

# Spring 2022 Industry Study

## Industry Report *Environment and Climate Industry Study*



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## ENVIRONMENT & CLIMATE INDUSTRY STUDY 2022

**ABSTRACT:** The overarching purpose of the Environment & Climate Industry Study is to assess U.S. and international competitiveness in the environmental and climate sector(s) of industry within the context of national security, broadly defined. The environmental industry includes firms providing a wide array of goods and services, all with an environmental aim — from waste management and environmental protection to water utilities and regulatory compliance. The related climate change industry includes those activities aimed at minimizing the negative impacts of human activity on the climate, like renewable energy, green buildings, and adaptation and mitigation efforts designed to help society cope with climate-related events without sacrificing quality of life. Firms operating in this “industry of industries” face numerous challenges, not the least of which is ideological. Widely identified as a national security threat, climate change is altering the way many on the planet live and contributing to geopolitical flashpoints that affect human, national, and global security. The U.S. government must recognize (a) the dependency of its economic strength on global environmental security, and (b) its leadership role in shaping environmental, climate, and economic policies, both domestically and internationally. By leveraging the strength of U.S. environmental firms that are already shaping market and consumer behavior, government can accelerate mitigation and adaptation efforts, embrace innovation that increases efficiency, sustainability, and resilience, and produce stronger domestic and global economies, with attendant benefits to human, environmental, national, and global security.

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## Industry Study Outreach and Field Studies

### **Visiting Speakers:**

ARCTECH, Inc.  
Center for International Environmental Law  
Columbia University  
Environmental Business International, Inc.  
Export-Import Bank of the United States  
Federal Permitting Improvement Steering Council  
George Washington University  
Global Environment Facility  
Global Environmental Management Initiative  
Greenberg Traurig, LLP  
Greenpeace USA  
Hogan Lovells US, LLP  
International Food Policy Research Institute  
International Union for Conservation of Nature  
Marstel-Day, LLC  
National Aeronautics and Space Administration  
Natural Resources Defense Council  
Pure Strategies, Inc.  
Reed Smith, LLP  
Rocky Mountain Institute  
United Nations Environment Programme  
United Nations Foundation  
U.S. Council for International Business  
U.S. Department of Commerce, NOAA, National Weather Service  
U.S. Department of Defense, Deputy Assistant Secretary for Environment & Energy Resilience  
U.S. Environmental Protection Agency, International & Tribal Affairs + Environmental Justice  
U.S. Green Building Council  
U.S. Department of State  
Veolia North America  
Washington Post  
Waste Management, Inc.  
White House Council on Environmental Quality, Office of Federal Sustainability Officer  
World Bank  
WSP Global, Inc.

### **Field Studies:**

Camden Yards Sports Complex  
Clearway Black Rock/Pinnacle Wind Farms  
D.C. Water Blue Plains Advanced Wastewater Treatment Facility  
Dominion Energy Coastal Virginia Offshore Virginia Wind Project  
Embassy of the Netherlands in Washington, D.C.  
Ocoquan Bay National Wildlife Refuge  
Port of Baltimore  
Smithfield Foods  
Spotsylvania Solar Energy Center

In its June 2008 National Intelligence Assessment on *The National Security Implications of Global Climate Change to 2030*, the National Intelligence Council stated:

We judge global climate change will have wide-ranging implications for U.S. national security interests over the next 20 years . . . . The United States depends on a smooth-functioning international system ensuring the flow of trade and market access to critical raw materials such as oil and gas, and security for its allies and partners. Climate change and climate change policies could affect all of these — domestic stability in a number of key states, the opening of new sea lanes and access to raw materials, and the global economy more broadly — with significant geopolitical consequences.<sup>1</sup>

Fourteen years and four presidential administrations later, the United States is still struggling to elicit a national consensus regarding climate change and to clearly establish itself as a leader in the Environment and Climate industries.

This report examines two integrally related, thriving and growing “industries” — Environment and Climate Change. The report seeks to reflect the truly unique nature of these industries and the challenges associated with their given status as industries, while communicating the vital role they play in supporting not only U.S. national security, but also domestic and global human security.

For the United States to meet its national security objectives, it must first shape the conditions for greater human security. The U.S., its allies, and its partners, must provide protection both *from* and *of* the environment by anticipating, mitigating, and adapting to environmental degradation in general and climate change in particular. The purpose of the Environment and Climate Industry Study, accordingly, has been to assess U.S. and international competitiveness in these critically related spaces of security.

To guide its efforts, the Environment/Climate seminar applied an analytical approach that surveyed the business, security, and regulatory aspects of the Environment and Climate Change industries through a broad series of discussions with environmental experts and site visits to examine environmental principles and practices in the field.<sup>2</sup> Some 40 lecturers shared perspectives from their respective fields, including legal, defense, environmental justice, activism, economics, and business (see Appendix A).

## **A Unique Industry with Ideological and Political Underpinnings**

The North American Industry Classification System (NAICS) doesn't provide a unified category that encompasses the totality of the Environment or Climate Change industries; there is no overarching industry trade association (as with, say, the Aircraft industry); and there is no central government repository for industry data (as with, say, the Energy industry). The two most-authoritative sources of data regarding these industries are Environmental Business International (EBI) and Engineering News-Record (ENR), both private-sector entities.

**Definition of Industry:** The Environment Industry is defined here using the most authoritative and widely accepted industry definition from Environment Business International (EBI): "All revenue generation associated with environmental protection, assessment, compliance with environmental regulations, pollution control, waste management, remediation of contaminated property, and the provision and delivery of environmental resources (see Appendices B and C)."<sup>3</sup>

Additionally, there are substantial partisan differences in the U.S. regarding global climate change, which is not the case in all countries, many of which recognize climate change as a major factor impacting their future, require government intervention to mitigate its effects, and support adaptive measures. In the U.S., 65 percent of Democrats say climate change should be a top priority, compared to just 11 percent of Republicans.<sup>4</sup> Sixty-nine percent of Americans say the U.S. should prioritize the development of renewable energy sources (wind and solar), while taking steps to become carbon-neutral by 2050.<sup>5</sup> However, of those regularly surveyed, many are less enthusiastic regarding a complete transition from fossil fuels and are worried about unexpected economic problems that could affect their daily lives<sup>6</sup> — despite projections that investing in clean energy would create 460,000 jobs by 2030, while coal mining and oil-related jobs will decline by more than 130,000 and result in positive net employment.<sup>7</sup>

Regarding U.S. contributions to address climate change, 75 percent of Americans support U.S. participation in international efforts to reduce its effects; however, 59 percent reject the idea that the U.S. has a responsibility to help developing countries build capacity for or provide financial assistance

to expand renewable energy as part of these efforts.<sup>8</sup> Russia's invasion of Ukraine has likely influenced these numbers by increasing uncertainty in global energy markets.

### **National Security as Human Security**

In simplest terms, *security* is the state of being free from danger or risk.<sup>9</sup> The Intergovernmental Panel on Climate Change (IPCC) defines *human security* as

a condition that is met when the vital core of human lives is protected, and when people have the freedom and capacity to live with dignity. In climate change, the vital core of human lives includes the universal and culturally specific, material and non-material elements necessary for people to act on behalf of their interests and to live with dignity.<sup>10</sup>

Threats to American security based on human needs (as postulated by Abraham Maslow) and rights (as enumerated in the Declaration of Independence and the Constitution) are those conditions, actors, and conditions, one might say, that promise to endanger, undermine, or diminish security. All three may either contribute to or diminish environmental security — security, in other words, both *from* and *of* the environment.<sup>11</sup> In this sense, environmental security as protection *from* and *of* the environment is a function of societal well-being rather than of military involvement (see Appendix D).<sup>12</sup>

Environmental concerns should be factored into security, development, and humanitarian strategies. There should also be coherence in environmental protection efforts at the global level. Most attempts to achieve governance structures to tackle the problems of global environmental degradation have not effectively addressed climate change, deforestation and desertification. Regional and global multilateral treaties on the environment are undermined by inadequate implementation and enforcement by the member states of the international system.<sup>13</sup>

Decisionmakers often focus on the symptoms of climate change, such as environmental degradation and resource scarcity, rather than on underlying causes — such as ignorance, resource inequality, government incapacity, and infrastructure deficiency. To some, this constitutes a *masking phenomenon* in which the political, social, military, and economic causes of unrest, violence, conflict,

and destabilization mask underlying, less visible, environmental sources of diminished quality of life and threats to safety and well-being. Unfortunately, in a four-year election cycle, the situations of the moment dominate decisionmakers, and symptoms dominate underlying causes. The climate crisis, like other crises, is preventable; where crisis occurs, strategy has failed.

### **Climate Threats: Toward Mitigation or Adaptation?**

Climate change is defined as long-term shifts in temperatures and global weather patterns. Since the industrial revolution, human activities have — arguably, in the minds of some — been the main cause of climate change.<sup>14</sup> As more and more greenhouse gases (GHGs) are emitted each year, more heat is trapped within the earth’s atmosphere, leading to global warming. Over the past 100 years, average global temperatures have increased by almost 2° Fahrenheit, and sea levels have risen between six and eight inches.<sup>15</sup> Climate change is also causing more frequent droughts, more intense storms, heatwaves, melting glaciers, and warming oceans.<sup>16</sup> Although each of these phenomena can occur naturally, climate change has exacerbated the strength and impacts of these events (see Appendix E). In his 2021 *Interim National Security Strategic Guidance*, President Biden states: “The climate crisis has been centuries in the making, and even with aggressive action, the United States and the world will experience increasing weather extremes and environmental stress in the years ahead.”<sup>17</sup> The President further contends that the U.S. must enhance resilience to climate change at home and in vulnerable countries abroad.<sup>18</sup>

### **Global Risks and Threat Assessment**

Climate change will increasingly exacerbate national security risks to the U.S., its allies, and its partners. Environmental degradation will intersect with and worsen climate change effects globally, particularly in low-income countries that are least able to adapt to changes, or to employ sound government practices for distributing resources and responding to emergencies.<sup>19</sup> Climate change is also likely to exacerbate domestic and cross-border geopolitical flashpoints, adding to instability and

increasing disputes over water scarcity and human migration. In the latest Global Risks report of the World Economic Forum, “climate action failure” ranks second as a short-term risk in the U.S. but 23<sup>rd</sup> in China — the two countries that are the world’s largest CO2 emitters. Climate Change ranks among the top 10 short-term risks in 11 other G20 economies.<sup>20</sup> In some cases, this dynamic will increase demand for U.S. and allied diplomatic, economic, military, and humanitarian resources, forcing difficult economic choices and increased dependence on technological breakthroughs to reduce emissions.<sup>21</sup>

Regarding GHG emissions, countries will debate who contributes to, bears responsibility for, and should pay to reduce such emissions, driving those countries to control resources and compete for new technologies needed for a clean energy transition. Geopolitical tensions will continue to rise as countries disagree on how to accelerate reductions in GHGs.<sup>22</sup> The 2021 United Nations Climate Change Conference (COP26) succeeded in getting 197 countries to align on the Glasgow Climate Pact and other landmark pledges, but even these new commitments are expected to miss the 1.5°C goal established in the 2016 Paris Climate Agreement.<sup>23</sup> This demanding strategic environment provides both backdrop and demand for the Environment and Climate Change Industry.

### **Firm Rankings and Current Environmental Industry Conditions**

The Environment Industry represents total U.S. revenues of over \$409 billion, generated by about 30,000 private sector companies and more than 80,000 public sector entities in the U.S., employing 1.7 million Americans. The global environmental market was about \$900 billion in 2019.<sup>24</sup> The top 200 environmental firms’ revenue measured \$90.2 billion, an almost 30 percent increase in revenue from the \$58.9 billion generated in 2019. Considering that the past decade ushered in \$54-59 billion, this leap is significant. The U.S. generated \$49.2 billion in revenue, just \$8 billion more than non-U.S. firms (167 firms reported profits; 18 reported losses; 15 didn’t report).<sup>25</sup>



Hazardous Waste is the leading market segment with regard to revenue at 28.1 percent of the market, followed by Water Supply and Wastewater Treatment at 18.1 percent and 17.7 percent respectively. Europe leads the globe in revenues by a large margin at 63.1 percent, followed by Canada at only 8.7 percent. Europe increased its revenues five-fold in 2020, leaping from just \$5.1 billion in 2019 to \$25.9 billion.<sup>26</sup>

Engineering News-Record (ENR) ranks the top 200 firms by market segment; Veolia, Jacobs, AECOM, Tetra Tech consistently rank within the top five firms across segments (see Appendix F). Seven of the top 10 firms are headquartered in the U.S., with Veolia (ranked #1) headquartered in France and WSP Global and Stantec (#8 and #9) both in Canada.<sup>27</sup> Environmental firms generated the most revenue from clients in the private sector (\$40.9 billion in revenue), followed by state or local clients (\$36.1 billion), and federal clients (\$13.3 billion) in 2020; all client bases have increased over the past three years.<sup>28</sup> Finally, Veolia Environmental S.A. (France) leads the Top 200 with \$29.7 billion in revenues (more than the next 10 companies combined), 93 percent of which is generated outside the U.S.. The top three U.S. companies — Jacobs, AECOM, and Tetra Tech — only generate a total of \$11.3 billion in revenue.<sup>29</sup>

Some industry analysts might classify many competitive firms within the Environment Industry as also being part of the Climate Change Industry, where rapidly expanding markets produced \$2.4 trillion in 2019 — almost twice the revenue of the Environment Industry. The four largest segments in the Climate Change Industry in terms of revenue and value contribution are Renewable Energy & Clean Power; Green Buildings; Energy Efficiency & Demand Response; and Transportation (Energy, Buildings, Transportation, Devices).

Some argue that many categories within these segments are still part of the problem, not the solution, despite the fact that they offer significant or at least substantial incremental improvements over the fossil-based or cheap-energy-era designs of the past.<sup>30</sup> It is worth noting that prior to the

COVID-19 pandemic, the Climate Change Industry generated almost twice the revenue of the Environment Industry globally (\$2.4 trillion vs. \$1.3 trillion in 2019). The U.S. garnered only 18.4 percent of the total global Climate Change Industry revenues (\$445.5 billion), which was still slightly more than it did in the Environment Industry (\$408.9 billion), where the U.S. percentage of global revenue generation was 31.6 percent in 2019.<sup>31</sup> All in all, the Climate Change Industry offers considerably more revenue potential for the U.S. than the Environment Industry.

The Biden administration, elected on a “Build Back Better” platform in 2020, promised to prioritize infrastructure and climate change, specifically climate studies, greenhouse gas mitigation, adaptation and resilience, and renewable energy.<sup>32</sup> The administration also prioritized the re-engagement of the U.S. in global policy discussions, including those regarding climate change.

While Environmental Health and Safety services have long been considered discretionary, environmental service companies have been expanding into non-discretionary services such as infrastructure, public-health activities, compliance, and resource management. This provides industry resilience for the future. Environmental Business International (EBI) notes that the areas of greatest growth have been in outsourcing environmental health and safety functions, water reuse capabilities, and monitoring and analysis. Conversely, areas that have experienced short-term declines are green building construction, informatics software and training, and construction management. While the pandemic likely impacted hygiene and construction capabilities in different ways, expectations are that there will be lingering economic impacts from delays to projects, slowdowns in refinery processes, and inefficiencies from human capital factors.<sup>33</sup>

### **Environmental Performance: Grading the U.S. and Its Competitors**

The 2020 Yale-Columbia Environmental Performance Index (EPI) ranks 180 countries by 32 performance indicators across 11 issue categories to gauge how close countries are to two policy objectives: Environmental Health and Ecosystem Vitality — essentially which countries “are best

addressing the environmental challenges that every nation faces.”<sup>34</sup> High scorers “exhibit long-standing policies and programs to protect public health, preserve natural resources, and decrease greenhouse gas emissions . . . . Countries making concerted efforts to decarbonize their electricity sectors have made the greatest gains in combating climate change, with associated benefits for ecosystems and human health”<sup>35</sup> (see Appendix G). Conclusions from the EPI rankings include:

- Good policy results are associated with wealth (defined as GDP per capita) suggesting that economic prosperity allows nations to invest in policies that lead to desirable outcomes in environmental health, which requires necessary infrastructure to provide clean drinking water, sanitation, to reduce air pollution, control hazardous waste, and respond to public health crises.
- The pursuit of economic prosperity (industrialization and urbanization) often results in more pollution and strains on ecosystem vitality, particularly in the developing world. However, the data suggest that countries do not need to sacrifice economic security for sustainability.
- Good governance (rule of law, freedom of the press, enforcement of regulations) correlates with higher EPI scores.<sup>36</sup>

The U.S. ranks 24 out of 180 countries on the EPI, with its best performance in pollution emissions; and its worst in fisheries and ecosystem services, both of which rank below world and regional averages.<sup>37</sup> Comparatively, China and Russia rank 120 and 58 respectively. China performs average or below average across all categories, its weakest being water resources.<sup>38</sup> Like the U.S., Russia’s best category is pollution emissions, but it performs abysmally in waste management and fisheries.<sup>39</sup> For the U.S., these rankings provide a snapshot of potential business opportunities, both abroad and at home.

Another way to measure the potential for business development is to use the 17 United Nations Sustainable Development Goals (SDGs), aimed at reconciling economic prosperity with reduced inequalities and addressing issues related to biodiversity loss and the climate crisis. Using the UN SDG dashboard (see Appendix H), the U.S. currently ranks 32 out of 165 countries for sustainable development.<sup>40</sup> No country in the world has achieved all 17 SDGs, nor is any country on track to achieve them by 2030. Additionally, the UN evaluates goals 7 (Access to Affordable Clean Energy) and 13 (Urgent Action to Combat Climate Change) as not yet on track to meet the targets.<sup>41</sup> The U.S.

achieves its best results on SDG 4 (Quality Education) and SDG 8 (Decent Work and Economic Growth) — arguably the two SDGs that set the foundation for achieving all other targets; yet American society, governments, and institutions continue to harness this potential for unsustainable development. High levels of CO2 emissions, pollution, and threats to biodiversity will require major transformations to achieve the SDGs by 2030. The U.S. also generates negative environmental and security externalities (or spillovers) that undermine other countries’ ability to achieve the SDGs.<sup>42</sup>

In comparison, Russia ranks 58 out of 180 on the EPI 2020 rankings.<sup>43</sup> And it ranks 46 of 165 in the SDG rankings.<sup>44</sup> Although top-third rankings are respectable, they don’t tell the whole story. Russia is warming much quicker than the rest of the globe. In 2020, hot temperatures “[contributed] to forest fires . . . [and] flash floods in Siberia destroyed entire villages and displaced thousands of residents.”<sup>45</sup> Permafrost thaw threatens arctic urban centers, pipelines, roads, and railways. While Russia is “the fourth-largest emitter of greenhouse gasses . . . its per capita emissions are . . . 53 percent higher than China and 79 percent higher than the EU, though 25 percent lower than the U.S.”<sup>46</sup> Prior to the Ukraine invasion, environmental activism in Russia was on the rise, despite laws enacted to curb protest activity; earlier this year, Russia criminalized anti-war protests with penalties up to 15 years.<sup>47</sup> While there are no data to show it, this crackdown on anti-war protests likely had a depressive effect on all protest activity. (See Appendix I for how the U.S. could leverage the Environment & Climate Change Industry in the Russia-Ukraine conflict.)

Finally, the Germanwatch e.V. Climate Change Performance Index (CCPI) evaluates the U.S., allied, and competitor-country performance regarding GHG emissions, renewable energy, and energy use.<sup>48</sup> The CCPI demonstrates that the U.S., Russia, and China fall decidedly behind the EU in clean energy, ranking at the bottom of the list of 60 ranked countries in positions 55, 56, and 60 respectively. The EPI, SDG, and CCPI rankings collectively show (see Appendix J) that the EU (led by the Nordic countries and Denmark) lead across the board, with the U.S. emerging just ahead of Russia, China,

and India (in that order) at the bottom of the so-called great-power brokers. Of these four countries, the U.S. is the only one in the top four GDP-per-capita countries — again suggesting that while the U.S. has immense potential for environmental progress on a par with the EU, it has arguably chosen to do otherwise.

### **The Environment/Climate Ecosystem: Stakeholders and Connections**

The environmental industry seeks to prevent or minimize damage to ecosystems, consisting of the network of living organisms (including humans) in a particular area and the nonliving components (air, water, soil) with which these organisms interact. In an industrial ecosystem, sustainability is critical. The Environment and Climate Industry leverages environmental protection, social equity, and economic prosperity to secure these resources without compromising nature, community, or society. All industries, from Energy to Space to Advanced Manufacturing, are affected by or affect the environment. Governments at all levels – domestic and international – have adopted environmental policies to combat air and water pollution, land and vegetation degradation, hazardous and non-hazardous waste, biodiversity loss, and the effects of climate change. Compliance with laws, regulations, and standards can be challenging for companies, which often must implement changes to infrastructure and processes that impose near-term costs seen as detrimental to profitability and competitiveness. Nongovernmental organizations, including advocacy/interest groups, laboratories, and financial institutions, marshal public support for environmental conservation and play an essential role in framing environmental policy (see Appendix K).

### **Assessing Performance: Structure – Conduct – Performance**

**Structure.** As noted previously, the Environment and Climate Change industry structures are contained in Appendices B and C. In reality, both industries are essentially a collection of supporting industries. Accepting that an industry is “a group of companies that are related based on their primary business activities,” using any industry-analysis model to look at the whole of this particular industry

is an effort in futility, as there is complementarity but little congruency of players across the sector.<sup>49</sup> EBI's analysis of the U.S. Environment Industry structure identifies myriad players — just shy of 200,000 in 2018 (see Appendix L). This includes small and large businesses, as well as municipalities that operate in some of the more essential services — wastewater treatment, solid waste management, and water utilities, for example. In these three segments alone, there are more public entities than private; and, with the exception of solid waste management, municipalities take in the lion's share of revenue. Most segments are dominated by a small number of big businesses while still offering revenue potential for small businesses. The more capital-intensive (renewable energy providers, utilities, waste management) segments have high entry and exit costs.

**Conduct.** Conduct differs greatly across the spectrum of participants in this sector. In relation to essential public services, providers are generally afforded monopoly status specific to a geographic area, thereby limiting competition. Prices are heavily regulated and set by the municipality, which indirectly limits price activity among inputs. For electricity specifically, power generation firms use long-term contracts called power purchase agreements (PPA) to help control for price fluctuation. Product differentiation is limited in these sectors as well — while there may be different ways to generate electricity; in most cases, there is no substitute for it. Many states enact renewable portfolio standards or clean energy standards to ensure that a minimum level of renewable energy is used and set targets for higher percentages in the future.<sup>50</sup> This creates market (and growth) opportunities for power generation entities producing electricity from renewable sources.

**Performance.** As of 2019, revenue across the EBI-defined U.S. environmental industry totaled \$408.9 billion, while the climate change industry totaled \$445.5 billion. The respective global numbers were roughly \$1.3 trillion and \$2.4 trillion.<sup>51</sup> Both environmental and climate change industries continue to grow; and, while much of the economy saw a COVID-19-induced downturn in 2020, many of the largest environmental firms were able to meet or exceed forecasts for the year.<sup>52</sup>

With current Biden administration priorities and international agreements made during COP 26, the industry seems quite likely to continue posting strong growth.

### **An Alternative Assessment: Porter's Five Forces**

Another model commonly used to analyze industry performance is the Five Forces model of Harvard University Professor Michael Porter. This model assesses the interrelationships between existing rivalry, buyer power, supplier power, threat of new entrants, and threat of substitutes within a clearly defined industry as an indicator of the industry's competitiveness.<sup>53</sup> As with the SCP model, the lack of an overarching industry structure makes it equally difficult to use the Five Forces to assess the Environment Industry as defined (and even more so when discussing environment and climate change together). The Environment Industry definition provided in the introduction and the related industry structure in Appendix B show multiple, distinct industries, each with an environmental component but different competitive environments. For example, waste management, water utilities, renewable energy, and power generation each fall squarely within the EBI definition but have quite different competitive landscapes based on Porter's model.

The inability to adequately assess this industry in its entirety is due less to deficiencies in the model than to an overly broad industry definition. That said, when focusing on one specific environment-connected industry, the Five Forces model can be quite instructive. Take the Waste Management industry for instance. In the U.S., China, and Russia, the model produces quite similar results, showing a weak competitive landscape.<sup>54</sup> This is illustrative of the fact that in discussing something as essential as waste management, where no substitutes exist, the industry is quite similar despite the different economic environments in which it operates. Due to its necessity, waste management providers are typically afforded regional monopoly status in each country; rivalry within a regional market is almost nonexistent, with most rivalry occurring over territory (expansion). Capital

requirements and the necessity to compete at scale keep new entrants at bay and raise exit costs. The lack of substitutes negatively impacts buyer power as well.

For an environment-related industry with a greater degree of competition, it is instructive to look at renewable energy. In the U.S., China, and Russia, the renewable energy industry is growing — though it is growing more slowly in Russia.<sup>55</sup> There are multiple reasons for this growth, including demand from individual consumers, industrial consumers trying to meet carbon reduction goals, and governments promoting or directing energy greening to meet COP26 goals. While there is growth and moderate competition in renewable energy across the three “great-power” countries, the economic setting clearly does impact the industry model – in both China and Russia, for example, where the threat of new entrants is weak.<sup>56</sup> In Russia, where this threat is weakest, it can be attributed to the Russian economy’s reliance on oil and gas; many of the favorable government policies to encourage renewable energy advances seen in other countries are not present in Russia.<sup>57</sup> In China, the dominance of a limited number of firms, supported by the state, precludes smaller firms from being able to compete at scale.<sup>58</sup> The war in Ukraine is not likely to jump start the renewable energy sector in Russia, though it may do so in nations reliant on Russian oil and gas. In all three countries, there is an oligopoly of suppliers that strengthens their power and a high degree of rivalry due to a small number of large firms competing in this space.<sup>59</sup>

Neither SCP nor Porter’s Five Forces provides an adequate basis for analysis regarding the entire breadth of the Environment and Climate industries. However, when focusing on various industry segments, both can be useful tools in developing understanding. When dealing with global markets, there will always be local peculiarities that provide opportunities or obstacles. Following is a quick look at potential opportunities within the environment and climate change related-industries that appear to exist in China and Russia.<sup>60</sup>



## **China and Russia: Abundant Green Market Potential**

China's environmental misfortunes have translated into a green opportunity for industry. China is home to the most prominent and fastest-growing environmental technologies market, and this expertise is critical as the country moves toward aligning policy and innovation with environmental goals.<sup>61</sup> China's Nationally Determined Contributions (NDCs) — derived from the 2016 Paris Climate Agreement — to increase non-fossil energy consumption to 20 percent and reduce carbon intensity and peak CO<sub>2</sub> emissions by 65 percent below 2005 levels by 2030, have defined the parameters of the country's current posture.<sup>62</sup> The fact that China hasn't stated what its peak CO<sub>2</sub> levels will be, how this is a different metric than any other country, and is non-binding in practice, calls into question China's climate trajectory and whether its policies will align with the global climate stabilization goals.<sup>63</sup> The renewable energy market is one of the most critical sectors to move China closer to meeting its NDCs.

China's renewable energy market had revenues of over \$200 billion in 2020, representing a compound annual growth rate of 11.8 percent between 2016 and 2020. This market consists of firms working in hydroelectricity, wind energy, solar, biomass, and geothermal.<sup>64</sup> China has once again reinvented itself as the “factory to the world,” producing most of its wind turbines, electric vehicles, and lithium-ion batteries.<sup>65</sup> In 2021, China increased subsidies for renewable energy projects to \$900 billion, with solar receiving the most significant subsidy.<sup>66</sup> Moreover, President Xi Jinping also committed to increasing solar and wind energy-installed capacity to 1,200 GW by 2030, shepherding Chinese businesses to become the world's largest manufacturers of solar panels.

China is on track to be the largest world economy by 2030, and its pollution problem presents sizable opportunities for multinational companies.<sup>67</sup> The country's environmental protection market is forecasted to reach \$2.5 trillion in the next several years, and large multinational environmental firms, like Tetra Tech and AECOM, have recognized this potential and positioned themselves to grow

with China's green economy sectors.<sup>68</sup> Joint ventures and public-private partnerships (PPPs) are model investment approaches for western firms seeking to exploit China's rapidly expanding environmental markets. For instance, in 2017, AECOM entered a joint venture with China Communications Construction Company, China's 14<sup>th</sup> largest state-owned enterprise to provide consulting and planning services for environmental restoration, soil and groundwater pollution projects, water resources, surface water and sediment remediation, and solid waste, air, and wastewater treatment.<sup>69</sup>

Like China, Russia is ripe with environmental and climate change industry opportunities. Russia is among the world's top fossil fuel producers and exporters.<sup>70</sup> Pre-COVID-19 fossil fuel exports were more than half of Russia's total exports, and revenue from its oil and gas exceeded a third of the nation's budget.<sup>71</sup> Russia's domestic energy mix is dominated by coal, oil, and natural gas.<sup>72</sup> The economy's fossil fuel dependence is a reason for the country's delay in adopting renewables on a grander scale, though Russia will inevitably need to make such a transition. Revenue volume explains continued fossil fuel dependence; however, as Russia's customers continue to adopt or expand renewable energy, the accompanying demand decrease will force Russia's move to renewables. Without an economic transition, it will be difficult to weather the storm of falling revenues. Russia's use of fossil fuel supply as a coercive tool in international relations and its war in Ukraine may serve, instructively enough, to dry up demand faster than expected.<sup>73</sup>

Russia's modest goals for renewable energy use (4.5 percent, excluding hydro, by 2025, a goal it is not on track to meet) and a longer horizon to net zero (2060), provide ample opportunity in its renewable energy markets.<sup>74</sup> The country's hydroelectric industry is already established, and it has policies for expanding wind and solar, as well as a seemingly endless amount of available land for development.<sup>75</sup> Bioenergy also provides ample opportunity with its varied uses, including agriculture, forestry, infrastructure, and trade.<sup>76</sup> The problem is not one of opportunity, but of stable access to

such opportunity. As recently as 2019, Russia considered banning foreign companies from taking a leading role in green energy projects, requiring activity in this space to be subordinated to a Russian entity, potentially adding an additional layer of bureaucracy and perceived risk.<sup>77</sup> While foreign investors in this sector have not left since the Ukraine invasion, progress has slowed.<sup>78</sup> Russia's reliance on foreign firms to revolutionize its renewable energy industry will grow over time, as the country is deficient in innovation, and the brain drain that plagued post-Soviet Russia has again flared up (actively encouraged by the U.S.).<sup>79</sup> Time is waning for Russia to take meaningful action on its own initiative; the international community, acting as a forcing function, will be its only option. Unfortunately, the country's rogue propensities in international relations provide little confidence for would-be green saviors.

### **Factor Condition: Government**

Government's role, according to one well-established line of thinking, is to provide for the collective security of its people. This is accomplished in several ways: enacting and enforcing policy (regulation), providing oversight, preparing for and responding to catastrophic emergencies, and forging international agreements, to name but a few. When looking at this industry, collective security includes, among other things, public health, environmental justice, renewable energy, access to water resources, and mitigation, adaptation, and resilience measures. Many of these efforts must now be viewed globally, rather than just domestically, as the world aims for its 2030 climate goals, and developed countries necessarily assume responsibility (in both ethical and security terms) to assist the world's less-developed regions in combating environmental degradation and climate change.

U.S. government is a federal system of divided and shared powers: executive-legislative, federal-state-local-multijurisdictional, international-intergovernmental. Unlike many other countries, the U.S. does not have a cabinet-/ministerial-level department to provide executive stewardship of environmental efforts. To be sure, we have a small federal environmental policy-setting body, the

Council on Environmental Quality, in the Executive Office of the President.<sup>80</sup> But the principal environmental regulatory arm is an Executive-Level II operating agency, the Environmental Protection Agency.

A number of other federal agencies have major environmental responsibilities and authority (see Appendix N): e.g., the National Oceanic and Atmospheric Administration and the International Trade Administration in the Department of Commerce; the Fish and Wildlife Service, the Bureau of Land Management, and the National Park Service in the Department of Interior. But much of the day-to-day “heavy lifting in American environmental protection is done by state and local governments.”<sup>81</sup> Such organizational arrangements require a great deal of coordination within and between all levels of government. Then there are the innumerable international and intergovernmental organizations (see Appendix O) that also play key roles in environmental and climate matters (e.g., the United Nations Environment Programme, the World Meteorological Organization, the World Health Organization, the World Trade Organization, and the International Organization for Standardization).

### **Factor Condition: Economics and Finance**

The economics of environmental management are extremely diverse, starting with the varied branding that attends the subject — from “environmental economics” to “green accounting” to “socially responsible investing” (see Appendix P). Much of this diversity stems from politics and the ideological debate about the relationship between corporate environmental actions and profitability. Critics commonly view the environment as having a negative, costly impact on business performance and job creation. But the converse of this is actually true. Sound environmental practices produce healthier workforces, project socially responsible imagery, and enhance long-term superior economic competitiveness. Look at the top companies in the Fortune 100, which include the likes of Walmart, Amazon, and ExxonMobil, and at the leading government and defense contractors, such as Lockheed Martin, Boeing, General Dynamics, and Raytheon. All of these top revenue earners have major

internal Environmental, Health, and Safety programs and annually issue Sustainability or Environmental, Social, and Governance reports trumpeting their achievements in these areas.

### **Factor Condition: Technology and R&D**

The U.S. economy has shown itself capable of continued growth while also reducing Greenhouse Gas (GHG) emissions, the leading cause of global warming and climate change. Thirty-five countries, including the United States, have increased their gross domestic product while simultaneously reducing carbon dioxide emissions; and, from 2000 to 2014, thirty-three states and the District of Columbia — a mix of politically red and blue — expanded their economies while reducing energy-related carbon emissions.<sup>82</sup> The conclusion to be drawn? Decoupling from carbon emissions is an “economic issue, not a political one.”<sup>83</sup>

The percentage of GHG emissions by sector is largest in the energy sector, where industry (24.4%), buildings (17.5%), and transport (16.2%) produce the most (see Appendix Q). The U.S. can have the most impact on GHG emissions by targeting these sectors for improved efficiency while increasing productivity. Recognizing the economic *and* climate/environmental benefits of reducing emissions, the U.S. Securities and Exchange Commission (SEC) has proposed rules to enhance and standardize climate-related disclosures for investors, including a requirement to disclose registrants’ GHG emissions.<sup>84</sup> Most of the world’s largest companies report their Scope 1 and 2 emissions (see Appendix R for definitions of these terms), but the trend now is moving toward reporting a fuller range of corporate value chain and product emissions (Scope 1, 2, and 3) since doing so delivers a positive return on investment.<sup>85</sup>

Leading Environment Industry firms, such as Veolia, AECOM, and Tetra Tech, are increasingly touting the use of artificial intelligence (AI) and machine learning (ML) — or the big data these platforms rely upon — to aid in mitigating and adapting to climate change.

A PwC study commissioned by Microsoft concluded that using AI for environmental applications has the potential to boost global GDP by 3.1–4.4 percent, while also reducing global GHG emissions by around 1.5–4.0 percent by 2030 relative to business as usual. AI applications in energy (up to -2.2%) and transport (up to -1.7%) have the largest impact.<sup>86</sup>

Both firms and governments realize that ML and AI can have a demonstrable impact on, but won't "fix," climate change. Still, in the energy sector, AI can be used to optimize demand forecasting of electricity and better grid management, particularly as it becomes more sophisticated and integrated with different forms of energy generation (solar, wind, stored, fossil fuels).<sup>87</sup> In the transport sector (which accounts for 25 percent of GHGs), AI can reduce the use of vehicles by optimizing flow and facilitating shared transport. However, the information and communications technologies that ML and AI rely upon are major contributors to GHG emissions: about 30 percent coming from manufacturing processes and 70 percent from actual use. Altogether, this creates a full lifecycle carbon footprint of between 2.1 and 3.9 percent of global GHG emissions (with the aviation industry at 2 percent, by way of comparison).<sup>88</sup>

Technology can play an especially important role in mitigating and adapting to the effects of climate change. In addition to electric vehicles, wind turbines, and solar panels, which are already making a difference in reducing carbon emissions, there are innumerable emerging technologies at various stages of development that can further climate mitigation and adaption (see Appendix S for a small sample).<sup>89</sup>

### **Demand Conditions: The Prospective Impact of the SDGs**

Perhaps the most telling indicator of demand for environmental and climate solutions are the 17 Sustainable Development Goals and their 169 supporting targets adopted by the member states of the United Nations in late 2015.<sup>90</sup> "The SDGs are also known as Global Goals and were adopted by the UN as a universal call to action to end poverty, protect the planet, and ensure that by 2030 all people enjoy peace and prosperity."<sup>91</sup> The SDGs constitute the core of the 2030 Agenda for Sustainable Development and set the guidelines to transform the world and guide all global development efforts

for the next 15 years.<sup>92</sup> Each SDG, to be actionable, needs to have specific targets and indicators to assess progress (or lack thereof). The targets provide ways to help accomplish the overall SDG, and the indicators assess how much progress is being made toward each target and overall SDG. It is common for some SDGs to have double-digit targets and indicators.

The SDGs' commitment to fairness, justice, environmental resilience, and sustained human well-being is relevant to the United States and the rest of the world for reasons that transcend narrowly conceived national interests and competitiveness.<sup>93</sup> Aside from the criticality of having a thriving environment conducive to enriching and fulfilling life on Earth, there are also business opportunities for companies, both U.S. and foreign. For example, one estimate for the value of “ecosystem services” is \$33 trillion per year, with most of this being outside formal markets.<sup>94</sup> Others have found that “the world was losing up to \$4 trillion in natural capital each year due to deforestation, ocean pollution, and other activities.”<sup>95</sup>

The SDGs are “central components to many national developmental plans and foreign aid strategies.”<sup>96</sup> These goals collectively provide a discernible path to responsible production, environmental stewardship, and sustainable consumption. Clearly, the environment impacts all life on the planet — in and through the air, on and in the land, and on and under the water. Even today, the threat of climate change (and climate change inaction) is affecting an incredible number of people globally. Eight-hundred million people are vulnerable to climate change impacts, including extreme weather, droughts, and floods.<sup>97</sup> An even greater number of people suffer food insecurity. There were 821 million undernourished people in 2017.<sup>98</sup> Without direct action, these numbers will only continue to increase. In addition, it isn't just the human population that is impacted. Global wildlife populations declined 60 percent in the last 40 years due to a variety of human actions.<sup>99</sup> One could argue that human activity is directly contributing to the “extinction event” that is currently ongoing. A further 75 percent of the earth's species could become extinct over the next 300 years.<sup>100</sup> Humans are also

solely responsible for the damage to the land and forests. Over 20 percent of the earth’s land area was degraded in 15 years.<sup>101</sup>

The 2021 SDG Index, prepared by the Sustainable Development Solutions Network, is topped by three Nordic countries — Finland, Sweden, and Denmark — yet even these countries face major challenges in achieving several of the SDGs. Low-income developing countries (LIDCs) are often unable to finance emergency response and investment-led recovery plans aligned with the SDGs. Additionally, for the first time since the adoption of the SDGs in 2015, the global average SDG index score for 2020 decreased from the previous year, largely due to increased poverty and unemployment following the COVID-19 pandemic, and further limited the capacity of LIDCs to obtain financing. While the governments of high-income countries have borrowed heavily in response to the pandemic, LIDCs have been unable to do so because of their lower market credit-worthiness.<sup>102</sup> Rich countries generate negative international spillover effects through unsustainable trade and supply chains, tax havens, and profit shifting — all of which undermine the ability of other countries to mobilize needed financial resources to achieve the SDGs. Various types of global tax reforms could significantly increase government revenue in developing countries.<sup>103</sup> Additionally, data gaps and time lags in official statistics highlight the need for further investments in statistical capacity and new approaches to monitor national commitments and progress on key SDG transformations. “More ‘forward-looking’ policy trackers are also needed to assess implementation efforts on key SDG transformations, and especially to monitor countries’ actions on sustainable land use, diets, and responses to the biodiversity crisis.”<sup>104</sup>

### **Policy Recommendations**

- **Philosophical/Strategic.** Address specific requirements for *environmental security* in The National Security Strategy (50 U.S. Code § 3043) and National Defense Strategy (10 U.S. Code § 113) documents including language that outlines the U.S. approach to fulfilling the 2030 Agenda for the UN Sustainable Development Goals. These recommendations will prioritize a systematic effort to integrate the NSS with the SDG Agenda, demonstrating U.S. leadership internationally and aiding in the



development of international coalitions, partnerships, and alliances formed alongside goals of sustainability, energy efficiency, and human security.

- **Bureaucratic.** Institutionalize private-sector participation in the U.S. strategic planning process to harness the soft-power potential of environmental business. This recommendation highlights the strategic necessity to identify and commit resources toward the underlying causes of security challenges (i.e., environmental degradation and resource scarcity) rather than the symptoms (fragile, corrupt states; instability; intra- and inter-state conflict).
- **Organizational.** Elevate the Environmental Protection Agency to an Executive Level 1 Cabinet-level department and call it the Department of Environment. Enact legislation to create a statutory (and thus formal and permanent) seat on the National Security Council (50 U.S. Code § 3021) for the Secretary of the Environment. Establish in each federal agency a strategically positioned seat for personnel from the Department of Environment, similar to State Department Political Advisors (POLADs) in DoD, but call them ENVADs, whose purpose would be to provide environmental advice and counsel. These recommendations will institutionalize the environment's role and stature across administrations.
- **Legal.** Reconsider ratifying major international agreements the U.S. has chosen to date not to ratify, such as the UN Convention on the Law of the Sea (1994), the Convention on Biological Diversity (1992), the Basel Convention on Control of Transboundary Movements of Hazardous Wastes and Their Disposal (1992), and the Stockholm Convention on Persistent Organic Pollutants (2001). Push Congress to conduct open public hearings to debate the strategic ramifications of legally binding ratification: demonstrating international leadership in supporting and complying with the rule of law vs. sacrificing freedom of action and relinquishing sovereignty vs. striving to meet or exceed treaty provisions without official ratification.
- **Economic/Financial.** Enact legislation to (a) decrease fossil fuel incentives (with a firm end date of 2025), (b) increase tax incentives for the individual purchase of electric vehicles, and (c) phase in rising consumption taxes for gasoline. Apply savings from these measures to clean energy producers to help lower start-up costs. Pressure Congress to establish federal emergency fund-distribution caps per fiscal year and prioritize distribution based on states' ability to meet and enforce minimal federal standards for protection of human life, property, and environment.
- **Technological.** Task the National Laboratories to undertake a Manhattan Project-like initiative to develop and field a comprehensive ecosystem of clean and renewable technologies aimed at reducing national emissions across all industries, starting with the largest emission-producing areas: industrial and transport. Exploit this massive undertaking to (a) enhance U.S. global competitiveness and leadership, (b) help the U.S. achieve its Nationally Determined Contributions (NDCs) in line with Article 4 of the Paris Agreement, and (c) potentially enabling the U.S. to set new, more ambitious NDCs beyond the economy-wide target of reducing net greenhouse gas emissions 50-52 percent below 2005 levels by 2030. Additionally, task an Interagency Working Group to (a) develop a portfolio of policies to accelerate the transition from fossil fuel to renewable energies, drive scientific discovery, and reshape the U.S. innovation and technology base; and (b) prioritize those sectors in which the USG should invest to address gaps the commercial industry would not address to drive advances in renewable energy technology and grid, land, and transportation optimization.
- **Educational.** In the interest of motivating public support, elevate American understanding of environmental and climate matters above other national priorities by undertaking and underwriting a nationwide environmental literacy campaign to educate Americans on the connections between the environment and the economy, security, infrastructure, and health. Include educating members of the medical profession on how to code illnesses associated with climate change events. Update primary

and secondary school curricula, to include information regarding public utilities and services (electric grid, water, sewer, trash), sources of energy, and natural resources.

- **International.** Take the lead in galvanizing international support for targeted, high-priority funding to the UN Environment Programme to reestablish/reinvigorate its program of conflict-/post-conflict environmental assessments, starting with Ukraine. Initiate an international fund (contributions made by partner nations as a percentage of GDP (or trade with developing countries)), whereby developed nations can finance mitigation and adaptation efforts in low-income developing countries.

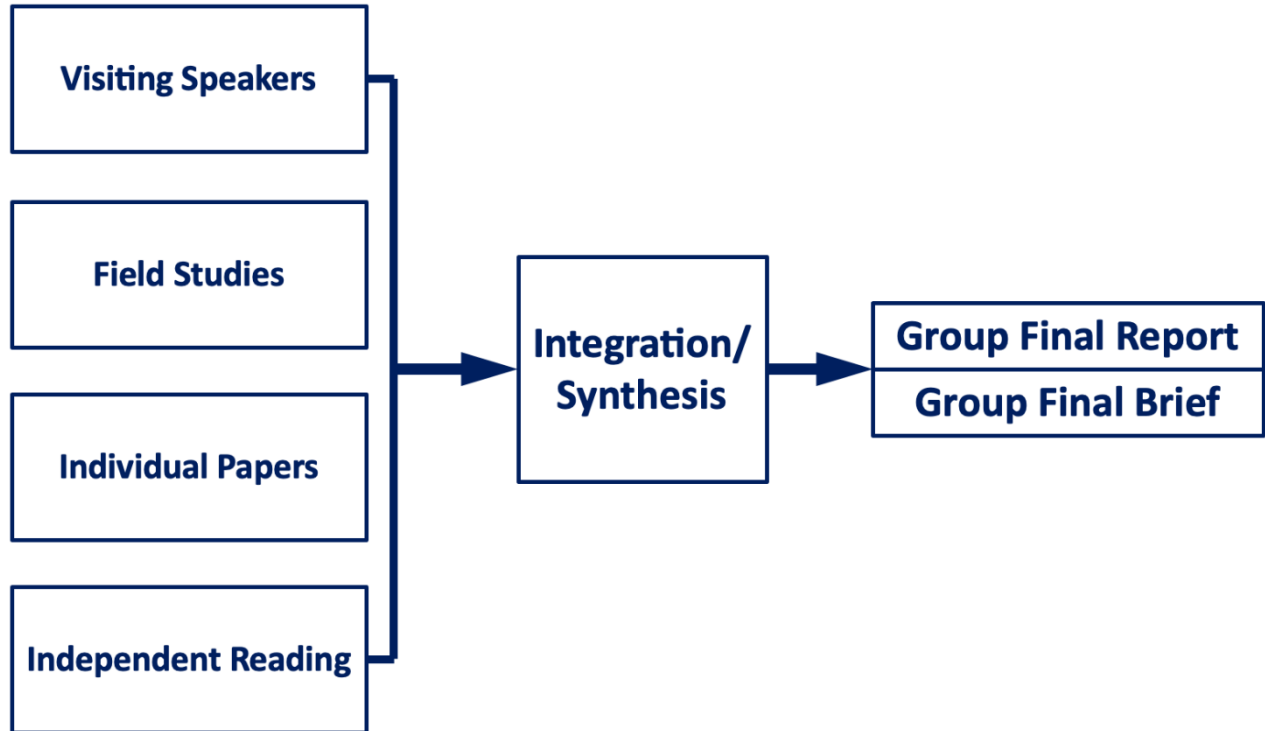
## **A Final Observation**

The United States clearly has the wherewithal to be *the* global leader in providing protection *from* and *of* the environment. There is a sufficiently robust, comprehensive body of domestic and international law in this field (see Appendices T and U) that regulatory direction, priorities, and boundaries aren't at issue. Indeed, U.S.-based environmental firms *are* at the forefront of this sector globally in terms of diversification and competition. However, the U.S. environmental industry has only scratched the surface of the business opportunities that exist, both domestically and internationally. Decreasing carbon emissions and investing in sustainable ways to efficiently use resources will increase business longevity and decrease costs through increased efficiency, thereby resulting in heightened productivity and economic growth. An ambitious domestic agenda and commitment across the political spectrum beyond current election cycles would speed a transition in thought and action; but U.S. firms almost assuredly will continue to innovate and lead the effort regardless of political and ideological obstacles, simply because environmental protection and climate mitigation and adaptation have shown themselves to be profitable.

By way of reiteration, it is useful to discuss the Environment and Climate Industry as an industry; but an “industry of industries” or “meta-industry” more accurately describes the spaces in which Environment and Climate stakeholders share interests, exchange goods, services, and solutions, and build upon and accentuate the performance of virtually every other existing industry. The Environment and Climate Industry, given its size, reach, and impact, is inarguably a strategic industry

— more so, to be sure, than many other industries that commonly command attention when the discussion at hand is security-related. Its concerns and imperatives affect firm and consumer behavior across all industries, underscoring in the process the importance of greater sustainability and resiliency to the U.S. economy and accentuating the integral relationship between the environment, the economy, and security at all levels.

## Analytical Approach



**APPENDIX B: Environmental Business International Environmental Industry Structure**

**Exhibit 1-1 Environmental Industry Segments**

<b>Segment</b>	<b>Description</b>	<b>Examples of Clients</b>
<b>Environmental Services</b>		
Environmental Testing & Analytical Services	Provide testing of "environmental samples" (soil, water, air and some biological tissues)	Regulated industries, Gov't, C&E, Hazardous waste and remediation contractors
Wastewater Treatment Works	Collection and treatment of residential, commercial and industrial wastewaters. Facilities are commonly known as POTWs or publicly owned treatment works.	Municipalities, Commercial Establishments & All industries
Water Utilities	Selling water to end users: Municipal entities and private companies	Consumers, Commercial, All industries, Institutions
Solid Waste Management	Collection, processing and disposal of solid waste & commercial collection of recyclables	Municipalities & All industries
Hazardous Waste Management	Collection, processing and disposal of hazardous, medical waste, nuclear waste	Chemical, Petroleum, Mfgs Government agencies
Remediation and Industrial Services	Cleanup of contaminated sites, buildings and environmental cleaning of operating facilities	Government agencies Property owners, Developers Industry
Environmental Consulting & Engineering (C&E)	Engineering, consulting, design, assessment, permitting, project management, O&M, monitoring, etc.	Industry, Government Municipalities Waste Mgmt. companies, POTWs
<b>Environmental Equipment</b>		
Water Equipment & Chemicals	Provide equipment, supplies and maintenance in the delivery and treatment of water and wastewater.	Municipalities & All industries
Instruments & Information Systems	Produce instrumentation for the analysis of environmental samples. Includes info systems and software.	Analytical services, Gov't Regulated companies
Air Pollution Control Equipment	Produce equipment and tech. to control air pollution. Includes vehicle controls.	Utilities, Waste-to-energy Industries, Auto industry
Waste Management Equipment	Equipment for handling, storing or transporting solid, liquid or haz. waste. Includes recycling and remediation eqmnt.	Municipalities Generating industries Solid waste companies
<b>Environmental Resources</b>		
Water Utilities	Selling water to end users	Consumers, Municipalities & All industries
Resource Recovery	Selling materials recovered and converted from industrial by-products or post-consumer waste	Municipalities Generating industries Solid waste companies
Clean Energy Systems & Power	Solar, wind, biomass, fuel cell, geothermal, and wave & tidal: Systems / equipment sales and Power value	Utilities All industries and consumers

Source: Environmental Business International Inc. (San Diego, Calif.)

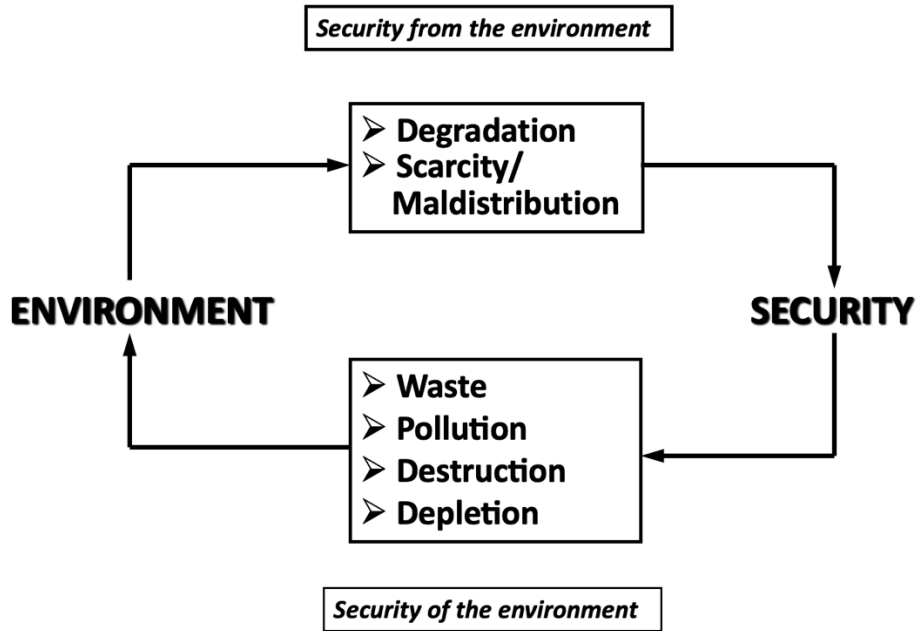
## APPENDIX C: Environmental Business International Climate Change Industry Structure

### CCBJ Definition of Climate Change Industry Segments

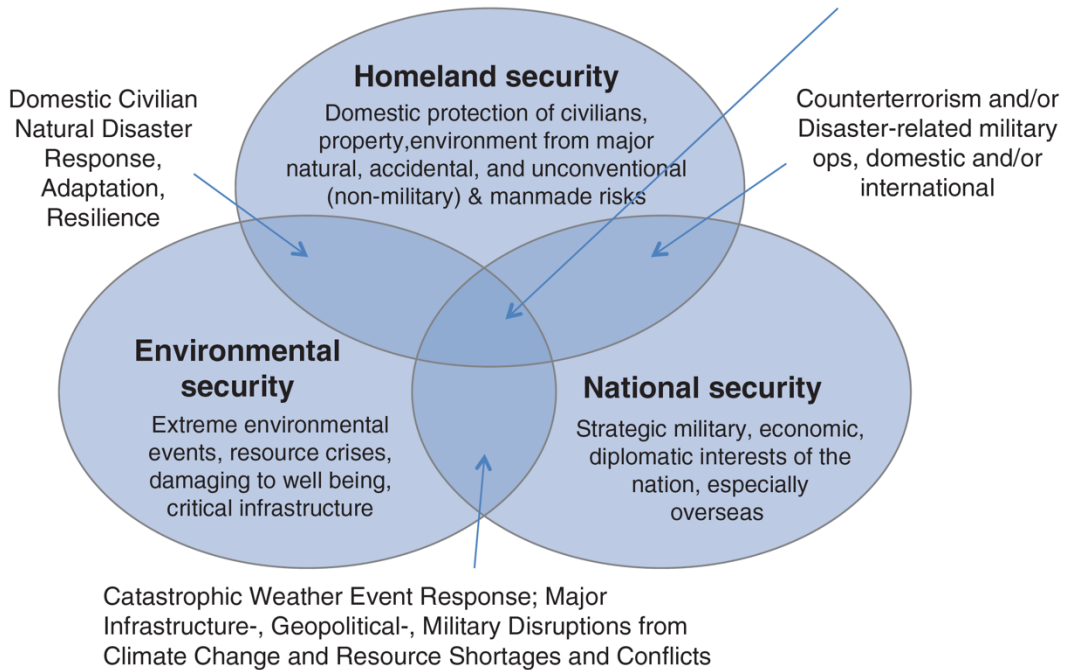
1. <b>Renewable Energy &amp; Clean Power:</b> Renewable Power Sales; Equipment, Systems, Supplies and Construction & Installation
2. <b>Carbon Capture &amp; Storage (CCS):</b> Systems, Equipment and Operations; *Value of Carbon Sequestered
3. <b>Energy Efficiency &amp; Demand Response:</b> Appliances, Devices, Equipment & Services including ESCOs, ESPs, DR & SmartGrid
4. <b>Energy Storage: Equipment &amp; Systems:</b> Utility-Scale Systems; Commercial, Residential & Vehicle Propulsion Batteries
5. <b>Green Buildings:</b> Value of Green Buildings Put-in-Place; Analysis, Planning & Permitting, Certification, Design & Development; Construction Management; Specialty Building Materials & Supply
6. <b>Transportation:</b> HEV, EV and AFV Vehicles, Biofuels and CNG & LNG Systems, Public Transit, GHG Planning & Engineering, Commuter Bikes
7. <b>Carbon Markets:</b> Credit & Offset Sales & Trading; *Project Development, Verification and Registration
8. <b>Adaptation &amp; Resilience:</b> Risk Assessment, Planning, Engineering, Design & Construction Management; *Adaptation Construction
9. <b>Consulting, Research &amp; Professional Services:</b> Professional Services for Mitigation & Compliance; Climate Research Funding

*Source: Environmental Business International & CCBJ annual model of climate change industry updated since 2008. \* Asterisks indicate subsegments not quantified in the figures published in this edition.*

## APPENDIX D: Environment-Security Linkage











Risk Mitigation of Political Violence (including Terrorism) Arising from Climate Change, Resource Shortages; Major Natural Disaster Response



**Figure 1** Hypothesized Relationships among Homeland, Environmental, and National Security.

## APPENDIX E: Current and Projected Climate Change Effects and Impacts

Climate Change Effect	Current <i>(at 1.1°C average warming)</i>	1.5°C Warming	2°C Warming	Impacts to Human Security
 <b>Heat</b>	5 percent of global population exposed to severe heat waves once in 20 years	14 percent of global population exposed to severe heat waves once in five years	37 percent of global population exposed to severe heat waves once in five years	More intense and frequent heat waves will reduce labor productivity, increase frequency and intensity of wildfires, undermine human health, and lead to loss of life
 <b>Heavy Precipitation and Flooding</b>	25 percent of land with significant increase in once-in-a-century floods	17 percent increased frequency of precipitation extremes over land	37 percent increased frequency of precipitation extremes over land	Increased flooding will lead to economic losses, increased calls for humanitarian assistance, and loss of life
 <b>Drought</b>	Observed increase in frequency and intensity of droughts in southern Europe, northern Africa, and Near East	Around 132 million more people exposed to severe droughts	Around 194 million more people exposed to severe droughts	More frequent, intense, and longer droughts will undermine food security in developing countries, cause more extreme wildfires, increase political instability, and drive migration
 <b>Sea Level Rise</b>	8 to 9 inches higher with the rate of increase doubling in the last 30 years compared to the 20th century	Total projected rise of between 11 and 32 inches, with a median of 19 inches	Total projected rise of between 11 and 38 inches, with a median of 22 inches	Rising sea levels will increasingly imperil coastal cities and exacerbate storm surges that damage infrastructure and inundate water systems
 <b>Arctic Ice Melt</b>	13 percent decline per decade of sea ice extent since 1979 90 percent decline of at least five year old thick ice	Probability of an ice-free summer—defined as less than 15 percent ice concentration—is one every 42 years	Probability of an ice-free summer—defined as less than 15 percent ice concentration—is one every five years	Accelerated melting of Arctic ice sheets will affect ocean circulation and salinity, threaten local ecosystems, and increase competition over resources and transit route access
 <b>Tropical Cyclones</b>	Global annual average has remained level since 1980 but geographic distribution has shifted, with more cyclones in the North Atlantic and northern Indian Oceans	Additional 2.1 category-4 hurricanes per year, compared to 2018 Additional 1.2 category-5 hurricanes per year, compared to 2018	Additional 1.4 category-4 hurricanes per year, compared to 2018 Additional 1.2 category-5 hurricanes per year, compared to 2018	More frequent, destructive, and shifting tracks of cyclones will lead to trillions of dollars in economic losses in tropical zones, increase calls for humanitarian assistance, drive population displacement and migration, and lead to loss of life
 <b>Coral Reefs</b>	33 percent threatened with loss	Projected long-term degradation of 70-90 percent	Projected long-term degradation of more than 99 percent	The disappearance of coral reefs will eliminate an ecosystem that serves 500 million people, impacting economic and food security
 <b>Biodiversity</b>	50 percent of terrestrial mammals and 25 percent of birds already under threat are affected by climate change	8 percent of plants, 6 percent of insects, and 4 percent of vertebrates will lose at least half of their geographic range	16 percent of plants, 18 percent of insects, and 8 percent of vertebrates will lose at least half of their geographic range	Loss of species will increase human health risks and threaten food security

Source: "Climate Change and International Responses Increasing Challenges to US National Security Through 2040" National Intelligence Estimate, Washington, DC, Office of the Director of National Intelligence, October 2021.





## APPENDIX G: Yale/Columbia Environmental Performance Index

The Environmental Performance Index ranks 180 countries on 32 performance indicators across 11 issue categories covering environmental health and ecosystem vitality. These metrics provide a general gauge at a national scale of how close countries are to established environmental policy targets.

**TABLE ES-1.** 2020 EPI rank, score, and regional rank (REG) for 180 countries.

RANK	COUNTRY	SCORE	REG	RANK	COUNTRY	SCORE	REG	RANK	COUNTRY	SCORE	REG
1	Denmark	82.5	1	61	Uruguay	49.1	9	120	Samoa	37.3	12
2	Luxembourg	82.3	2	62	Albania	49.0	16	122	Qatar	37.1	15
3	Switzerland	81.5	3	63	Antigua and Barbuda	48.5	10	123	Zimbabwe	37.0	11
4	United Kingdom	81.3	4	64	Cuba	48.4	11	124	Central African Republic	36.9	12
5	France	80.0	5		St. Vincent and Grenadines	48.4	11	125	Dem. Rep. Congo	36.4	13
6	Austria	79.6	6	66	Jamaica	48.2	13	126	Guyana	35.9	30
7	Finland	78.9	7	67	Iran	48.0	6	127	Maldives	35.6	3
8	Sweden	78.7	8	68	Malaysia	47.9	6		Uganda	35.6	14
9	Norway	77.7	9	69	Trinidad and Tobago	47.5	14	129	Timor-Leste	35.3	14
10	Germany	77.2	10	70	Panama	47.3	15	130	Laos	34.8	15
11	Netherlands	75.3	11	71	Tunisia	46.7	7		Sudan	34.8	16
12	Japan	75.1	1	72	Azerbaijan	46.5	5	132	Kenya	34.7	15
13	Australia	74.9	12	73	Paraguay	46.4	16		Zambia	34.7	15
14	Spain	74.3	13	74	Dominican Republic	46.3	17	134	Ethiopia	34.4	17
15	Belgium	73.3	14		Montenegro	46.3	17		Fiji	34.4	16
16	Ireland	72.8	15	76	Gabon	45.8	2	136	Mozambique	33.9	18
17	Iceland	72.3	16	77	Barbados	45.6	18	137	Eswatini	33.8	19
18	Slovenia	72.0	1	78	Bosnia and Herzegovina	45.4	18		Rwanda	33.8	19
19	New Zealand	71.3	17		Lebanon	45.4	8	139	Cambodia	33.6	17
20	Canada	71.0	18		Thailand	45.4	7		Cameroon	33.6	21
	Czech Republic	71.0	2	81	Suriname	45.2	19	141	Viet Nam	33.4	18
	Italy	71.0	18	82	Mauritius	45.1	3	142	Pakistan	33.1	4
23	Malta	70.7	20		Tonga	45.1	8	143	Micronesia	33.0	19
24	United States of America	69.3	21	84	Algeria	44.8	9	144	Cabo Verde	32.8	22
25	Greece	69.1	3	85	Kazakhstan	44.7	6	145	Nepal	32.7	5
26	Slovakia	68.3	4	86	Dominica	44.6	20	146	Papua New Guinea	32.4	20
27	Portugal	67.0	22	87	Moldova	44.4	7	147	Mongolia	32.2	21
28	South Korea	66.5	2	88	Bolivia	44.3	21	148	Comoros	32.1	23
29	Israel	65.8	1		Uzbekistan	44.3	8	149	Guatemala	31.8	31
30	Estonia	65.3	5	90	Peru	44.0	22	150	Tanzania	31.1	24
31	Cyprus	64.8	6		Saudi Arabia	44.0	10	151	Nigeria	31.0	25
32	Romania	64.7	7	92	Turkmenistan	43.9	9	152	Marshall Islands	30.8	22
33	Hungary	63.7	8	93	Bahamas	43.5	23		Niger	30.8	26
34	Croatia	63.1	9	94	Egypt	43.3	11		Republic of Congo	30.8	26
35	Lithuania	62.9	10	95	El Salvador	43.1	24	155	Senegal	30.7	28
36	Latvia	61.6	11		Grenada	43.1	24	156	Eritrea	30.4	29
37	Poland	60.9	12		Saint Lucia	43.1	24	157	Benin	30.0	30
38	Seychelles	58.2	1		South Africa	43.1	4	158	Angola	29.7	31
39	Singapore	58.1	3	99	Turkey	42.6	19	159	Togo	29.5	32
40	Taiwan	57.2	4	100	Morocco	42.3	12	160	Mali	29.4	33
41	Bulgaria	57.0	13	101	Belize	41.9	27	161	Guinea-Bissau	29.1	34
42	United Arab Emirates	55.6	2	102	Georgia	41.3	10	162	Bangladesh	29.0	6
43	North Macedonia	55.4	14	103	Botswana	40.4	5	163	Vanuatu	28.9	23
44	Chile	55.3	1	104	Namibia	40.2	6	164	Djibouti	28.1	35
45	Serbia	55.2	15	105	Kyrgyzstan	39.8	11	165	Lesotho	28.0	36
46	Brunei Darussalam	54.8	5	106	Iraq	39.5	13	166	Gambia	27.9	37
47	Kuwait	53.6	3	107	Bhutan	39.3	1	167	Mauritania	27.7	38
48	Jordan	53.4	4	108	Nicaragua	39.2	28	168	Ghana	27.6	39
49	Belarus	53.0	1	109	Sri Lanka	39.0	2		India	27.6	7
50	Colombia	52.9	2	110	Oman	38.5	14	170	Burundi	27.0	40
51	Mexico	52.6	3	111	Philippines	38.4	9		Haiti	27.0	32
52	Costa Rica	52.5	4	112	Burkina Faso	38.3	7	172	Chad	26.7	41
53	Armenia	52.3	2		Malawi	38.3	7		Solomon Islands	26.7	24
54	Argentina	52.2	5	114	Tajikistan	38.2	12	174	Madagascar	26.5	42
55	Brazil	51.2	6	115	Equatorial Guinea	38.1	9	175	Guinea	26.4	43
56	Bahrain	51.0	5	116	Honduras	37.8	29	176	Côte d'Ivoire	25.8	44
	Ecuador	51.0	7		Indonesia	37.8	10	177	Sierra Leone	25.7	45
58	Russia	50.5	3	118	Kiribati	37.7	11	178	Afghanistan	25.5	8
59	Venezuela	50.3	8	119	São Tomé and Príncipe	37.6	10	179	Myanmar	25.1	25
60	Ukraine	49.5	4	120	China	37.3	12	180	Liberia	22.6	46



## APPENDIX H: United Nations Sustainable Development Goals (SDGs)



- Goal 1 End poverty in all its forms everywhere.
- Goal 2 End hunger, achieve food security and improved nutrition and promote sustainable agriculture.
- Goal 3 Ensure healthy lives and promote well-being for all at all ages.
- Goal 4 Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.
- Goal 5 Achieve gender equality and empower all women and girls.
- Goal 6 Ensure availability and sustainable management of water and sanitation for all.
- Goal 7 Ensure access to affordable, reliable, sustainable and modern energy for all.
- Goal 8 Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all.
- Goal 9 Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.
- Goal 10 Reduce inequality within and among countries.
- Goal 11 Make cities and human settlements inclusive, safe, resilient and sustainable.
- Goal 12 Ensure sustainable consumption and production patterns.
- Goal 13 Take urgent action to combat climate change and its impacts.
- Goal 14 Conserve and sustainably use the oceans, seas and marine resources for sustainable development.
- Goal 15 Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.
- Goal 16 Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels.
- Goal 17 Strengthen the means of implementation and revitalize the global partnership for sustainable development.

## **APPENDIX I: Recommendations for Leveraging the Environment/Climate Industry in the Russia-Ukraine Conflict**

**Question:** *Given that U.S. policy is to support Ukraine in this war instigated by Russia, what options are available within the context of the Environment/Climate Industry Study to do so? Include recommendations to support broader U.S. policy.*

### **Background**

Secretary of State Anthony Blinken has stated: “The United States’ commitment to Ukraine’s independence, sovereignty, and territorial integrity is ironclad.”<sup>105</sup> Ukraine, both physically and ideologically, is strategically located between NATO nations and Russia, and should it be completely overtaken by Russia, this would dramatically alter the regional and global balances of power. President Biden has stated that should autocracies win out in the 21st century, “the whole world changes.”<sup>106</sup> The Environment/Climate Industry could support and assist Ukraine in a number of important ways.

### **Environmental Rehabilitation and Restoration**

In war, environmental and health hazards are very often overlooked in the struggle for survival.<sup>107</sup> Extensive environmental damage has already occurred in Ukraine, and it is highly likely that significant portions of Ukraine’s environment will continue to be damaged and destroyed in the future. There have already been fires at nuclear facilities, attacks on ammonia pipelines that released toxic substances, and strikes on chemical plants.<sup>108</sup>

It is important to recognize that war-related damage and deterioration to Ukraine’s environment will only exacerbate and worsen conditions that were already in an imperfect state before the war began. In the 2020 Yale-Columbia Environmental Performance Index, for example, which ranks 180 countries by 32 performance indicators across 11 issue categories, Ukraine ranked 60<sup>th</sup> overall – behind Belarus, Armenia, Russia (ranked 58<sup>th</sup>), and the United States (ranked 24<sup>th</sup>), but well ahead of China (ranked 120<sup>th</sup>). The country ranked 139<sup>th</sup> in the world in biodiversity and habitat, 108<sup>th</sup> in ecosystem services (tree-cover, grassland, and wetland loss), 86<sup>th</sup> in air quality, and 66<sup>th</sup> in sanitation and drinking water. Similarly, in the 2021 Sustainable Development Goals Index, the country ranked 36<sup>th</sup> out of 165 countries (compared with the U.S. at 32<sup>nd</sup>, Russia at 46<sup>th</sup>, and China at 57<sup>th</sup>), with major challenges in life below water and life on land, and significant challenges in clean water and sanitation and infrastructure.

The environmental damage of today will remain problematic for years into the future. Even now, a large fire that began at a Ukrainian oil depot on May 8, 2022, continues to burn and can’t be extinguished because of constant Russian shelling.<sup>109</sup> The current conflict rages on and, with it, environmental damage continues unabated.

The U.S. must provide environmental expertise and available resources to Ukraine, in conjunction with partner nations, to prevent and mitigate environmental destruction while helping to protect the civilian population. Damage to the environment always lasts much longer than the actual conflict itself. The U.S. can help to remove munitions (as Russia is rumored to employ land mines in Ukraine), remediate hazardous waste sites (like Chernobyl), and help Ukraine develop sustainability goals and strategies for long-term environmental rehabilitation and restoration. In more general terms, the very

structure of the Environmental Industry, as defined by Environmental Business International, the most authoritative source of data on the industry, provides a window on the full range of U.S. capabilities this sector can bring to bear in Ukraine: Environmental Services (Analytical Services, Wastewater Treatment, Solid Waste Management, Hazardous Waste Management, Remediation/Industrial Services, Consulting and Engineering); Environmental Equipment (Water Equipment and Chemicals, Instruments and Information Systems, Air Pollution Control Equipment, Waste Management Equipment); and Resource Management (Water Utilities, Resource Recovery, Clean Energy Systems and Power).

### **Infrastructure and Utilities Resilience/Rebuild**

Ukraine needs assistance along two fronts in particular: ensuring resiliency for current infrastructure and rapidly rebuilding destroyed infrastructure. Ukraine's internal infrastructure is being systematically damaged or destroyed by Russia (to include, for example, Russian occupation of the Chernobyl power plant. A joint statement between the U.S. Department of Energy and the Ministry of Energy of Ukraine has stressed the need to ensure the resiliency of Ukraine's critical energy infrastructure and mitigate malign efforts to disrupt Ukraine's ability to meet the energy needs of its civilians.<sup>110</sup> Resilient infrastructure is needed now, not just after the conflict, to ensure that the current situation doesn't spiral into an even worse humanitarian crisis than at present where people are cut off from utility access.

In the aftermath of the current conflict, rebuilding the utilities infrastructure will be a mammoth undertaking ~~that~~ the U.S. can help lead. The U.S. has in-depth expertise on water, waste, and energy systems and is uniquely positioned to support and even facilitate Ukraine's integration into the European Union and the attendant closer ties in the utilities sector. In addition, the U.S. can help Ukraine with smart-grid technologies, battery energy storage systems, and rebuilding resilient utilities infrastructure. The key to a peaceful and prosperous Ukraine will lie, in important measure, in the country's willingness to sever ties to Russian utilities and integrate with the European Union.

### **Pivot to Renewable and Non-Russian Energy Sources**

Russia's unprovoked invasion of Ukraine has illustrated the problematic nature of U.S. allies who are heavily dependent on Russian energy sources. Even before this invasion, President Biden stated that Russia remained determined to play a disruptive role on the world stage.<sup>111</sup> It is essential that the U.S. use its expertise and available resources to help Ukraine pivot to renewable energy sources and allow for greater independence from Russian energy sources. Today's conflict has only exacerbated the need to develop and implement renewable energy sources quickly.

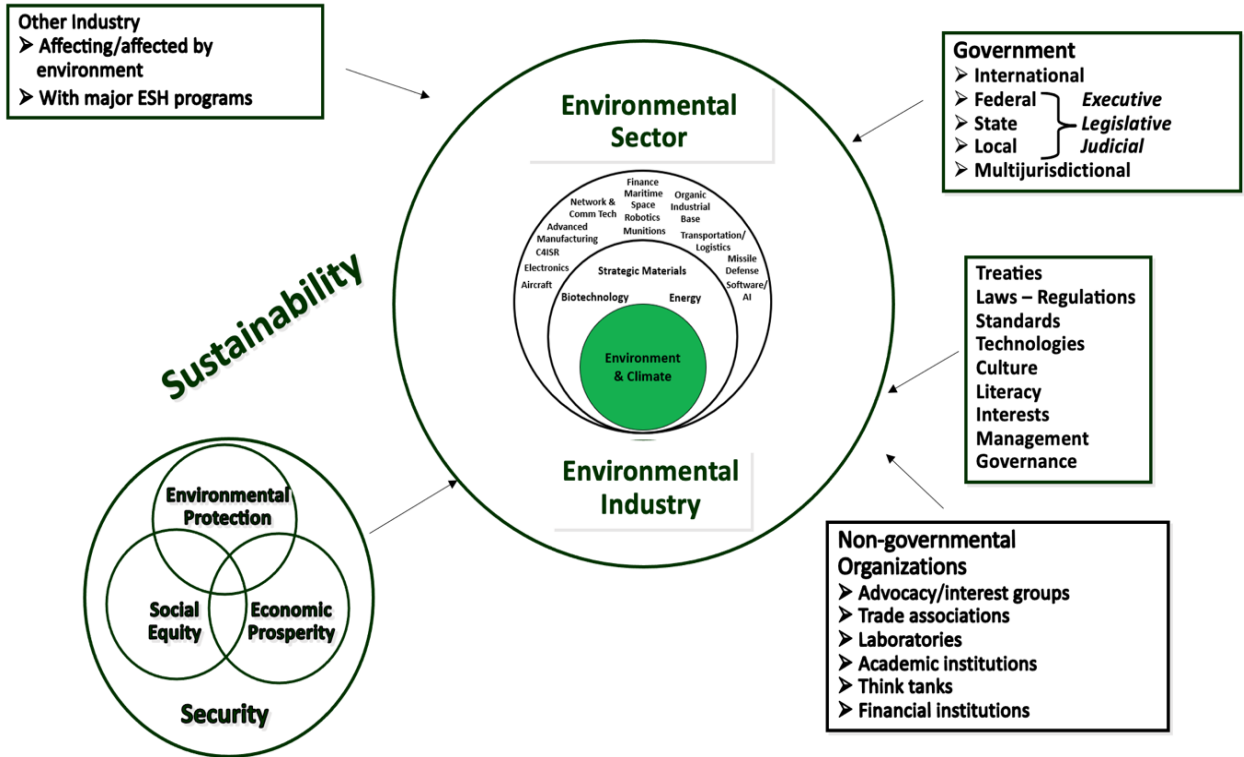
The U.S. must work with Ukraine and allies to replace Russian fossil fuels with other fossil fuel sources and, more importantly, renewable energy capabilities — e.g., wind and solar — that collectively reduce the harm to Ukraine's environment.

## APPENDIX J: Environmental Great Power Rankings

	EPI Rank	SDG Rank	Adjusted Spillover Rank	CCPI Rank	Adjusted Rank	Emissions Per Capita	Rank w/per capita	GDP per capita (in \$1,000)
Denmark	1	3	16	4	6	4.43	26.58	58.9
Norway	9	7	11	6	33	13.24	436.92	65.8
UK	4	17	9	7	37	4.07	150.59	44.1
Switzerland	3	16	5	15	39	4.66	181.74	72.8
Sweden	8	2	25	5	40	7.25	290	54.1
France	5	8	10	17	40	4.26	170.4	46
Germany	10	4	15	13	42	7.29	306.18	54
Finland	7	1	31	14	53	4.18	221.54	49.8
Austria	6	6	12	36	60	7.74	464.4	55.2
Luxembourg	2	42	3	18	65	7.72	501.8	118
US	24	32	20	55	131	13.68	1792.08	63.4
Russia	58	46	47	56	207	11.64	2409.48	27.9
China	120	57	85	60	322	8.2	2640.4	17.1
India	168	120	134	10	432	1.74	751.68	6.4

APPENDIX K: Environment & Climate Change Industry Ecosystem

# Environment & Climate Industry Ecosystem



## APPENDIX L: Environment Industry Revenue, Growth, and Participation by Segment

**Exhibit 1-4 The U.S. Environmental Industry in 2017-2019 (\$bil)**

INDUSTRY SEGMENT	2017	17Growth	2018	Growth	2019e	Growth
<b>Environmental Services</b>						
Analytical Services	2.0	2.3%	2.1	2.2%	2.1	2.1%
Wastewater Treatment Works	61.2	3.6%	63.1	3.0%	65.3	3.5%
Solid Waste Management	62.9	3.1%	64.6	2.6%	66.4	2.8%
Hazardous Waste Management	10.9	0.3%	11.0	0.6%	11.0	0.5%
Remediation/Industrial Services	14.0	2.4%	14.2	1.2%	14.4	1.8%
Consulting & Engineering	31.3	4.0%	32.7	4.3%	33.8	3.4%
<b>Environmental Equipment</b>						
Water Equipment and Chemicals	31.8	3.8%	32.8	3.1%	33.8	3.0%
Instruments & Info sSystems	7.5	5.4%	7.9	5.4%	8.3	5.4%
Air Pollution Control Equipment	17.4	3.6%	17.3	-0.5%	17.2	-0.5%
Waste Management Equipment	15.6	3.2%	15.8	1.4%	16.0	0.8%
<b>Resource Management</b>						
Water Utilities	59.2	4.4%	61.8	4.3%	64.4	4.2%
Resource Recovery	26.1	2.2%	23.0	-11.9%	21.6	-6.0%
Clean Energy Systems & Power	42.9	8.6%	48.5	13.1%	54.8	13.0%
<b>TOTALS:</b>	<b>382.8</b>	<b>4.0%</b>	<b>394.5</b>	<b>3.0%</b>	<b>408.9</b>	<b>3.7%</b>

Source: Environmental Business Journal, units in \$bil.

**Exhibit 1-5 The U.S. Environmental Industry: Share of Small Companies in 2018**

INDUSTRY SEGMENT	BY NUMBER OF COMPANIES			BY REVENUE %			
	small business	big business	mun/s	small biz	big biz	mun/s	rev \$bil
<b>SERVICES</b>							
Analytical Services	810	6	0	59%	41%	0%	2.1
Wastewater Treatment Works	11,400	6	14,780	3%	1%	96%	63.1
Solid Waste Management	10,730	16	80,000	4%	65%	31%	64.6
Hazardous Waste Management	630	15	0	29%	67%	4%	11.0
Remediation/Industrial Svcs.	2,110	26	0	34%	66%	0%	14.2
Consulting & Engineering	3,230	77	0	27%	73%	0%	32.7
<b>EQUIPMENT</b>							
Water Equipment & Chemicals	2,020	33	0	24%	76%	0%	32.8
Instruments & Info. Systems	590	13	0	33%	67%	0%	7.7
Air Pollution Control Equipment	1,570	17	0	36%	64%	0%	17.3
Waste Management Equipment	750	11	0	47%	53%	0%	15.8
<b>RESOURCES</b>							
Water Utilities	26,700	20	34,200	20%	22%	58%	61.8
Resource Recovery	5,530	22	0	28%	55%	17%	23.0
Clean Energy Systems & Power	2,460	19	0	36%	61%	3%	48.5
<b>Totals:</b>	<b>68,530</b>	<b>281</b>	<b>128,980</b>	<b>21%</b>	<b>48%</b>	<b>31%</b>	<b>394.3</b>

Source: EBJ, Environmental Business International, Inc., San Diego, Copyright EBI Inc. Note: Small business designations vary by segment, but generally the top end are in the \$40-100 million range.



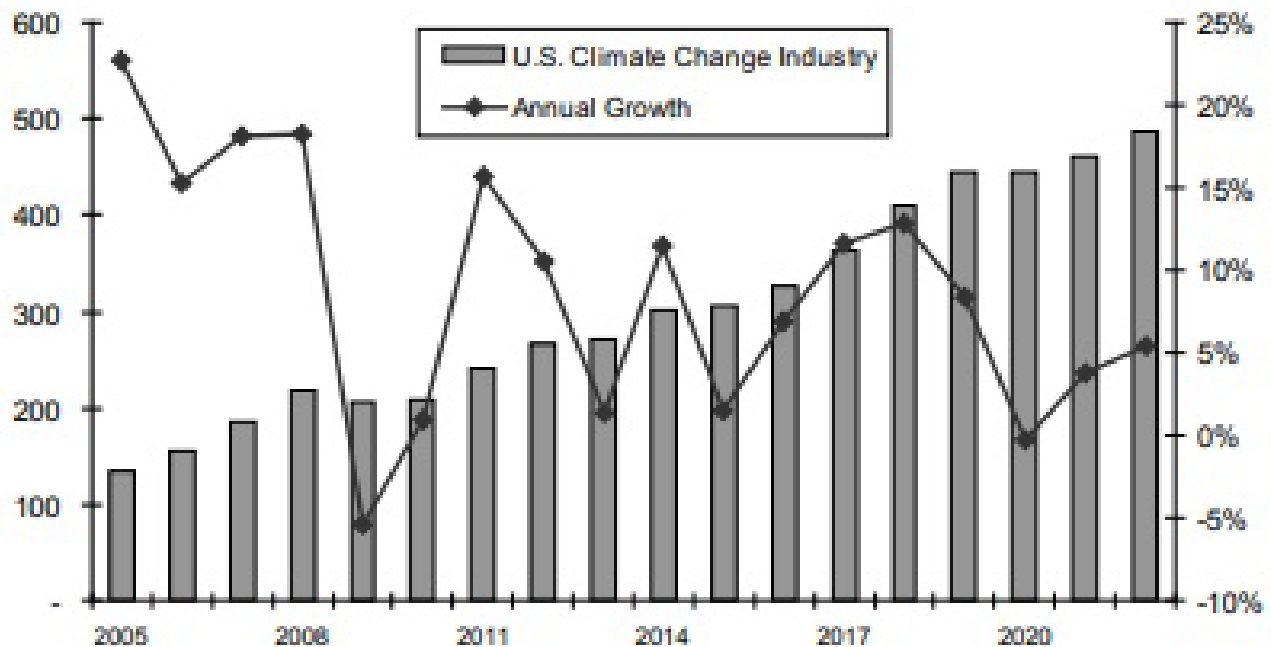
## APPENDIX M: Climate Change Industry Revenue and Growth 2019

### USA vs. Global Climate Change Industry in 2019 (\$billion)

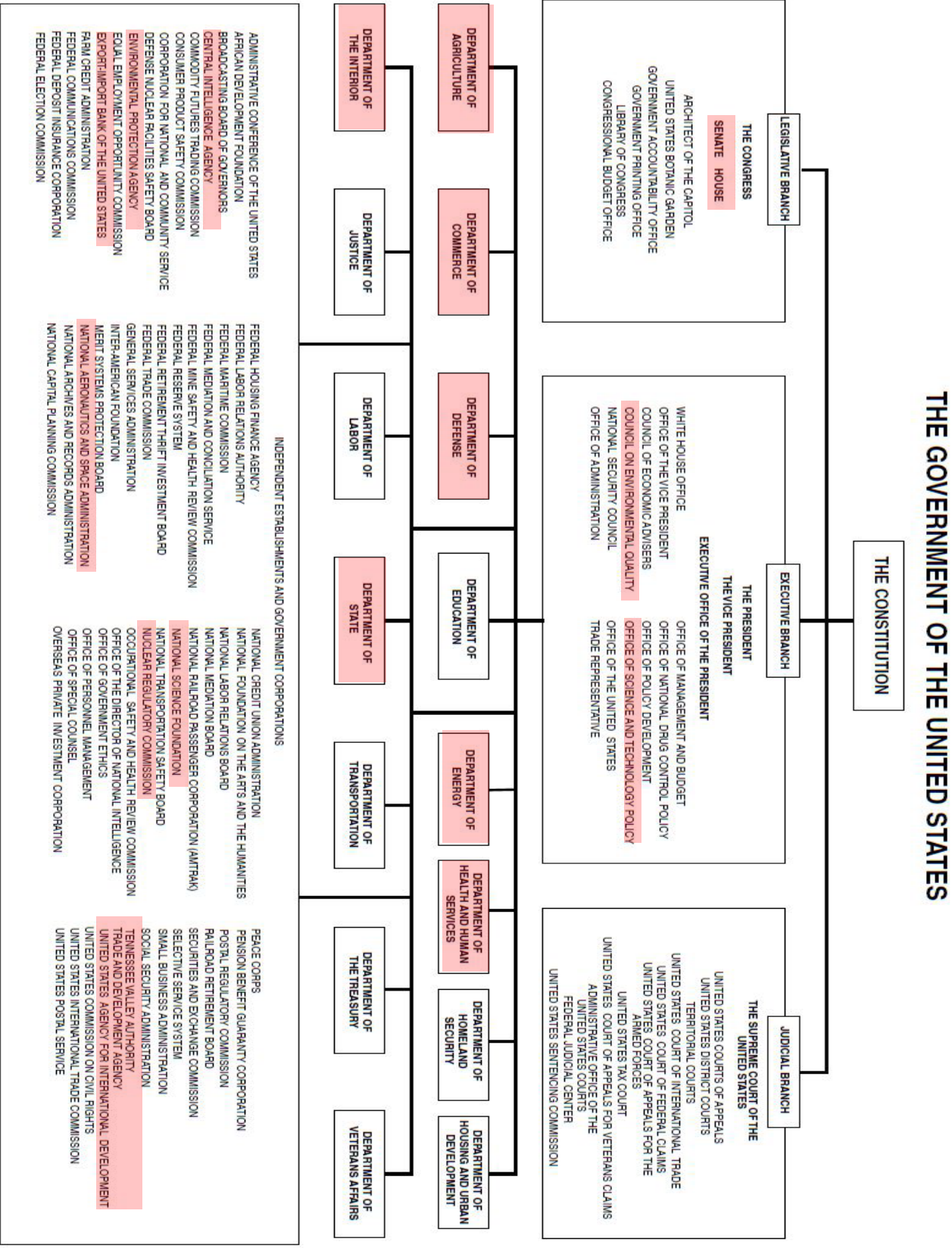
	USA 2019 (\$bil)	Global 2019 (\$bil)	% USA in 2019
Renewable Energy & Clean Power	66.6	544.8	12.2%
Carbon Capture & Storage	1.1	1.3	83.5%
Energy Efficiency & DR	70.5	284.6	24.8%
Energy Storage	2.0	9.8	20.2%
Green Buildings	171.3	761.2	22.5%
Transportation	104.9	583.1	18.0%
Carbon Markets	25.0	215.4	11.6%
Adaptation & Resilience	2.4	7.4	32.6%
Mitigation Consulting & Research	1.7	8.5	20.0%
<b>Total Climate Change Industry</b>	<b>445.5</b>	<b>2,416.0</b>	<b>18.4%</b>
<b>Environmental Industry</b>	<b>408.9</b>	<b>1,293.3</b>	<b>31.6%</b>
<b>Economic Output (GDP &amp; GWP)</b>	<b>19,083.1</b>	<b>86,137.2</b>	<b>22.2%</b>

Source: Climate Change Business Journal; Environmental Business International, Inc., San Diego, Calif.

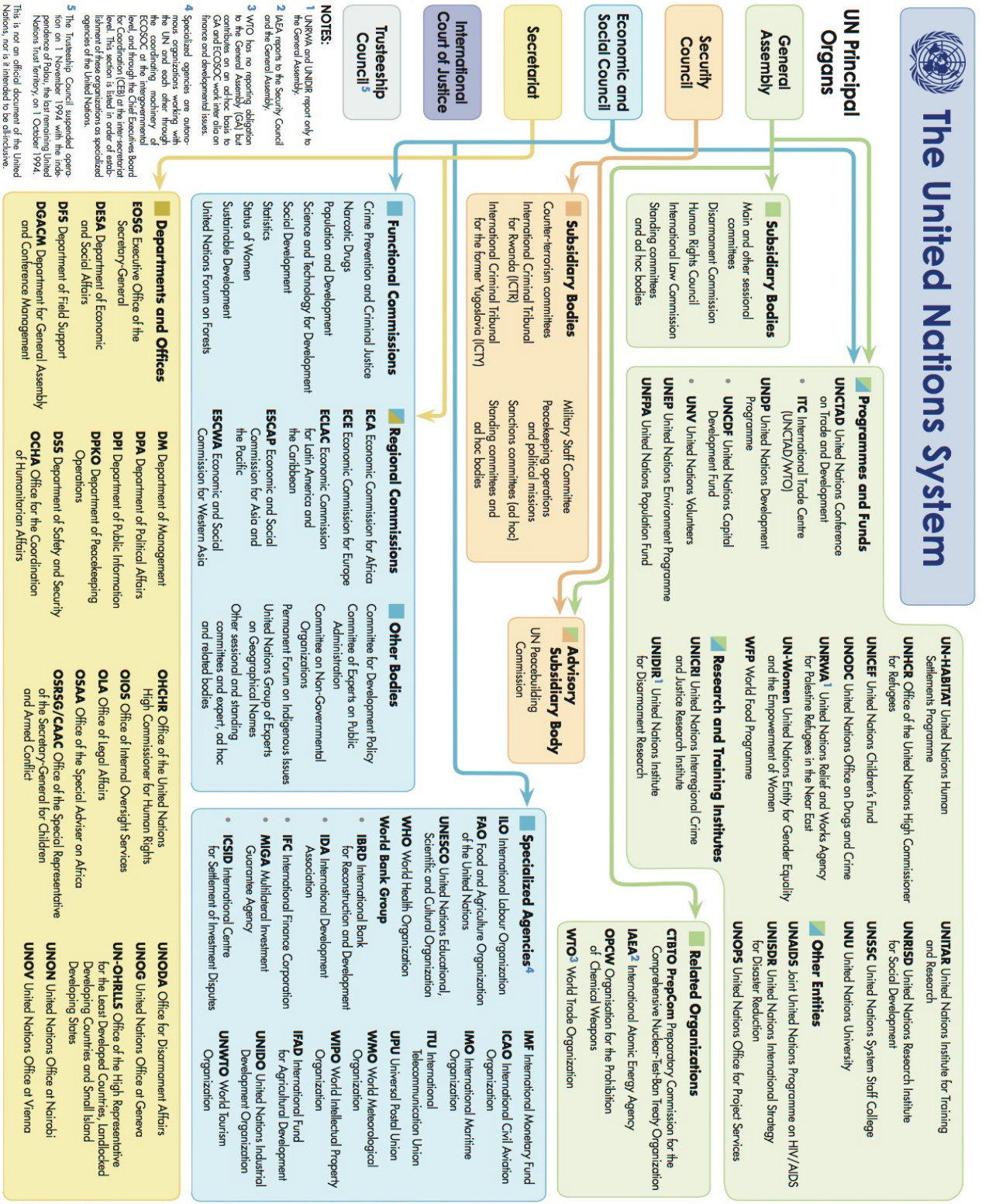
### U.S. Climate Change Industry & Growth (\$billion)



# APPENDIX N: U.S. Government Roles



# APPENDIX O: The United Nations System



Published by the United Nations Department of Public Information  
 DP/2420 rev.2-11 3429-October 2011

## APPENDIX P: Definitions of Environmental Economics Terms

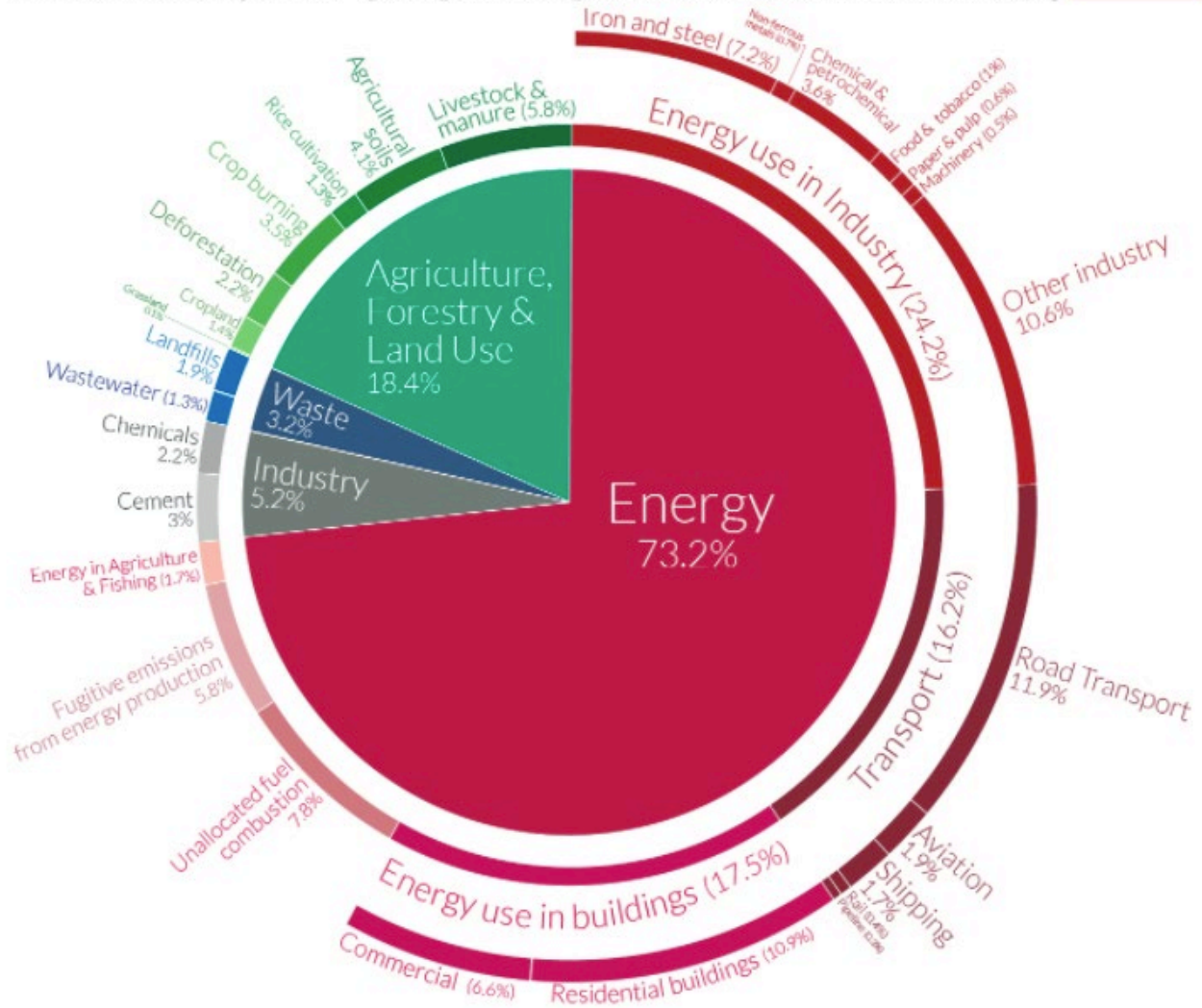
- (1) **Environmental Economics** — the study of the economic effects of environmental policies, focusing on efficient allocation of environmental and natural resources and how alternative policies deal with environmental damage.<sup>112</sup> It is concerned with sustained gross domestic product growth while accepting some loss of flora and fauna.
- (2) **Ecological Economics** — addresses the “cause-effect chains, interactions and feedback between natural and human-economic system.”<sup>113</sup> It argues against continued human encroachment at the cost of species on the planet.
- (3) **Green Economy** — a model, claiming sustainable economic growth requires a balance between the environmental impact of economic growth and the assimilative capacity of the environment.<sup>114</sup> This model incorporates political realities to Ecological Economics.
- (4) **Circular Economy** — a model of production and consumption, involving sharing, leasing, reusing, repairing, refurbishing, and recycling existing materials and products. The life cycle of products is extended, reducing waste to a minimum.<sup>115</sup> Within the United States, this concept is aligned legally in the Resource Conservation and Recovery Act, enacted in 1976.
- (5) **Green Accounting** — accounting practice that attempts to factor environmental costs into the financial results of operations. It argues gross domestic product ignores the environment; therefore, policymakers need a revised model.<sup>116</sup> Its detractors argue that environmental protections negatively impact GDP, whereas advocates state preserving nature is an investment in the future.
- (6) **Socially Responsible Investing (SRI)** — Not unique to environmental economics, SRI is a business/investment strategy based on aligning one’s investment decisions with their personal belief system, taking into account other, non-financial factors such as social good, environmental impact, and religious beliefs.<sup>117</sup> Only about 25 percent of U.S. investors are aware of this type of investing.<sup>118</sup>
- (7) **Eco-investing** — a form of socially responsible investing in “public companies that stand to profit in the near future from our transition to a carbon neutral and sustainable world.”<sup>119</sup>

## Appendix Q: Global Greenhouse Gas Emissions by Sector

# Global greenhouse gas emissions by sector



This is shown for the year 2016 – global greenhouse gas emissions were 49.4 billion tonnes CO<sub>2</sub>eq.



OurWorldinData.org – Research and data to make progress against the world's largest problems.

Source: Climate Watch, the World Resources Institute (2020).

Licensed under CC-BY by the author Hannah Ritchie (2020).

## Appendix R: Addressing Scopes 1, 2, & 3 Emissions

# ADDRESSING SCOPE 1, 2 & 3 EMISSIONS



**SCOPE 1**

Direct emissions from owned or controlled sources

**SAMPLE SOLUTIONS:**

- ✓ Energy efficiency
- ✓ Electrification initiatives
- ✓ Renewable natural gas (Biogas)
- ✓ Carbon credits/project development
- ✓ Refrigerant switching

*Commercial buildings could cut their GHG emissions by*

## 70%

*with efficient design and use of cleaner electricity<sup>1</sup>*



COMBUSTION IN BOILERS, FURNACES, OR VEHICLES OWNED BY AN ORGANIZATION

**SAMPLE SOLUTIONS:**

- ✓ PPA & VPPA
- ✓ Utility voluntary renewable programs
- ✓ Green retail supply
- ✓ Onsite renewables
- ✓ Community solar
- ✓ Energy efficiency
- ✓ Unbundled RECs/EACs



**SCOPE 2**

Indirect emissions from the generation of purchased electricity, steam, heating and cooling consumed by the reporting company



PURCHASED ELECTRICITY

Over **300** companies have committed to RE100 goals<sup>2</sup>



**SCOPE 3**

Emissions that are a consequence of an organization's activities but are not owned or controlled by the organization

**SAMPLE SOLUTIONS:**

- ✓ Supply chain GHG reduction
- ✓ Carbon credits/project development
- ✓ Transportation electrification/decarbonization

*For the Fortune 500 companies that report to CDP, Scope 3 emissions are on average approximately*

## 5.7 TIMES

*their combined Scope 1 and 2 emissions<sup>3</sup>*



UPSTREAM AND DOWNSTREAM TRANSPORTATION, BUSINESS TRAVEL, PRODUCT DISPOSAL

1. <https://www.aceee.org/press/2019/09/energy-efficiency-can-slash>  
 2. <https://www.there100.org/re100-members>  
 3. [https://www.fint.awsassets.panda.org/downloads/power\\_forward\\_4\\_0.pdf](https://www.fint.awsassets.panda.org/downloads/power_forward_4_0.pdf)



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## Appendix S: A Small Sample of Emerging Green/Clean Technologies

### Emerging Technologies

Mitigation Technology	Stage	Cost	Prospective Impacts	Feasibility
Red Seaweed	R&D	Low	Reduce methane	R&D phase - small clinical trials
Pattern AG	Mature	Medium	Increase farm yields	Budgetary prohibitive for farmers
Carbon Mapper	R&D	High	Mitigate methane and carbon dioxide emissions	Still in R&D phase
eFuel	R&D	Medium	Reduce carbon dioxide	Long lead time for eFuel plant - to begin production plant in Chili in mid-2022.
Molten Oxide Electrolysis (MOE)	Mature	Low	Reduce greenhouse gases	Long lead time for commercial steel production
Net Zero Tesside (NZT)	R&D	High	Reduce carbon dioxide	Politically contentious in U.S.
Advanced Weather Forecasting	Mature	High	Advanced hurricane warning	First GPS-RO is past operational life. Currently plan to launch new satellites in 2022 and 2024.
Food Coating	Mature	Low	Decrease food waste	Available but not popular and well known
Genetically Modified Trees	Mature	Low	Reduce greenhouse gas/increase carbon "sinks"	Ideologically contentious
Acoustic Nanotube Technology	Mature	Low	Clean water in low water areas	Patent available for firms to license and evolve for commercial use.

## Appendix T: Key U.S. Environmental Laws

- **Atomic Energy Act (AEA)** – Enacted in 1954, the AEA established the Atomic Energy Commission (AEC) to progress the “utilization of atomic energy for peaceful purposes to the maximum extent consistent with the common defense and security and with the health and safety of the public.”<sup>120</sup> Much of the AEA, which encompasses the development, regulation, and disposal of nuclear materials and facilities in the U.S., is carried out by the Nuclear Regulatory Commission and the U.S. Department of Energy.<sup>121</sup> However, the AEC’s authority to issue generally applicable environmental radiation standards transferred to the U.S. Environmental Protection Agency (EPA), which also received the Federal Radiation Council’s authority under the AEA to (a) Develop guidance for federal and state agencies containing recommendations for their use in developing radiation protection requirements; and (b) Work with states to establish and execute radiation protection programs.<sup>122</sup>
- **Clean Air Act (CAA)** – The establishment of the CAA in 1970 and its 1990 amendment represents a landmark piece of legislation that standardizes the gases and particles placed into the air or released by stationary and mobile sources and “defines EPA’s responsibilities for protecting and improving the Nation’s air quality and the stratospheric ozone layer.”<sup>123 124</sup> Under authorities provided by this Act, the EPA sets goals to (a) Achieve N[ational] A[m]bient A[ir] Q[uality] S[tandards (NAAQS)] in every state by 1975; (b) Protect public health and public welfare; and (c) Regulate emissions of hazardous air pollutants.”<sup>125</sup> Since several states neglected to attain the goals, Congress amended the Act in 1977 and 1990 to establish new dates for attaining NAAQS.<sup>126</sup> Significant environmental and public health benefits have occurred across the U.S. since the signing of the amendments.
- **Clean Water Act (CWA)** – Initially termed the Federal Water Pollution Control Act and enacted in 1948, the CWA forms the foundational construct for (a) Controlling the release of contaminants into streams, rivers, and other waters of the U.S.; and (b) Governing the quality standards for “any body of water above ground, including streams, rivers, lakes, wetlands, reservoirs, and creeks” (i.e., surface waters).<sup>127 128</sup> The public’s growing level of understanding regarding the importance and implications of controlling water pollution led to sweeping reforms and ultimately amendments, in 1972, to what universally became known as the “Clean Water Act.” Under the CWA, EPA established national water quality criteria for contaminants in surface waters; and wastewater standards for industrial effluent.<sup>129</sup> The CWA constitutes it illegal, without authorization, to emit contaminants from “any discernible, confined, and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft” (i.e., a point source) into “the waters of the United States, including the territorial seas” (i.e., navigable waters).<sup>130 131</sup>
- **Comprehensive Environmental Response, Compensation and Liability Act (CERCLA)** – CERCLA was established in 1980 and created the “Superfund” by taxing the chemical and petroleum industries.<sup>132</sup> The Act creates a trust fund to finance cleanup efforts when responsible parties cannot be named and gives the EPA the ability to force responsible parties to remediate contaminated locations damaged by hazardous waste or provide reimbursement for EPA-led efforts.<sup>133</sup> CERCLA functions on four baseline objectives: (a) protecting human health and the environment; (b) holding responsible parties accountable for the cleanup; (c) involving communities in the cleanup process; and (d) returning contaminated sites to productive use.<sup>134</sup> As of March 18, 2022, CERCLA has effectively returned four hundred and forty-seven contaminated sites on its National Priorities List (NPL) to productive use.<sup>135</sup> Commensurate with being the Nation’s largest polluter, DoD possesses approximately one hundred and forty contaminated sites on the NPL still awaiting Superfund cleanup, with two additional sites proposed for the NPL.<sup>136 137</sup>
- **Emergency Planning and Community Right-to-Know Act (EPCRA)** – The 1984 accidental release of methyl isocyanate prompted “concerns regarding the environmental and safety hazards posed by the storage and handling of toxic chemicals.”<sup>138</sup> The concerns ultimately led to the passing of the RPCRA in 1986. The Act is “to help communities plan for chemical emergencies. It also requires the industry to report on the storage, use, and release of hazardous substances to federal, state, and local governments. EPCRA requires state and local governments and Indian tribes to use this [right-to-know] information to prepare for and protect their communities from potential risks.”<sup>139</sup>



- **Endangered Species Act (ESA)** – The realization that many of the country’s native plants and animals would vanish without implementing safeguard measures provoked Congress to enact the ESA in 1973. In doing so, Congress “distinguish[ed] that the natural heritage of the U.S. was of an “esthetic, ecological, educational, recreational, and scientific value to our Nation and its people.”<sup>140</sup> Under the ESA, the National Oceanic and Atmospheric Administration Fisheries and the U.S. Fish and Wildlife Service share the jurisdiction over and responsibility to protect endangered species (i.e., species that are in danger of extinction throughout all or a significant portion of their range); threatened species (i.e., species that are likely to become endangered in the foreseeable future); and critical habitats. Specific areas are (a) Within the geographical area occupied by the species at the time of listing (i.e., if they contain physical or biological features essential to conservation and those features may require special management considerations or protection); and (b) Outside the geographical area occupied by the species (i.e., if the agency determines the area itself is essential for conservation).<sup>141</sup>
- **Energy Independence and Security Act (EISA) (2007)** – Signed in 2007, “EISA aims to (a) move the United States toward greater energy independence and security; (b) increase the production of clean renewable fuels; (c) protect consumers; (d) increase the efficiency of products, buildings, and vehicles; (e) promote research on and deploy greenhouse gas capture and storage options; (f) improve the energy performance of the Federal Government; and (g) increase U.S. energy security, develop renewable fuel production, and improve vehicle fuel economy.”<sup>142</sup> The Act ultimately seeks “to improve vehicle fuel economy and reduce U.S. dependence on petroleum” through three key provisions on corporate fuel economy, renewable fuel, and appliance and lighting efficiency.<sup>143 144</sup> Thus, EISA reinforces the energy reduction goals for federal agencies presented in Executive Order 13423 while introducing more assertive conditions.<sup>145</sup>
- **Energy Policy Act (EPAct)** – The passage of the EPAct in 1992 illustrates the consensus for a new federal role that includes promoting competitive forces and embracing more governmental involvement in the energy sector.<sup>146</sup> In particular, “the Act addresses energy production in the U.S., including energy efficiency; renewable energy; oil and gas; coal; Tribal energy; nuclear matters and security; vehicles and motor fuels, including ethanol; hydrogen; electricity; energy tax incentives; hydropower and geothermal energy; and climate change technology. For example, the Act provides loan guarantees for entities that develop or use innovative technologies that avoid the by-production of Greenhouse Gases (GHG). [In 2005,] another provision of the Act increases the amount of biofuel that must be mixed with gasoline sold in the United States.”<sup>147</sup> A second provision of the EPAct refocused the U.S. Department of Energy’s research and development programs in 2020.<sup>148</sup>
- **Federal Food, Drug, and Cosmetic Act (FFDCA)** – The enactment of the FFDCA resulted shortly after inadequacies in the 1906 Pure Food and Drug Act became obvious. Thus, “Congress crafted the modern [F]FDCA in 1938, requiring drug manufacturers to submit an application showing that new drugs were safe before they could be marketed, and gave FDA the authority to regulate [the safety of food,] cosmetics and medical devices.”<sup>149</sup> The 2002 provision of the Act also authorized “EPA to set tolerances, or maximum residue limits, for pesticide residues on foods.”<sup>150</sup>
- **Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)** – “Congress enacted the original version of FIFRA in 1947, but a revision in 1972 is the basis of current pesticide policy. Substantial changes were made in 1988, with a focus on the reregistration of older pesticides.”<sup>151</sup> Ultimately, FIFRA regulates pesticide registration while ensuring protection of the environment; distribution, sale, and use of pesticides in the U.S.; and safety of those using them.
- **Lautenberg Chemical Safety Act** – The Frank R. Lautenberg Chemical Safety for the 21st Century Act (i.e., Lautenberg Chemical Safety Act) was signed into law in 2016 and “amends the Toxic Substances Control Act (TSCA), the Nation’s primary chemicals management law.”<sup>152</sup> The Act provides a “consistent source of funding for EPA to carry out the responsibilities under the new law, which encompasses a mandatory requirement for EPA to evaluate existing chemicals with clear and enforceable deadlines; risk-based chemical assessments; and increased public transparency for chemical information.”<sup>153</sup>
- **Magnuson-Stevens Fishery Conservation and Management Act** – The Magnuson-Stevens Fishery Conservation and Management Act is commonly referred to as the “Magnuson-Stevens Act (MSA)” and consists of the principal law that “governs marine fisheries management in U.S. federal waters.”<sup>154</sup> Signed into law in

1976, MSA advances “the long-term biological and economic sustainability of marine fisheries” through (a) preventing overfishing; (b) rebuilding overfished stocks; (c) increasing long-term economic and social benefits; (d) ensuring a safe and sustainable supply of seafood; and (e) protecting [the] habitat that fish need to spawn, breed, feed, and grow to maturity.”<sup>155</sup> Congress has passed two significant improvements to MSA. The first was in 1996 and comprised the Sustainable Fisheries Act, which “enacted numerous science, management, and conservation mandates. It recognized the importance of healthy habitat for commercial and recreational fisheries.”<sup>156</sup> The second was the MSA Reauthorization Act of 2007, which honed fisheries science, management, and conservation by (a) establishing annual catch limits and accountability measures; (b) promoting market-based management strategies; (c) strengthening ... peer review[s], scientific and statistical committees, and the Marine Recreational Information Program; and (d) enhancing international cooperation by addressing illegal, unregulated, and unreported fishing and bycatch.<sup>157</sup>

- **Marine Mammal Protection Act (MMPA)** – Enacted in 1972, the MMPA “established a national policy to prevent marine mammal species and population stocks from declining beyond the point where they ceased to be significant functioning elements of the ecosystems of which they are a part.”<sup>158</sup> MMPA protects all marine mammals while shifting the U.S.’s conservation efforts from species to the ecosystem. In an effort “to protect all marine mammals, the MMPA prohibits the “taking” [(i.e., to hunt, harass, capture, or kill any marine mammal or attempting to do so)] of any marine mammal species in U.S. waters; and the import and export of marine mammals and their parts or products.”<sup>159</sup> In 1992, the Act’s initial amendment incorporated Title IV and the Marine Mammal Health and Stranding Response Program.<sup>160</sup> Modified in 2000, Title IV incorporated the “John H. Prescott Marine Mammal Rescue Assistance Grant Program, which provides grants or cooperative agreements to eligible stranding network participants for recovery and treatment (i.e., rehabilitation) of stranded marine mammals; data collection from living or dead stranded marine mammals; and facility upgrades, operational costs, and staffing needs that are directly related to the recovery and treatment of stranded marine mammals; and the collection of data from living or dead stranded marine mammals.”<sup>161</sup> In 1994, the second modification to MMPA occurred to provide (a) a statutory definition of the term “harassment,” which is a prohibited activity; (b) certain exceptions to the moratorium on take, including for takes of small numbers of marine mammals incidental to specified activities, when access by Alaska Natives to marine mammal subsistence resources can be preserved, and the general authorization for scientific research; (c) [Marine Mammal Authorization] Program to authorize and reduce the taking of marine mammals incidental to commercial fishing operations; (d) a requirement to prepare Stock Assessments [Reports] for all marine mammal stocks in waters under U.S. jurisdiction; and (e) studies of interactions between pinnipeds [(i.e.,] seals and sea lions) and fisheries.”<sup>162</sup>
- **Marine Protection, Research, and Sanctuaries Act (MPRSA)** – Enacted in 1972, the first two titles of MPRSA are commonly referred to as the “Ocean Dumping Act” as they essentially ban transportation of material from the United States for the purpose of ocean dumping; transportation of material from anywhere for the purpose of ocean dumping by U.S. agencies or U.S.-flagged vessels; and dumping of material transported from outside the United States into the U.S. territorial sea.”<sup>163</sup> Under MPRSA, a permit application and issuance are required from the EPA to stray from the bans. The benchmark for permit issuance is whether the dumping will “unreasonably degrade or endanger” human health, welfare, or the marine environment.<sup>164</sup>
- **Migratory Bird Treaty Act (MBTA)** – The Act implements four international conservation treaties that the U.S. entered into with Canada in 1916, Mexico in 1936, Japan in 1972, and Russia in 1976 to ensure the sustainability of populations of all protected migratory bird species.<sup>165</sup> MBTA forbids the killing, capturing, taking, selling, trading, and transporting of protected migratory bird species without prior authorization by the U.S. Department of the Interior’s U.S. Fish and Wildlife Service, which manages migratory birds on behalf of the U.S.<sup>166</sup>
- **National Environmental Policy Act (NEPA)** – Enacted by the 91<sup>st</sup> U.S. Congress under Public Law 91-190, NEPA became effective on January 1, 1970. It was the first noteworthy environmental law in the U.S. and is considered by many as the “Magna Carta” of Federal environmental laws.<sup>167</sup> As the U.S.’s overarching environmental policy for more than forty years now, NEPA pertains to “major federal actions significantly affecting the quality of the human environment” and serves as the basis for numerous advances in the nation’s environmental laws.<sup>168</sup> It results in cleaner water, purer air, and an environment that is more protected and healthier overall. With indispensable due diligence for federal planning and decision-making, NEPA, coupled with its collaborative review procedures, engages millions of Americans; provides citizens and communities the

chance to vocalize concerns about the influence of federal acts on well-being, security, ecosystem, and society; and compels the federal government to consider sounder options in developing more holistic solutions to dilemmas.<sup>169</sup> Thus, “NEPA protects people by providing transparency in federal projects[,] much like the Magna Carta protected people from the dangers of monarchical rule.”<sup>170</sup>

- **National Marine Sanctuaries Act (NMSA)** – In 1972, NMSA was first passed into law with a “primary objective to protect marine resources, such as coral reefs, sunken historical vessels, and unique habitats.”<sup>171</sup> Amended and reauthorized multiple times, the Act “authorize[d] the U.S. Secretary of Commerce to designate and protect areas of the marine environment with special national significance (i.e., due to their conservation, recreational, ecological, historical, scientific, cultural, archeological, educational, or esthetic qualities as national marine sanctuaries).”<sup>172</sup> Presently, the National Marine Sanctuary System includes fifteen national marine sanctuaries, five national marine monuments, and a network of underwater parks encompassing more than 600,000 square miles of marine and Great Lakes waters, spanning from Washington state to the Florida Keys.<sup>173</sup>
- **National Wildlife Refuge System Administration Act (NWRSA)** – Passed by Congress in 1966, the NWRSA consolidated the authorities administered by the Secretary for the Conservation of Fish and Wildlife and the Secretary of Wildlife Refuges under the “National Wildlife Refuge System” and “provide[d] authority, guidelines and directives for the [U.S. Fish and Wildlife] Service to (a) improve the National Wildlife Refuge System; (b) administer a national network of lands and waters for the conservation, management, and restoration of fish, wildlife and plant resources and habitat; (c) ensure the biological integrity, diversity, and environmental health of refuges [are] maintained; (d) define compatible wildlife-dependent recreation as appropriate general public use of refuges; (e) establish hunting, fishing, wildlife observation, photography, and environmental education as priority uses; (f) establish a formal process for determining compatible uses of refuges; and (g) provide for public involvement in developing comprehensive conservation plans for refuges.”<sup>174 175</sup>
- **Noise Control Act (NCA)** – Whether produced by vehicles and equipment, machinery, appliances, or other products in commerce, the NCA is the national policy to promote an environment free from noise that jeopardizes Americans’ health and welfare.<sup>176</sup> The Act also establishes a means for effective coordination of Federal research and activities in noise control; authorize[s] the establishment of Federal noise emission standards for products distributed in commerce; and provide[s] information to the public respecting the noise emission and noise reduction characteristics of such products.”<sup>177</sup>
- **Nuclear Waste Policy Act (NWPA)** – NWPA was enacted in 1982 to support deep geologic repositories for the safe storage and/or disposal of high-level radioactive waste and spent nuclear fuel.<sup>178</sup> The Act establishes a program of research, development, and demonstration regarding the disposal of high-level radioactive waste and spent nuclear fuel, and for other purposes<sup>179</sup>; and procedures to evaluate and select sites for geologic repositories and interact [with] state and federal governments.<sup>180</sup> NWPA also specifies “a timetable of key milestones the federal agencies must meet in carrying out the program. The NWPA assigns the [U.S.] Department of Energy (DOE) the responsibility to site, build, and operate a deep geologic repository for the disposal of high-level waste and spent nuclear fuel. It directs EPA to develop standards for [the] protection of the general environment from offsite releases of radioactive material in repositories. The Act directs the Nuclear Regulatory Commission to license DOE to operate a repository only if it meets EPA’s standards and all other relevant requirements.”<sup>181</sup>
- **Occupational Safety and Health Act (OSHA)** – The rising number of workplace hazards coupled with related accidents, injuries, and deaths of the Nation’s workers ultimately led to the enactment of OSHA. In 1970, Congress declared its intent to “make sure employers provide their workers a place of employment [that is] free from recognized hazards to safety and health, such as exposure to toxic chemicals, excessive noise levels, mechanical dangers, heat or cold stress, or unsanitary conditions.”<sup>182</sup> To ensure “standards for workplace health and safety, the Act also created the National Institute for Occupational Safety and Health as the research institution for the Occupational Safety and Health Administration.”<sup>183</sup>
- **Oil Pollution Act (OPA)** – In 1990, Congress passed OPA in response to the Exxon Valdez oil spill, which was the largest oil spill in U.S. waters – at the time. The Act amended the CWA and substantially improved the measures preventing, preparing for, responding to, and paying for oil pollution.<sup>184</sup> Under OPA, parties that spill

or discharge oil into the environment (i.e., responsible parties) must have an Oil Spill Response Plan and are accountable for the impacted wildlife and cleanup costs.<sup>185</sup>

- **Pollution Prevention Act (PPA)** – Enacted by Congress in 1990, PPA “focused industry, government, and public attention on reducing the amount of pollution through cost-effective changes in production, operation, and raw materials use. Opportunities for source reduction are often not realized because of existing regulations and the industrial resources required for compliance, focus on treatment, and disposal. Pollution prevention includes practices that increase efficiency in the use of energy, water, or other natural resources, and protect our resource base through conservation.”<sup>186</sup>
- **Resource Conservation and Recovery Act (RCRA)** – The RCRA was enacted in 1976 and established the regulatory construct for the national management of solid waste, whether hazardous or non-hazardous.<sup>187</sup> The Act also provides EPA the authority to (a) control hazardous waste from “cradle-to-grave,” which includes the generation, transportation, treatment, storage and disposal of hazardous waste; (b) develop regulations, guidance, and policies that ensure[s] the safe management and cleanup of solid and hazardous waste; and (c) establish “programs that encourage source reduction and beneficial reuse.”<sup>188</sup> Military munitions become subject to RCRA when “there is an intent to dispose [of] or destroy them.”<sup>189</sup> Once identified, DoD must handle, store, and transport the munitions as hazardous waste. However, “recycling (i.e., use, reuse, or reclamation) [of the munitions] is ordinarily not considered a form of discard.”<sup>190</sup> This construct is also applicable to unused munitions.
- **Safe Drinking Water Act (SDWA)** – Established in 1974 to protect the quality of the U.S.’s drinking water was the SDWA.<sup>191</sup> The Act encompasses all waters (i.e., actually or potentially) designed for drinking use, whether from above ground or underground sources.<sup>192</sup> The Act permits EPA to establish minimum standards for safeguarding the U.S.’s tap water by requiring all owners or operators of public water systems to comply with the primary health-related standards; and protecting underground drinking water sources from endangerment by underground injection of fluids through state programs.<sup>193</sup> Frequently, state governments encourage the attainment of secondary standards.
- **Shore Protection Act (SPA)** – Title IV of Public Law 100-668 amended the MPRSA and created the SPA in 1988. SPA “prohibits the transportation of municipal or commercial waste within coastal waters by a vessel without a permit and number or other marking[s]. Permits are not to run beyond renewable five-year terms and will terminate when the vessel is sold. In consultation with the U.S. Coast Guard, the EPA is responsible for developing regulations governing the loading, securing, offloading, and cleaning up such wastes from waste sources, reception facilities, and vessels. The goals of the regulations are to minimize the release of waste into coastal waters during vessel loading, transport, and unloading; and ensure that any released waste is reported and cleaned up.”<sup>194</sup>
- **Toxic Substances Control Act (TSCA)** – TSCA was established in 1976 and comprised the Nation’s primary chemicals management law. It “provides EPA with authority to require reporting, record-keeping and testing requirements, and restrictions relating to chemical substances and/or mixtures.”<sup>195</sup> The focus of the TSCA is on the production, importation, use, and disposal of certain chemicals such as polychlorinated biphenyls, asbestos, radon, and lead-based paint.<sup>196</sup> The Lautenberg Chemical Safety Act amended TSCA in 2016.

## Appendix U: Key Environmental Treaties

- **Agenda 21** – The United Nations Conference on Environmental and Development (UNCED) in Rio de Janeiro, Brazil, produced Agenda 21 in 1992. “Agenda 21 is a [non-binding] comprehensive plan of action to be taken globally, nationally and locally by organizations of the United Nations System, Governments, and Major Groups in every area in which human impacts on the environment.”<sup>197</sup> “Agenda 21 addresses the pressing problems of today and also aims at preparing the world for the challenges of the next century. It reflects a global consensus and political commitment at the highest level on development and environment cooperation.”<sup>198</sup> A significant activity of the Agenda 21 initiative required local governments to “enter into a dialogue with its citizens, local organizations and private enterprises and adopt “a local Agenda 21” for the community” with an initial aim to achieve global sustainable development by the turn of the 21<sup>st</sup> century.<sup>199</sup>
- **Convention on Biological Diversity (CBD)** – CBD was entered into force on December 29, 1993, and “is an international legally-binding treaty with three main goals: conservation of biodiversity; sustainable use of biodiversity; and the fair and equitable sharing of the benefits arising from the use of genetic resources. Its overall objective is to encourage actions [that] will lead to a sustainable future. The conservation of biodiversity is a common concern of humankind. The CBD covers biodiversity at all levels: ecosystems, species, and genetic resources. It also covers biotechnology through the Cartagena Protocol on Biosafety. In fact, it covers all possible domains that are directly or indirectly related to biodiversity and its role in development, ranging from science, politics, and education to agriculture, business, culture, and much more. The governing body of the CBD is the Conference of the Parties. This ultimate authority of all governments (or Parties) that have ratified the treaty meets every two years to review progress, set priorities, and commit to work plans. In 2010, Parties to the CBD adopted the Strategic Plan for Biodiversity 2011–2020, a ten-year framework for action by all countries and stakeholders to safeguard biodiversity and the benefits it provides to people.”<sup>200</sup> Although the decade has concluded, the United Nations (UN) encourages countries to carry on with their existing pledges. Following the Strategic Plan for Biodiversity is the UN Decade on Ecosystem Restoration, which “aims to prevent, halt and reverse the degradation of ecosystems on every continent and in every ocean.”<sup>201</sup>
- **Declaration on the Principles of Forest Management** – The Declaration on the Principles of Forest Management consists of “a [non-legally binding] document that contains a series of guid[ing principles] for the most sustainable management of forests in the world. It corresponds to Part 11 of Agenda 21, approved at the Rio Summit 1992.”<sup>202</sup> The guiding principles of forest management ultimately seek to (a) strengthen national institutions dealing with forestry issues; (b) expand the scope and effectiveness of activities related to the management, conservation, and sustainable development of forests and effectively ensure the sustainable use and production of forest goods and services, both in developed and developing countries; and (c) strengthen the capacity and competence of national institutions so that they can acquire the necessary knowledge to protect and conserve forests, as well as expand their sphere of action and, consequently, increase the effectiveness of programs and activities related to forest management and development.<sup>203</sup> The principles reflected the first global consensus on forests and apply to all types of forests, whether natural or planted, in all geographic regions and climate zones.<sup>204</sup>
- **Kyoto Protocol to the United Nations Framework Convention on Climate Change** – The foremost international endeavor to lessen the pace of global climate change and thus, combat global warming was the Kyoto Protocol to the UNFCCC, commonly known as the “Kyoto Protocol.” Based on the principles and provisions of the UNFCCC, the Kyoto Protocol functionalized the UNFCCC by compelling developed countries and transitioning markets to lessen or constrain GHG emissions consistent with the specific targets established.<sup>205</sup> The individual commitments comprised the overall five percent average emission reduction compared to the 1990 GHG levels.<sup>206</sup> Implemented on December 11, 1997, and commenced on February 16, 2005, the Kyoto Protocol required one hundred and ninety-two participants (i.e., nation-states) to implement policies, undertake mitigation procedures, and submit occasional progress reports.<sup>207</sup> However, the protocol merely bound industrialized countries per the principle of “common but differentiated responsibility and respective capabilities.”<sup>208</sup> Under the Kyoto Protocol’s first commitment period, the 2012 Doha Amendment extended the principles and provisions that fostered GHG emissions’ overall five percent reduction target. Although, the amendment bolstered participating countries’ GHG reduction commitment to eighteen percent below 1990’s levels.<sup>209</sup> The second commitment period became effective in 2013 and culminated in 2020.

- **The Montreal Protocol on Substances that Deplete the Ozone Layer (The Montreal Protocol)** – The Montreal Protocol consists of a historic environmental treaty “that regulates the production and consumption of nearly 100 man-made chemicals referred to as Ozone-Depleting Substances (ODS). When released [in]to the atmosphere, those chemicals, such as chlorofluorocarbons] damage the stratospheric ozone layer [(i.e., Earth’s protective shield that protects humans and the environment from harmful levels of ultraviolet radiation from the sun)]. Adopted on September 15, 1987, the Protocol is to date the only UN treaty ever that has been ratified [by] every country on Earth – all 198 UN Member States. The Montreal Protocol phases down the consumption and production of the different ODS in a step-wise manner, with different timetables for developed and developing countries [(i.e.,] referred to as “Article 5 countries”). Under this treaty, all parties have specific responsibilities related to the phase-out of the different groups of ODS, control of ODS trade, annual reporting of data, national licensing systems to control ODS imports and exports, and other matters. Developing and developed countries have equal but differentiated responsibilities, but most importantly, both groups of countries have binding, time-targeted and measurable commitments. The treaty evolved over time in light of new scientific, technical, and economic developments, and it continues to be amended and adjusted. The Meeting of the Parties is the governance body for the treaty, with technical support provided by an Open-ended Working Group, both of which meet on an annual basis[, and] the Ozone Secretariat,” who assists the Parties.<sup>210</sup>
- **Paris Agreement Under the United Nations Framework Convention on Climate Change** – The Paris Agreement under the UNFCCC is frequently truncated and referred to as the “Paris Agreement.” One hundred and ninety-six countries welcomed it in 2015 to tackle climate change while reducing the adverse effects of a changing climate.<sup>211</sup> The Paris Agreement is an international accord that “aims to substantially reduce global greenhouse gas emissions in an effort to limit the global temperature increase in this century to 2 degrees Celsius above pre-industrial levels while pursuing the means to limit the increase to 1.5 degrees.”<sup>212</sup> On November 4, 2016, the agreement became effective after “55 nations, representing at least 55 percent of global emissions had formally joined.”<sup>213</sup> The agreement established binding commitments by all ratifying countries to prepare, communicate and maintain a Nationally Determined Contribution (NDC) and pursue domestic measures to achieve them. Participating countries must also present their progressively ambitious NDC quinquennially with requisite clarity and transparency to reduce GHG emissions further.<sup>214</sup> Furthermore, the Paris Agreement “attempts to address climate-security threats before they spiral out of control.”<sup>215</sup>
- **Rio Declaration on Environment and Development (Rio Declaration)** – The UNCED had many outstanding achievements, including signing the Rio Declaration and its twenty-seven universal principles by one hundred and seventy-five countries in 1992.<sup>216</sup> The twenty-seven universal principles sought to guide countries’ future sustainable development efforts and range from “human beings [existing] at the centre of concerns for sustainable development” (i.e., Principle 1) to “states enact[ing] effective environmental legislation” (i.e., Principle 11). Principle 7 even reminds states to “cooperate in a spirit of global partnership to conserve, protect and restore the health and integrity of the Earth’s ecosystem” (i.e., Principle 7).<sup>217</sup> Since signed, the international community has convened in 1997 and 2002 to assess the implementation of the Rio Declaration’s guiding principles.
- **United Nations Framework Convention on Climate Change (UNFCCC)** – The UNFCCC entered into force on March 21, 1994, and has near-universal membership today, with 197 countries ratifying the Convention.<sup>218</sup> “Preventing “dangerous” human interference with the climate system is the ultimate aim of the UNFCCC [while its] ultimate objective is to stabilize GHG concentrations at a level that would prevent dangerous anthropogenic [(i.e.,] human-induced) interference with the climate system. It states that such a level should be achieved within a time frame sufficient to (a) allow ecosystems to adapt naturally to climate change; (b) ensure that food production is not threatened; and (c) enable economic development to proceed in a sustainable manner.”<sup>219</sup> Industrialized nations agree under the Convention to (a) “Do the most to cut emissions on home ground” as they are the source of most past and current GHG emissions. In fact, by the year 2000, industrialized countries were expected to reduce emissions to 1990 levels, which some countries have achieved; (b) “Support climate change activities in developing countries by providing financial support [(i.e., a system of grants and loans, which the Convention’s Global Environment Facility manages)] for action on climate change – above and beyond any financial assistance they already provide to these countries; (c) “Share technology with less-advanced nations”; and “Report Regularly on their climate change policies and measures, [and] submit [an] annual inventory of their greenhouse gas emissions, including data for their base year [(i.e.,] 1990) and all years since.”<sup>220</sup>

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<sup>1</sup> The White House, “Findings from Select Federal Reports: The National Security Implications of a Changing Climate,” (Washington, D.C.: GPO, May, 19 2015), 2, [https://obamawhitehouse.archives.gov/sites/default/files/docs/National\\_Security\\_Implications\\_of\\_Changing\\_Climate\\_Final\\_051915.pdf](https://obamawhitehouse.archives.gov/sites/default/files/docs/National_Security_Implications_of_Changing_Climate_Final_051915.pdf).

<sup>2</sup> The domestic field studies portion of the seminar focused locally within and near the nation’s capital of Washington, D.C. Leading the nation on many fronts, the nation’s capital and the tri-state area—including Baltimore, Virginia Beach, and Northeast West Virginia—lead the nation in tackling multiple environmental challenges ranging from the world’s first LEED-certified city to the world’s largest waste-water treatment facility, the U.S.’s first off-shore wind farm to be approved by the Bureau of Ocean Energy Management (second constructed in the U.S.), conversion of the largest coal-producing state to wind energy, and the world’s largest pork producer’s journey towards sustainability.

<sup>3</sup> Grant Ferrier et al., "U.S. Environmental Industry Overview, Industry Summary", *Environmental Business Journal* 13, no.10-11-12, (Fourth Quarter, 2020), 1-13, [https://ebionline.org/wp-content/uploads/woocomerce\\_uploads/2017/06/EBIReport.2020B.Q3.2019.pdf](https://ebionline.org/wp-content/uploads/woocomerce_uploads/2017/06/EBIReport.2020B.Q3.2019.pdf).

<sup>4</sup> “Public’s Top Priority for 2022: Strengthening the Nation’s Economy,” Pew Research Center, February 2022, <https://www.pewresearch.org/politics/2022/02/16/publics-top-priority-for-2022-strengthening-the-nations-economy>.

<sup>5</sup> Ibid.

<sup>6</sup> Alec Tyson, Cary Funk, and Brian Kennedy, “Americans Largely Favor U.S. Taking Steps To Become Carbon Neutral by 2050,” *Pew Research Center* (blog), March 1, 2022, <https://www.pewresearch.org/science/2022/03/01/americans-largely-favor-u-s-taking-steps-to-become-carbon-neutral-by-2050/>. A Pew Research Center survey of 10,237 U.S. adults conducted from Jan. 24 to 30, 2022 found that 69% of U.S. adults prioritize developing alternative energy sources, such as wind and solar, over expanding the production of oil, coal and natural gas to become carbon neutral by 2050, which is a key component of the Biden administration’s climate and energy policy agenda. Only 31% of Americans believe the U.S. should phase out oil, coal, and natural gas completely, with 67% saying the U.S. should use mix of fossil fuels and renewable energy sources.

<sup>7</sup> Helen Mountford and Joel Jaeger, “America Doesn’t Have to Choose Between the Economy and the Climate,” World Resources Institute, March 6, 2017, <https://www.wri.org/insights/america-doesnt-have-choose-between-economy-and-climate>.

<sup>8</sup> Alison Spencer and Cary Funk, “Americans Largely Support U.S. Joining International Efforts to Address Climate Change,” Pew Research Center, March 9, 2022, <https://www.pewresearch.org/fact-tank/2022/03/09/americans-largely-support-u-s-joining-international-efforts-to-address-climate-change/>. People from around the world are concerned about the personal impact of climate change. A median of 72% said they thought they would be personally harmed by climate change in their lifetime while 30% said they were not too or not at all concerned. Fifty-seven percent from Greece (high) said they were very concerned about climate change harming them while only 15% (low) from Sweden felt very threatened despite Sweden being one of the top three countries ranked on the Sustainable Development Goals Index. A median of 80% across 17 publics said they would be willing to make some changes to their lives to reduce the effects of climate change. In North America, about three-quarters or more of both Canadians (82%) and Americans (74%) said they were willing to make at least some changes to help reduce the effects of global climate change. Carrie Blazina, “Fast Facts about International Views of Climate Change as Biden Attends UN COP26 Conference,” *Pew Research Center* (blog), October 29, 2021, <https://www.pewresearch.org/fact-tank/2021/10/29/fast-facts-about-international-views-of-climate-change-as-biden-attends-un-cop26-conference/>.

<sup>9</sup> “Definition of Security,” Dictionary.com, April 22, 2022, <https://www.dictionary.com/browse/security>.

<sup>10</sup> Jim Skea et al., “Climate Change 2022: Mitigation of Climate Change” (Geneva: Intergovernmental Panel on Climate Change, 2022), I-23, [https://report.ipcc.ch/ar6wg3/pdf/IPCC\\_AR6\\_WGIII\\_FinalDraft\\_FullReport.pdf](https://report.ipcc.ch/ar6wg3/pdf/IPCC_AR6_WGIII_FinalDraft_FullReport.pdf).

<sup>11</sup> Security of the environment includes security from degradation, scarcity, and maldistribution while security from the environment includes waste, pollution, destruction, and depletion of scarce resources. Security of the environment also is security of air, water, land (including soil and vegetation), resources (renewable and nonrenewable), and wildlife.

<sup>12</sup> Individuals themselves cannot provide for climate and environmental security; neither can institutions or even individual societies. The solution to climate security requires all levels to share a common vision and responsibility to shape this security environment. Using a holistic, futuristic, and causation-oriented strategic perspective,

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governments can take a proactive, preventative, and ethical approach to their role as steward of the environment and its resources.

<sup>13</sup> United Nations, “The Secretary-General’s High-Level Panel Report on Threats, Challenges and Change, A More Secure World: Our Shared Responsibility” (New York: United Nations, December 2, 2004), 26, [https://www.un.org/ruleoflaw/files/gaA.59.565\\_En.pdf](https://www.un.org/ruleoflaw/files/gaA.59.565_En.pdf).

<sup>14</sup> United Nations, “What Is Climate Change?,” May 9, 2022, <https://www.un.org/en/climatechange/what-is-climate-change>.

<sup>15</sup> “How Long Have Sea Levels Been Rising? How Does Recent Sea-Level Rise Compare to That over the Previous Centuries?,” NASA EarthData, November 12, 2021, <https://sealevel.nasa.gov/faq/13/how-long-have-sea-levels-been-rising-how-does-recent-sea-level-rise-compare-to-that-over-the-previous>; E/The Environmental Magazine, “Earth Talks: Measuring the Daily Destruction of the World’s Rainforests,” *Scientific American*, November 19, 2009, <https://www.scientificamerican.com/article/earth-talks-daily-destruction/>. As rainforests continue to be cut down at an alarming rate, the earth’s natural carbon absorbing potential continues to decrease in the face of increasing carbon emissions. Some experts have estimated that 80,000 acres of tropical rainforest are cut down each day and a further 80,000 acres are degraded each day.

<sup>16</sup> World Wildlife Fund, “Effects of Climate Change,” November 13, 2021, <https://www.worldwildlife.org/threats/effects-of-climate-change>.

<sup>17</sup> United States and Joseph R. Biden, “Interim National Security Strategic Guidance”, Washington, D.C.: GPO, March 2021.

<sup>18</sup> *Ibid.*

<sup>19</sup> World Economic Forum “Global Risks Report 2022”, January 11, 2022, <https://www.weforum.org/reports/global-risks-report-2022/>. Respondents from the 2022 Global Risk Report signal the health of the planet will dominate concerns over the next ten years with “climate action failure”, “extreme weather”, and “biodiversity loss” ranking as the top three most severe risks.

<sup>20</sup> *Ibid.*, 18.

<sup>21</sup> *Ibid.*, 8-9. Climate change is already manifesting rapidly in the form of droughts, fires, floods, resource scarcity and species loss, among other impacts. Multiple cities around the world experienced extreme temperatures and set record high of 42.7°C in Madrid, a 72-year low of -19°C in Dallas, and the Arctic Circle averaged summer temperatures 10°C higher than in prior years. Governments, businesses, and societies will increasingly face pressure to mitigate and adapt to the consequences of climate change while navigating “a disorderly climate transition characterized by divergent trajectories worldwide and across sectors further driv[ing] apart countries and bifurcat[ing] societies, creating barriers to cooperation.” Governments and businesses that continue to rely on carbon-intensive sectors risk losing competitive advantage through a “higher cost of carbon, reduced resilience, failure to keep up with technological innovation and limited leverage in trade agreements while shifting away from carbon-intense industries, which currently employ millions of workers, will trigger economic volatility, deepen unemployment and increase societal and geopolitical tensions.” Additionally, governments that adopt hasty environmental policies could have unintended consequences for nature in fields such as biotechnical and geoeengineering technologies. Lack of public support for land use transitions or new pricing scheme will also create political tensions leading to slowed action.

<sup>22</sup> Office of the Director of National Intelligence, “2022 Annual Threat Assessment of the U.S. Intelligence Community,” (Washington, D.C., GPO February 7, 2022), <https://www.dni.gov/index.php/newsroom/reports-publications/reports-publications-2022/item/2279-2022-annual-threat-assessment-of-the-u-s-intelligence-community>.; Current governmental policies across the globe would cause a rise of 1.5C by 2030, passing 2C by 2050.

<sup>23</sup> World Economic Forum, “Global Risks Report 2022.”, 18.

<sup>24</sup> Ferrier et al., U.S. “Environmental Industry Overview”, 1-13.

<sup>25</sup> Debra K. Rubin, Mary B. Powers, and Peter Reina, “The Top 200 Environmental Firms,” *Engineering News-Record*, July 2021., 54.

<sup>26</sup> *Ibid.*, 55. The Middle East and Africa produce the least amount of revenue at only 3.6% and 3.7%.

<sup>27</sup> *Ibid.*, 61.

<sup>28</sup> *Ibid.*, 56.

<sup>29</sup> *Ibid.*, 61.

<sup>30</sup> Grant Ferrier et al., “U.S. Environmental Industry Overview, Industry Summary”, 1.



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<sup>31</sup> Ibid., 2.

<sup>32</sup> Ibid., 4.

<sup>33</sup> Ibid., 6.

<sup>34</sup> Zachary A. Wendling et al., "Environmental Performance Index", (New Haven, CT: Yale Center for Environmental Law & Policy, 2020), [epi.yale.edu](http://epi.yale.edu). The rankings do not reflect recent developments such as the reduction in air pollution during the COVID-19 pandemic or the increase in greenhouse gas emissions from the Amazonian fires in 2019.

<sup>35</sup> Ibid.

<sup>36</sup> Ibid. Denmark, Luxembourg, and Switzerland rank as the top three with "leading-edge commitments and outcomes" across most issues. Those countries at the bottom of the rankings have various challenges; emerging economies and regional leaders such as India and Nigeria (#168 and #151) need to focus on critical issues such as air and water quality, biodiversity, and climate change while other laggards such as Nepal and Afghanistan must overcome civil unrest and improve their weak governance before making strides in air and water quality. The current Russia-Ukraine war will pose additional challenges to both countries, decreasing their 2020 rankings of #58 and #60 respectively as violent conflict degrades and de-prioritizes Environmental Health and Ecosystem Vitality.

<sup>37</sup> Zachary A. Wendling et al., "Environmental Performance Index: United States", (New Haven, CT: Yale Center for Environmental Law & Policy, 2020), [epi.yale.edu](http://epi.yale.edu). <https://epi.yale.edu/epi-results/2020/country/usa>.

<sup>38</sup> Zachary A. Wendling et al., "Environmental Performance Index: China", (New Haven, CT: Yale Center for Environmental Law & Policy, 2020), <https://epi.yale.edu/epi-results/2020/country/chn>.

<sup>39</sup> Zachary A. Wendling et al., "Environmental Performance Index: Russia", (New Haven, CT: Yale Center for Environmental Law & Policy, 2020), <https://epi.yale.edu/epi-results/2020/country/rus>.

<sup>40</sup> United Nations Sustainable Development Group, "UNSDG Data Portal", (New York: United Nations 2022), <https://uninfo.org/>. The SDG Index is an assessment of each country's overall performance on the 17 SDGs, giving equal weight to each Goal. The score signifies a country's position between the worst possible outcome (0) and the best, or target outcome (100). For example, Finland's overall index score (85.9) suggests it is, on average, 86 percent of the way to the best possible outcome across the 17 Goals. This year's SDG Index and Dashboards introduces six new global indicators (see table 4.1 on page 66), bringing the total to 91 for all countries (up from 85 last year) as well as an additional 30 indicators for OECD countries.

<sup>41</sup> Minoru Takada, United Nations, Division of Sustainable Goals, Presentation, April 21, 2022.

<sup>42</sup> Jeffery Sachs, et al., "Sustainable Development Report 2019", (New York: Bertelsmann Stiftung and Sustainable Development Solutions Network, June 28, 2019), 3, <https://www.sdgindex.org/news/the-united-states-ranked-35th-globally-on-sustainable-development/>.

<sup>43</sup> Zachary A. Wendling et al., "Environmental Performance Index: Russia", 10.

<sup>44</sup> Jeffrey D Sachs et al., "Sustainable Development Report 2021: The Decade of Action for the Sustainable Development Goals" (New York: Cambridge University Press, 2021), 10.

<sup>45</sup> Heather Conley and Cyrus Newlin, "Climate Change Will Reshape Russia," Center for Strategic & International Studies, January 13, 2021, <https://www.csis.org/analysis/climate-change-will-reshape-russia>; Daniel Kozin, "Is Russia Finally Waking Up to Climate Change?," *The Moscow Times*, March 4, 2020, <https://www.themoscowtimes.com/2020/03/04/is-russia-finally-waking-up-to-climate-change-a69517>.

<sup>46</sup> Ibid.

<sup>47</sup> Angelina Davydova, "Environmental Activism in Russia: Strategies and Prospects," Center for Strategic & International Studies, March 3, 2021, <https://www.csis.org/analysis/environmental-activism-russia-strategies-and-prospects>; "Russia: End of the Road for Those Seeking to Exercise Their Right to Protest," Amnesty International, August 12, 2021, <https://www.amnesty.org/en/latest/news/2021/08/russia-end-of-the-road-for-those-seeking-to-exercise-their-right-to-protest/>; "Russia Criminalizes Independent War Reporting, Anti-War Protests," *Human Rights Watch* (blog), March 7, 2022, <https://www.hrw.org/news/2022/03/07/russia-criminalizes-independent-war-reporting-anti-war-protests>.

<sup>48</sup> Jan Burck et al., "Climate Change Performance Index 2022," (Bonn, Germany, Climate Action Network International, November 9, 2021), <https://ccpi.org/download/climate-change-performance-index-2022-2/>. CCPI 2022 evaluates and compares the climate protection performance of 60 countries and the European Union (EU), which collectively account for more than 92% of global greenhouse gas (GHG) emissions.

- 80% of the assessment is based on quantitative data from internationally recognized institutions.

- Around 80% of the assessment of a countries' performance is based on quantitative data from the International Energy Agency (IEA), PRIMAP, the Food and Agriculture Organization (FAO), and the national GHG inventories submitted to the UNFCCC. CCPI 2022 is calculated using data recorded in 2019, as this is the most recent data available.
- The three quantitative categories GHG Emissions, Renewable Energy, and Energy Use are each defined by four indicators: Current Level, Past Trend, Well-Below-2°C Compatibility of the Current Level, and Well-Below-2°C Compatibility of the Countries' 2030 Target
- 20% of the assessment is based on the unique Climate Policy section
- The remaining 20% of the assessment is based on the CCPI's globally unique Climate Policy section. With this category, the index covers the most recent developments in national climate policy frameworks. The quantitative data alone cannot project these.
- This category's indicators are National Climate Policy and International Climate Policy. The qualitative data for these indicators is assessed annually in a comprehensive study. A performance rating provided by climate and energy policy experts from the evaluated countries serves as the basis for this.

<sup>49</sup> Will Kenton, "What Is an Industry?," *Investopedia*, March, 31, 2021,

<https://www.investopedia.com/terms/i/industry.asp>.

<sup>50</sup> "State Renewable Portfolio Standards and Goals," National Conference of State Legislatures, August 13, 2021, <https://www.ncsl.org/research/energy/renewable-portfolio-standards.aspx>.

<sup>51</sup> Grant Ferrier et al., "U.S. Environmental Industry Overview, Industry Summary", 1-232.

<sup>52</sup> *Ibid.*, 1-233; Rubin, Powers, and Reina, "The Top 200 Environmental Firms."

<sup>53</sup> Michael E. Porter, "The Five Competitive Forces That Shape Strategy", *Harvard Business Review*, January 2008, <http://nduezproxy.idm.oclc.org/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=buh&AN=28000138&site=ehost-live>.

<sup>54</sup> MarketLine, "Industry Profile: Waste Management in the United States", (London: Progressive Digital Media, August 2021), <https://advantage-marketline-com.nduezproxy.idm.oclc.org/Analysis/ViewasPDF/united-states-waste-management-138051>; MarketLine, "Industry Profile: Waste Management in China," (London: Progressive Digital Media, August 2021), <https://advantage-marketline-com.nduezproxy.idm.oclc.org/Analysis/ViewasPDF/china-waste-management-138037>; MarketLine, "Industry Profile, Waste Management in Russia," (London: Progressive Digital Media, August 2021), <https://advantage-marketline-com.nduezproxy.idm.oclc.org/Analysis/ViewasPDF/russia-waste-management-138045>.

<sup>55</sup> MarketLine, "Industry Profile: Renewable Energy in the United States," (London: Progressive Digital Media, June 2021), <https://advantage-marketline-com.nduezproxy.idm.oclc.org/Analysis/ViewasPDF/united-states-renewable-energy-135143>; MarketLine, "Industry Profile: Renewable Energy in China," (London: Progressive Digital Media, June 2021), <https://advantage-marketline-com.nduezproxy.idm.oclc.org/Analysis/ViewasPDF/china-renewable-energy-135123>; MarketLine, "Industry Profile: Renewable Energy in Russia," (London: Progressive Digital Media, June 2021), <https://advantage-marketline-com.nduezproxy.idm.oclc.org/Analysis/ViewasPDF/russia-renewable-energy-135135>.

<sup>56</sup> MarketLine, "Renewable Energy in the United States;" MarketLine, "Renewable Energy in China;" MarketLine, "Renewable Energy in Russia."

<sup>57</sup> MarketLine, "Renewable Energy in Russia."

<sup>58</sup> MarketLine, "Renewable Energy in China."

<sup>59</sup> MarketLine, "Renewable Energy in the United States;" MarketLine, "Renewable Energy in China;" MarketLine, "Renewable Energy in Russia."

<sup>60</sup> While this paper focuses on China and Russia as a result of renewed GPC, these are not the only two markets of import. Often it is the worse environmental conditions that afford greater economic opportunity within the environmental and climate change industries. India and Africa are great examples of this axiom. As one of the fastest growing economies in the world, India provides limitless potential for U.S. public and private engagement in air pollution, sustainable energy, disaster risk management, and water security. U.S. private and public sector entities already have strong ties with and a sizeable presence in India; increasing this engagement/assistance can have great soft power impacts in tandem with the environmental benefits during this global transition. The U.S. is far less present and has a woefully underdeveloped trade relationship with Africa. Crude petroleum exports dominate U.S. trade with Africa, making up about 90 percent of all U.S.-Africa trade. (See Joshua P. Meltzer, "Deepening the United States-Africa Trade and Investment Relationship," Brookings Institute, January 28, 2016,

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<https://www.brookings.edu/testimonies/deepening-the-united-states-africa-trade-and-investment-relationship/?msclkid=d2d32ef4c57c11eca03aca3251846f55.>) Through its Belt and Road Initiative, China displays much greater attention to Africa relations and is much better positioned to benefit from the lucrative market opportunities in Africa.

<sup>61</sup> “China Environmental Products and Services Market,” United States Department of Commerce: International Trade Administration, accessed May 7, 2022, <https://www.trade.gov/china-environmental-market>; “China Environmental Products and Services Market,” United States Department of Commerce: International Trade Administration, accessed May 7, 2022, <https://www.trade.gov/china-environmental-market>.

<sup>62</sup> Joanne Lewis and Laura Edwards, “Assessing China’s Energy and Climate Goals,” (Washington, D.C.: *Center for American Progress*, May 6, 2021), <https://cdn.americanprogress.org/content/uploads/2021/05/05090646/ChinaClimate-report.pdf>.

<sup>63</sup> “China,” Climate Action Tracker, November 3, 2021, <https://climateactiontracker.org/countries/china/>.

<sup>64</sup> MarketLine, “Market Summary: Renewable Energy in China Competitive Analysis and Forecast to 2025,” (London: Progressive Digital Media, June 2021), <https://www.researchandmarkets.com/reports/5397409/renewable-energy-in-china-market-summary>.

<sup>65</sup> James Temple, “How China Rules Clean Tech, in Charts,” *MIT Technology Review*, August 19, 2020, <https://www.technologyreview.com/2020/08/19/1006430/how-china-rules-clean-tech-in-charts/>.

<sup>66</sup> Carrie Xiao, “China Unveils Boost for 2021 Renewable Subsidies, Solar Wins Biggest Share,” *PV Tech*, November 25, 2020, <https://www.pv-tech.org/china-unveils-boost-for-2021-renewable-subsidies-solar-wins-biggest-share/>.

<sup>67</sup> Nicolas Rapp and Brian O’Keefe, “This Chart Shows How China Will Soar Past the U.S. to Become the World’s Largest Economy by 2030,” *Fortune*, January 30, 2022, <https://fortune.com/longform/global-gdp-growth-100-trillion-2022-inflation-china-worlds-largest-economy-2030/>.

<sup>68</sup> U.S.-China Business Council, “The U.S.-China Economic Relationship: A Crucial Partnership at a Critical Juncture,” *Oxford Economics*, January 2021, [https://www.uschina.org/sites/default/files/the\\_us-china\\_economic\\_relationship\\_-\\_a\\_crucial\\_partnership\\_at\\_a\\_critical\\_juncture.pdf](https://www.uschina.org/sites/default/files/the_us-china_economic_relationship_-_a_crucial_partnership_at_a_critical_juncture.pdf).

<sup>69</sup> “AECOM and China Communications Construction Corporation Subsidiary Establish Joint Venture Company to Service Environmental Solutions Opportunities in People’s Republic of China,” *Informed Infrastructure* (blog), August 9, 2017, <https://informedinfrastructure.com/33236/aecom-and-china-communications-construction-corporation-subsidiary-establish-joint-venture-company-to-service-environmental-solutions-opportunities-in-peoples-republic-of-china>.

<sup>70</sup> “Total Energy Production from Natural Gas 2019,” U.S. Energy Information Administration (EIA), accessed May 6, 2022,

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<sup>72</sup> *Ibid.*

<sup>73</sup> Suriya Jayanti, “Russia Is Still Winning the Energy War,” *Time*, April 29, 2022, <https://time.com/6172292/russia-ukraine-invasion-energy/>; Gabriel Collins, “Issue Brief: Russia’s Use of the ‘Energy Weapon’ in Europe”, Baker Institute for Public Policy, July 18, 2017, [https://www.bakerinstitute.org/media/files/files/ac785a2b/BI-Brief-071817-CES\\_Russia1.pdf](https://www.bakerinstitute.org/media/files/files/ac785a2b/BI-Brief-071817-CES_Russia1.pdf).

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<sup>80</sup> “Council on Environmental Quality,” The White House, accessed May 5, 2022, <https://www.whitehouse.gov/ceq/>.

<sup>81</sup> Steve Cohen, “The State and Local Role in Protecting America’s Environment,” *State of the Planet* (blog), July 16, 2018, <https://news.climate.columbia.edu/2018/07/16/state-local-role-protecting-americas-environment/>.

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<sup>83</sup> Mountford and Jaeger, “America Doesn’t Have to Choose Between the Economy and the Climate.”

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<sup>86</sup> Michael Blakiston and Peter Waters, “How AI Can Help Tackle Climate Change - Lexology,” *Lexology*, November 9, 2021, <https://www.lexology.com/library/detail.aspx?g=f83f52ea-25f0-42ab-8c6d-a8a5153a4898>.

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