

Building Resilience from the Ground Up: Local Supply and Demand Management with Renewables, Prosumers, Energy Efficiency, Critical Minerals, and the Circular Economy

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I. Introduction

Can we reduce the extent to which we are hurt by disruptions if we source our energy and materials from nearer at hand, and become able to get by with less of them? An examination of this question allows us to explore resilience on the demand side of the energy and natural resources equation rather than the supply side, and to see what the users and buyers of energy and mineral resources can do to manage their use and demand, and source it locally, in order to reduce their vulnerability to disruption. Consumers and consumer countries can make active choices in the origins of what they use, and how much they need; and legal consequences can flow from those choices. Interestingly, in broad terms the same questions can be asked for both energy and mineral resources. We therefore turn first to the local production of energy as a form of resilience, followed by energy efficiency as another, and then to minerals, first to policy for the sourcing of minerals and materials, and then to recycling and the circular economy.

The chapter is a forward-looking or even speculative inquiry, but it attempts to bring together strands of thinking and research that have long been part of the literature and are the subject of considerable law and policy effort. The challenges that we face – climate change, the pandemic, and the continuing imperative of addressing poverty – call on us to look at everything afresh. Some of the disruptions that test our resilience have long been with us – storms, earthquakes, civil unrest, international coercion, war – but new weather risks are posed by climate change, and cybercrime is a new kind of disruption.¹ In addition, many of our social and economic systems have become more complex and globalized than ever.

II. Energy Resilience in Closer Supply and Efficiency

A. Energy Security Traditionally

What we must now think of in terms of resilience in the energy sector has sometimes been thought of as energy security. The author and some of the other contributors to this volume, in a predecessor study, defined energy security as “a condition in which a nation and all, or most, of its citizens and businesses have access to sufficient energy resources at reasonable prices for the foreseeable future free from serious risk of major disruption of service.”² The

¹ Benjamin Monarch, ‘Black Start: the Risk of Grid Failure from a Cyber Attack and the Policies Needed to Prepare for it’ (2020) 38 *Journal of Energy and Natural Resources Law* (hereafter JERL) 131.

² B Barton, C Redgwell, A Rønne, D Zillman, eds, *Energy Security: Managing Risk in a Dynamic Legal and Regulatory Environment* (Oxford University Press, 2004), editors’ Introduction.

International Energy Agency (the IEA) defines it as “the uninterrupted availability of energy sources at an affordable price”³ and notes that it has both long-term and short-term aspects.

For crude oil, security and resilience has long been a matter of geopolitical importance. The supply crisis of 1973-1974 led to the Agreement on an International Energy Program of 1974 which commits signatory countries to hold emergency oil stocks equivalent to at least 90 days’ net oil imports (60 days until 1976).⁴ Oil continues to be a special concern as the energy backbone of the modern economy although over time oil exporters have not been able to use oil as a weapon in international affairs.⁵ Natural gas is more broadly distributed than oil, but pipelines as the main means of transporting it expose it to threats whether from natural hazards or political developments. Coal is even more diversified in its supply. However the energy transition now under way opens up a set of resilience challenges that are different from those that have affected oil and other fossil fuels for many years.

B. The Energy Transition and the Localization of Supply

The enormous transition under way in energy is largely driven by climate change, but also by the emergence of new energy technologies at a scale and at low enough a cost that they appear likely to displace much use of oil and gas and coal. The transition has the potential to increase local supply, and to reduce the length, complexity and vulnerability of energy supply chains. In turn we consider the roles of renewables, electrification, and distributed generation.

1. Renewables

Renewable energy is one of the fundamentals of the energy transition, and has been growing rapidly in significance. Under its Stated Policies Scenario, which envisages less change than its other scenarios, the IEA sees that renewable sources of electricity will rise two-thirds between 2020 and 2030, and that by 2025 renewables will overtake coal as the primary means of producing electricity.⁶ Hydroelectricity continues to be the largest renewable source of electricity, but wind and especially solar photovoltaic generation is growing massively and no longer needs direct financial support to be commercially viable. Renewable fuels outside the electricity sector (solid biomass, liquid biofuels and biogases) continue to grow, but rely on policy support.⁷

The increasing role of renewable energy, especially in electricity generation, has the potential to increase the resilience of energy systems, although the picture has a good deal of variation in it and we should be cautious of going too far with generalizations. Certainly, hydro and

³ International Energy Agency (hereafter IEA), ‘Energy Security’, <https://www.iea.org/topics/energy-security> accessed 17 June 2021.

⁴ Agreement on an International Energy Program (with annex) (adopted 18 November 1974, entered into force 19 January 1976) 1040 UNTS 272; R Scott, *The History of the International Energy Agency* (5 vols), <https://www.iea.org/about/history>; Mason Willrich and Melvin A Conant, ‘The International Energy Agency: An Interpretation and Assessment’ (1977) 71 *Amer J of International Law* 199. The Agreement is related to the IEA but was established separately from the IEA’s origins in the OECD.

⁵ IEA, *World Energy Outlook* (2020) 258; OPEC plus Russia produces less than half of the world’s oil.

⁶ IEA, *World Energy Outlook* (2020) 214, 222.

⁷ IEA, *World Energy Outlook* (2020) 285.

geothermal power generation must be located where the resource is to be found, and may therefore require long transmission lines to bring the power to cities and other load centres. Wind farms and solar installations can be located closer to load centres, although ideal sites may be further away, and for high rates of penetration the quality of the transmission network is an important factor.⁸ So too is the overall configuration of the system in its ability to handle the variable qualities of wind and solar. Solid biomass (such as wood chips or bagasse) and methane from waste are often sourced locally.

But even taking all due care about the contribution that renewables can make to resilience, we must bear in mind that the comparison is with fossil fuels, oil and gas and coal. Whether renewable energy sources are used directly or through the medium of electricity or hydrogen, they are less likely to depend on international trade to be brought to consumers. In addition, wind, sunlight, and water (usually) are free so renewables are not subject to fuel prices that may be commercially unpredictable or politically volatile. However the question is not well explored, and empirical research would be desirable to more fully understand the resilience benefits of renewable energy that are likely to accompany their value in reducing greenhouse gas emissions.

2. Electrification

Electricity is gaining on other means of providing energy to consumers,⁹ and it offers the prospect of greater resilience in the form of more localized production. It is a kind of fuel switching, and occurs for example where a natural gas furnace is replaced with a heat pump, or where an internal combustion engine is replaced with an electric vehicle. Electrification is central to emissions reduction efforts, even though it is not viable for some energy uses; shipping, aviation, heavy-duty trucking, cement making, and steel making will need low-carbon fuels or carbon capture systems for some time to come.¹⁰ Electrification is already a global trend, especially in light industry and household consumption, and indeed the growth of electricity demand in recent years is consistently running at around twice the pace of overall energy demand growth.¹¹ The IEA expects that the trend will continue, and that under its Sustainable Development Scenario, where heat pumps, electric vehicles and electrolytic hydrogen take off, electricity would move even more dramatically to the centre of the energy stage.¹²

Electrification can tend to produce higher levels of local supply of energy. One should not overstate the possibility, recognizing that the circumstances of different countries and regions will produce very different results. But on a global scale electricity is less traded

⁸ IEA, *Net Zero by 2050: A Roadmap for the Global Energy Sector* (2021) 180 (hereafter IEA, *Net Zero*).

⁹ The global source share of energy total final consumption held by electricity was 9.4% in 1973, 19.3% in 2018: IEA, *Key World Energy Statistics 2020*, 34.

¹⁰ IEA, *World Energy Outlook* (2020) 159; IEA, *Net Zero* (n 8) 14.

¹¹ IEA, *World Energy Outlook* (2020) 36, 216.

¹² In the Stated Policies Scenario electricity demand growth globally outpaces all other fuels, and meets 21% of global final energy consumption by 2030 and 24% by 2040. The Sustainable Development Scenario sees electricity's share reaching 24% by 2030 and 31% by 2040. IEA, *World Energy Outlook* (2020) 213, 216, and 221-226.

internationally than oil, natural gas, or coal.¹³ Much oil is traded in elaborate international supply chains. Natural gas may be supplied from domestic sources, but if it is in international trade it depends on either pipeline systems and a complex web of commercial and political relationships, or (for liquefied natural gas) elaborate maritime supply chains. Compared with them, electricity supply chains – although complex in their own way – are less vulnerable to the far-off disasters that may affect oil and gas fields, refineries, ports and shipping, and less vulnerable to global political and security problems. Globally, most electricity is produced domestically. Electric vehicles in the writer’s home jurisdiction of New Zealand demonstrate the resilience benefits; buying one is a shift from petroleum as the fuel, mostly imported, to electricity, mostly produced from domestic renewable resources, and a shift to a fuel priced in local currency, reducing exchange risks.¹⁴

3. Distributed generation and Prosumers

Distributed generation is another element of the energy transition that increases resilience. It allows electricity to be generated closer to where it is required and allows the system to be managed locally.¹⁵ A more decentralized system with shorter supply chains has more ability to ride out disruptions such as natural disasters or cyber-attacks. Improvements in transmission and hardware are accompanied by digitalization so as to create a ‘smart grid.’¹⁶ In another chapter in this book Louis de Fontanelle points to the benefits of this decentralization in energy citizenship and as a guard against global risks, and discusses its implications for energy industry structure.

Distributed generation has taken different forms. Some of the first departures from highly centralized systems were sparked in the United States by the Public Utility Regulatory Policies Act 1978 which gave priority to ‘qualifying facilities’ that had to be either solar, wind, or co-generation, and which obliged the conventional utility companies to buy their output.¹⁷ Co-generation often led to significant improvements in energy efficiency, such as where a heat plant installed a gas turbine to generate electricity before using the hot gases to heat its boilers. Alternatively distributed generation can simply be small generation units that allow utilities or users to manage outages or peak demand periods. Regulatory reform has generally been necessary to enable such decentralization to occur.

The most spectacular recent form of distributed generation is the rooftop solar photovoltaic arrays that allow consumers even at the household scale to generate some or all of their electricity needs. A household can become both a producer and consumer of electricity, a ‘prosumer.’¹⁸ When solar arrays or other power sources are connected to storage batteries,

¹³ Globally, the percentage of energy sources produced that are imported by one country from another are: crude oil 48%, natural gas 24%, coal 17%, electricity 14%: IEA, *Key World Energy Statistics 2020*, 13-33.

¹⁴ B Barton and P Schütte, *Electric Vehicle Policy: New Zealand in a Comparative Context* (Research Report, Centre for Environmental, Resources and Energy Law) 2015.

¹⁵ Frederick R Fucci, ‘Distributed Generation’ in M Gerrard (ed), *The Law of Clean Energy* (ABA Publishing, 2011) (hereafter Fucci).

¹⁶ IEA, ‘Smart Grids Tracking Report’ (2020) <https://www.iea.org/reports/smart-grids> accessed 17 June 2021.

¹⁷ Fucci (n 15).

¹⁸ Yael Parag and Benjamin Sovacool, ‘Electricity Market Design for the Prosumer Era’ (2016) 1 *Nature Energy* 1; Daniela Aguilar Abaunza, ‘Getting Ready for the Future’ [2018] NZLJ 292.

electric vehicles and smart appliances, then a household, company, or institution can achieve a high level of autonomy in meeting its energy needs. The user will often want to retain the advantages of a connection to the electricity distribution network, and at that point the matter becomes considerably more complex, in law and regulation, in the relationship of the user with the distribution operator, retailers and the electricity market generally. The distribution network and transmission network are not obsolete but they change their roles significantly. For all that change and complexity, the prosumer dimension of the energy transition offers substantial increases in energy system resilience.

C. Energy Efficiency

The demand side of energy policy is at least as important as the supply side, in thinking about energy resilience as much as anything else. Demand side management (demand flexibility or demand response) is deployed more and more in electricity systems to reduce load and deal with fluctuations such as variable renewable energy supply. It mainly addresses short-term peaks in demand, but it can also provide a degree of short-term resilience when a disaster strikes, especially if it can be provided locally.¹⁹ However one probably needs to turn to energy efficiency for long-term resilience.

Energy efficiency is the level of energy consumption to provide a given service; how many kilowatt-hours to light up a building, or how many litres of fuel to drive a vehicle 100 kilometres.²⁰ Energy efficiency has long been known to offer great economic benefits, advantages in moderating the need to build more energy infrastructure, and progress in alleviating energy poverty by increasing the benefits that a customer receives such as in the form of a warm house to live in. It is one of the key elements of any climate change strategy. A common general indicator of energy efficiency is energy intensity, a country's total energy supply in relation to its gross domestic product, and globally energy intensity has decreased by 36% between 1990 and 2018; in China the reduction was 70%.²¹ However these energy efficiency gains have slowed down since 2015, which is troubling; the IEA's Sustainable Development Scenario relies on efficiency to deliver more than 40% of the reduction of energy-related greenhouse gas emissions over the next 20 years.²²

Energy efficiency can lead directly to resilience. It reduces the degree of dependence on fuels or energy sources to deliver the services required, and in particular it can reduce the reliance of a country or a company on imports of oil, gas and coal. Efficiency gains can have enormous effects. In IEA and other major economies, efficiency gains since 2000 avoided the need for over 11 EJ of fossil fuel imports in 2017, which would have been 20% more.²³ Energy efficiency can often produce these gains in a cost-negative manner in that the improvements often pay for themselves even before the benefits in energy security and risk

¹⁹ IEA, 'Demand Response' (Tracking Report, June 2020) <https://www.iea.org/reports/demand-response> accessed 17 June 2021. The chapter by Louis de Fontanelle in this book gives detailed consideration to demand side flexibility in the European Union.

²⁰ IEA, *Spreading the Net: the Multiple Benefits of Energy Efficiency Improvements* (Insights Series 2012) 9.

²¹ IEA, *Energy Efficiency 2020* (2020); IEA, *Energy Efficiency Indicators Highlights 2020* (2020) 2.

²² IEA, *Energy Efficiency 2020* (2020) 10; IEA, *Net Zero* (n 8) 14.

²³ IEA, 'Multiple Benefits of Energy Efficiency' (2019) online report <https://www.iea.org/reports/multiple-benefits-of-energy-efficiency> accessed 17 June 2021 (hereafter IEA, Multiple Benefits).

reduction are taken into account. Energy efficiency also reduces the likelihood of supply interruptions: ‘the only energy source that cannot be interrupted is the energy that is not used.’²⁴ Efficiency measures can also play a role after a disaster, along with emergency conservation actions, as was demonstrated in the response to the Great East Japan Earthquake in 2011.

Curiously, energy efficiency is often downplayed as a policy option. For example, American public utility regulation, as Inara Scott shows, imposes restrictions on energy efficiency measures, such as a cost-effectiveness test, that it does not impose on renewable energy measures.²⁵ An undue preoccupation with renewables or new technology can produce a policy discussion, even among progressive voices, that pushes for increases in the renewables proportion of energy supply without stopping to think of what total supply is actually needed and how we might do something to modify it.²⁶ Certainly, energy efficiency is a debated concept,²⁷ especially because it involves analysis from different disciplinary perspectives and at different scales.²⁸ What is clear is that more than in most fields of energy policy it concerns human behaviour, and that makes for a complexity that requires transdisciplinary research efforts to understand.²⁹ Also clear is the role that legal analysis must play in formulating policy that seeks to shift human behaviour.³⁰ Resilience and security stand out as strong reasons for legal and policy action to accelerate energy efficiency.

III. Minerals

Having considered the localization of supply and efficient use as contributors to resilience in the context of energy, we can proceed to consider the comparable contributions in relation to mineral resources. The parallels are striking.

Over the last fifty years, the countries that produce the most minerals and the countries that consume the most of them have drifted into separate groupings. The historical industrialization of Europe and North America was based largely on mineral raw materials produced locally, but after decades of globalization the domestic mining industries of many

²⁴ IEA, Multiple Benefits (n 23).

²⁵ Inara Scott, “Dancing Backwards in High Heels”: Examining and Addressing the Disparate Regulatory Treatment of Energy Efficiency and Renewable Resources’ (2013) 43 *Environmental Law* 255.

²⁶ Barry Barton, ‘The Denominator Problem: Energy Demand in a Sustainable Energy Policy’ (2013) 9 *Policy Quarterly* 3.

²⁷ Horace Herring, ‘Energy Efficiency – a Critical View’ (2006) 31 *Energy* 10 voices the view that energy efficiency gains are usually swallowed up by a rebound effect where demand increases. Elizabeth Shove in ‘What is Wrong with Energy Efficiency?’ (2018) 46 *Building Research & Information* 779 questions the relationship with energy sufficiency.

²⁸ Tian Goh and BW Ang, ‘Four Reasons Why There is so Much Confusion about Energy Efficiency’ (2020) 146 *Energy Policy* 111832.

²⁹ Janet Stephenson et al, ‘Energy Cultures: a Framework for Understanding Energy Behaviours’ (2010) 38 *Energy Policy* 6120; Felix Creutzig et al, ‘Towards Demand-Side Solutions for Mitigating Climate Change’ (2018) 8 *Nature Climate Change* 260. The IEA emphasizes the role of behaviour changes in its Sustainable Development and Net Zero Emissions 2050 Scenarios: IEA, *World Energy Outlook* (2020) 142.

³⁰ M Eusterfeldhaus and B Barton, ‘Energy Efficiency: A Comparative Analysis of the New Zealand Legal Framework’ (2011) 29 *JERL* 431.

advanced economies have shrunk back in the face of cheaper mineral imports from distant countries. Industrialization has taken place in countries with limited domestic resources, especially in Asia, and mineral production has grown most in regions without the same levels of industrial activity; Australasia, Latin America, Africa, and Asia excluding Japan and China. In 1960 the world's major consumer countries supplied 82% of their own iron ore, 78% of their nickel, and 52% of their copper; by 2010 the proportions had fallen to 35%, 38%, and 27%; about half of what it had been.³¹ The consequence is that a greater proportion of mineral inputs are in international trade, and the supply chains are longer and more complex. Some minerals are produced in countries that struggle with poverty, corruption, and weak governments; some are beset by periodic bouts of resource nationalism – all of which are threats to supply. In addition, some mineral supplies are very concentrated, as the example of rare earth elements below will show; and the non-fuel minerals are very diverse and some of them do not have easy substitutes. As a result there are more reasons to be concerned about the disruption of mineral supplies than for many other commodities. But it is only recently that these concerns have drawn the attention of policymakers.

A. Minerals Required for Electrification

One of the main reasons why policymakers have recently begun to examine the resilience of mineral supplies is the enormous change under way in how we produce and use energy, driven by climate change concerns but also driven by changing technology costs. The trend towards renewable energy and electrification changes the mix of metals and other minerals required to manufacture equipment and products of all kinds, as the IEA explains.³²

Copper, lithium, cobalt and platinum are at the core of the energy transition: copper is needed for transmission and distribution lines; lithium and cobalt for the currently prevailing lithium-ion battery designs; and platinum in fuel cells. The material with the most fragile supply chain is cobalt, which has highly geographically concentrated mining and processing facilities. The supply chain risks were made clear by a very sharp price hike in 2018, which provided a strong incentive for battery producers to reduce the cobalt content of battery chemistries: several chemistries are now being developed that do not require cobalt, although their timescales are uncertain. Lithium currently has a more stable supply chain, but it is likely to keep its status as a critical material because its physical properties make it nearly non-substitutable in the production of high energy density batteries.

The technologies of the low-carbon future are often more material-intensive than traditional fossil-fuel-based systems, because of the extra effort required to use energy sources that are less energy-dense than oil, gas, and coal. Solar power requires more copper than does thermal power, and electric vehicles require three times as much as conventional vehicles.³³ Indeed electric vehicles require a more exotic mix of materials than do internal combustion vehicles, which mainly need steel. Non-energy products often have similar needs for diverse materials; computers and information technology devices are examples.

³¹ David Humphreys, *The Remaking of the Mining Industry* (Palgrave Macmillan, 2015) 175.

³² IEA, *Energy Technology Perspectives 2020*, 98; also World Bank, *The Growing Role of Minerals and Metals for a Low Carbon Future* (2017).

³³ Takuma Watari et al, 'Analysis of Potential for Critical Metal Resource Constraints in the International Energy Agency's Long-Term Low-Carbon Energy Scenarios' (2018) *Minerals* 8, 156 (hereafter Watari).

A new study by the IEA emphasizes that the rising importance of minerals in decarbonization requires energy policy makers to expand their horizons: ‘Concerns about price volatility and security of supply do not disappear in an electrified, renewables-rich energy system.’³⁴ The study suggests that by 2040 total mineral demand from clean energy technologies (excluding steel and aluminium) double in the Stated Policies Scenario and quadruple in the Sustainable Development Scenario; and that lithium sees the fastest growth rate, with demand growing by over 40 times in the latter Scenario. It recommends a number of actions to improve the resilience, reliability, and diversity of mineral supply chains.

B. Critical Minerals Strategies

An awareness that the flow of important materials could be vulnerable has come to the attention of many policymakers. The European Union has been developing its materials resilience policy since 2008,³⁵ looking ahead to the needs of new electric technology and the underlying fact that it is between 75% and 100% reliant on imports for most metals. It listed its critical raw materials using a methodology that identified the factors of economic importance and supply risk. The list is a factual tool to support policy, for example in trade negotiations and research funding. The 2020 version deleted helium and added bauxite, lithium, titanium and strontium, and proposed a four-point action plan.³⁶ The first point was to develop resilient value chains for raw materials for EU industrial ecosystems, adjusting the lending policies of the European Investment Bank and mobilizing support for compliant exploration, mining and processing projects for critical raw materials. The second was to reduce dependency through the circular use of resources, under the Action Plan that will be discussed below. The third was to strengthen sourcing from within the EU, developing territorial just transition plans and examining the obstacles that make it difficult to bring new mines into operation; but without, one notices, actually declaring a policy of encouraging more mines. The fourth is diversified sourcing from third countries, removing distortions in international trade and building partnerships with developed mining countries like Canada and Australia, integrating the Western Balkans and other near regions into EU supply chains, and developing relations with key countries in Africa and Latin America.

As a Communication this does not have the legal status in the EU of a directive, regulation, decision, or even a policy, but it may have legal effect as a formal statement of aspirations that decision-makers can properly take into account. For instance a company with a rare earth elements mining project at Norra Kärr in Sweden seized on the Commission’s plan as a reason why the project should go ahead. The company’s opponents in the district worry that the plan could cause authorities to wave the project through despite legal doubts: ‘Legally, it should not have an impact, but I am afraid it will, because the judges and the people at the Mining Inspectorate are only people, so if they get those kinds of signals from the EU, of

³⁴ IEA, *The Role of Critical Minerals in Clean Energy Transitions* (2021) 5, 50 (hereafter IEA, *Critical Minerals*). Also see Florencia Heredia, Agostina L Martinez, Valentina Surraco Urtubey, ‘The Importance of Lithium for Achieving a Low-Carbon Future: Overview of the Lithium Extraction in the “Lithium Triangle”’ (2020) 38 JERL 213.

³⁵ European Commission, ‘Raw Materials Initiative – Meeting our Critical Needs for Growth and Jobs in Europe’ Communication COM (2008) 699 final, 4.11.2008.

³⁶ European Commission, ‘Critical Raw Materials Resilience: Charting a Path towards Greater Security and Sustainability’ Communication COM(2020) 474 final, 3.9.2020.

course that might influence them.’³⁷ The proper weight to give to such signals would be an issue in many legal systems.

In the United States, concern about the supply of critical minerals has often been framed as a matter of national security and protection against disruption by a foreign adversary. An executive order in 2017 declared a policy of reducing this vulnerability.³⁸ A second order in 2020 declared a national emergency to deal with the threat posed by the nation’s undue reliance on critical minerals from foreign adversaries, and to enhance its domestic mining and processing capacity.³⁹ Relevant agencies were to prioritize the expansion of the domestic supply chain for minerals, and to accelerate the issuance of permits and the completion of projects for that purpose – all as appropriate and consistent with applicable law. Through the Development Finance Corporation the government took a US\$25 million stake in a battery metals miner with a nickel-cobalt project in Brazil to reduce the country’s reliance on China.⁴⁰ Another order by the incoming Biden administration called for a wider evaluation of supply chain resilience in the face of pandemics, cyber-attacks, climate shocks, terrorist attacks and geopolitical and economic competition, with a special focus on semiconductor manufacturing, advanced packaging, high-capacity batteries, rare earth elements, and pharmaceuticals.⁴¹ In 2021 the US Senate passed a bill authorizing a grant program to finance pilot projects for the domestic development of critical minerals and called for work by the US Trade Representative on rare earth minerals.⁴²

Policymakers in other countries have been re-examining their manufacturing needs in relation to their mineral inheritance.⁴³ Australia launched a Critical Minerals Strategy in 2019,⁴⁴ giving critical minerals extra emphasis in exploration funding, government research and geological spending, led by a Critical Minerals Facilitation Office. In early 2021 it launched a Resources Technology and Critical Minerals Processing roadmap.⁴⁵ Canada has a list of critical minerals⁴⁶ and emphasizes its mutual interest with the United States in improving critical mineral security, and its role as a dependable supplier of minerals. A joint action plan

³⁷ Charlie Duxbury, ‘Sweden’s Ground Zero for the EU’s Strategic Materials Plan’ *Politico* (20 November 2020) quoting Högberg Björck, lawyer for NGOs and local residents.

³⁸ Executive Order 13817, *A Federal Strategy to Ensure Secure and Reliable Supplies of Critical Minerals*, 20 December 2017, 82 Federal Register 60835; Department of the Interior, *Final List of Critical Minerals 2018*, 83 Federal Register 23296.

³⁹ Executive Order 13953, *Addressing the Threat to the Domestic Supply Chain from Reliance on Critical Minerals from Foreign Adversaries*, 30 September 2020, 85 Federal Register 62539.

⁴⁰ Cecilia Jamasmie, ‘U.S. Grabs Stake in Battery Metals Miner to Fight Chinese Control’ *The Northern Miner* (Toronto, 12-25 October, 2020) 16.

⁴¹ Executive Order 14017, *America’s Supply Chains*, 24 February 2021, 86 Federal Register 11849.

⁴² United States Innovation and Competition Act of 2021, 117th Congress 1st Session S. 1260.

⁴³ Rajesh Chadha, *Skewed Critical Minerals Global Supply Chains post-COVID-19: Reforms for Making India Self-Reliant* (Brookings India, discussion note, 2020).

⁴⁴ Government of Australia, *Australia’s Critical Minerals Strategy* (2019).

⁴⁵ Government of Australia, ‘Using our Resources Strengths to Grow Manufacturing’ (media release, Scott Morrison, Prime Minister, 4 March 2021).

⁴⁶ Natural Resources Canada, ‘Canada Announces Critical Minerals List’ (news release, 11 March 2021).

has been announced.⁴⁷ However the Canadian Minerals and Metals Plan of 2019 said little about supply resilience or critical minerals,⁴⁸ and an update did not address them either.⁴⁹

For their part, mining companies ask how should they position themselves to survive these struggles between states, and how to avoid being sacrificed on the altar of national interest.⁵⁰ For example a miner producing a critical material may find itself restricted in the sale of its product and forbidden from selling its output overseas. Such restrictions could put companies in a legally difficult situation where long-term offtake or streaming agreements are in place as part of a mine's financing.⁵¹

C. Rare Earth Elements and Cobalt

The story of rare earth elements over the last fifteen years is instructive although we have to be careful generalizing from it. This group of elements or materials is not as rare as its name might suggest, but viable deposits are few, and new supply is slow to appear.⁵² Their unique chemical properties make them valuable even in trace quantities in a number of applications, but it is in electronics, permanent magnets, and batteries that they are essential for modern technology and in particular advanced wind turbines and electric vehicles. Demand for them began to surge in the mid-2000s. China has a near-monopoly on rare earth production and processing, and in 2008 it began to consolidate the industry, cracking down on informal mines, and imposing environmental controls, export taxes, production quotas, and export quotas.⁵³ Exports declined and international prices rose dramatically. Although controls were justified to clean up the industry, the restrictions were also used to exert diplomatic pressure on Japan. The United States was concerned about the supply of materials for its defence industry and other manufacturing. Both countries took counter-measures to diversify supply, open or reopen rare earth mines, and fund mineral exploration. They and other countries initiated dispute proceedings at the World Trade Organisation, arguing that China's actions on rare earths (and tungsten and molybdenum) contravened provisions of the General Agreement on Tariffs and Trade that prohibited restrictions on exports, and contravened the terms on which China had acceded to the WTO. The WTO panel and the Appellate Body ruled in favour of the claimants, and in 2014 the Chinese government abolished the export quotas and

⁴⁷ Natural Resources Canada, 'Canada and U.S. Finalize Joint Action Plan on Critical Minerals Collaboration' (news release, 9 January 2020). It is not clear whether the Plan exists as a document separately from the press release.

⁴⁸ Government of Canada, 'Canadian Minerals and Metals Plan' (2019).

⁴⁹ Government of Canada, 'Canadian Minerals and Metals Plan: Update to Action Plan 2020.'

⁵⁰ For example, Fasken Martineau DuMoulin, 'Critical Minerals in the COVID-19 Era: Supply Chain and Survival' (webinar 1 March 2021) <https://www.fasken.com/en/faskeninstitute/2021/03/pdac-critical-minerals>, accessed 12 March 2021.

⁵¹ Barry Barton, *Canadian Law of Mining*, 2d edn (LexisNexis, 2019) 904 (hereafter Barton, *Canadian Mining*).

⁵² Nimila Dushyantha et al, 'The Story of Rare Earth Elements (REEs): Occurrences, Global Distribution, Genesis, Geology, Mineralogy and Global Production' (2020) 122 *Ore Geology Reviews* 103521 (hereafter Dushyantha).

⁵³ Jeffrey Wilson, 'Whatever Happened to the Rare Earths Weapon? Critical Materials and International Security in Asia' (2018) 14 *Asian Security* 358 (hereafter Wilson); Nabeel Mancheri, 'World Trade in Rare Earths, Chinese Export Restrictions, and Implications' (2016) 46 *Resources Policy* 262.

replaced the export tax with a set of ad valorem royalties.⁵⁴ The threat to international security did not last long.

Jeffrey Wilson argues convincingly that there were three reasons why the Chinese government was not able to wield rare earths as a strategic weapon. First, demand was very sensitive to price movements; manufacturers in importer countries proved to be good at reducing the amounts of rare earth minerals they needed. Secondly, the Chinese government did not have the institutional capacity to enforce its export controls and prevent the massive smuggling that took place to avoid them. Thirdly, its monopoly on current production did not translate into control of future supply, because the mining industry could react to high prices by finding new mines, reopening old mines, and reopening old processing facilities. The conditions necessary to use rare earths as an instrument of coercion were absent, and Wilson goes on to suggest that no other mineral, even oil, is likely to be usable in that way either.⁵⁵ Even cobalt, which attracts advocacy similar to rare earth elements, might be difficult, despite the concentration of more than half of production and reserves in the Democratic Republic of Congo and of more than half the refining capacity in China.⁵⁶

D. The Role for Critical Minerals Policies

What role do we see, then, for critical minerals policies and other efforts to increase the resilience of supply chains? If international rivals cannot use rare earths and other minerals as coercive weapons, and if the market will provide, what need is there for resilience initiatives from the government? Certainly there are difficulties with these initiatives. Policymakers need to be careful with the abundant opportunities the issue presents for industries to play on national security fears and lobby for subsidies, import protection, easier mineral exploration access to public lands, funding for research, and tax breaks for domestic mineral exploration and production.⁵⁷ As for the market, it is certainly true that the mining industry is versatile in reacting to price signals; it is engaged in a constant process of evaluation and re-evaluation of mineralizations and assets. Mineral explorationists may be searching new ground in order to find a mine, or, more typically, they are learning more about a mineral occurrence that is already known but only partly understood. Often they are trying to look at it in a new way, such as with a new geological theory, to unlock possibilities that others have not seen. Even the operators of existing mines can re-evaluate their geology and milling operations in order to recover mineral values that had not been considered previously. Experts in extractive metallurgy may find opportunities to extract newly-valuable materials from old tailings deposits. Policy-making is also complicated by the fact that mineral resources are imperfectly known; it is rather difficult for a government to strategize about a mineral resource when it does not know what quantities of it might be found within its jurisdiction.

⁵⁴ World Trade Organisation, *China – Measures Related to the Exportation of Rare Earths, Tungsten, and Molybdenum*, WT/DS431/AB/R, WT/DS432/AB/R, WT/DS433/AB/R, 7 August 2014 (Reports of the Appellate Body AB-2014-3, AB-2014-5, AB-2014-6).

⁵⁵ Wilson (n 53) 370 points out that OPEC's efforts to use oil as a diplomatic weapon have not been effective. Only network-reliant resources, such as natural gas supplies from Russia to Europe, may provide leverage, at least in the short term.

⁵⁶ IEA, *World Energy Outlook* (2018) 59; also IEA, *Critical Minerals* (n 34) 32, 90.

⁵⁷ For examples, see Congressional Research Service (US), 'An Overview of Rare Earth Elements and Related Issues for Congress' (R46618, B Tracy, 24 November, 2020).

For all that these difficulties exist, we can identify several factors that may make critical minerals strategies worthwhile. War, internal conflict, cybercrime and catastrophic storms can cut supply chains as much as strategic competition; we should not let the rare earths example dominate our thinking about resilience. There will be other pinch points in supply lines for the many materials that are necessary for the modern economy. In addition, supply and demand sometimes take years or decades to adjust, because the mineral exploration and development process is a long one.⁵⁸ New supply may emerge years after it is called for, so prices of mineral commodities are notoriously cyclical, and the boom-and-bust cycles can hurt manufacturers. Further, there are growing non-financial reasons for mineral-importing countries and mineral-using companies to pay attention to the sources of their supplies, and be aware of the hazards of corruption, human rights abuses, environmental damage and carbon footprint that may attend distant mineral operations.⁵⁹ Arguably, then, there are substantial benefits in resilience to be had from strategic planning for minerals and raw material supplies. Countries are not helpless in the face of international market forces; they can plan for different contingencies, and decide what activities they want to support, within and beyond their borders, in order to strengthen and diversify their lines of supply. Increased domestic mineral production may encounter resistance in developed countries where mining has become unfamiliar, even though opponents face an ethical problem if in effect they argue that mineral needs should be met from mining in distant developing countries.

E. Demand Side Measures: the Circular Economy

Protecting the sources of supply of materials, and diversifying them, is one way of building resilience, but another is managing demand; the amount of materials that we need. Substitution of one material for another in the design of a product is a form of demand management that we noted in the context of rare earth elements, and so is design that can simply reduce the amount of a material that is required to produce the finished product.

A more general approach to these matters is the concept of a circular economy that is an alternative to the traditional extract-produce-use-dispose model of materials flows in the economy. In a circular economy, materials, components and products are kept at their highest value for as long as possible, by using cyclical materials flows, renewable energy sources and cascading energy flows.⁶⁰ True circularity goes beyond recycling and waste management and involves all elements of the value chain, to include the re-use of materials, re-manufacturing, and the design of products so that they can be disassembled, repaired, and re-purposed. It seeks “cradle-to-cradle” flows of materials, rather than “cradle-to-grave” flows that produce waste. It builds on well-established insights into our relationship with the natural world such as the frontier economy of taking and discarding resources and the need to change to thinking of a “spaceship” economy where humanity takes care of its life-supporting systems.⁶¹ There are now many approaches to the concept and debate about its relationship with sustainable development; it can be seen as an implementation of Sustainable Development Goal 12,

⁵⁸ Some of these characteristics are described in Barton, *Canadian Mining* (n 51) 4, 797.

⁵⁹ Steven Van Bockstael, ‘The Emergence of Conflict-free, Ethical and Fair Trade Mineral Supply Chain Certification Systems: A Brief Introduction’ (2018) 5 *The Extractive Industries and Society* 52.

⁶⁰ Jouni Korhonen, Antero Honkasalo, Jyri Seppälä, ‘Circular Economy: the Concept and its Limitations’ (2018) 143 *Ecological Economics* 37.

⁶¹ KE Boulding, ‘The Economics of the Coming Spaceship Earth’ in H Jarrett (ed) *Environmental Quality in a Growing Economy* (Resources for the Future, 1966).

ensuring sustainable consumption and production patterns.⁶² It has attracted a great deal of interest and commitment from the business world and in environmental and economic policy.⁶³

However, behavioural change to improve material handling, both in commerce and in households, is often difficult to bring about, and so is the establishment of new businesses and industries that can be run profitably on circular economy principles. Technical change is necessary too; the small traces of diverse metals in electronic equipment are difficult to separate economically, the recycling of rare earth elements from electric and electronic waste is in its infancy, and technical innovation is necessary to better exploit mine tailings and other secondary sources.⁶⁴ One study suggests that primary metal demand for low carbon energy technology could be reduced by 20% to 70% by 2060 with recycling.⁶⁵

What has this got to do with resilience? Circularity improves resilience by reducing dependency on fresh raw materials, and that is accompanied by a reduction in dependency on complex processing and transport systems, with their associated greenhouse gas emissions. Even a partial increase in circularity means that an industry or an economy is more able to find its inputs nearby, with less importing, less reliance on global transport chains, and fewer concerns about commercial and political instability. Circularity and recycling are a form of local provision. Thus the European Commission identifies the benefits of a more circular use of critical raw materials as ensuring security of supply, reduced energy use, and reduced water use; and there may also be less harm to the biosphere and less waste produced per tonne of material obtained.⁶⁶ The European Union has committed itself to the concept of the circular economy in ways that are significant for materials supply resilience. It has formulated a Circular Economy Action Plan as one of the key components of its industrial strategy and its European Green Deal strategy.⁶⁷ The Plan emphasizes that circularity is an integral part of the transition to a low-carbon economy.

Elements of the mining industry are looking ahead to a circular economy. An industry leader at a symposium in 2021 said that companies initially see the circular economy as ‘anti-mining’ but are increasingly building circular concepts into their strategic planning and

⁶² Julian Kirchherr, Denise Reike, Marko Hekkert, ‘Conceptualizing the Circular Economy: an Analysis of 114 Definitions’ (2017) 127 *Resources, Conservation & Recycling* 221; Neal Millar, Eoin McLaughlin, Tobias Börger, ‘The Circular Economy: Swings and Roundabouts?’ (2019) 158 *Ecological Economics* 11.

⁶³ World Economic Forum, *Towards the Circular Economy: Accelerating the Scale-up across Global Supply Chains* (2014); Ellen MacArthur Foundation, *Universal Circular Economy Policy Goals: Enabling the Transition to Scale* (2021).

⁶⁴ Dushyantha (n 52).

⁶⁵ Watari (n 33), 156.

⁶⁶ European Commission, *Report on Critical Raw Materials and the Circular Economy* (2018).

⁶⁷ European Commission, *A New Circular Economy Action Plan for a Cleaner and More Competitive Europe* (Communication COM (2020) 98 final). It comes after earlier policy work, in particular European Commission, *Closing the Loop – An EU Action Plan for the Circular Economy* (Communication and Action Plan COM(2015) 614). Also European Commission, *Critical Raw Materials Resilience: Charting a Path towards Greater Security and Sustainability* (COM(2020) 474 final) 9.

modelling.⁶⁸ The CEO of Anglo American spoke of the strong rationale to engage with the circular economy; in the past the company saw itself as a mining company, in the present sees itself as a metals and mining company, and tomorrow may well characterize itself as a materials solutions company.

Materials circularity is not the whole answer to climate change or any other sustainability problem, any more than is energy efficiency; but both are hugely important parts of the solution, and should be the subjects of substantial policy and law reform effort.

IV. Discussion

The two themes that we have explored, local provision (or more locally-controlled provision), and managing or reducing demand through prudent use, are broad ones, and to discern them we have had to pull some very different threads together. But it is striking how the two themes both appear in energy and in minerals; the two sectors have a good deal in common.

Local provision and management of demand clearly have significant contributions to make to improving resilience and reducing the effects of disruption. Local provision in energy takes the form of distributed energy supply, prosumer participation, renewables and electrification; and in minerals, critical minerals policies seek to reduce dependence on distant sources especially when supply of a mineral is concentrated. Management of demand in energy takes the form of energy efficiency and demand response; and in minerals, the emerging concept of the circular economy, and in both energy and minerals consumers, on the demand side, can take a role in reducing and modifying their dependence on external sources of supply.

The opportunities for significant gains in resilience seem to be substantial. Suitable legal measures can enable nations, companies, and people to reduce their dependence on complex national or global networks and supply chains (even if they cannot discard them altogether), and thereby reduce their risks, increase their autonomy, and improve their ability to withstand unexpected shocks. Empirical analysis of the opportunities would be very desirable. Also calling for closer examination is the line between localism and insularity; we see resilience value in local supply, autonomy, shortened supply chains, and self-sufficiency, but we can distinguish that from xenophobia and protectionism. The benefits of resilience need to be weighed against those of international cooperation.⁶⁹ Certainly there is no call for an end to international cooperation, or trade; what is called for, rather, is for consumers (at the national, corporate or individual level) to make active choices in deciding where to get their energy and resources, and how much they need.

It is striking that local provision and demand management can produce many benefits other than resilience. Energy efficiency, distributed generation, renewables, and circularity are well recognized as vital elements of a transition to address climate change, reduce poverty, and improve economic performance. They contribute to a just and effective transition, rather than being in tension with it, which is enormously important because resilience can never be an excuse for going light on sustainability or mitigation. The reason why they contribute rather than detract is that they are mainly on the demand side of the energy and minerals equation rather than the supply side. Because of their multiple benefits, policy and law reform

⁶⁸ ‘The Circular Economy Set to Transform the Mining Industry, says Panel at the Global Mining Symposium’ *The Northern Miner* (Toronto, 25 February 2021) quoting Andrew Cheatle and Mark Cutifani.

⁶⁹ IEA, *Net Zero* (n 8) 187.

processes must give them substantial attention, and avoid a framing of resilience policy as a matter of simply strengthening supply.

The law reform agenda, as our final point, seems to be different for energy and minerals, notwithstanding the similarities we have discussed. Renewable energy, electrification, distributed energy, prosumers and energy efficiency are already the subject of legal and regulatory action in many countries, but it seems desirable to add resilience to the list of objectives or purposes which regulators are to pursue in promoting them. As to minerals and materials, a foreseeable problem is the legal significance to be given to critical minerals strategies. At the present they are usually policy statements, not made in a specific legal framework, and without specified legal consequences. It will be a live question in many legal systems whether a strategy can or should be taken into account in making statutory decisions about mineral development, as in the Swedish case we noted. Similarly, should mining companies prepare for restrictions on international sales of their products because of resilience concerns? Will circular economy initiatives produce regulatory action in primary and secondary markets for raw materials? New measures localizing supply and managing demand seem very promising in order to promote resilience, but are sure to create new legal questions.