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ARTICLE

'Socialism is not just Built for a Hundred Years': Renewable Energy and Planetary Thought in the Early Soviet Union (1917–1945)

Daniela Russ

Department of Historical Sociology, University of Toronto, Toronto, Canada; Faculty of History, Arts and Regional Studies, Universität Leipzig, Leipzig, Germany; Department of History, University of Guelph, Guelph, Canada
daniela.russ@utoronto.ca

The humanities recently rediscovered the category of the 'planetary' for a social theory of the Anthropocene critical of the human remaking of the planet. This article brings together Dipesh Chakrabarty's work with Russian planetary and geopolitical thought. Focusing on Vladimir Vernadsky's and Boris Veinberg's research around the Commission for the Study of Natural Productive Forces, it argues that knowledge on planetary interconnections informed the territorial and industrial expansion of the Russian Empire and the Soviet Union. According to planetary scientists, humanity's peculiarity as a species and planetary reach hinged on its control of energy. As 'cosmic technologies', wind and solar power could expand the biosphere and make the territory's fringes habitable. Thus, insight into the vast scales of the universe did not dwarf but augment humanity – and particularly scientists. The article concludes that the planetary should be understood as an extension of global politics rather than a divergence from it.

> The use of these winds will be the first step to the organization of a chief administration of the sun's energy . . . (Kozmin to Lenin, Notes on wind power stations, 1921)

Introduction

From the outpost of Soviet science in the Siberian city of Tomsk, the geophysicist Boris Veinberg wrote one of the first works of Anthropocene fiction – a scientific fantasy about the state of humanity in the very distant year 22,300. In the short story published in 'Siberian Nature' in 1922, he imagined a world in which humanity has entirely remade the biosphere. In the age of solar energy, following the age of coal, humanity has finally created the institutional structures necessary to collectively manage the planet's surface. With humanity's life depending on ever more solar power, the 'Committee for the Improvement of the Terrestrial Globe' begins to consider the destruction of the oceans to create new space for settlement and the harnessing of solar radiation. Veinberg's humanity has not only learned to behave as a single political entity (which held a global plebiscite on the matter in the year 2300), but also to act on time-scales far beyond those of an individual human's experience. It takes the committee roughly 8000 years to concentrate the planet's oceans in two reservoirs at the poles and another couple of thousand years to bring the climate, disrupted by carbon dioxide from coal combustion and the reshuffling of large amounts of water, under control.[1] In the year 22,300, humanity finally lives equipped with ample solar power in a totally standardised and regulated climate,

[1] Boris Veinberg, 'K dvukhdesiatitysacheletiiu nachala rabot po unichtozheniiu okeanov: ocherk istorii chelovechestva ot pervobytnogo sostoianiia do 22 300 g.', *Sibirskaia Priroda*, 2 (1922), 24, 35.

no longer subject to the 'chaotic change of weather, which has been characteristic of the terrestrial globe for so long'.[2]

Russian thinking on human life through a planetary perspective can be seen as one of the European contributions to the nexus of ecology and economic thought that is at the heart of this special issue. The concept of the 'biosphere' is the most prominent treasure that has been recovered from this literature in recent decades. First introduced by the Austrian geologist Eduard Suess, it was further developed by the Russian mineralogist and geochemist Vladimir I. Vernadsky. Denoting the narrow stretch between the atmosphere and the earth's crust on which most life dwells, the biosphere introduces a new mechanism into the planetary system – life's ability to harness solar power, generate biogeochemical energy and transform the planet's surface. James Lovelock and Paul Crutzen both recognise the biosphere as an antecedent to their frameworks of 'Gaia' and the 'Anthropocene'.[3] In the 1970s and 1980s, Soviet ecologists began to reconnect to this earlier tradition.[4] Today, the concept is still being used in ecological economics, where 'biosphere economies' are an attempt to establish the boundaries within which society's economic activities are safe for planetary life.[5]

The humanities and social sciences have recently begun to reappropriate the category of the 'planetary' to develop a social theory suitable for the Anthropocene.[6] While Vernadsky is credited as a predecessor, most accounts date the category to the Cold War space programmes and the environmental movements of the 1970s and 1980s, assuming a break between a pre-planetary consciousness and a planetary awakening.[7] Among those who have developed the concept furthest is Dipesh Chakrabarty. In his understanding, the planetary refers to the earth as a system of which the oceans, solar radiation, the chemical structure of the atmosphere, etc., form parts. The planetary decentres the human by emphasising the precarious interconnectedness of all life and locating it on timescales that go far beyond the temporal horizons of human beings. Like Gayatri Spivak before him, Chakrabarty distinguishes the planetary from the category of the global.[8] The latter refers to the imperial expansion and capitalist exploitation of the biosphere, but also to politics in general. The earth system influences life – just like life and human activities can alter and affect the earth system – but unlike the 'globe', it remains alien to the norms and values that humanity has made for itself.[9] The question at the centre of

[2] Veinberg, 'K dvukhdesiatitysacheletiiu nachala', 35. The eerie similarity between Veinberg's ideas and those of today's technocrats of the Anthropocene does not end here: he was not only a strong proponent of solar power but even invented a vacuum train, a predecessor to Elon Musk's hyperloop, 'Traveling at 500 Miles Per Hour in the Future Electric Railway', *The Electrical Experimenter*, Mar. 1913.

[3] James E. Lovelock, 'Prehistory of Gaia', *New Scientist*, 17 July 1986, 1517; Will Steffen, Jacques Grinevald, Paul J. Crutzen and John McNeill, 'The Anthropocene: Conceptual and Historical Perspectives', *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Science*s, 369, 1938 (2011), 842–67; Paul J. Crutzen, 'The "Anthropocene"', in Eckart Ehlers and Thomas Krafft, eds., *Earth System Science in the Anthropocene* (Berlin: Springer, 2006), 13–18; Jacques Grinevald and Giulia Rispoli, 'Vladimir Vernadsky and the Co-Evolution of the Biosphere, the Noosphere and the Technosphere', *Technosphere Magazine* (2018), 1–9, 20 June 2018, https://technosphere-magazine.hkw.de/p/Vladimir-Vernadsky-andthe-Co-evolution-of-the-Biosphere-the-Noosphere-and-the-Technosphere-nuJGbW9KPxrREPxXxz95hr.

[4] Giulia Rispoli, 'Between "Biosphere" and "Gaia": Earth as a Living Organism in Soviet Geo-Ecology', *Cosmos and History: The Journal of Natural and Social Philosophy*, 10, 2 (2014), 78–91; Eglė Rindzevičiūtė, 'Soviet Policy Sciences and Earth System Governmentality', *Modern Intellectual History*, 17, 1 (2020), 179–208.

[5] Anne-Sophie Crépin and Carl Folke, 'The Economy, the Biosphere and Planetary Boundaries: Towards Biosphere Economics', *International Review of Environmental and Resource Economics*, 8, 1 (2015), 57–100.

[6] Gayatri Chakravorty Spivak, *Death of a Discipline*, The Wellek Library Lecturers in Critical Theory (New York: Columbia University Press, 2003); Dipesh Chakrabarty, *The Climate of History in a Planetary Age* (Chicago: University of Chicago Press, 2021); Bruno Latour, *Facing Gaia: Eight Lectures on the New Climatic Regime* (Cambridge: Polity, 2017); Frederic Hanusch, Claus Leggewie and Erik Meyer, *Planetar denken: ein Einstieg* (Bielefeld: transcript, 2021).

[7] Christophe Bonneuil and Jean-Baptiste Fressoz, *The Shock of the Anthropocene: The Earth, History and Us* (London: Verso Books, 2016).

[8] Spivak, *Death of a Discipline*, 72.

[9] Chakrabarty, *The Climate of History*.

planetary thought 'is *not* what life is or how it is managed in the interest of power but rather what makes a planet friendly to the continuous existence of complex life'.[10] There is an underlying directionality in Chakrabarty's account, suggesting that, with the growing insight into the biochemical relations linking life, industrial production and the atmosphere, the planetary gradually emerges and 'the age of the global as such is ending'.[11] In this sense, the global 'reveals' the planetary.

It has been argued that such accounts downplay the planetary consciousness of the past. Not only that the scientific inquiry into the common order linking the heavens and the earth – the old meaning of cosmos – reaches back centuries.[12] There was a golden age of planetary thought and scientific research into solar-terrestrial phenomena in the late nineteenth and early twentieth century, as Christoph Bonneuil has recently pointed out.[13] Cosmical physics – the study of solar-terrestrial relationships – flourished around the turn of the century, particularly in countries where aurora borealis or other magnetic or electric phenomena could be witnessed. This field encompassed the geophysical, meteorological, and astronomical sciences but also reached into chemistry, as spectrography treated light as information and enabled the study of chemical elements in the universe.[14]

The purpose of this text is to bring contemporary accounts of the emergence of the planetary into conversation with the rich culture of planetary thinking in early twentieth-century Russia. Yet my point is not simply to insist that something happened earlier. By underestimating the planetary thought of the past, contemporary accounts tend to overstate today's planetary consciousness. What is more, only by stripping the planetary away from the 'geopolitical' context in which it historically appeared can it be defended as a pure category of alterity, a critical category acting *against* human matters. I argue that the Russian tradition of planetary thinking strengthens Chakrabarty's point that politics, war and imperial expansion (the 'global' in his notation) reveals the planetary. In the first part, I show how Vernadsky's and Veinberg's work was connected to science-led territorial expansion and economic development in Imperial Russia and, later, the Soviet Union. Both were students of Dmitrii Mendeleev, who not only drew up the periodic table, but also a geopolitical plan for Russia's eastward expansion.[15] The Academy of Science's Commission for the Study of Natural Productive Forces (*Komissiia po izucheniiu estestvennykh proizvoditelnykh sil*; KEPS, 1915–30), a survey of Russian natural resources adopted by the Bolsheviks after the revolution, embodied this spirit of appropriating the terrestrial globe for human life. With Vernadsky as its initiator and Veinberg as a participating scientist, the commission serves as the connecting thread of this article. I then show that, for both scientific and utopian planetary thinkers of that time, the nature, scope and speed of energy conversions determined to a large part humanity's peculiarity as a species and its planetary reach. Wind and solar power were seen as 'cosmic technologies' that were vital to expand the biosphere and make the fringes of the Soviet Union habitable. Juxtaposing the limitedness of fossil fuels to an abundance of renewables, the planetary perspective brought about a brief summer of wind and solar power research during the 1920s–30s. Throughout the paper, I show that for Vernadsky and Veinberg, the planet had already become historical, altered through life and changeable through a planetary biopolitics; but this marked only a yet further expansion of humanity's power. *Contra* Chakrabarty, I conclude then that the planetary should be understood as an extension of the global, rather than a divergence from it.[16]

10 Ibid., 83.

11 Ibid., 285.

12 Helge Kragh, *Conceptions of Cosmos: From Myths to the Accelerating Universe: A History of Cosmology* (Oxford: Oxford University Press, 2007).

13 Christophe Bonneuil, 'Der Historiker und der Planet. Planetaritätsregimes an der Schnittstelle von Welt-Ökologien, ökologischen Reflexivitäten und Geo-Mächten', in Frank Adloff and Sighard Neckel, eds., *Gesellschaftstheorie im Anthropozän* (Frankfurt am Main: Campus Verlag, 2020), 63.

14 Helge Kragh, 'Nordic Cosmogonies: Birkeland, Arrhenius and Fin-de-Siècle Cosmical Physics', *The European Physical Journal H*, 38, 4 (2013), 549–72.

15 G.D. Gloveli, 'D.I. Mendeleev i Evraziistvo', *Filosofia Khoziaistva*, 2 (2009), 252–65.

16 Chakrabarty, *The Climate of History*, 80.

Noospheric Practice and the Commission for the Study of Natural Productive Forces

In late Imperial Russia, the problems of economic development and industrialisation, imperialism and nationalism, and the rise of the natural sciences, come together in a specific way. Influenced by German romanticism, Russian nationalist and imperialist thought adopted strongly organicistic tones over the nineteenth century. The native soil movement (*pochvenichestvo*) imagined the nation as a living organism growing from the soil and likened empires to blooming and waning plants.[17] Eurasianism – a Russian strand of imperialist thought – described Russia as a continental empire between Europe and Asia, united by a distinct geography that accounted for its unique character. With its population centre to the west of a huge, sparsely populated Siberia, however, the Russian Empire suffered from a displaced centre of gravity. Halford Mackinder famously described the Eurasian heartland as the 'geographical pivot of history'.[18] Like other geopolitical thinkers of the time, such as Rudolf Kjéllen and Friedrich Ratzel, Eurasianists drew heavily on science, describing 'the unity of the imperial space of Russia in a scientistic manner'.[19] On the basis of science and a soil-based understanding of the nation, large, unsettled tracts of land could become native territories waiting to be reappropriated for the national project. Even in the liberal and Bolshevik projects, science was crucial to get to know the territory and its resources, become economically independent and find ways to expand settlement into Siberia.

Two scientists, Vassilii Dokuchaev and Dmitri Mendeleev, pioneered an interdisciplinary approach and the application of scientific knowledge to national ends at the University of St. Peterburg, Vernadsky's and Veinberg's alma mater.[20] Dokuchaev, a chemist and soil scientist, held that scientific achievements in the nineteenth century had relied on neatly separating bodies and phenomena from each other. For all the astonishing results this method had yielded, however, the sciences had neglected to study

> interrelationships, this *genetic*, eternal and always *regular* connection that exists between *forces*, *bodies* and *phenomena*, between *inert* and *living* nature, between the realms of plants, animals and minerals on the one hand, and man, his life, and even his spiritual world, on the other. Yet, it is these *interrelationships*, these lawful *interactions* that comprise the essence of our cognition of nature, the core of a true natural philosophy, the best and highest charm of natural sciences![21]

In his broad natural-philosophic understanding, Dokuchaev conceived of soil as an interaction of organic and anorganic matter with climatic and vegetative factors.[22] Eurasionists like Piotr Savitskii saw in Dokuchaev's approach the beginning of a place-based, Russian science, which could unravel the natural history of the empire through knowledge of its soils.[23] Vernadsky studied closely with Dokuchaev, took part in his excursion to the black earth regions and was deeply influenced by his synthetic approach to science.[24]

17 Mieka Erley, *On Russian Soil: Myth and Materiality* (Ithaca, NY: Cornell University Press, 2021), 20–9.

18 Halford J. Mackinder, 'The Geographical Pivot of History', *The Geographical Journal*, 23, 4 (1904), 421–37.

19 Sergei Glebov, 'A Life with Imperial Dreams: Petr Nikolaevich Savitsky, Eurasianism, and the Invention of "Structuralist" Geography', *Ab Imperio*, 2005, 3 (2005), 325.

20 Alexei Kojevnikov, 'The Great War, the Russian Civil War, and the Invention of Big Science', *Science in Context*, 15, 2 (2002), 243.

21 Vassilii Vasilevich Dokuchaev, *Kucheniiu o zonakh prirody* (St. Petersburg: Tipografiia Spb. Gradonachalstva, 1899), 5; I borrowed the English translation, with minor modifications, from Glebov, 'A Life with Imperial Dreams', 313.

22 Jonathan D. Oldfield and Denis J. B. Shaw, *The Development of Russian Environmental Thought: Scientific and Geographical Perspectives on the Natural Environment* (New York: Routledge, 2016), 48–77; Erley, *On Russian Soil*, 31.

23 Glebov, 'A Life with Imperial Dreams', 313.

24 Kendall E. Bailes, *Science and Russian Culture in an Age of Revolutions: V. I. Vernadsky and His Scientific School, 1863–1945* (Indianapolis, IN: Indiana University Press, 1990), 20.

The second scientist who exerted considerable influence on Vernadsky and Veinberg is Dmitri Mendeleev, who systemised elements in a periodical table in 1871. Mendeleev took an active part in politics, particularly in questions concerning economic policy, industrial development and the standardisation of measures. From Veinberg's shorthand notes, we get an idea of the broad perspective Mendeleev sought to convey in his lecture on inorganic chemistry, which Vernadsky had attended a couple of years earlier. Like Dokuchaev, Mendeleev sought an interdisciplinary approach, encompassing astrophysics, geology, chemistry, cosmogony and meteorology. Describing science as a 'lantern' that illuminates and reveals nature for what it is and can be, Mendeleev emphasised the role of research in the Russian empire's economic development. Russia had so far lived off resources close to the surface and imported most of its raw materials, but science could unveil the riches that lay more hidden.[25] Since 'only economic independence is real independence',[26] Mendeleev supported the exploration and development of domestic resources, a conviction he translated into his work as a consultant with the Ministry of Finances under Alexander III.[27]

Given Russia's geographical position between Europe and Asia, economic independence could only be achieved if the vast Siberian landmass would be explored and developed. In 'Toward a Knowledge of Russia' (*K poznaniiu Rossii*, 1906), Mendeleev argued that Russia's population and industrial centre should shift towards the east. In Russia, 85 per cent of the population lived on 25 per cent of the territory, huddled together on the western fringes of the empire.[28] Mendeleev suggested that the ongoing migration over thousands of years would gradually come to an end when the 'general development of industriousness and industry, guided by science – that is, by an empirical search for truth – will take possession of the bowels of the earth and solar energy, the transformation of matter and the nutrition of people, the construction of dwellings and the use of the oceans'.[29] Only then would human life everywhere have improved to the extent that migration was unnecessary. In this perspective, science becomes an outpost of empire and excursions prepare the ground for settlement.[30] Before the First World War, both Veinberg and Vernadsky regularly went on scientific excursions. Working towards an encyclopaedia of the 'mineral kingdom' of Imperial Russia, Vernadsky took his students on summer excursions to discover and catalogue new minerals.[31] Veinberg was the first to measure the earth's magnetic field in Siberia, as part of the general magnetic survey of the Department of Terrestrial Magnetism at the Carnegie Institute, a global undertaking already envisioned in Humboldt's *Kosmos*.[32]

Vernadsky would later coin (or rather, borrow) a concept for this scientific remaking of nature – the noosphere. When researching the biosphere over the 1920s and 1930s, Vernadsky sought to express the fact that the biosphere's natural history became more and more folded into human history. The noosphere ('sphere of the mind') denotes a state of the biosphere in which it becomes entirely remade and controlled by human reason.[33] In Vernadsky's view, the seat of this progressive reason was not politics but science. In a proto-anthropocenic argument,[34] he described the noosphere as 'a

[25] Boris P. Veinberg, *Iz vospominanii Dmitrii Ivanovich Mendeleev kak lektor* (Tomsk: Tipografiia Gubernskaia Upravleniia, 1910), 11–12.

[26] Veinberg, *Iz vospominanii*, 12.

[27] Michael D. Gordin, *A Well-Ordered Thing: Dmitrii Mendeleev and the Shadow of the Periodic Table* (Princeton: Princeton University Press, 2019), 142.

[28] Dmitri Mendeleev, *K poznaniiu Rossii* (St. Petersburg: A. S. Surovina, 1907), 145.

[29] Mendeleev, *K poznaniiu Rossii*, 34.

[30] Mendeleev was involved in the foundation of Tomsk University in Siberia in 1878, where Veinberg would later become a professor. Rumour has it that Mendeleev preferred Tomsk to Omsk a few hundred kilometers to the west, as he held that the frontier of science was the frontier of the empire.

[31] Bailes, *Science and Russian Culture*, 71–7.

[32] Gregory A. Good, 'Vision of a Global Physics: The Carnegie Institution and the First World Magnetic Survey', in Gregory A. Good, ed., *History of Geophysics*, vol. 5 (Washington, DC: American Geophysical Union, 1994), 31.

[33] Bailes, *Science and Russian Culture*, 162.

[34] Vernadsky developed the concept over the 1920s and 1930s, in dialogue with the French geologist Teilhard de Chardin, who used both 'biosphere' and 'noosphere' with a different meaning. Steffen et al., 'The Anthropocene'; Crutzen, 'The

new geological phenomenon on our planet. In it for the first time Man becomes a large-scale geological force. He can and must rebuild the province of his life by his work and thought, rebuild it radically in comparison with the past'. By doing so, '[w]ider and wider creative possibilities open before him'.[35] Rather than decentring human-beings, one of the earliest planetary thinkers aggrandises scientists, making science into the quintessential human activity and the peak of nature's self-consciousness.

The First World War was crucial for the institutionalisation of applied research and the foundation of research institutes in Russia.[36] During the war, Vernadsky and other academicians lobbied for the foundation of a commission in the Russian Academy of Sciences (*Akademiia Nauk*, AN) that would take stock of, map and study the natural resources slumbering under the empire's territory. Conceiving of scientific work as a 'force' in its own right, Vernadsky held that 'living forces' – scientists backed by generous state funding – should explore and develop Russia's economic potential.[37] Earlier, Vernadsky had called for a distribution of scientific institutions over Russia.[38] These local scientific centres, he argued, were much more effective than any central organisation of science. As their scientific work would be linked to the social and cultural life on site, they could 'invoke and use spiritual forces that are otherwise inaccessible to excitement. In this way, the maximum intensification of scientific work is achieved'.[39] The Commission for the Study of Natural Productive Forces can be seen as a quintessentially noospheric institution, expanding scientific reason over the entire territory, penetrating the biosphere with ever deeper scrutiny and remaking materials into forces capable of sustaining human life.

Even though 'natural productive forces' has a vaguely Marxist ring to it, the phrasing was inspired by the Russian reading of German national economics (*Nationalökonomie*). Friedrich List, who stressed intellectual work as a productive force, had influenced Russian economic thought over the nineteenth century.[40] Sergei Witte, with whom Mendeleev had worked on the infrastructural and economic reforms of the late czarist state, was an admirer of List and thought that Russia could learn from

"Anthropocene"', 13–18; Julia Nordblad, 'The Future of the Noosphere', *Forum Interdisziplinäre Begriffsgeschichte*, 3, 2 (2014), 33–42; Jacques Grinevald, 'Introduction', in Vladimir I. Vernadsky, ed., *The Biosphere* (New York: Springer, 1998), 24–5.

35 Vladimir I. Vernadsky, 'The Biosphere and the Noosphere', *American Scientist* 33, 1 (1945), 9.

36 Kojevnikov, 'The Great War'.

37 Vladimir I. Vernadsky, 'Ob izuchenii estestvennykh proizvoditelnykh sil Rossii', *Izvestiia Imperatorskoi Akademii Nauk*, 9, 8 (1915), 680.

38 Anatolii Vasilevich Kolzov, 'Deiatelnost Komissii po izucheniiu estestvennykh proizvoditelnykh sil Rossii: 1914–1918 gody', in *Sovremennoe Proizvoditelnie Sily*, 1 (2015), 13.

39 Cited in Anatolii Vasilevich Kolzov, *Rol' Akademii Nauk v Organizacii Regionalnykh Nauchnykh Centrov* (Leningrad: Nauka, 1988), 13.

40 Vincent Barnett and Joachim Zweynert, *Economics in Russia: Studies in Intellectual History* (London: Routledge, 2016); V. Avtonomov and E. Burina, 'Friedrich List in Russia', *Obshchestvennye Nauki i Sovremennost*, 2 (2019), 145–59. Drawing on Friedrich Schelling's romanticism, Friedrich List emphasised the role of 'productive forces' (*produktive Kräfte*) for an economy to prosper. Against British political economists, he argued that wealth was not so much the result of land, work and the accumulation of capital in trade, but the result of what made these factors productive. The productiveness of land or coal changed very little by itself, nor did it change by a generic activity of work. Only human creativity and ingeniousness could bring about steam engines, railroads, and electrical systems. Material resources do not by themselves constitute national wealth, they must be appropriated and made into 'forces'; see Friedrich List, *Das nationale System der politischen Oekonomie* (Stuttgart: J.G. Cotta, 1841). Marie-Luise Heuser, 'Romantik Und Gesellschaft. Die Ökonomische Theorie Der Produktiven Kräfte', in Myriam Gerhard, ed., *Oldenburger Jahrbuch für Philosophie* (Oldenburg: Bis Verlag, 2007), 268. Vernadsky's understanding that scientific thought was a geological force and a 'planetary phenomenon' – indeed, a 'natural productive force' itself – resonates with Schelling's concept of productivity; see Marie-Luise Heuser-Kessler, *Die Produktivität der Natur: Schellings Naturphilosophie und das neue Paradigma der Selbstorganisation in den Naturwissenschaften* (Berlin: Duncker & Humblot, 1986); Heuser, 'Romantik Und Gesellschaft', 269. It has been noted in the literature on Vernadsky, and stated by himself, that his views were closer to the natural-philosophic ideas of the eighteenth than to the mechanist or energetic ideas of the nineteenth century; see Alexei M. Ghilarov, 'Vernadsky's Biosphere Concept: A Historical Perspective', *The Quarterly Review of Biology* 70, 2 (1995), 199–200.

Germany's 'belated' industrialisation.[41] Mendeleev believed a state- and science-led industrial expansion eastwards and the settlement of industry according to scientific principles would ultimately draw together the European and Asian spaces Imperial Russia spanned. This Eurasian idea was echoed in the mission of KEPS. Looking at the empire's vast territory, Vernadsky was optimistic that 'within the limits of a solid piece of the Earth's crust', such as Russia occupied, and 'which makes up about 1/6 of the entire land area of the globe', all elements of the periodic table were present in concentrations necessary for industrial development.[42]

Vernadsky placed this war-time effort into the broader historical context of global expansion. 'As human culture expands over an ever-larger part of the terrestrial globe', he wrote, 'it is faced with the question of organizing those useful forces, which are concentrated in its surrounding nature'.[43] It was no longer enough to exploit resources. Echoing Mendeleev, Vernadsky stressed that organisation now meant the *scientific creation* of resources. Instead of looking for more of the materials one has already used, it was necessary to combine explorations with studies on new materials to tap entirely unused potential resources. The artificial production of naturally rare minerals (as in the Haber Bosch process or in his lab-made crystals) was to him evidence of the coming noosphere. The commission's mission would extend over both dead and living matter and involve a wide range of scientific institutes. By 1917, it had grown to a 139 members. Headed by Vernadsky, it completed over a dozen excursions, focusing mainly on the exploration of minerals, fuels and salts of various kinds. However, a lack of funding and the distrust of czarist officials minimised its immediate impact on the war.[44]

While 'productive forces' are not 'natural' for Marxists, the concept translated easily enough between a former liberal-nationalist elite and the Bolsheviks.[45] For a liberal scientist like Vladimir Vernadsky, the Bolsheviks differed from previous governments in their willingness to support scientific research.[46] Lenin's short note on science policy from 1918 highlighted the need to study the most rational use of Russia's productive forces and read like a description of KEPS' mission. Even though the general assembly of the Academy of Science had greeted the October revolution with hostility and published a memorandum condemning the seizure of power,[47] the Bolshevik state took a keen interest in the commission early on. Indeed, the Academy was the first scientific institution drawn into the Bolshevik project of state-building and economic reconstruction. Thanks to good relations between the head of the Academy of Science, Sergei Oldenburg, and parts of the Bolshevik state administration, KEPS expanded its work and set up a broad range of research institutes over the 1920s. Between 1918–20, more than forty new institutes under the auspices of the AN (or *Narkompros*) were founded, more than half of the seventy that existed by 1922.[48] Over the 1920s, KEPS' number of sub-commissions and associated institutes continued to rise, among them the Institute for Physical-Chemical Analysis, the Institute for the Study of Metals, the Radium Institute and the Commission for Living Matter (both headed by Vernadsky). The short-lived Institute for the Study of Siberia in Tomsk particularly embodied Vernadsky's principle of localising science to permeate Russia's vast expanse. Boris Veinberg, the author whose science fiction this paper began with, became its director.[49]

41 It is difficult to say how familiar Vernadsky – or any of the academicians – was with the origin of the concept. As part of the liberal opposition, Vernadsky was certainly familiar with Witte's writings on List, and perhaps even with List's own texts, as his father was a well-known professor of economics who had criticised List's protectionism.

42 Cited in Gloveli, 'D.I. Mendeleev i evraziistvo', 255.

43 Vernadsky, 'Ob izuchenii', 685.

44 Bailes, *Science and Russian Culture*, 139–40.

45 Russian economists at the turn of the century saw no contradiction between List's and Marx's concept of productive forces, particularly when it came to the concrete technologies employed in industrialisation (in the thought of P. Struve for instance; Gloveli, 'D.I. Mendeleev i evraziistvo', 259.). That Marx had been a sharp critic of List's understanding of industrialisation became known only in the 1970s.

46 Bailes, *Science and Russian Culture*.

47 Ibid., 148.

48 Ibid.

49 Eduard Izrailevich Kolchinskii, 'RAN i institutionalizaciia nauki v 1918 g.', *Problemy deiatelnosti uchenogo i nauchnykh kollektivov*, 35, 5 (2019), 16–52.

The 'natural' in 'natural productive forces' was only dropped in the 1930s, when KEPS was reorganised as the Council for the Study of Productive Forces (SOPS) and, along with other scientific institutions, brought under tighter control of the party.

Despite their common goal in mobilising Russia's natural resources, the alliance between bourgeois scientists and Bolsheviks remained precarious over the 1920s. Fewer and fewer Bolsheviks shared the understanding that engineers and scientists arrived at communism through their own research. The party's claim to scientific authority led to fierce clashes in the late 1920s, when Stalin began to wage a series of public trials against scientists and engineers.[50] When the party coerced the Academy of Science to restructure and admit a certain number of Bolshevik scientists between 1929–31, the conflict arrived at the self-acclaimed centre of Russian science.[51] It did not escape the Bolsheviks that planetary thinking stood in an ambivalent relation to their state power – it enhanced their ability to manipulate nature *and* dwarfed politics by focusing on the questions of life, evolution and the human mind. Vernadsky's writings on the noosphere (published only after Stalin's death) could be read against the proletarian revolution spearheading human progress.[52] While natural scientists could not publish anything they liked, particularly if it touched upon broader societal issues, they could rely on a relatively stable funding for their research – even more so if it aligned with the Bolshevik project of economic emancipation.[53]

The Energetics of Planetary Life

One of the fields where the 'material' reality of scientists and the Bolshevik's project to remake Soviet nature continued to overlap was the redirection of energy to sustain human life. When liberal scientists like Vernadsky and Veinberg studied solar-terrestrial relationships, Russian cosmists and artists of Proletkult cherished inter-planetary travel, solar power, and the appropriation of the universe. In a general sense, energy was seen as a 'cosmic' mechanism linking the earth to the universe and human life to the cosmos. Humanity inhabited a planet that followed a thermodynamic history of declining energy availability. Life resists this creeping entropy. Organisms draw energy from their surroundings, give off chemically and energetically changed matter, and thus maintain a thermodynamic disequilibrium against their surroundings for a certain time. By doing so, they actively, yet unconsciously, change the planet's crust and atmosphere. This planetary condition of human life did not so much limit than specify human activities and potentials: by understanding the principles of the biosphere, humans could increase their energy use and remake their planetary environment. For both scientists and cosmists, humanity's planetary reach hinged on its control and appropriation of the earth's energy budget. This had a direct geopolitical meaning as land limited access to the sun's energy and the harnessing of solar radiation enabled the sustenance of life in formerly barren regions.

The roots of Russian cosmism, a quasi-religious strand of thought expressing a planetary prometheanism, reach back into the nineteenth century. The writings of Nikolai Federov, a shy and secluded librarian from St. Petersburg, were particularly influential. Federov held that humanity had the moral obligation to overcome all natural boundaries – including the most consequential one, death. He called for the extension of the Marxist project of paradise on earth to all previous generations, who had suffered to bring it about but could not share in its enjoyment. The 'common task' of all human-beings was to resurrect the dead by physically putting them back together, 'archiving' them in places like museums, or making them inhabit foreign planets.[54] Though Federov's works

50 Kendall E. Bailes, *Technology and Society under Lenin and Stalin: Origins of the Soviet Technical Intelligentsia, 1917–1941* (Princeton, NJ: Princeton University Press, 1978), 69–143.

51 Loren R. Graham, *The Soviet Academy of Sciences and the Communist Party, 1927–1932* (Princeton, NJ: Princeton University Press, 1967).

52 Bolshevik philosophers like Abram Deborin attacked his understanding of life as idealist.

53 David Joravsky, *Soviet Marxism and Natural Science, 1917–1932* (London: Routledge, 2009); Nikolai Krementsov, *Stalinist Science* (Princeton: Princeton University Press, 1996), 22.

54 Boris Groys, 'Introduction: Russian Cosmism and the Technology of Immortality', in Boris Groys, ed., *Russian Cosmism* (Cambridge, MA: MIT Press, 2018), 4–8.

were only published after his death in 1903, he was well-known among the capital's intelligentsia during his lifetime and corresponded with Lev Tolstoi and Fyodor Dostoevsky. Konstantin Tsiolkovskii, a contemporary of Vernadsky and Veinberg and an acquaintance of Federov, formulated his rocket research in the context of Federov's cosmic biopolitics. Working towards 'the transformation of the planets into inhabitable places for the resurrected ancestors',[55] he lay the groundwork for the later Soviet space program.[56]

No earthly energy source could power such a project of intergalactic colonisation. Drawing on Vasilii Karazin's idea of harnessing atmospheric electricity for human purposes formulated in the early nineteenth century, Federov envisioned a united, solar-powered humanity to become the helmsman of the Earth Ship.[57]

> Imagine now that the energy sent to the Earth by the Sun, which presently scatters off into space, could instead be conducted onto the Earth, thanks to a massive configuration of lightning rod–aerostats, implements that will drive solar light to our planet. Imagine that this solar energy, once directed earthward, might alter the density of its new home, weaken the bonds of its gravity, giving rise in turn to the possibility of manipulating its celestial course through the heavens, rendering the planet Earth, in effect, a great electric boat. No sooner will this creation have gazed up to the heavens than it will begin sailing the celestial seas, with the sum total of the human race rendered as captain, crew, and maintenance staff of this Earth Ship.[58]

Influenced by Federov, a group of anarchist-poets formulated a programme of 'biocosmism' in the early 1920s, proclaiming that 'freedom from "natural necessity" and humanity's right to eternal existence in the cosmos manifests the supreme freedom and supreme right of the individual'.[59] To achieve this freedom, 'cosmic technologies' were needed; humanity could no longer stick to the 'outdated technology of coal' that tied it to the past. Next to solar power and weather modification, the biocosmists' leading theoretician, Aleksandr Agienko, bet on wind power to instil a common cosmic experience in the earth's population: 'the idea that the light and warmth in which we always already live is the result of the wind humming outside the window, that is, of this almost cosmic force . . . should involuntarily expand our consciousness into a social, biocosmic consciousness, awaken the thought and will to victory over the cosmos and death'.[60] In the context of this widespread cosmic thought, mixing space colonisation, the harnessing of solar radiation and the remaking of the planet's surface, Veinberg's phantasy seems not so bizarre after all.

The cosmists looked at human life through the category of the cosmos, which could mean the totality of all things past and present or the scientifically observable universe, and placed a strong emphasis on technology. Both of these perspectives were shared by Vernadsky and Veinberg. Boris Groys describes cosmic thought as the idea of a 'total biopower', the management of the human species writ large. This biopower is total in the sense that it is no longer limited to the population existing at a certain time and space, but encompasses all humans of all times past, present, and future – it guarantees 'eternal life on Earth', or any inhabitable planet, 'for everyone'.[61] However, as Michael Hagemeister points out, the cosmists differ from the scientific utopians like Teilhard de Chardin and Vernadsky in their insistence on a

[55] Ibid., 12.

[56] Virgiliu Pop, 'Viewpoint: Space and Religion in Russia: Cosmonaut Worship to Orthodox Revival', *Astropolitics*, 7, 2 (2009), 150–63.

[57] Vasilii N. Karazin, 'O vozmozhnosti prilozhit' elektricheskuiu silu verkhnikh sloev atmosfery k potrebnostiam cheloveka (1818)', in Dmitri Ivanovich Bagalei, ed., *Sochineniia, pisma i bumagi* (Kharkov: Izdanie Kharkovskogo Universiteta, 1910), 430–36; Michael Hagemeister, *Nikolaj Fedorov: Studien zu Leben, Werk und Wirkung* (München: Sagner, 1989), 118.

[58] Nikolai Fedorov, 'Astronomy and Architecture', in Groys, ed., *Russian Cosmism*, 56.

[59] Aleksandr Sviatogor, 'The Doctrine of the Fathers and Anarchism-Biocosmism', in Groys, ed., *Russian Cosmism*, 74–5.

[60] Aleksandr Agienko, 'K voprosu o kosmicheskoi tekhnike (anemofikaciia)', *Biokosmist*, 2 (1922), 6–7.

[61] Groys, 'Introduction', 7.

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human measure of progress *contra* nature: progress is not the insight into a development that lies in nature and is objectively necessary, but the *suspension of all necessity*.[62]

The cosmists' planetary prometheanism was science fiction, but one rooted in scientific research. Solar-terrestrial physics and organic chemistry made an argument about life's planetary reach, and about energy as a cosmic mechanism, that could be turned into a vision of technological prowess. The Swedish physicist and chemist Svante Arrhenius' calculation of the amount of solar energy reaching the earth, converted by plants and transformed into fossil fuels, figured prominently in Vernadsky's and Veinberg's research. Drawing on Arvid Högbom, who had found that carbon dioxide emissions from human activities, such as coal combustion, and natural causes were at the same order of magnitude, Arrhenius had calculated that the carbon dioxide emissions could lead to an increase in atmospheric temperature.[63] This hypothesis of a human impact on the climate was not widely accepted at the time.[64] Yet in Veinberg's scientific fantasy, the hypothesis had been proven correct, the coal age had indeed triggered a climate change that would make people leave the areas around the equator and settle in northern Europe. Neither Arrhenius nor Veinberg were particularly worried by a warming climate. Quite the opposite, in Veinberg's utopia it only serves to usher in a time in which humanity consciously controls the climate. It is therefore consequent that the oceans, which counterbalance the human effect by absorbing carbon dioxide, must be annihilated to allow a fully artificial climate. However, in Veinberg's fantasy, humanity only gets to regulate the climate once it can harness enough solar power to displace oceans. Thus, access to land, solar power and climate regulation condition each other.

Similar to Arrhenius, Vernadsky conceptualised the biosphere as a region where cosmic energy was transformed 'into active energy in electrical, chemical, mechanical, thermal, and other forms'.[65] Thus, it is the joint product of solar radiation and the conversion of the sun's rays into new and varied forms of energy by living matter. The stratosphere absorbs a great amount of solar energy and blocks all wavelengths fatal to living organisms. This energy – which consists not only of rays but also of particles – can be observed as electric and magnetic phenomena, such as aurora borealis, lightning and zodiacal light. The sun's energy reaches the atmosphere and crust as radiant heat, or infrared radiation, which is transformed into mechanical, molecular, or chemical energy. The movement of winds, rivers, and ocean currents, rain, snowfall and the action of glaciers are effects of this radiation. Another essential form of energy in the biosphere, however, stems from living organisms themselves, which convert the visible radiation of the sun into the active chemical energy of the biosphere via photosynthesis.[66] While the transformation of ultraviolet and infrared radiation 'takes place by action on atomic and molecular substances that were created entirely independently of the radiation . . . photosynthesis . . . proceeds by means of complicated, specific mechanisms created by photosynthesis itself'.[67] In other words, life has become a self-sustaining planetary phenomenon.[68]

While the biosphere must be seen in its cosmic context, Vernadsky's own work focused mainly on interactions within the biosphere and living matter's influence on the chemical history of the earth's crust. Here, again, living matter has an energetic function. 'Living matter is a source of energy whose budget affects the natural chemical reactions, that is, the formation of minerals. It collects energy from the sun and turns it into chemical energy. In so doing, it proves to be a conveyor and a storer of cosmic energy'.[69] Thus, organisms are the mediators of the sun's energy and producers of a peculiar type of

62 Hagemeister, *Nikolaj Fedorov*, 72.

63 Svante Arrhenius, 'On the Influence of Carbonic Acis in the Air upon the Temperature of the Ground', *Philosophical Magazine and Journal of Science*, 5 (1896), 237–76; Spencer R. Weart, *Discovery of Global Warming* (Cambridge, MA: Harvard University Press, 2008), 6–7.

64 Ibid., 10, 15.

65 Vernadsky, *The Biosphere*, 47.

66 Ibid., 48–9.

67 Ibid., 50.

68 Ibid., 97–8.

69 Vladimir I. Vernadsky, *Zhivoe Veshchestvo* (Moscow: Nauka, 1978).

energy, which Vernadsky called 'biogeochemical'. The highest concentration of this biogeochemical energy is concentrated in soil – with the black earth he had studied as a student as the most active. But the chemical products of living matter also reach beyond the biosphere. The chemical compounds into which living matter has formed cosmic energy can penetrate deeper regions of the planet that are otherwise not touched by solar radiation.[70] Life did not take place on a planet fixed and prepared. Living matter was responsible for most of the matter present in the biosphere; it had entirely remade the sphere between the earth's crust and the atmosphere.

As only living matter spawns living matter, life has no beginning for Vernadsky. But it has a history over which it expanded its reproduction and converted ever more solar energy into biogeochemical energy available in the biosphere. Geopoliticians like Friedrich Ratzel, who Vernadsky credited for having worked on the biosphere *avant la lettre*,[71] already viewed global expansion through an energetic and planetary lens. Ratzel's infamous lebensraum concept rests on the view that 'territory conditioned societal evolution because it dictated the "sum of the telluric, solar, and cosmic influences" permeating . . . terrestrial space'.[72] Global expansion was justified in the general struggle for social evolution on a planet whose limited surface conditioned the access to cosmic energy. In a formulation that today sounds Vernadskian, Ratzel stressed that the earth's crust was covered 'with organisms that live and absorb sunlight and use this force to create a continuous sum of chemical differences'.[73] Vernadsky saw his scientific research into biogeochemical energy in this broader geopolitical context.

Within larger natural history, the energy choices of a nation or humanity at large appeared in a different light. From a planetary perspective, fossil fuels could never be more than an interlude. Arrhenius could calculate the outer boundaries of fossil resources by estimating how much organic matter could have possibly turned into coal by the early twentieth century. At the current consumption level, humanity would run out of fossil fuels in less than two centuries.[74] While these numbers were not exactly worrying for people who had to make their living on human timescales, they still conveyed the insight that the conditions for human existence were unsustainable. 'It is evident that very shortly mankind must modify its housekeeping methods and discontinue its present prodigal use of coal.'[75] It was time to think of more long-term solutions to humanity's energy problem.

Harvesting Solar Radiation: Wind Power and Heliotechnics

Energy historians typically see the first half of the twentieth century as a double transition to more versatile forms of energy, electricity and petroleum.[76] This view lumps together types of energy contemporaries perceived as very different – not only because one was a primary, the other a secondary form of energy, but also because not everyone was convinced that petroleum was the future. The perspective from which oil and electricity merge easily into the same kind of modernity reflects an Anglo-Saxon history of the Anthropocene. From another point of view, common among Soviet physicists and power engineers, a centrally-planned electric system would mediate the use of local power sources – wood, peat, coal, and water – and then lead over into a future of nuclear or solar power. Until

[70] Vernadsky, *The Biosphere*, 137.
[71] Igor V. Krout, 'Vladimir Ivanovich Vernadsky, 1863–1945', in T. W. Freeman, ed., *Geographers: Biobibliographical Studies* (London: Bloomsbury, 2016), 135–44.
[72] Thomas Turnbull, 'From Incommensurability to Ubiquity: An Energy History of Geographic Thought', *Journal of Historical Geography*, 73 (2021), 13.
[73] Friedrich Ratzel, *Anthropogeographie: Teil 1, Grundzüge der Anwendung der Erdkunde auf die Geschichte* (Leipzig: Wissenschaftliche Buchgesellschaft, 1975), 2–3. English translation from Turnbull, 'From Incommensurability to Ubiquity'.
[74] Svante Arrhenius, *Chemistry in Modern Life* (New York: D. Van Nostrand Company, 1925), 162–3.
[75] Ibid., 164.
[76] Astrid Kander, Paolo Malanima, and Paul Warde, *Power to the People: Energy in Europe over the Last Five Centuries* (Princeton, NJ: Princeton University Press, 2014).

the Second World War, oil was not widely accepted as a successor to coal in the Soviet Union. Some saw the future in a more direct use of the sun's energy.[77]

This may come as a surprise as the Baku oil industry had by the turn of the century developed into the largest in the world.[78] Experiencing the imperial scramble for oil firsthand, the Bolsheviks found themselves cut off from their oil supplies from Baku in 1918. Still, after recapturing the wells and restoring production, their interest in oil as a domestic fuel remained limited: it was predominantly exported to gain foreign currency and did not figure prominently in the cherished visions of a socialist energy economy based on electricity.[79] The industry reached pre-war production levels only in 1929 and then continued to grow gradually, with export shares between 20–50 per cent of total production. Between 1929 and 1950, the share of liquid fuels in total energy consumption declined in the Soviet Union.[80] Thus, despite inheriting a well-established oil industry, the Soviet Union's energy balance developed contrary to the industrial world in the interwar years. Local fuels like wood and peat, coal, waterpower and electricity became the mainstay of the early Soviet energy system.[81]

From the vantage point of an oil-based economy, this has often been described as a failure. This judgement neglects the contemporary rationale behind it. The finitude of fossil fuels was present in the minds of late nineteenth and early twentieth century energy engineers everywhere, as fears of scarcity and repeated calls for conservation indicate.[82] For planetary thinkers, oil was 'a dwarfish and short-lived appendage to coal'.[83] But even more down-to-earth engineers, such as Leonid Ramzin, director of the Institute for Thermal Engineering (*teplotekhnika*) and an authority in energy statistics, thought petroleum resources far too limited to be considered 'the basis of the world energy economy'.[84] This self-reassuring perspective was not uncommon among engineers and economists working in the steam economy, particularly as oil resources everywhere seemed to dwindle.[85] Others, including Mendeleev, saw in oil a rare material with a huge chemical potential that was far too precious to simply burn up.[86] A more socialist critique of oil held among Soviet power engineers invoked its implication with imperialism and wasteful individualised transport.[87] Bolshevik engineers particularly cherished electricity's capacity to centralise and co-ordinate energy production and the transition to new forms of energy sources.[88]

The experimentation with harvesting solar radiation took place in this context of a centrally planned, place-based energy system. Just as cosmism inspired real scientific experiments in rocket

[77] Jeronim Perović, 'The Soviet Union's Rise as an International Energy Power: A Short History', in Jeronim Perović, ed., *Cold War Energy: A Transnational History of Soviet Oil and Gas* (Cham: Palgrave MacMillan, 2017), 1–43.

[78] Felix Rehschuh, *Aufstieg zur Energiemacht. Der sowjetische Weg ins Erdölzeitalter, 1930er bis 1950er Jahr* (Köln: Böhlau, 2019), 12, 33. Robert W. Tolf, *The Russian Rockefellers: The Saga of the Nobel Family and the Russian Oil Industry* (Stanford, CA: Hoover Press, 1976), 182.

[79] Rehschuh, *Aufstieg zur Energiemacht*, 15.

[80] United Nations, 'World Energy Supplies in Selected Years, 1929–1950', Statistical Paper Series (New York: United Nations, 1952), 41–2; Marshall I. Goldman, *Petrostate: Putin, Power, and the New Russia* (Oxford: Oxford University Press, 2008), 4–6.

[81] Felix Frey, *Arktischer Heizraum: Das Energiesystem Kola zwischen regionaler Autarkie und gesamtstaatlicher Verflechtung 1928–1974* (Wien: Böhlau, 2019), 104.

[82] Ian R. Tyrrell, *Crisis of the Wasteful Nation: Empire and Conservation in Theodore Roosevelt's America* (Chicago: University of Chicago Press, 2015); Nuno Luis Madureira, 'The Anxiety of Abundance: William Stanley Jevons and Coal Scarcity in the Nineteenth Century', *Environment and History*, 18, 3 (2012), 395–421.

[83] Boris P. Veinberg, 'Predposylki k izpolzovaniiu solnechnoi energii v SSSR', *Planovoe Khoziaistvo*, 6 (1927), 3.

[84] Leonid K. Ramzin, *Energeticheskie Resurcy SSSR* (Moskau: Teplotekhnicheskii Institut, 1925).

[85] With Pennsylvanian oil running out, and before other major oil deposits had been discovered, diagnoses of peak oil were not uncommon in the 1920s.

[86] Dmitri Mendeleev, 'Po neftianym delam', in Viacheslav Evgenevich Tishchenko, ed., *Sochineniia*, Vol. 10 (Moskva: Izvodstvo Akademiia Nauk, 1949), 387–606.

[87] See for instance the electrification plan: Gosudarstvennoi Komissii po elektrifikacii Rossii, *Plan Elektrifikacii RSFSR, Vvedenie k Dokladu 8-mu s'ezdu sovetov* (Moscow: Nauchno-Tekhnicheskii Otdel Vysshego Sovet Narodnogo Khozyaystvo, 1920), 50.

[88] Gleb M. Krzhizhanovskii, 'Energetika i Socialisticheskaia Rekonstrukciia', *Planovoe Khoziaistvo*, 1 (1929), 7–53.

science, it also led to a brief summer of experimentation in solar and wind power. Of course no one imagined switching to renewables in a matter of decades, but the future was close enough to start researching it now. Nikolai Semenov, head of the Institute for Chemical Physics and later Nobel laureate, advised that new energy sources, such as solar power, 'should constitute a special place on our research agenda, even if these works do not promise immediate results. Socialism is not just built for 100 years. Therefore, it is necessary to create research cells in the field of energy science that are designed for a long and systematic siege of the question'.[89]

This view was common among Soviet physicists: Abram Ioffe, head of the Leningrad Physical-Technical Institute and an influential Soviet school of physics, was committed to a development of solar power as well.[90] Over the 1920s and 1930s, scientists in the Academy of Science conducted research on wind power, photoelectricity and solar-thermal technology. At the centre of these efforts stood several institutes that emerged from KEPS or co-operated with it.

The sun's abundance stood in a striking contrast to earthly scarcity. Arrhenius had given the maximum amount of solar energy captured in the atmosphere, transformed into the movement of air, and the amount reaching the surface. Seen from this planetary perspective, wind and solar power resources dwarfed coal and all other fossil fuels. Citing Arrhenius' data, a 1927 article in Gosplan's journal *Planning Economy* estimated that the total wind power that theoretically could be harnessed globally exceeded coal reserves by a factor of 13.5, and by a factor of ten in Russia.[91] Similar calculations regarding solar power were common as well.[92] Neglecting competing land uses, it portrayed the sun as a vast untapped potential source of energy, not unlike the dreams of nuclear cornucopianism two decades later.

The very first report published under the auspices of KEPS in 1919 was dedicated to 'Wind as motive force' (*Veter kak dvigatelnaia sila*). The report assembled information on volume and duration of wind power from the few existing meteorological stations, concluding that scattered measurements were not enough and that the movements of air in the atmosphere over the Russian territory should be more properly studied, so that differences could be explained and foreseen, rather than registered.[93] Not only the biocosmist Agienko saw wind as a cosmic technology: in 1921, the agricultural engineer and expert in flour mills, Petr A. Kozmin, urged Lenin to set up a wind power commission. In his view, this would constitute 'a first step to the organization of a chief administration of the sun's energy [*glavsolnca*]'.[94] While the concrete chain of events has not yet been established, two wind power commissions were indeed set up in the following years: one in the Academy of Science (connected to the report mentioned above) and the other in the Central Aero-Hydrodynamic Institute (ZAGI), which had been formed as an institute of applied sciences under VSNKh in 1918 and was to study all kinds of aero- and hydrodynamic phenomena.

The Department on Wind Turbines in ZAGI, headed by Nikolai V. Krasovskii, experimented with windmills of different size, power and turbine shapes. By the mid-1920s, there were several smaller windmills in operation, one employed in Baku's oil industry (working in parallel with an oil motor) and others for irrigation purposes. Wind power, particularly when it was used for direct

89 Nikolai N. Semenov, 'Problema Energii', *Nauchnoe Slovo*, 2–3 (1931), 12.

90 Paul R. Josephson, *Physics and Politics in Revolutionary Russia* (Berkeley, CA: University of California Press, 1991), 30.

91 Nikolai V. Krasovskii, 'Dostizheniia i Perspektivy v Ispolzovanii Energii Vetra v SSSR', *Planovoe Khoziaistvo*, 4 (1927), 186–7.

92 Boris P. Veinberg, 'Solnechnie dvigateli: perspektivy geliotekhniki', *Vestnik Znaniia*, 4 (1928), 206–20; Boris P. Veinberg, *Zheltyi ugol (moshchnost luchistoi energii solnca)* (Leningrad: Akademia Nauk SSSR, 1929).

93 Komissiia po izucheniiu estestvennykh proizvoditelnykh sil (KEPS), *Estestvennye Proizvoditelnye Sily Rossii, Tom 1: Veter, kak dvigatelnaia sila* (Petrograd: Vtoraia Gosudarstvennaia Tipografiia, 1919), 113–14.

94 Vladimir Ilich Lenin and Petr A. Kozmin, 'Zametki o vetrosilovykh ustanovkakh', in V.V. Adoratskii, V.M. Molotov, M.A. Saveliev, and V.G. Sorin, eds., *Leninskii Sbornik*, Vol. 10 (Moscow: Institut Marksa-Engelsa-Lenina, 1932), 217. The proposal caught Lenin's eye. He marked it with a 'hm!??', and passed it on to Gleb Krzhizhanovskii, a Bolshevik engineer and head of the electrification commission, whose energetic expertise he trusted; see Daniela Russ, 'Energetika: Gleb Krzhizhanovskii's Conception of the Nature–Society Metabolism', *Historical Materialism* 29, 2 (2021), 188–218.

mechanical power, was mainly seen as a technology for the spatial and social fringes of the Soviet empire, the coastal or mountainous regions far away from fuel resources, as well as for the backward countryside of the peasantry. Yet Krasovskii's department also explored more ambitious projects, where wind power could be deployed at a larger industrial scale. Realising that wind power based on batteries (at that time made of lead) would never be economically feasible, the department worked on integrated systems of different energy sources, or systems, in which the grid itself could store energy.[95]

ZAGI's work was so promising that a Central Wind Power Institute was founded in 1930 – the first of its kind worldwide. The following years saw many wind power plants (*veterenergeticheskie stancii*, or VES) planned and a few constructed. Already in 1931, a 100-kW power plant was built in the Balaklavskii region in the north-west corner of Crimea. The system integrated thermal and wind power and was one of the most powerful plants worldwide.[96] But engineers were convinced they could achieve even higher outputs. A few years later, KEPS' Commission on Wind Power announced a contest on a wind power station of up to 25,000 kW. In 1934, they adopted the design of the young rocket scientist Yuri Kondratiuk, who had proposed a 12,000-kW plant.[97] Influenced by the cosmist atmosphere of his time, Kondratiuk had then already published his proposal of how to land a spacecraft on the moon ('Conquering Interplanetary Space', 1925), which later informed actual space travel.[98] Then head of VSNKh, the Georgian Bolshevik Sergei Ordzhonikidze supported the wind power project, but after his fallout with Stalin and his sudden death (potentially by suicide) in 1937, however, the project was cancelled.[99]

What made wind power a real option in the 1930s was the decision by Soviet engineers to focus on integrating wind power into local electricity grids, a problem that remained unsolved for solar power. As wind power plants harnessed a *motion* prompted by the latitude-dependent absorption of solar radiation in the lower atmosphere, it could be directly transformed into electricity via a turbine. The use of solar *radiation* (meaning infrared and visible wavelengths) proved more challenging, but also potentially more rewarding. At least this was how solar enthusiasts like Boris Veinberg thought about it: his utopian society ran exclusively on solar power. As a physicist working on exceptionally wide-ranging research fields, Veinberg had a special interest in the impact of solar radiation on the globe's surface and began to think about various ways to use solar energy technically, a field he called 'heliotechnics' [*geliotekhnika*]. He was familiar with Frank Shuman's work in Egypt and Adolf Markuse's work on solar power plants in Berlin.[100] An expert in thermal phenomena, he experimented with apparatuses that used solar power to generate steam, hot water, and mechanical energy.[101] Returning from Tomsk to Leningrad in the mid-1920s, he became head of the Main Geophysical Observatory (MGO). There, he developed a theory of the concentration of the sun's radiation and a method to calculate solar installations.[102] He argued that solar power, as an irregular source of

95 Krasovskii, 'Dostizheniia i perspektivy', 189–93; V. R. Sektorov, 'Sovremennoe sostaianie proektirovaniia i opytnogo stroitelstva krupnykh vetroelektricheskikh ustanovok', *Elektrichestvo*, 2 (1933), 9–13.

96 Brandon Owens, *The Wind Power Story: A Century of Innovation that Reshaped the Global Energy Landscape* (Hoboken, NJ: Wiley IEEE Press, 2019), 47; V. C. Podgurenko, I. V. Stepanec, and V. E. Terekhov, 'Mnogovekovye tradicii Ukrainy v izpolzovanii energii vetra', *Alternativnaia Energetika*, 123, 5 (2014), 43–4.

97 Podgurenko, Stepanec, and Terekhov, 'Mnogovekovye tradicii', 47–8.

98 Nadezhda K. Konstantinovna and Gennadii A. Evgenevich, 'Uchenyi-Kosmist Iu. V. Kondratiuk – ternistyj put k bessmertiiu', *Filosofiia i Kosmologiia*, 1, 7 (2009), 275–87.

99 Podgurenko, Stepanec and Terekhov, 'Mnogovekovye tradicii', 48.

100 Veinberg, 'Solnechnie Dvigateli'; John Perlin, *From Space to Earth: The Story of Solar Electricity* (Cambridge, MA: Harvard University Press, 2002), 6; Frank Kryza, *The Power of Light: The Epic Story of Man's Quest to Harness the Sun* (New York: McGraw-Hill, 2003).

101 Vitalii A. Butuzov, 'Rossiiskaia solnechnaia elektroenergetika', *Okruzhaiushchaia sreda i energovedenie*, 2 (2020), 11; Svetlana I. Kuznetsova, 'Trudunaia sudba professora TTI B. P. Veinberga', *Izvestiia Tomskogo Politekhnicheskogo Universiteta*, 315, 2 (2009); G.B. Ostrovskaia, 'Doroga zhizni professora B. P. Veinberga i ego ledianaia gora. K 140-letiiu B. P. Veinberga i 70-letiiu dorogi zhizni', *Stranitsy Istorii TPU*, 319, 2 (2011), 149–56.

102 Butuzov, 'Rossiiskaia solnechnaia elektroenergetika', 11; Kuznetsova, 'Trudunaia sudba professora TTI B. P. Veinberga', 201.

power, should be applied to irregular, seasonal uses, such as irrigation, and even began to design a solar-powered irrigation system for central Asia.[103]

In Veinberg's scientific fantasy, society no longer relies on infrared radiation and thermal technology. At some point in the novel, scientists achieve a breakthrough and can produce a material called 'pentanitrodiaminedimethylmetaphenylene, a substance that exploded drop by drop in the turbines, turning the energy of the sun into motion'.[104] Such 'photo-chemical' and 'photo-electric' reactions in matter had been researched in Russia since the nineteenth century and captured the public imagination. Andrei Platonov mentions a so-called 'photoelectric resonance transformator' in his novels, an apparatus he was trying to construct in his electro-agrarian laboratory in Voronezh.[105] Both Semenov and his teacher Ioffe were occupied with the physico-chemical questions related to solar power, before contributing to the nuclear power programme. Based on Ioffe's research on photoelectricity, the Leningrad Physical-Technical Institute focused on technical applications for semi-conductors, among them the direct conversion of solar radiation into electricity.[106] In the late 1930s, years before Bell's photovoltaic project, Ioffe even submitted a proposal for constructing 'solar roofs' to the government, but it is unclear what became of this project.[107]

The Institute of Energetics (ENIN), headed by Gleb M. Krzhizhanovskii, became the centre of applied solar research in the 1930s. It co-operated with other parts of the Academy, particularly the Commission for Solar Research. This commission organised the first 'All-Russian Conference on Solar Research and Solar Energy' in 1931, which announced that research on the sun was insufficient to 'satisfy the current economic needs in the field of heliotechnics, weather service, and radio communications'.[108] From the beginning, Krzhizhanovskii declared that his institute was interested in the commission's work 'on calculating the amount of solar energy absorbed by the planet' as this was crucial for ENIN's own agenda.[109] Solar power even became a section in the Institute of Energetics, focusing on the development of photoelements, solar heating and cooling, and thermal solar power (i.e. the generation of steam for heating or mechanical purposes).

How the planetary and the geopolitical came together in the institute's outlook on energy can be seen from a longer article by Nikolai Simonov, who had worked in KEPS' wind power commission. Energy is explicitly linked here to the settlement in hostile regions. Meant to tie the newly established field of energetics to other research going on in the Academy, Simonov sketched out a programme which placed energy, and particularly renewables, at the centre of the institute. 'Among other types of productive forces, energy resources – reserves of solar heat energy, fossil and vegetable fuels, flowing waters and moving air masses – occupy a particularly important place, as they enable the widest and most complete use of the entire complex of various productive forces'.[110] The leading role of energy is evident from how it can 'unlock' productive sources and glean the life-sustaining components from dead matter: Energy is involved in extracting aluminium from simple clay and nitrogen from the air. What is more, it is crucial for expanding the biosphere itself, as 'energy converted into heat can induce organic life in the most severe climatic conditions'.[111]

In practice, renewable energy remained primarily a solution for the fringes of the Soviet Union. In the early 1940s, Federico Molero, a Spanish communist and engineer fleeing the Franco regime after

[103] Veinberg, 'Predposylki'. After Veinberg's death during the siege of Leningrad, his son Vsevolod continued to work on solar devices for salt-making, cooking, or drying fruit.

[104] Veinberg, 'K dvukhdesiatitysacheletiiu nachala', 23.

[105] Andrei P. Platonov, *Dshan oder die erste sozialistische Tragödie: Prosa – Essays – Briefe* (Berlin: Quintus, 2019), 301–2.

[106] Ia. I. Frenkel, *Abram Federovich Ioffe* (Moscow: Izdatel'stvo Nauka, 1968), 14.

[107] Oleg Shevaleevskiy, 'The Future of Solar Photovoltaics: A New Challenge for Chemical Physics', *Pure and Applied Chemistry*, 80, 10 (2008), 2080.

[108] D. I. Ieropkin, 'Itogi pervoi vsesoiuznoi Konferencii Po Izucheniiu Solnca i Solnechnoi Energii', *Vestnik Akademii Nauk SSSR*, 6 (1931), 55–6.

[109] L. Fedorov, 'Komissiia Po Issledovaniiu Solnca (KISO)', *Vestnik Akademiia Nauk*, 1 (1932), 48.

[110] Nikolai V. Simonov, 'Problema energetiki v sviazi s zadachami ekspeditsii Akademii Nauk', *Vestnik Akademii Nauk SSSR*, 11 (1932), 35.

[111] Simonov, 'Problema energetiki', 37.

the Spanish civil war, took over ENIN's solar power section and developed it into a 'solar laboratory',[112] where the generation of superheated steam from a solar boiler was achieved for the first time. As reported in the international electrotechnical press, Molero designed and erected a thermal solar power plant in Tashkent in 1945, which could 'produce steam at all temperatures and pressures required in industry'.[113] A lively, but underfunded, solar power research landscape emerged in central Asia but began to decline in the 1970s, when serious exploration and development of Siberian oil deposits began.[114] In the 1960s, a new imperial frontier opened up – space. The development of photovoltaic cells became affiliated with the Soviet space programme and moved into the Institute for Cosmic Research in 1965.

The intertwined histories of renewable energy and planetary thinking in the Soviet Union remain largely unwritten,[115] even though a significant number of scientists and engineers believed in the 1920s and 1930s that solar radiation – in the form of motion, heat, or light – was the energy of the future. Crimean wind power and Uzbek solar power plants can be seen as the result of a noospheric practice that aimed at making use of local 'natural forces', to expand and thicken the biosphere for human life. The turn to oil in the wake of the Second World War has been well documented,[116] but it is less clear what happened to the institutions researching renewable energy. Did research on solar radiation produce too little applicable results, so that it shared the fate of other fields of fundamental research? Or did nuclear power grip the imagination of planetary thinkers when it became feasible? Lastly, faced with war, the urgency to secure a national energy supply might well have occluded the planetary perspective, one that tied the present to a future looming two centuries ahead.

Ecological Awakening or Continuity of a Planetary Biopolitics?

What is at stake in this introduction of Russian planetary thought into today's discussion of the Anthropocene is the question whether we should place any hope in the category of the planetary to criticise, oppose and overcome the logics of global expansion and exploitation. This article contributes to the accruing evidence that this conception of the planetary as a critical category is unconvincing if we look at its longer conceptual history and the geopolitical practices it has informed.

In the Russian original of 'Scientific Thought as a Planetary Phenomenon', Vernadsky referred to Veinberg's curious utopia on ocean annihilation when discussing the size of the land mass humanity could use for the development of its biogeochemical energy. At that time, Soviet land development policy (*meliorizaciia*) projected to increase cultivated land mass by 40 per cent through measures such as irrigation. Yet, he added, 'if humanity finds it necessary or desirable, it could develop the energy that is required to expand agriculture over the entire land mass, or even further'. While 'scientific utopias more than once expressed the possibility of capturing the oceans . . . already at a time when the physical insignificance of man paled before their power', these questions were no longer outlandish for the empowered human mind, but 'to a certain extent . . . undoubtedly real'.[117] This episode is not only interesting because it links this article's two main characters, but also because it brings out the peculiar character of Anthropocene thought, in which human beings master the handling of superhuman scales. Knowledge of the biosphere does not shatter

[112] Kirpichev, 'Pervoe svesoiuznoe soveshchanie geliotekhniki', *Vestnik Akademii Nauk SSSR*, 1949, 89.

[113] 'Russia Builds Solar Power Plant in Asia', *The Electrical World*, 24 Nov. 1945.

[114] Rafael Méndez, 'El Ingeniero que domó el Sol: Federico Molero, buluarte de la defensa de Madrid, disenó en la URSS en 1945, una central pionera de energía solar', *El País*, 30 Aug. 2013, https://elpais.com/cultura/2013/08/30/actualidad/1377879972_969661.html; 'Kratkie soobshcheniia: problemy sovremmenoi geliotekhniki', *Vestnik Akademii Nauk SSSR*, 7 (1959), 69–70; D. M. Shchegoleev, 'Razvitie geliotekhniki', *Vestnik Akademii Nauk SSSR*, 1 (1961), 122–3.

[115] See for a recent exception Rindzevičiūtė, 'Soviet Policy Sciences and Earth System Governmentality'.

[116] Rehschuh, *Aufstieg zur Energiemacht*; Jeronim Perović, ed., *Cold War Energy: A Transnational History of Soviet Oil and Gas* (Cham: Palgrave Macmillan, 2017).

[117] Vladimir I. Vernadsky, *Nauchnaia mysl kak planetnoe iavlenie* (Moscow: Nauka, 1991), 138.

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human plans. Rather, an insight into how the biosphere can maximise its harvest of solar power enables the expansion of land settlement. It is perhaps not surprising that scientists of a continental empire would imagine the annihilation of the oceans, the very medium on which the geopolitical power of the empires of the sea rests. In that sense, planetary thought reconfigures the geopolitical spaces of sea, land, and air.[118]

Over the last decades, Vernadsky has been rightly credited in Western ecological thought for spelling out life's planetary interconnectedness. However, unlike today's ecologists, Vernadsky never pits the 'good of the planet' against human concerns and wishes. Vernadsky's assertion that 'human beings realize only now that they are inhabitants of the planet and that they can – must – think and act not only with regard to the individual, the family, the state, or union, but also regarding the planet', places the planetary squarely among other human matters. If anything, their research made Veinberg and Vernadsky optimistic about humanity's ability to consciously appropriate the biosphere and regulate the climate. To them, the Anthropocene was a promise, not a shock.

If Vernadsky likens the planet to other social institutions like the family or the state, he neglects that the planetary hinges on a certain social group – scientists – to become a common matter. The singling out of science is evident in all planetary thought: Chakrabarty's account of the planetary foregrounds Lovelock's epiphany of Gaia – a sublime vision of planetary life – emerging amidst the 'most respectable scientific environment' of the National Aeronautics and Space Association (NASA) in 1979,[119] a scientific institution deeply entangled in Cold War politics and military research. In the above cited episode by Vernadsky, the bygone power of the oceans only serves to reinforce humanity's newfound scientific prowess. It is not accidental that he emphasised the role of the human mind in progress and Veinberg staffed his fictitious 'Committee for the Improvement of the Terrestrial Globe' with unelected scientists and engineers ruling by acclamation. From early cosmical physics to today's Earth System Science, the planetary perspective does not 'decentre' all human beings equally but authorises the scientists who command the knowledge on the biosphere.

It is questionable whether the insights of cosmical physics and Earth Systems Science ever shocked, humiliated and enlightened them – and the humanist thinkers drawing on this knowledge – into a new kind of imagination of human life on the planet, which can then act from within, and more importantly, 'against our immediate human concerns and aspirations'.[120] Leaving aside the question whether global expansion can be called a 'human' aspiration, planetary thought has never stopped but often furthered exploitation. The way in which the concept of life in planetary thought mediates between the social and the natural is crucial here: If humanity stands in a natural history and the noosphere is a necessary moment of the planet's evolution, the radical remaking of the biosphere by human society becomes naturalised. Similarly, Leah Aronowsky shows how Lovelock's Gaia hypothesis of a self-regulating, living planet has been used by the oil industry to soothe concern about possible climate disruption.[121] Even more common is the technological exploitation of planetary insights. The US National Science Foundation's 'Research Applied to National Needs' programme (which is somewhat reminiscent of the Soviet KEPS), of which NASA was a central research partner, wanted to put the cosmic mechanism to work for national purposes by researching solar and wind power in the 1970s, just as the Soviets had done decades earlier.[122] One of the first uses of photovoltaic cells was in satellites, an apparatus with an obvious military and intelligence purpose; today's tech companies are the largest investors in renewables. Chakrabarty mentions solar power as an attempt 'to bring into the fold of the global an aspect of what we have called the planetary'[123] and calls for a kind of planetary biopolitics, which begins 'from the same old premise of securing human life but now ground[s] itself

118 Carl Schmitt, *Land and Sea: A World-Historical Meditation* (Candor, NY: Telos Press, 2015).
119 Chakrabarty, *The Climate of History*, 80–1; Lovelock, 'Prehistory of Gaia', xiv.
120 Chakrabarty, *The Climate of History*, 90.
121 Leah Aronowsky, 'Gas Guzzling Gaia, or: A Prehistory of Climate Change Denialism', *Critical Inquiry*, 47, 2 (2021), 306–27.
122 Thomas Turnbull and Cyrus Mody, 'Turn and Turn Again: How Big Science Both Helped and Hindered Alternative Energy in the 1970s', 2021, unpublished manuscript.
123 Chakrabarty, *The Climate of History*, 85.

. . . in a new understanding of the changing place of humans in the web of life and in the connected but different histories of the globe and the planet'.[124] This is not the beginning but a mere moment in a planetary biopolitics that has been underway for a century, ever since knowledge on cosmic mechanisms was turned into technological politics.

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124 Ibid., 91.

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