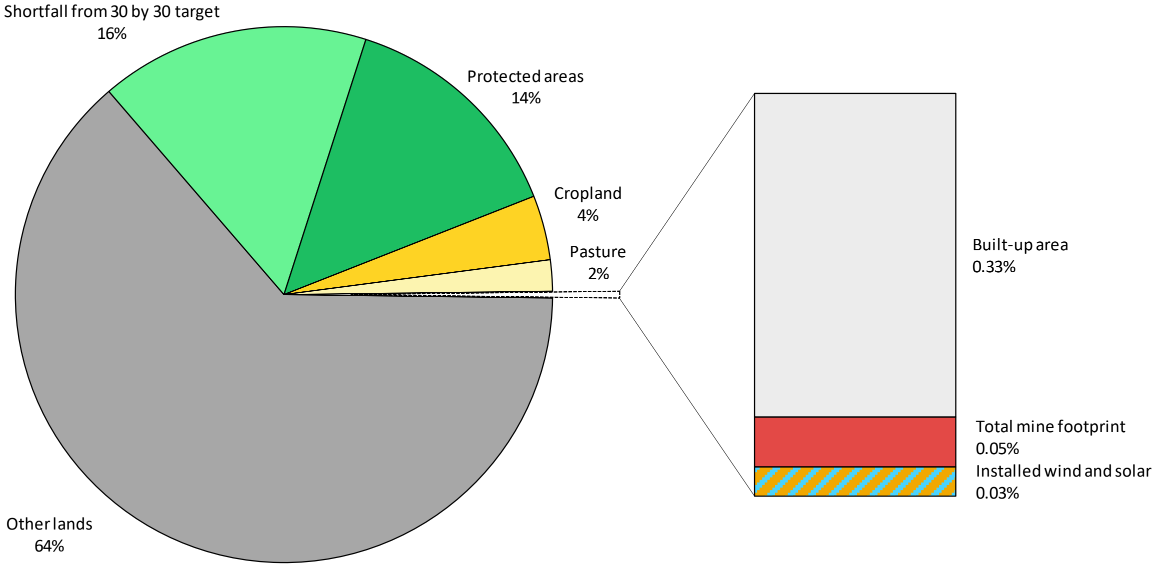
Given the global scope of the 30% by 2030 conservation target, this model leverages a wide range of official and open-source datasets that have robust global coverage to enable the results to be replicated globally. This analysis is not intended to provide specific recommendations on which lands to protect and which to develop; rather it outlines what is physically possible with the land available and highlights areas of potential conflict. The high-level insights this model produces are designed to demonstrate the value of geospatial data in aligning energy transition planning with coinciding land-use objectives by assessing the competitive pressure of wind and solar power on land. While this model cannot fulfil all aspects of the requisite environmental and social impact assessments renewable energy and mining projects require, it is well suited to inform decision makers on the limitations, trade-offs and opportunities afforded by the spatial distribution of their natural resources.

Canada as a case study

Canada provides a compelling case study to calibrate the REALM framework and explore the potential overlap between the land needed to meet decarbonisation and biodiversity conservation goals in tandem. In Canada, conservation and climate goals can and must be pursued in a synergistic manner through approaches that thoroughly evaluate trade-offs and optimise outcomes. As the second-largest country in the world, Canada is home to immense renewable and mineral resources, as well as globally significant biodiversity hotspots. Canada's onshore wind resources offer the second-highest average capacity factor globally and its solar resources in provinces like Alberta and Ontario are comparable to southern Europe. Moreover, Canada possesses the world's sixth-largest inventory of key energy transition mineral resources and ranks sixth in terms of the size of its priority areas for global biodiversity conservation.[2]

Canada's size provides flexibility to manage potential land-use conflicts, but it likewise makes the 30% by 2030 target sizable. Over 30 000 km² of Canada's land is currently built-up area, representing around 0.3% of its total land area. Protected areas cover nearly 1 300 000 km², representing approximately 14% of Canada's land area. Croplands, based on global land cover data, total over 330 000 km², representing approximately 4% of Canada's land area. Around 0.05% of Canada's land is allocated to mining, while only around 0.03% is used by wind and solar projects.

Land use in Canada by share, 2024



Notes: The bar shown on the right illustrates the relative breakdown of land uses that together represent less than 1% of Canada's total landmass. The measurements shown here align with official statistics published by Canada's national statistics agency; however, some discrepancies may arise due to the inherent uncertainty of disparate geospatial datasets.

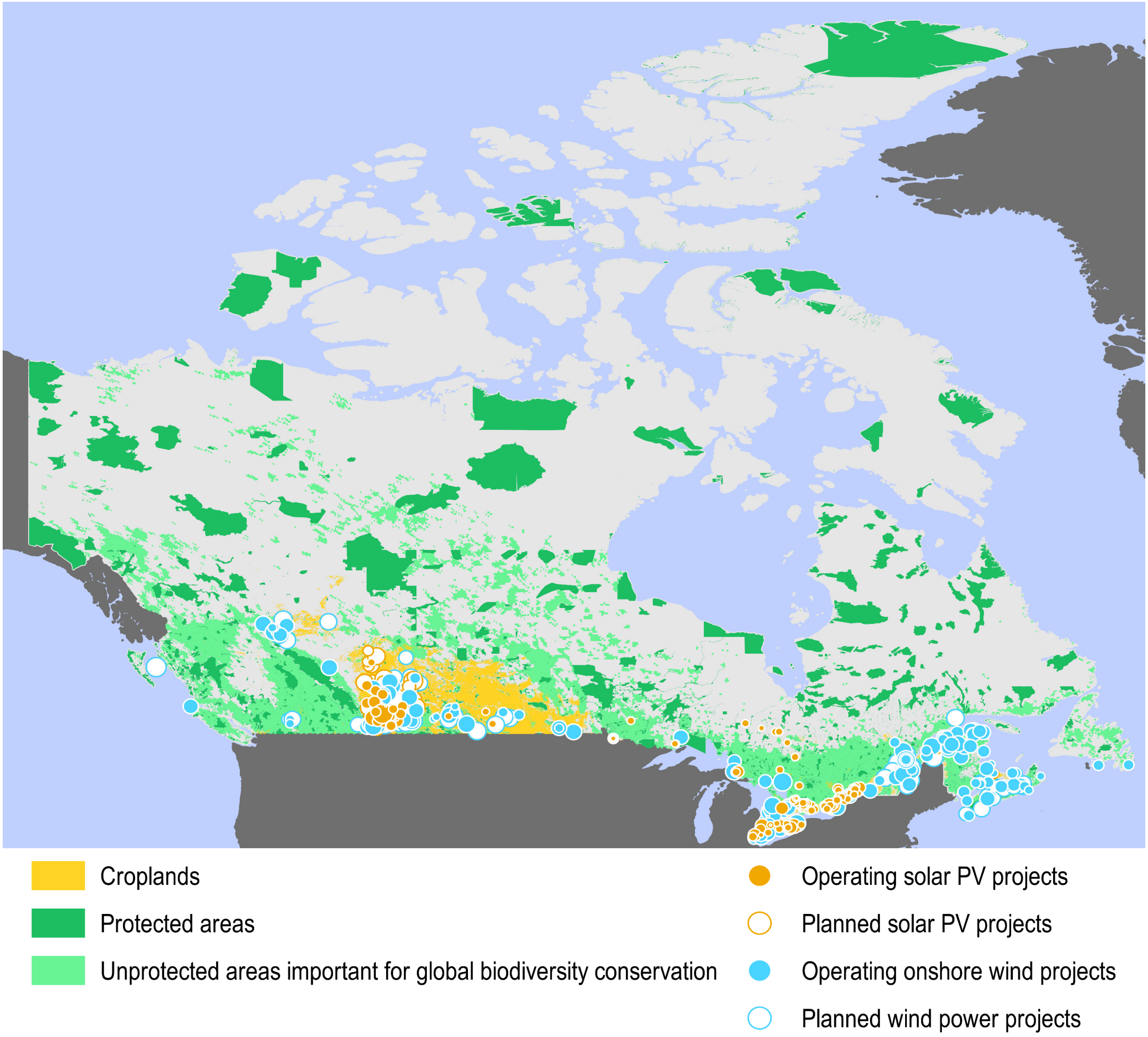
Sources: IEA analysis of wind and solar projects from the Global Energy Monitor's (2024), Global Integrated Power Tracker; mine area from V. Maus et al., An update on global mining land use; built-up area from the European Commission's Joint Research Centre, Global Human Settlement Layer; protected areas from UNEP-WCMC and IUCN (2024), The World Database on Protected Areas; and cropland from ESA (2022), Climate Change Initiative Land Cover.

Given that Canada has already protected nearly 14% of its landmass, another 16% needs to be protected to reach the 30 by 30 target. Which lands are ultimately set aside for protection ultimately must consider a diverse set of ecological and cultural factors, but for the purposes of this study the remaining 16% of unprotected land needed to reach the 30% by 2030 target are selected from the areas of Canada that are most important for global biodiversity. These priority conservation areas are based on a global dataset that considers both the density of plants and animals and the diversity within species in that region, and whether those species can be found widely in other regions or not.

[2] This ranking is derived according to the average importance for global biodiversity from M. Jung et al. (2021), Areas of global importance for conserving terrestrial biodiversity.

Wind and solar power

Location of utility-scale solar PV and onshore wind projects under development with respect to unprotected areas important for global biodiversity conservation, protected areas and croplands, Canada, 2024

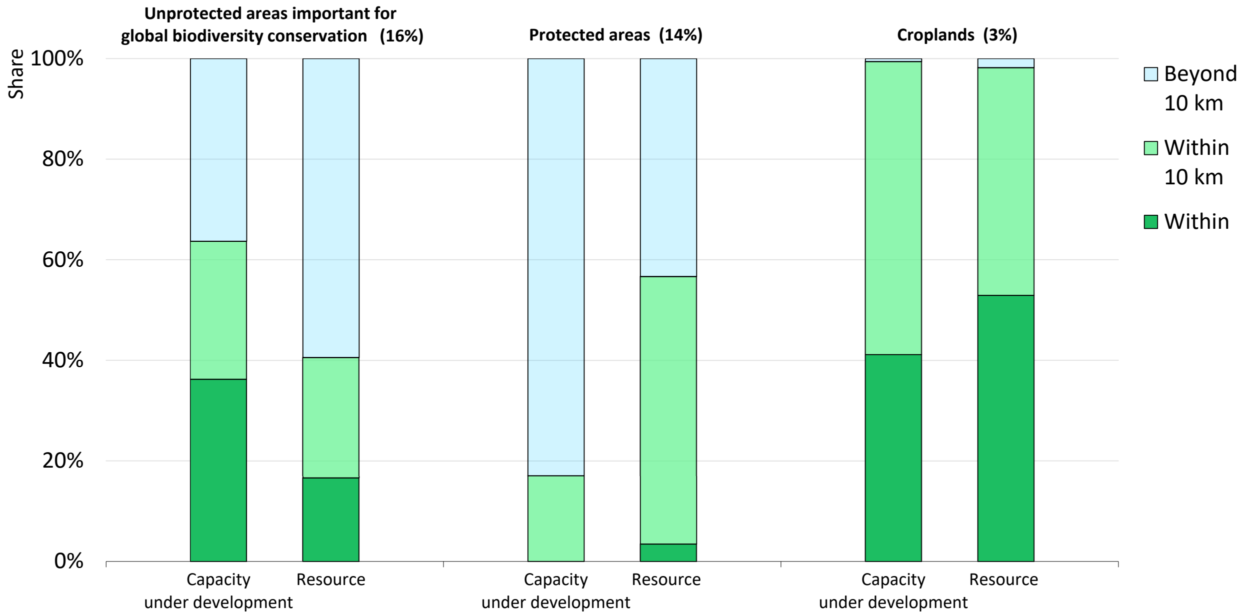


Sources: IEA analysis of wind and solar projects from the Global Energy Monitor's (2024), Global Integrated Power Tracker; protected areas from UNEP-WCMC and IUCN (2024), The World Database on Protected Areas; conservation priority areas from M. Jung et al. (2021), Areas of global importance for conserving terrestrial biodiversity; and cropland from ESA (2022), Climate Change Initiative Land Cover.

Canada has far more land that is viable for utility-scale wind and solar than is needed to meet its net zero by 2050 target. Currently, Canada has around 4 GW of utility-scale solar PV and 16 GW of onshore wind capacity installed, which together occupied nearly 3 000 km² in 2024. To achieve all of Canada's announced climate targets, utility-scale solar PV capacity would need to expand to over 13 GW and onshore wind capacity to over 35 GW by 2030, requiring approximately 300 km² and 5 000 km² respectively based on the current global average land-use intensities for these technologies. By 2050 this grows to over 50 GW of solar and nearly 80 GW of wind, together requiring 15 000 km² of land. This is far less than the physically available land suitable for renewable energy expansion in Canada. Approximately 500 000 km² of land is physically suitable for utility-scale solar PV and over 1 200 000 km² for onshore wind, which is nearly 70 times more than the amount needed even by 2050 for Canada to reach its net zero target. These areas exclude urban zones, rough terrain, water bodies and areas beyond 20 km from the existing grid, and have a resource potential that is above the average of sites developed in Canada thus far.

Onshore wind and utility-scale solar PV projects under development in Canada largely overlap with the country's croplands. There are currently 41 solar PV projects totalling 6 GW and 62 onshore wind projects totalling 10 GW under development. Nearly 30% of this new solar PV and onshore wind capacity is being installed in agricultural areas, notably in the prairie provinces of Manitoba, Saskatchewan and Alberta, but also along the St Lawrence River for wind. In some regions, solar PV developments have come into direct competition with cropland, with developers purchasing prime farmland for new developments, sparking policy maker intervention.

Share of utility-scale solar PV capacity under development and solar resource that intersect with other selected land-use designations in Canada, 2023

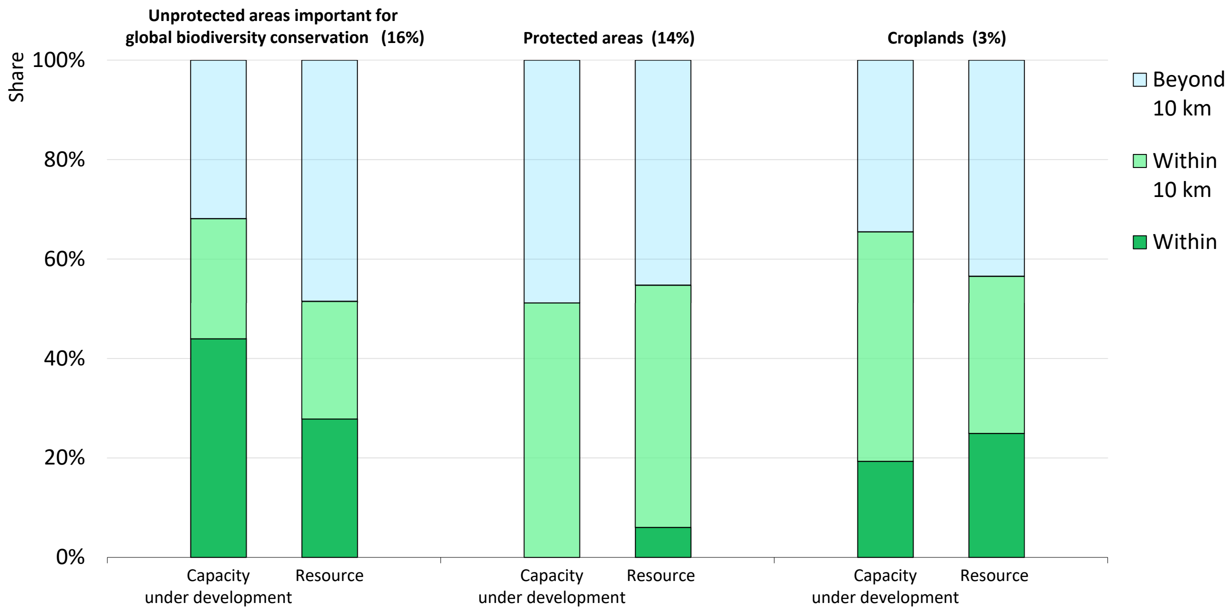


Notes: Solar resources here are areas receiving an annual average solar insolation, in terms of W/km², that is equal to or greater than the average for sites already developed for utility-scale solar PV in Canada. Percentages at top are the land use category's share of Canada's total land area.

Sources: IEA analysis of data from Global Energy Monitor (2024), Global Integrated Power Tracker; SolarGIS (2019), Global Solar Atlas; protected areas from UNEP-WCMC and IUCN (2024), The World Database on Protected Areas; conservation priority areas from M. Jung et al. (2021), Areas of global importance for conserving terrestrial biodiversity; and cropland from ESA (2022), Climate Change Initiative Land Cover.

Onshore wind and utility-scale solar PV projects under development also show substantial overlap with areas of value for global biodiversity conservation. By the IEA's assessment, over 40% of new capacity is being installed in areas important for global biodiversity conservation, reflecting the lack of suitable information available to help direct wind and solar development away from these lands. Conversely, the majority of wind and solar capacity under development falls more than 10 km away from a protected area, illustrating that a clear indication of natural landscape's value can be effective in redirecting the focus of development.

Share of onshore wind capacity under development and wind resource that intersect with other selected land-use designations in Canada, 2023

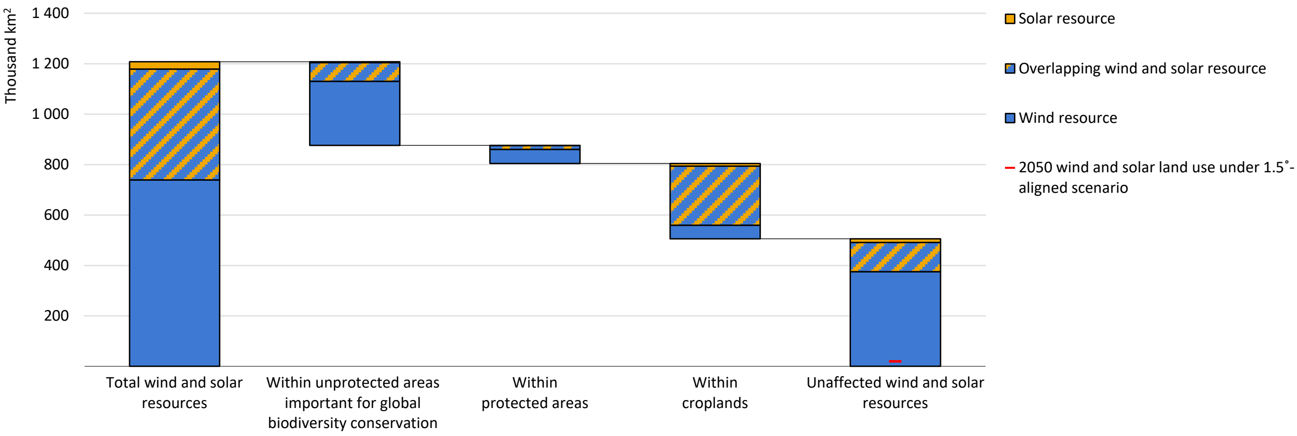


Notes: Wind resources here are areas with an annual average wind power density, in terms of W/km^2, that is equal to or greater than the average for sites already developed for onshore wind in Canada. Percentages at top are the land use category's share of Canada's total land area.

Sources: IEA analysis of data from Global Energy Monitor (2024), Global Integrated Power Tracker; Davis et al. (2023), The Global Wind Atlas; protected areas from UNEP-WCMC and IUCN (2024), The World Database on Protected Areas; conservation priority areas from M. Jung et al. (2021), Areas of global importance for conserving terrestrial biodiversity; and cropland from ESA (2022), Climate Change Initiative Land Cover.

Canada can reach its 30% by 2030 target by protecting the vast majority of areas important for global biodiversity conservation without significantly hindering the wind and solar development needed to reach its net zero targets. Renewables development does pose risks to sensitive ecosystems in Canada, notably the large swathes of intact grassland across the prairies and parklands of Alberta, Saskatchewan and Manitoba, as well as the mixed wood plains along the St Lawrence Valley in Ontario and Quebec. However, excluding all of the most important lands for global biodiversity conservation and all croplands from future wind and solar development would still leave around 500 000 km² of land available that has prime wind and solar resource and is suitable for development, 30 times more than the land needed for wind and solar by 2050 for Canada to reach its net zero target.

Land with top-tier wind and solar resources by intersection with other land-use designations in Canada, 2024



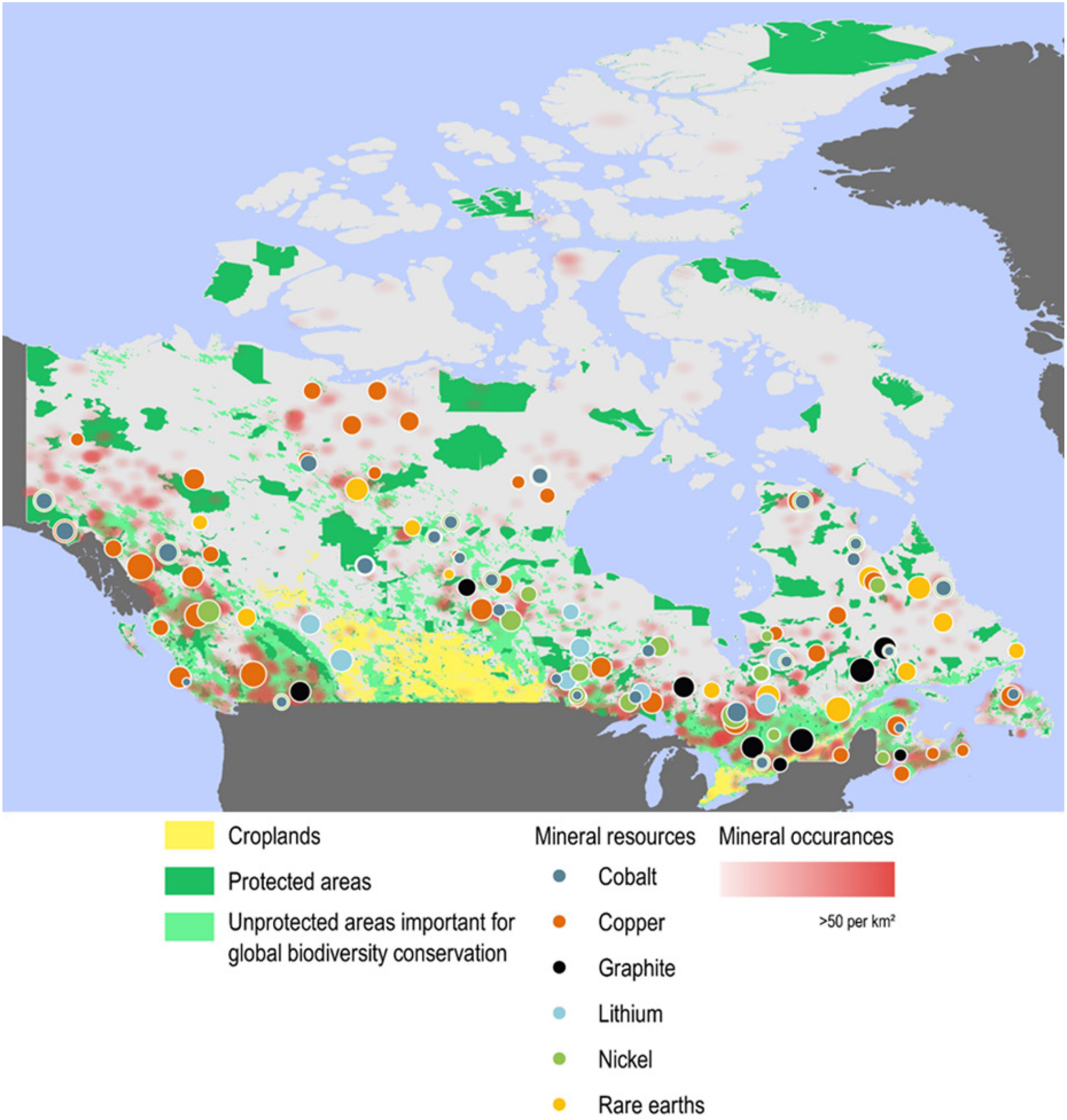
Sources: IEA analysis of Davis et al. (2023), The Global Wind Atlas; protected areas from UNEP-WCMC and IUCN (2024), The World Database on Protected Areas; conservation priority areas from M. Jung et al. (2021), Areas of global importance for conserving terrestrial biodiversity; and cropland from ESA (2022), Climate Change Initiative Land Cover.

Critical minerals

Canada has significant reserves of critical minerals essential for clean energy technologies, notably lithium, cobalt, copper and graphite. We identify nearly 5 000 records of known key energy transition mineral occurrences and over 200 Mt of measured resources in Canada from publicly available sources. Analysis of current and planned projects indicates that domestic production of lithium and graphite in Canada could rise nearly sevenfold and fivefold, respectively, by 2030.

The exposure of mineral resources to competing lands varies by mineral. Copper and graphite resources are the most exposed to biodiversity, with over 40% of both copper and graphite resources falling within the unprotected areas important for global biodiversity conservation. Several of these resources already overlap with lands currently protected under today's regulations. Over 15% of Canada's cobalt resources and 5% of its copper resources fall within protected lands, although in both cases this is related to a single known resource: the Windy Craggy deposit within the Kluane/Wrangell-St. Elias/Glacier Bay/Tatshenshini-Alsek international park system spanning across Yukon and British Columbia and into the US state of Alaska. Of Canada's lithium resources, 34% overlap with today's croplands, although again, these represent a single resource: the Clearwater lithium brine deposit in Central Alberta, estimated to hold over 2 Mt of lithium. Building an average-sized mine atop all known key energy transition mineral resources would represent around 5% of the unprotected areas important for global biodiversity conservation as defined in this report.

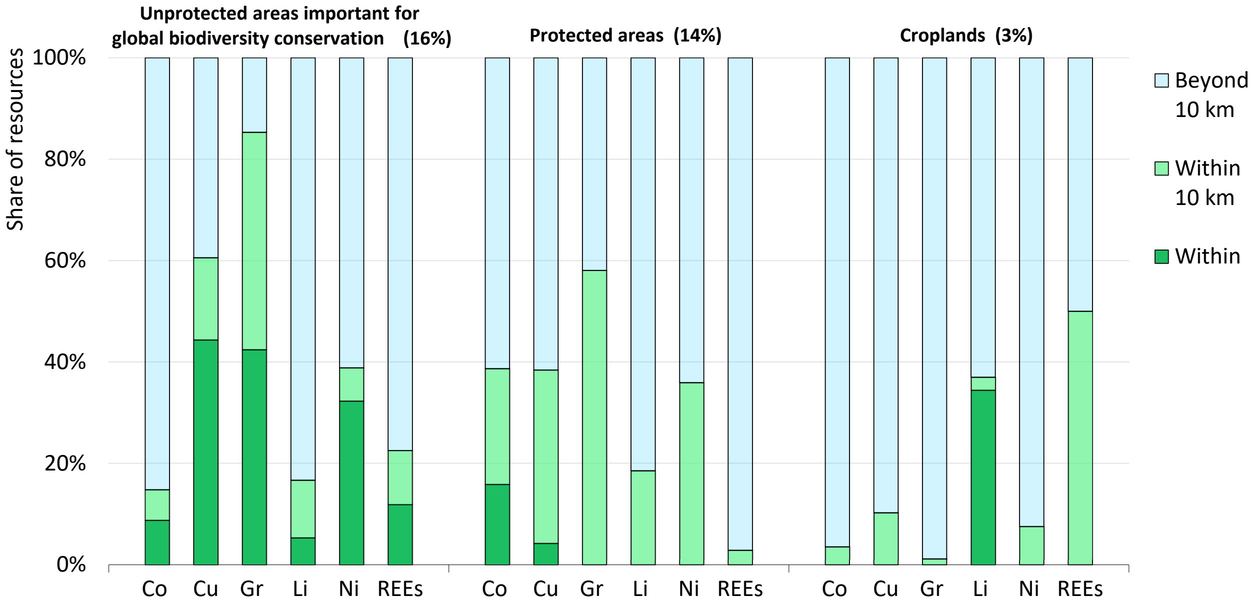
Location of key energy transition mineral resources and occurrences with respect to unprotected areas important for global biodiversity conservation, protected areas and croplands in Canada, 2024



Notes: Resources here show sites where an investment has been made into characterising the amount of metal that is recoverable from orebody. Occurrences represent sites where a mineral is known to exist, but do not provide an indication of the size or grade of the orebody.

Sources: IEA analysis of mineral resource and reserves from Owen et al. (2022), Energy Transition Minerals (ETMs): A global dataset of projects; occurrences from Hudson Institute of Mineralogy (2024), MinDat.org, USGS (2011), Mineral Resources Data System, GSC (2015), World Ni-Cu-PGE-Cr deposit database and S&P (2024), Capital IQ Pro; protected areas from UNEP-WCMC and IUCN (2024), The World Database on Protected Areas; conservation priority areas from M. Jung et al. (2021), Areas of global importance for conserving terrestrial biodiversity.

Share of key energy transition mineral resources that intersect with other selected land-use designations in Canada, 2023

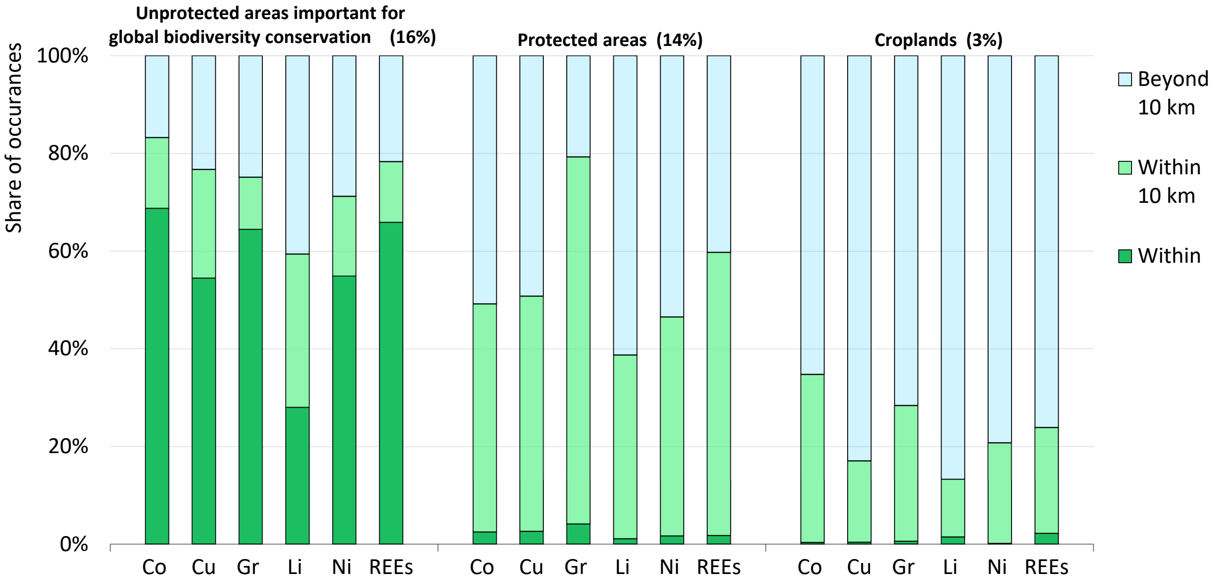


Notes: Co = cobalt; Cu = copper; Gr = graphite; Li = lithium; Ni = nickel; REEs = rare earth elements. Resources represent the estimated amount of metal that is technically recoverable from sites where an investment has been made into characterising an orebody for development.

Sources: IEA analysis of mineral resource and reserves data from Owen et al. (2022), Energy Transition Minerals (ETMs): A global dataset of projects; protected areas from UNEP-WCMC and IUCN (2024), The World Database on Protected Areas; conservation priority areas from M. Jung et al. (2021), Areas of global importance for conserving terrestrial biodiversity.

Compared to known resources, known occurrences of key energy transition minerals are more widely distributed across Canada, and proactive guidance can help ensure that future exploration takes potential impacts on biodiversity into account. Occurrences provide a record of exploration activity and are indicative of where new mineral resources key to the energy transition are likely to be found, but further exploration is needed to assess the size of the orebody and if the target minerals are present in high enough concentrations to be economically viable for production. Over 50% of recorded occurrences in Canada fall within areas most important for global biodiversity conservation; in contrast, only 2% of occurrences are in currently protected areas, reflecting that protected areas have successfully redirected exploration activities. However, 50% of occurrences fall within 10 km of protected areas, presenting potential conflict if currently protected areas were to be expanded to reach the 30 by 30 target.

Share of key energy transition mineral occurrences that intersect with other selected land-use designations in Canada, 2023

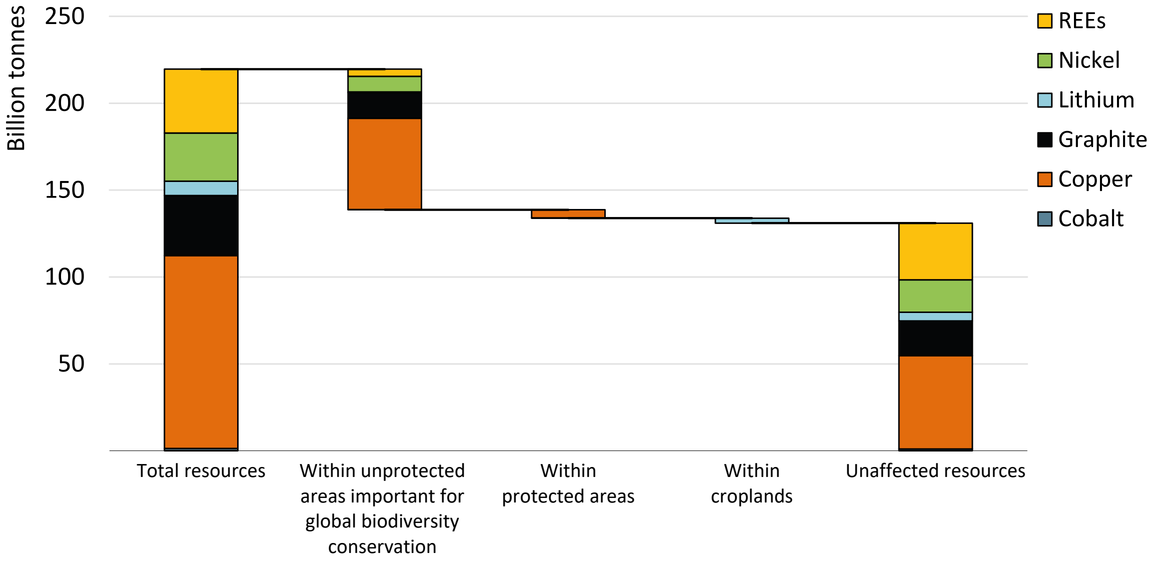


Note: Occurrences represent sites where a mineral is known to exist, but do not provide an indication of the size or grade of the orebody.

Sources: IEA analysis of mineral occurrences from Hudson Institute of Mineralogy (2024), MinDat.org, USGS (2011), Mineral Resources Data System, GSC (2015), World Ni-Cu-PGE-Cr deposit database and S&P (2024), Capital IQ Pro; protected areas from UNEP-WCMC and IUCN (2024), The World Database on Protected Areas; conservation priority areas from M. Jung et al. (2021), Areas of global importance for conserving terrestrial biodiversity; cropland from ESA (2022), Climate Change Initiative Land Cover.

New exploration could reveal potential resources both within and outside the unprotected areas important for global biodiversity conservation, croplands or other sensitive areas. Different policy approaches could be used to direct new exploration away from these intersections, including incentives such as expedited permitting for discoveries uncovered in well-explored provinces. Policies that require additional surveying to evaluate concentrations of key minerals before lands are set aside for conservation would help inform decision makers that are seeking to balance competing environmental and economic objectives throughout the transition. Nevertheless, it remains crucial to consider the impacts of new developments beyond the immediate mining operations, notably in terms of run-off in rivers, fragmentation of habitats and windborne dust.

Nominal key energy transition mineral resources by intersection with other land-use designations in Canada, 2023



Notes: Co = cobalt; Cu = copper; Gr = graphite; Li = lithium; Ni = nickel; REEs = rare earth elements. Resources and reserves represent the size of known and economically recoverable orebodies where investment has been committed to characterise the deposit for development.

Sources: IEA analysis of mineral resource and reserves data from Owen et al. (2022), Energy Transition Minerals (ETMs): A global dataset of projects; protected areas from UNEP-WCMC and IUCN (2024), The World Database on Protected Areas; conservation priority areas from M. Jung et al. (2021), Areas of global importance for conserving terrestrial biodiversity; cropland from ESA (2022), Climate Change Initiative Land Cover.

Energy transition and biodiversity goals can be achieved in tandem, with the right policy frameworks

Ultimately, Canada does have the capacity to develop its solar, wind and mineral resources while also expanding its network of protected areas in a way that prioritises the conservation of important areas for global biodiversity. Meeting the 30% by 2030 target would require Canada to set aside an additional 1.6 million km² for conservation. If Canada were to prioritise protecting areas defined within this report as important for global biodiversity, only around 10% would overlap with top-tier solar, wind or key energy transition mineral resources. Excluding this 10% of land that overlaps would leave another 750 000 km² of land with prime wind and solar resources that do not intersect with unprotected areas important for global biodiversity conservation, roughly 50 times larger than what is needed for wind and solar in 2050 in a scenario that has Canada meeting its net zero target on time and in full. Similarly, our research indicates that the land area needed to meet Canada's projected mineral production of key energy transition minerals between now and 2040 can be achieved by using around 20% of the total area holding identified resources.[3]

[3] This assumes extraction of no more than 10% of Canada's key energy transition mineral resources, starting from the largest active orebodies.

Making progress on both renewable and mineral development will still increase competition for land among other stakeholders, emphasising the need for nuanced policy frameworks that redirect new development away from important areas for global biodiversity conservation and incentivise efficient use of land. Pre-screening areas for biodiversity risks can support the creation of renewable energy zones eligible for expedited environmental review, while also optimising the conservation of the most biodiverse land and serving to mitigate the indirect and cumulative impacts of renewables development. Government programmes could identify and set aside lands for renewable energy development that do not conflict with important areas for global biodiversity conservation. These could be pre-screened for environmental permitting, which could lower transaction costs compared with having each private actor carry these out individually and could prevent developments from unnecessarily fragmenting ecosystems by prioritising the expansion of a more coherent network of protected areas. Such an approach could also address rising concerns about long permitting and interconnection times. Policies promoting the co-location of wind and solar together or alongside agriculture, as well as incentivising brownfield development can all unlock greater land-use efficiency and reduce these competitive pressures. Ongoing consultation with Indigenous groups will continue to be vital to ensure their rights are respected. Engagement of local communities also remains an important aspect to the development of new projects and conservation areas.

Indigenous lands

One aspect critical to land usage decisions for protecting biodiversity and developing energy projects in Canada is recognition of Indigenous lands. The Government of Canada has a duty to consult and, where appropriate, accommodate Indigenous groups when it considers conduct that might adversely impact potential or established Aboriginal or treaty rights.

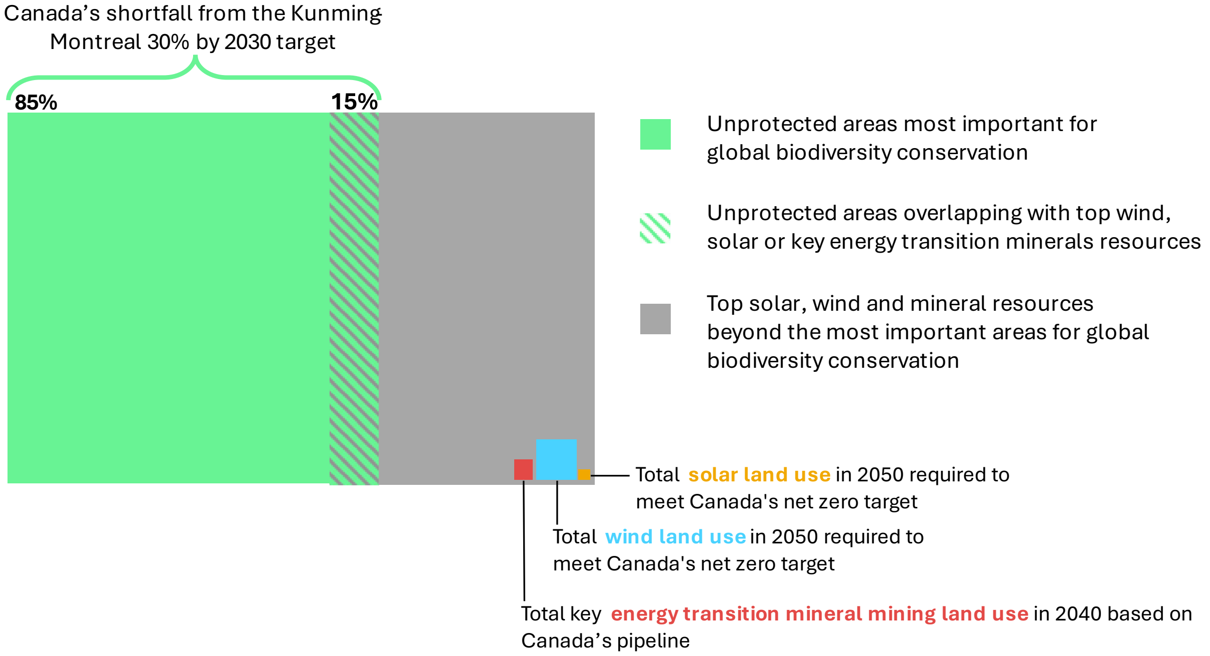
The Government of Canada is committed to meaningful engagement and consultation with Indigenous peoples on natural resource projects that could potentially impact Indigenous rights and title to ensure their views are reflected.

Early engagement offers Indigenous groups with the opportunity to share information and concerns on potential impacts to their rights during the design and development phases of a project, fosters sound decision-making, supports Canada's commitments to reconciliation and the implementation of the United Nations Declaration on the Rights of Indigenous Peoples, and allows meaningful opportunities for Indigenous peoples to participate in the natural resource space.

Engaging Indigenous groups is an important consideration not just in Canada, but globally as well. An estimated 19 million km^2, or 18%, of global terrestrial areas today is recognised as Indigenous Peoples' and Local Communities' (IPLCs) land, and the rights of these groups to develop various resources and set their land conservation agenda is central to their remit in many parts of the world today. This should be explored in more detail in any future analysis.

Integrated spatial planning can be an important tool for policy makers to clarify areas of competing land use and propose ways forward; however, it is one tool within a wider set of policy tools used to assess the local impacts of projects. The REALM framework developed by the IEA provides multi-criteria constraint mapping of different resources, and can play an important role in navigating the trade-offs that must be considered to align energy transition and biodiversity conservation objectives. This analysis is not intended to provide specific recommendations on which lands to protect and which to develop; rather it outlines what is physically possible with the land available and highlights areas of potential conflict. The high-level insights this model produces are intended to support a strategic assessment of land use, but cannot fulfil all the aspects that other environmental and social impact assessments can provide for renewable energy and mining projects.

Graphic representation of Canada's land area showing overlap between areas to meet conservation goals and areas best suited to solar, wind and mineral resource projects



Notes: Top wind and solar resources here are areas with an annual average solar insolation or wind power density that is equal to or greater than the average for sites already developed for utility-scale solar PV or wind in Canada and do not include areas beyond 20 km of the existing grid, areas too rough for development, urban areas or inland water bodies. Top mineral resources are known deposits where an investment had been made to quantify the size of the orebody. These figures show only the relative size of these land areas.

Sources: IEA analysis based on data from Owen et al. (2022), Energy Transition Minerals (ETMs): A global dataset of projects; SolarGIS (2019), Global Solar Atlas; Davis et al. (2023), The Global Wind Atlas; unprotected lands high in priority for conservation from M. Jung et al. (2021), Areas of global importance for conserving terrestrial biodiversity.

The IEA intends to expand this modelling initiative to additional countries and explore other potentially relevant intersections of energy infrastructure development and land use. The context of how different land uses intersect is specific to each country. Although Canada benefits from its large size and abundant resources, all countries face unique challenges related to the distribution of resources, biodiversity and land use, which need to be assessed with granular, local data to understand potential land-use intersections. Additional considerations for future implementation include mapping natural carbon sequestration, freshwater provision, bird migration corridors, ecosystem contiguity and edge effects, impacts on downstream watersheds and sustainable livestock grazing, as well as accounting for seasonal variations in the generation profile of solar PV and onshore wind power.

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