INNOVATION COOPERATION: ENERGY BIOSCIENCES AND LAW

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This Article analyzes the development and dissemination of environmentally sound technologies that can address climate change. Climate change poses catastrophic health and security risks on a global scale. Universities, individual innovators, private firms, civil society, governments, and the United Nations can unite in the common goal to address climate change. This Article recommends means by which legal, scientific, engineering, and a host of other public and private actors can bring environmentally sound innovation into widespread use to achieve sustainable development. In particular, universities can facilitate this collaboration by fostering global innovation and diffusion networks.

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I. INTRODUCTION: ACCELERATING INVENTION AND DIFFUSION

Energy innovation is a crucial element in addressing climate change. Environmentally sound technology can be invented, demonstrated, and widely shared over the next decade to achieve greenhouse gas emission reductions in line with scientific recommendations.[1] Global greenhouse gas emissions have risen approximately fifty percent since 1970 and are projected to rise by another half by 2030.[2] Highlighting the dangerous vacuums in governance and pointing out that stimulus plans are prone to economic nationalism,[3] David Victor and Linda Yueh call for multilateral energy coordination.[4] Similarly, the World Economic Forum calls for $515 billion USD a year to be directed toward environmentally sound energy investment.[5] Such investments were $155 billion in 2008.[6] In a scramble to understand the recent financial crisis, the international community continues to respond inadequately to the larger threat that climate change poses to security. Good governance enhances security and is key to achieving environmental sustainability. It enables sustainable development, participation, human rights, rule of law, anti-corruption, transparency, accountability, and access to information.[7] Procedural and substantive measures are at the core of the international community's ability to agree upon a binding legal framework on climate change. Environmentally sound technology can be commercially deployed over the next decade to achieve greenhouse gas emission reductions and adaptation in line with scientific recommendations.

The international community must find a timely means by which to expand access to innovation.[8] Sorting out public versus private, current

1. United Nations Conference on Environment and Development, Rio de Janeiro, Braz., June 3-14, 1992, *Agenda 21*, ¶¶ 34.1–34.5, U.N. Doc. A/CONF.151/26/Rev.1 (Vol. I), Annex II (Aug. 12, 1992) [hereinafter *Agenda 21*], *available at* http://www.un.org/esa/dsd/agenda21/res_agenda21_34.shtml.

2. Krittivas Mukherjee, *U.N. Climate Chief Says Industry Keen on Deal*, REUTERS (Feb. 5, 2009), http://in.reuters.com/article/idINIndia-37861020090205.

3. David G. Victor & Linda Yueh, *The New Energy Order: Managing Insecurities in the Twenty-First Century*, FOREIGN AFF., Jan.–Feb. 2010, at 61, 63, 70.

4. *Id.* at 70.

5. Larry Elliott, *World Economic Forum Wants $10tn to Save the World*, GUARDIAN (Jan. 29, 2009), http://www.guardian.co.uk/business/2009/jan/29/davos-green-energy. Elliott also identifies eight clean energy projects that will play a crucial role in climate change adaptation. *Id.* These projects include "onshore wind, offshore wind, solar photovoltaic, solar thermal electricity generation, municipal solar waste-to-energy, sugar-based ethanol, cellulosic and next-generation biofuels, and geothermal power." *Id.*

6. *Clean Energy Spending Needs to More than Triple: Report*, REUTERS (Simon Jessop ed., Jan. 29, 2009), http://www.reuters.com/article/idUSTRE50S3KY20090129; *see also* Rebecca Smith, *Surprise Drop in Power Use Delivers Jolt to Utilities*, WALL ST. J., Nov. 21, 2008, at B1 ("Utilities are expected to invest $1.5 trillion to $2 trillion by 2030 to modernize their electric systems and meet future needs . . . .").

7. *See* UNESCO, MEDIA AND GOOD GOVERNANCE 5–8, 11–12 (2005), http://unesdoc.unesco.org/images/0014/001463/146311e.pdf.

8. *See* United Nations Framework Convention on Climate Change, art. 4.5, May 9, 1992, S. TREATY DOC. NO. 102-38, 1771 U.N.T.S. 164, 166, 170 [hereinafter UNFCCC] ("The developed country Parties and other developed Parties included in Annex II shall take all practicable steps to pro-

versus future, and domestic versus international dimensions of international property rights continues to stymie consensus-building efforts. Drivers for change include a desire to lower utility bills, produce jobs, increase productivity, breathe clean air, drink safe water, and achieve energy security. These objectives can coalesce in a transition to a sound energy policy irrespective of geopolitical divisions regarding climate change.

This Article analyzes the role of law and science in facilitating energy innovation to achieve sustainable development. Part I addresses how to accelerate invention and diffusion while Part II explains how universities can provide global innovation leadership. Part III uses the case study of algae-to-fuel to address sensible bioenergy innovation. Part IV analyzes the opportunities and obstacles with regard to universities and global diffusion leadership while Part V provides an overview of the international climate negotiations. Part VI sets forth recommendations for energy security and innovation through international innovation cooperation. Recognizing that law can facilitate energy innovation, this analysis considers opportunities and strategies for technological innovation through transdisciplinary international engagement. This Article concludes that equitable and efficient climate-friendly innovation and diffusion can occur through cooperation across fields and scales of geopolitics.

II. UNIVERSITIES AND GLOBAL INNOVATION LEADERSHIP

"Universities have become potent innovation engines"[9]

Implementation of a climate plan of action can occur through the coordinated expertise of non-state actors. In particular, innovation centers can play an important role. Universities already have the infrastructure and can gain the insight and inclination to become environmentally sound technology powerhouses.[10] From cooperative data collection[11] to regional and international energy research centers,[12] collaboration is al-

mote, facilitate and finance, as appropriate, the transfer of, or access to, environmentally sound technologies and know-how to other Parties, particularly developing country Parties, to enable them to implement the provisions of the Convention. In this process, the developed country Parties shall support the development and enhancement of endogenous capacities and technologies of developing country Parties. Other Parties and organizations in a position to do so may also assist in facilitating the transfer of such technologies."); *cf.* A Universal Declaration of Human Rights, G.A. Res. 217 (III) A, art. 27(1), U.N. Doc. A/RES/217(III), (Dec. 10, 1948), *available at* http://www.un.org/en/documents/udhr/index.shtml#a27 ("Everyone has the right freely to participate in the cultural life of the community, to enjoy the arts and to share in scientific advancement and its benefits.").

9. MICHAEL A. GOLLIN, DRIVING INNOVATION: INTELLECTUAL PROPERTY STRATEGIES FOR A DYNAMIC WORLD 34 (Cambridge University Press 2008). "Yesterday's innovation becomes part of today's accessible knowledge." *Id.* at 19.

10. *See* Scott A. Shane, *Can Academics Be Entrepreneurial?*, N.Y. TIMES (Nov. 16, 2009), http://boss.blogs.nytimes.com/2009/11/16/can-academics-be-entrepreneurial.

11. *See* Juliet Eilperin, *U.S. and China Reach Accord on Data Collection*, WASH. POST (Nov. 19, 2009), http://www.washingtonpost.com/wp-dyn/content/article/2009/11/18/AR2009111803058.html.

12. *See America, China and Climate Change: Let's Agree to Agree*, ECONOMIST (Nov. 19, 2009), http://www.economist.com/world/unitedstates/displaystory.cfm?story_id=14915108&fsrc=rss.

ready underway. A ramping up of collective willpower, integrity, imagination, and intelligence can relegate energy scarcity and environmental externality concerns to historical anecdotes. This is not to say that a magic bullet is guaranteed to be hiding just around the bend. Assembling the rails and capacity to look around the bend, however, increases the likelihood of recognizing and implementing a sound energy policy. That policy may include increased use of concentrated solar power. Water may be seen as a valuable energy storage solution without displacing millions of people. Facilitating a transition to energy-water use that minimizes climate destabilization can and should be central in international, national, local, and individual actions going forward. This can be accomplished by becoming informed decision makers able to work together across disciplines, gender differences, age, ethnicity, race, disability, nationality, and all the other ways that have so often hindered collaboration. Consensus building comes from shared perspectives being listened to and distilled into a common vision for the future. This can be an inclusive process that maximizes human security through legal coordination to achieve sustainable development.

A. Design Innovation

Emerging networks of universities occupy a unique and important position to recognize and engage the vast array of unprecedented and multifaceted environmental and political challenges that our society faces through transdisciplinary design innovation strategies.[13]

To do so effectively, they must assess their strengths and leverage opportunities within their institutions and beyond. Through collaborations that forge new alliances with industry, diverse communities, and global partners, universities can become key leaders in fostering new transdisciplinary visions for sustainability security through applied local and international innovation and by designing and implementing effective solutions.[14] David Kelley sees design innovation moving beyond products to focus on experiences and relationships.[15] His colleague, Harry West, notes that, "[d]esign is a set of principles and ways of thinking that help us to manage and create in the material world. It values creativity as much as analysis. It is a way of seeing and painting a new, bigger picture."[16] Across these perspectives is a growing understanding that

13. *See* Colin Macilwain, *The Arizona Experiment*, 446 NATURE 968, 968 (2007) ("A shift in population, money and political influence to America's 'sunbelt states' is helping to reshape its research universities.").

14. *See, e.g.*, *A New American University*, ARIZ. STATE UNIV., http://newamericanuniversity.asu.edu/ (last visited Dec. 20, 2010).

15. TED2002, *David Kelley on Human-Centered Design*, TED (Feb. 2002), http://www.ted.com/talks/david_kelley_on_human_centered_design.html (discussing innovation).

16. Harry West, *The Cross-Discipline Design Imperative*, BLOOMBERG BUSINESSWEEK (Oct. 4, 2007), http://www.businessweek.com/innovate/content/oct2007/id2007104_562559.htm ("There is a tremendous demand for design thinkers today. In industry and in consulting, those who can marry creative right-brain thinking and analytical left-brain thinking are at a premium. That's because inno-

these approaches are not limited to product design, but hold significant potential for communities, systems, organizations, and governments as well. They must be brought to bear on the pressing challenges of sustainability and security.

As universities focus on leadership, innovation, and entrepreneurship in co-located and virtual learning environments, they should strive to be creative organizations that lead by empowering individuals, teams, and communities to be their best. Their charters can easily be interpreted to foster individuals' intrinsic motivation, domain expertise, and thinking style in concert with a suitably challenging environment that provides actualizing rewards, appropriate time pressure, focused activity, and positive affect—conditions that Teresa Amabile has shown are fundamental to creative innovation.[17] They should realize the important and motivating role of energetic progress and use this to produce effective teams and leaders that employ holistic rather than reductionist approaches to design and environmental sustainability.[18] With an appreciation of the "10,000-hour rule,"[19] these organizations should commit to creating a new breed of creative experts: design leaders that have deep and flexible understandings developed through rich, varied, and fluent design experience.[20] Embracing these understandings of individual and organizational creativity, creative leadership, design, and entrepreneurship, universities must be fundamentally committed to empowering people to realize their full potentials as actualized individuals, not only as leaders of design innovation, idea economies, and the creative class, but as individuals, groups, and networks empowered to realize local and global inclusive progress toward sustainable security.[21]

B. Strategic Development

This model and network can leverage industry collaborations and community programs, borrowing lessons from Stanford's MediaX and MIT Media Lab's industry and community sponsor relationships to dis-

vation often happens not in the center of a discipline but in the space between disciplines, and right now a lot of new value is being found at the intersection of design and business. Professionals who can understand and respect both sides are at an advantage in our increasingly creative economy.").

17. Teresa M. Amabile & Steven J. Kramer, *What Really Motivates Workers: Understanding the Power of Progress*, HARV. BUS. REV., Jan.–Feb. 2010, at 44, 44–45.

18. *See* Domenico Grasso & David Martinelli, *Holistic Engineering*, CHRON. REV., Mar. 16, 2007, at B8, http://www.uvm.edu/~cems/explore/holistic.pdf.

19. K. Anders Ericsson, Ralf Th. Krampe & Clemens Tesch-Römer, *The Role of Deliberate Practice in the Acquisition of Expert Performance*, 100 PSYCHOL. REV. 363, 393–394 (1993).

20. *See* K. Anders Ericsson, Michale J. Prietula & Edward T. Cokely, *The Making of an Expert*, HARV. BUS. REV., July–Aug. 2007, at 115, 116, 118–119.

21. *See* EDGAR FAURE, FELIPE HERRERA, ABDUL-RAZZAK KADDOURA, HENRI LOPES, ARTHUR V. PETROVSKY, MAJID RAHNEMA & FREDERICK CHAMPION WARD, LEARNING TO BE: THE WORLD OF EDUCATION TODAY AND TOMORROW, 148–150 (UNESCO 1972).

seminate high impact design innovations.[22] Universities can be focal points for coordinated strategic development initiatives that advance design innovation at all levels. Organizations that support creativity, entrepreneurship, and social impact should be central to these engagements, across national agencies and international organizations.[23] Likewise, direct and equitable collaborations with industries are important to advancing multifaceted design innovation, as these types of industry relationships are often sources of inspiration, expertise, technology, resources, and opportunities that support the development and deployment of products, technologies, and applied learning opportunities that have widespread impact and which can create a solid foundation for sustainable institutions and endeavors.

C. Transformational Education Experiences

Universities can create a series of flagship programs to connect across disciplines to local and global communities. The National Academy of Engineering emphasizes that the engineer of 2020 must be equipped to apply practical ingenuity, creativity, and engage in lifelong learning, especially since students are being prepared to take on jobs and solve problems that do not yet exist.[24] Schools must invest in the creation of a sustainable infrastructure aimed at recruiting, retaining, placing, and offering lifelong empowering learning experiences and environmentally ambitious engagements to their students, stakeholders, and the public.

These institutions have the capacity to create the transdisciplinary environmental experts that the world needs at this time. The full-time undergraduate experience affords approximately 10,000 hours of training with which universities should strive to develop creative experts in sustainable design innovation through actualizing experiences. A great deal of learning occurs beyond the formal curriculum, through self-motivated pursuits and collaborations.[25] Students should be supported and rewarded for their participation in environmentally focused design competitions and challenges. Student activities and organizations should be encouraged. Entrepreneurial and social incubators should be established that go beyond contests to provide long-term and in-depth mentoring

22. Bob Tedeschi, *The Idea Incubator Goes to Campus*, N.Y. TIMES (June 26, 2010), http://www.nytimes.com/2010/06/27/business/27incubate.html (discussing innovation on university campuses).

23. *See, e.g.*, DESIGN THAT MATTERS, http://www.designthatmatters.org (last visited Dec. 20, 2010).

24. NAT'L ACAD. OF ENG'G, THE ENGINEER OF 2020: VISIONS OF ENGINEERING IN THE NEW CENTURY 4–5 (2004); *see also* JAMES J. DUDERSTADT, ENGINEERING FOR A CHANGING WORLD: A ROADMAP TO THE FUTURE OF ENGINEERING PRACTICE, RESEARCH, AND EDUCATION 1–5 (Univ. of Mich. 2008).

25. *See generally* Richard M. Felder & Linda K. Silverman, *Learning and Teaching Styles in Engineering Education*, 78 ENGINEERING EDUC. 674, 674–681 (1988).

and development experiences for students.[26] Pro bono and service-oriented design consultancy experiences should be fostered that promote strong international and cross-cultural experiences—internships, mentoring and shadowing relationships, and leadership training and experience should be a priority.[27] Universities should develop rich and creative networks to foster design innovation communities with strong advisory boards and host summits that involve leaders in sustainability and technological innovation. These leaders should not only provide inspiration through their presentations, masters classes, and workshops, but also act as external advisors, evaluators, consultants, and facilitators of industry connections and opportunities. Engineers and entrepreneurs should be encouraged to engage in a given university's offerings.[28]

In today's increasingly global and multicultural world, universities should be highly engaged in initiatives that enhance their ability to advance international and cross-cultural design innovation toward sustainable security. This can be accomplished through internships, courses, semesters abroad, and opportunities for global leadership and exchange.[29] A strong array of universities should also recognize the opportunities afforded by networked collaboration and global inclusion.[30] Domestic exchanges with complementary programs, such as the Art Center, Stanford's D School, MIT Media Lab, Rhode Island School of Design (RISD), Northwestern, Illinois Institute of Technology (IIT), Arizona State University (ASU), and others should be encouraged.[31] Explorations based on the Watson Fellowship, "Mini-Watsons," should encourage design adventures, residencies, and deep dives.[32] Connections with such social entrepreneurship organizations as Future Generations, Design that Matters, ASU's Global Resolve, and United Nations initiatives should be a prominent element of universities' international agendas. These should include virtual and online global collaboration and fabrication that is rapidly becoming the hallmark of today's design prac-

26. *See, e.g.*, MIT $100K ENTREPRENEURSHIP COMPETITION, http://www.mit100k.org (last visited Dec. 20, 2010).

27. *See, e.g.*, MIT SLOAN ACTION LABS, http://actionlearning.mit.edu/ (last visited Dec. 20, 2010) (especially "G-Lab" tab); *see also D-Lab: Development Through Dialogue, Design & Dissemination*, MIT, http://d-lab.mit.edu/ (last visited Dec. 20, 2010); *Global Resolve*, ARIZ. STATE UNIV., http://globalresolve.asu.edu/ (last visited Dec. 20, 2010).

28. *See generally Talks on Sustainability*, TED, http://www.ted.com/talks/tags/id/43 (last visited Dec. 20, 2010) (offering talks ranging from green tech to biodiversity).

29. *See, e.g.*, AIESEC, http://www.aiesec.org/ (last visited Dec. 20, 2010).

30. For example, a "grassroots" collaborative constellation might be forged between Hong Kong Polytechnic or Nanyang Technological University's School of Art, Design & Media (SADM) in Singapore, TU Delft, Copenhagen IT University, ESDI Brasil, and others across the globe.

31. *See* Jennifer Merritt & Louis Lavelle, *Tomorrow's B-School? It Might Be a D-School*, BLOOMBERG BUSINESSWEEK (Aug. 1, 2005), http://www.businessweek.com/magazine/content/05_31/b3945418.htm.

32. THOMAS J. WATSON FELLOWSHIP, http://www.watsonfellowship.org/site/index.html (last visited Dec. 20, 2010).

tices.[33] Outreach and mentorship of a global community of the next generation of designers, K–12 innovators, and life-long learners should be central to these agendas.

D. Inventors Workshops: Designing the Future, Today and Tomorrow

Universities can offer design innovation experiences, resources, and fabrication capabilities that epitomize the challenges and opportunities that will confront the next generation of global citizens. They can provide collaborative transdisciplinary experiences that push the boundaries of what is possible through human-centered approaches that advance a broad understanding of design innovation and sustainability, its diverse methodologies, applications, potentials, and responsibilities. There are exciting examples of what is possible. Consider for instance, a society that desires ubiquitous customized on-demand products, makes products by the billions,[34] and understands how to ensure that they are sustainable.[35] These, and other challenging and complex contexts will guide the skills, methodologies, technologies, and materials with which the next generation of innovators need to be prepared to demonstrate design thinking and sustainable innovation. Through human-centered approaches to advanced materials, processes, and systems, design innovators will need to be equipped with the toolsets and experiences that prepare them to excel at designing for the future.[36] Through shape, form, function, dynamic behavior, relationship, and evolving social dynamics people can continue to expand the capabilities of emerging technologies.

Universities must enable their equipment to be connected to advanced fabrication resources, such as the Fab Lab Network. They can augment these with courses on "how to design great things, relationships, and experiences,"[37] collectively through open education resources such as MIT's OpenCourseWare initiative.[38] These universities must play an active role in contributing to virtual and distributed collaboration tools and sustainable solutions—such as the advanced visualization, modeling, and

33. *See* Andy Greenberg, *The Fab Life*, FORBES (Aug. 13, 2008), http://www.forbes.com/2008/08/13/diy-innovation-gershenfeld-tech-egang08-cx_ag_0813gershenfeld.html.

34. Khalifa Saber, *Sandia/GM Study Finds Large-Scale Biofuel Is Sustainable*, ALT.ENERGY (Feb. 11, 2009), http://www.altdotenergy.com/2009/02/sandia-gm-study-finds-large-scale-biofuel-is-sustainable.

35. *See* Rachel Swaby, *Scientists Create First Self-Replicating Synthetic Life*, WIRED (May 20, 2010), http://www.wired.com/wiredscience/2010/05/scientists-create-first-self-replicating-synthetic-life (describing a future that might incorporate living material into everyday products to improve their form and function).

36. IDEO, HUMAN CENTERED DESIGN TOOLKIT 1 (2d ed. 2009), *available at* http://www.ideo.com/work/item/human-centered-design-toolkit.

37. *Fablab Network Worldwide*, FABLAB, http://fablab.waag.org/content/fablab-network-worldwide (last visited Dec. 20, 2010); *see also MAS.863 How to Make (Almost) Anything*, MIT OPEN COURSEWARE, http://ocw.mit.edu/courses/media-arts-and-sciences/mas-863-how-to-make-almost-anything-fall-2002/ (last visited Dec. 20, 2010) (taught by Professors Isaac Chuang and Neil Gershenfeld).

38. *See generally* MIT OPENCOURSEWARE, http://ocw.mit.edu/courses/ (last visited Dec. 20, 2010).

rapid prototyping employed by ASU's Partnerships for Research in Spatial Modeling and those used by Deutsche Telekom Innovation Center, Phillips, Design that Matters, and MIT's Fab Lab Network to connect to industry partners and rural communities in China, South America, and Africa.[39] These should be ubiquitous and central to the development of inventor workshops.

Inventor workshops can be places, networks of facilities, and diverse nurturing communities that span universities and extend to peer institutions, to realize multifaceted centers that attract and generate industry collaboration. They can be places where individuals and teams learn to fail over and over again, at the smallest and the biggest challenges of our time, en route to developing fundamental (deep and broad) personal and collective strategies for success and expert understanding of robust, empowering, and transformative solutions. They have the potential to radically transform universities by providing innovative empowering frameworks to train the next generation of transdisciplinary designers, engineers, scientists, educators, entrepreneurs, artists, writers, etcetera to pursue and excel at ambitious and profoundly meaningful activities.[40]

III. ALGAE AND COLLABORATIVE BIOFUEL INNOVATION[41]

Algae energy provides a useful case study with which to analyze optimal innovation and diffusion of climate-friendly measures.[42] As director of the University of Texas' Culture Collection of Algae, Jerry Brand takes care of a repository of 3000 organisms. He explains that biofuel scientists like a particular algae strain called *Neochloris oleoabundans* for its high oil-producing capacity.[43] Algae convert sunlight into oil that can be processed into biofuel.[44] Algae's need for carbon dioxide makes it

39. *See, e.g.*, MIT Ctr. for Bits & Atoms, *About*, FAB CENT., http://fab.cba.mit.edu (last visited Dec. 20, 2010).

40. *See, e.g.*, *Motivational Environments*, ARIZ. STATE UNIV., http://ame2.asu.edu/projects/intrinsic/Motivational_Environments/About_Us.html (last visited Dec. 20, 2010).

41. *See Algae Research*, SMITHSONIAN NAT'L MUSEUM NATURAL HISTORY, http://botany.si.edu/projects/algae/ (last visited Dec. 20, 2010) ("Algae are photosynthetic organisms that occur in most habitats. They vary from small, single-celled forms to complex multicellular forms, such as the giant kelps that grow to 65 meters in length. The US Algal Collection is represented by almost 300,000 accessioned and inventoried herbarium specimens.").

42. *See generally* Laura Isensee, *Commercial Green Fuel from Algae Still Years Away*, REUTERS (Oct. 8, 2009), http://www.reuters.com/article/idUSN0852895820091008 ("[F]inding the right strain of algae among thousands of species that will produce high yields; designing systems where the desired algae can multiply and other species don't invade and disrupt the process; and extracting its oils without degrading other parts of the algae that can be made into side products and sold as well. . . . Oil giants Exxon Mobil Corp . . . , Chevron Corp . . . and BP Plc . . . , as well as investors and the U.S. military, are sinking millions into the emerging industry.").

43. Russell Gold, *Pond Scum Gets Its Moment in the Limelight: An Algae Collection in Texas Is a Big Hit with the Biofuel Crowd*, WALL ST. J. (Apr. 11, 2009), http://online.wsj.com/article/SB123940976513610235.html#articleTabs%3Dvideo (video).

44. *Id.*; *see also* Deepa Babington, *Venice Seaport Eyes Algae to Fuel Energy Needs*, REUTERS (Mar. 24, 2009), http://www.reuters.com/article/idUSTRE52N59E20090324 ("Venice's seaport plans to

suitable as a means of reducing industrial carbon emissions.[45] The race is on to identify which strains of algae absorb the most carbon dioxide in differing growing mediums.[46] The National Renewable Energy Laboratory (NREL) can play an important role in coordinating university and public researchers, industry, and start-ups into networks that can bring such innovations into the marketplace.[47]

The *Wall Street Journal* notes that "[a]lgae are fast-growing, consume carbon dioxide and have the potential to produce more oil per acre than other biofuels. The oils they produce can be used to make substitutes for diesel fuel, aviation fuel and gasoline."[48] The Defense Advanced Research Projects Agency (DARPA) has already reduced the cost of extracting oil from algal ponds to $2 per gallon and is ramping up mass production of algae for jet fuel refining at a projected cost of $1 per gallon.[49] The U.S. Department of Defense is the single largest energy user in the United States, spending $18 billion on energy in 2008.[50] Its alternative fuel initiative seeks to save lives lost transporting fuel through war zones.[51] Top research priorities include optimizing use of jet fuel. Funds have been made available to convert algae into "jet propulsion

become self-sufficient in its energy needs by building a power plant fueled by algae . . . . [T]he algae will be cultivated in laboratories and put in plastic cylinders where water, carbon dioxide, and sunshine trigger photosynthesis. The resulting biomass will be treated further to produce a fuel to turn turbines. The carbon dioxide produced in the process is to be fed back to the algae, resulting in zero emissions from the plant. . . . [E]xcess energy could be supplied to ships docked at the harbor . . . .").

45. Stuart McDill, *Can Algae Save the World—Again?*, REUTERS (Feb. 11, 2009), http://www.reuters.com/article/idUSTRE5196HB20090211.

46. *Id.* ("The U.S. government began funding research in the 1970s and only discontinued the program in 1996 when it was reported that producing bio-diesel simply cost too much and would not become economic until oil prices rose to $40 a barrel.").

47. *See Commercialization & Technology Transfer*, NAT'L RENEWABLE ENERGY LAB., http://www.nrel.gov/technologytransfer/ (last visited Dec. 20, 2010); *see also* Bernie Woodall, *Algae Oil Developer OriginOil Signs Pact with U.S. DOE*, REUTERS (Feb. 17, 2009), http://in.reuters.com/article/idINTRE51G3WH20090217 ("Algae-to-energy developer OriginOil has signed an agreement with the U.S. Department of Energy to cooperate in research, the company said on Tuesday. Los Angeles-based OriginOil and the DOE's Idaho National Laboratory will work to validate the company's technology of growing algae for fuel in a 'photobioreactor'. . . . Its bioreactor attempts to speed the growth of algae in a tank by blending light emitted from a rotating shaft with nutrients.").

48. Michael Totty, *The Long Road to an Alternative-Energy Future*, WALL ST. J., Feb. 22, 2010, at R1.

49. Suzanne Goldenberg, *Algae to Solve the Pentagon's Jet Fuel Problem*, GUARDIAN (Feb. 13, 2010), http://www.guardian.co.uk/environment/2010/feb/13/algae-solve-pentagon-fuel-problem ("The work is part of a broader Pentagon effort to reduce the military's thirst for oil, which runs at between 60 and 75 million barrels of oil a year. Much of that is used to keep the US Air Force in flight. Commercial airlines—such as Continental and Virgin Atlantic—have also been looking at the viability of an algae-based jet fuel, as has the Chinese government. . . . The switch is partly driven by cost, but military commanders in Afghanistan and Iraq are also anxious to create a lighter, more fuel-efficient force that is less dependent on supply convoys, which are vulnerable to attack from insurgents.").

50. Steve Vogel, *Pentagon Prioritizes Pursuit of Alternative Fuel Sources*, WASH. POST, Apr. 13, 2009, at A13, *available at* http://www.washingtonpost.com/wp-dyn/content/article/2009/04/12/AR2009041202437.html?wprss=rss_politics/fedpage.

51. *Id.*

fuel 8" for Navy and Air Force aircraft.[52] Use of military buffer land for energy production could be applied at many installations.[53]

Remaining challenges include identifying inexpensive drying methods and fast-growing, high-oil content algae. If this can be done, algae can become a cost competitive, environmentally sound energy source that reduces carbon dioxide emissions and produces a nutritious residual cake that can be used as feedstock.[54]

Collaboration with the Aquatic Species Program of the U.S. Department of Energy led to ASU research on algal-based biofuel ranging from algae selection, to photobioreactor innovation, to optimizing drying and oil extraction, to conversion, to biodiesel and jet fuel, and to life cycle assessment.[55] Similar innovations are likely to result from research sponsored by recent stimulus funds. The American Recovery and Reinvestment Act, otherwise known as the 2009 stimulus package, allocated to the U.S. Department of Energy $1.6 billion and the National Science Foundation $2.5 billion for basic science research.[56] The Department of Energy Secretary awarded $44 million in federal stimulus funds to the National Alliance for Advanced Biofuels and Bioproducts, a consortium with patent-pending algae technology that has nutritional and energy ap-

52. *Id.*

53. *Id.* "[I]nsulating thousands of tents in Iraq and Afghanistan" has saved "$2 million in energy costs per day." *Id.* This has taken fuel trucks off "'some of the most dangerous roads in the world,'" saving lives. *Id.*

54. *See* David Shukman, *America's Energy Policy Dilemma*, BBC NEWS (Nov. 2, 2009), http://news.bbc.co.uk/2/hi/science/nature/8338164.stm ("Paddle wheels keep the algae circulating around vast shallow 'racetracks'. . . . [A]lgae will thrive even in brackish water, such as run-off from farmland . . . . [Profit margins can rise by] farming fish in the algae ponds or extracting valuable dyes from the microscopic plants.").

55. *Algal-Based Biofuels and Biomaterials*, ARIZ. STATE UNIV., http://biofuels.asu.edu/biomaterials.shtml (last visited Dec. 20, 2010) ("Although algal biomass residues derived from the oil extraction process can be used for animal feed or fertilizer, we are currently exploring, in collaboration with our industrial partners, the opportunity for using biomass residues to produce ethanol, and methane, and high-value biomaterials, such as biopolymers, carotenoids, and very long-chain polyunsaturated fatty acids. Collaboration with industrial partners to provide flue gas (APS), animal wastewater (United Dairymen of Arizona), commercial algal feedstock production capabilities (PetroAlgae), technical assistance with conversion of algae oil to biofuels (UOP and Honeywell Aerospace Division), and assistance with marketing of algal feedstock (Cargill) has either been initiated or is ongoing.").

56. American Recovery and Reinvestment Act of 2009, Pub. L. No. 111-5, 123 Stat. 115, 131, 139–40; *see also* Patrick J. Berry et al., *US: Summary of Energy and Environmental Provisions of the Federal Stimulus Legislation*, 4 I.E.L.R. 124 (2009); Mark A. Lemley & Bhaven Sampat, *Examining Patent Examination*, 2010 STAN. TECH. L. REV. 2, 33 (2010) ("[A]pplicants have opted for a slower process, either because they want delay so that they can modify their applications to track developments in the marketplace or because they want multiple patents to build an effective fence around a single invention."); Lisa Larrimore Ouellette, *Addressing the Green Patent Global Deadlock Through Bayh-Dole Reform*, 119 YALE L.J. 1727, 1734–1736 (2010) ("Socially responsible licensing policies for green technologies should make nonpatenting or nonexclusive licenses the default . . . . A congressional amendment to the Bayh-Dole Act would be a straightforward reform and would send a clear international signal. Congress could add a goal of global dissemination of federally funded research for humanitarian needs, and could give agencies the discretion necessary to create technology transfer policies consistent with these goals. In the absence of congressional action, however, there is room for change within the current Bayh-Dole regime to make university practices more consistent with the purposes of the Act." (footnote omitted)).

plications.[57] Algae can be farmed in mixed shallow salt/brackish water open ponds, and efforts are underway to produce low-cost, high-oil yield from selected algae species.[58] Such government incentives can be the single most effective means by which to ramp up energy innovation in the time frame needed to address climate change.

Similarly, equitable public-private partnerships can become powerful collaborative innovation initiatives worthy of financial and capacity building support. Catherine Hornby notes that, "[c]ompanies are racing to find economic ways to turn algae, one of the planet's oldest life forms, into vegetable oil that can be made into biodiesel, kerosene for jets and other fuels."[59] A demonstration algae plant, created by a public-private partnership between start-up Algenol Biofuels, industry giant Dow Chemical, a university, and a national laboratory, seeks to use algae to turn carbon dioxide into ethanol to produce plastics and vehicle fuel.[60] The Georgia Institute of Technology will research the separation of the oxygen and water from the ethanol, and the National Renewable Energy Laboratory will study the carbon dioxide impact on algae.[61] Matthew Wald notes that

> The process also produces oxygen, which could be used to burn coal in a power plant cleanly . . . . The exhaust from such a plant would be mostly carbon dioxide, which could be reused to make more al-

57. *Palmer Labs Awarded U.S. Department of Energy Funding for Algae Biofuel Research*, FORBES, PR NEWSWIRE (Jan. 14, 2010), http://www.prnewswire.com/news-releases/palmer-labs-awarded-us-department-of-energy-funding-for-algae-biofuel-research-81591082.html ("National Alliance for Advanced Biofuels and Bioproducts (NAABB) . . . will develop a systems approach for sustainable commercialization of algal biofuel (such as renewable gasoline, diesel, and jet fuel) and bioproducts. NAABB will integrate resources from companies, universities, and national laboratories to overcome the critical barriers of cost, resource use and efficiency, greenhouse gas emissions, and commercial viability. It will develop and demonstrate the science and technology necessary to significantly increase production of algal biomass and lipids, efficiently harvest and extract algae and algal products, and establish valuable certified co-products that scale with renewable fuel production. Co-products include animal feed, industrial feedstocks, and additional energy generation. Multiple test sites will cover diverse environmental regions to facilitate broad deployment."); *see also* Russell Gold, *Really Green Fuel: The EPA Opens the Door to Algae*, WALL ST. J. (July 28, 2009), http://blogs.wsj.com/environmentalcapital/2009/07/28/really-green-fuel-the-epa-opens-the-door-to-algae/ ("[T]he Environmental Protection Agency will count algae as an advanced biofuel under Renewable Fuel Standard rules being developed.").

58. *See Algae Biofuels Challenge*, CARBON TRUST, http://www.carbontrust.co.uk/emerging-technologies/current-focus-areas/algae-biofuels-challenge/pages/algae-biofuels-challenge.aspx (last visited Dec. 20, 2010) (noting that the Carbon Trust has fostered the "development of microalgae . . . biofuels towards commercial production for use in aviation and road transport by 2020").

59. Catherine Hornby, *From Dutch Sewers to Jet Fuel—Via Algae*, REUTERS (Feb. 12, 2009), http://uk.reuters.com/article/idUKTRE51B3K820090212 ("Dutch biotechnology firm Ingrepro plans to harness waste from sewers, farms and industry to produce biofuel and algae . . . . 'We are not focusing on biodiesel we are focusing on aviation fuel because we think the car industry will go electric and liquid fuels will only be needed in airplanes.'").

60. Matthew L. Wald, *Algae Farm Aims to Turn Carbon Dioxide into Fuel*, N.Y. TIMES (June 28, 2009), http://www.nytimes.com/2009/06/29/business/energy-environment/29biofuel.html?_r=1.

61. "The ethanol would be sold as fuel, the companies said, but Dow's long-term interest is in using it as an ingredient for plastics, replacing natural gas." *Id.* ("Because algae does not require any farmland or much space, many energy companies are trying to use it to make commercial quantities of hydrocarbons for fuel and chemicals.").

> gae. "We give them the oxygen, we get very pure carbon dioxide, and the output is very cheap ethanol" . . . .[62]

Another public-private partnership, the Energy Biosciences Institute, seeks to create dynamic intellectual bridges among agronomy, microbiology, mechanical and chemical engineering, biochemistry, chemistry, geography, economics, law, and policy analysis.[63] The Institute is researching the extent to which land can sustain cellulosic fuel globally before overwhelming ecosystems and food security.[64] Research is also under way to assess optimal feedstocks for energy production and minimize inputs as well as storage and transportation.[65]

Highlighting bioenergy collaboration, Bernice Lee, Ilian Iliev, and Felix Preston note that

> In July 2009 ExxonMobil announced a collaborative initiative with Synthetic Genomics Inc. on the commercialization of fuels produced from genetically engineered algae. BP invested $90m into a cellulose biofuels joint venture with Verenium, and a separate one with DuPont. This indicates a convergence between players from the oil and gas, biotech, biomass and chemicals industries into what may become a consolidated bioenergy sector.[66]

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62. *Id.*

63. The Energy Biosciences Institute brings together the Lawrence Berkeley National Laboratory, UC Berkeley, the University of Illinois, and BP. *See* ENERGY BIOSCIENCES INST., EXPLORING THE APPLICATIONS OF MODERN BIOLOGY TO THE ENERGY SECTOR: 2008 ANNUAL REPORT 2–3, 12–14 (2008), http://www.energybiosciencesinstitute.org/dmdocs/EBI-Annual-Report-2008.pdf.

64. *Id.* at 21–26.

65. *Id.* at 24 ("[T]he average soybean crop yields only about 63 gallons of biodiesel per acre. Contrast this with the much higher yields of cellulosic biomass that could be grown on the same acres—estimated at more than 1,500 gallons of cellulosic ethanol."). Additionally, farmers could "produce about half of all transportation fuels by growing a plant like Miscanthus on about 1 percent of the terrestrial surface area." *Id.* at 22. *See generally* MISCANTHUS BIOMASS RESEARCH UNIV. ILL., http://miscanthus.illinois.edu (last visited Dec. 20, 2010) (researching initiative at the University of Illinois aimed at using Miscanthus as a renewable energy source).

66. BERNICE LEE, ILIAN ILIEV & FELIX PRESTON, CHATHAM HOUSE, WHO OWNS OUR LOW CARBON FUTURE? INTELLECTUAL PROPERTY AND ENERGY TECHNOLOGIES 44 (2009), http://www.chathamhouse.org.uk/files/14699_r0909_lowcarbonfuture.pdf; *see also* Tom Bergin, *Shell Seeks to Make Diesel Fuel from Algae*, REUTERS (Dec. 11, 2007), http://www.reuters.com/article/idUSL1153718120071211 ("Shell is to fund a project that aims to produce transport fuel from algae, as biofuel production from palm oil and crops are increasingly criticized for causing deforestation and higher food prices. . . . In the late 1980s the U.S. government-funded National Renewable Energy Laboratory (NREL) researched the use of algae to produce biodiesel. However in the mid 1990s, the Department of Energy cut funding to the research, choosing to focus resources on researching production of ethanol, which is produced from sugars in crops such as corn or cane. In October, NREL said it was to collaborate with U.S. major oil company Chevron on research into producing road fuel from algae."); Timothy Gardner, *Green Fuel Solution Lurks in Pond Scum*, REUTERS (Oct. 26, 2007), http://in.reuters.com/article/idINIndia-30166620071026 ("Algae converts carbon dioxide, the main greenhouse gas blamed for global warming, into a vegetable oil . . . . Algae doesn't need prime farmland, vast quantities of fertilizer, or large harvest vehicles to be grown and harvested, unlike corn which is the main U.S. feedstock for ethanol, the top alternative motor fuel. . . . [A]lgae greenhouses can produce far more vegetable oil per acre than soybeans, currently the top U.S. biodiesel feedstock. Algae can produce 378,540 liters [100,000 gallons] of oil an acre annually, compared with about 50 gallons per acre for soybeans . . . ."); *Renewed Interest in Turning Algae into Fuel Generated*, SCIENCEDAILY (Jan. 19, 2008), http://www.sciencedaily.com/releases/2008/01/080115132840.htm

Countries can facilitate energy efficiency and alternatives to fossil fuels by enacting sound energy policies. Algae can play a role in transitioning to environmentally sound energy use around the globe. Algae technology is unique in its ability to produce a useful, high-volume product from waste carbon dioxide.[67] The international community should establish sustainability criteria that considers the origins of biofuels and life cycle costing.[68] The new International Renewable Energy Agency (IRENA) is well positioned to play a policy role in this regard.[69] Suzanne Goldenberg notes that

> Unlike corn-based ethanol,[70] algal farms do not threaten food supplies. Some strains are being grown on household waste and in brackish water. Algae draw carbon dioxide from the atmosphere when growing; when the derived fuel is burned, the same CO_2 is re-

("Soybeans produce about 50 gallons of oil per acre per year, and canola produces about 130 . . . . Algae, however, produces about 4,000 gallons per acre a year . . . .").

67. For discussions of algae as a pollutant, see generally Mary Jane Angelo, *Stumbling Toward Success: A Story of Adaptive Law and Ecological Resilience*, 87 NEB. L. REV. 950 (2009); Fred Bosselman, *Swamp Swaps: The "Second Nature" of Wetlands*, 39 ENVTL. L. 577 (2009); William S. Eubanks II, *The Sustainable Farm Bill: A Proposal for Permanent Environmental Change*, 39 ENVTL. L. REP.: NEWS & ANALYSIS 10,493 (2009); James Salzman, *Is It Safe to Drink the Water?*, 19 DUKE ENVTL. L. & POL'Y F. 1 (2008); Sandra Zellmer & Lance Gunderson, *Why Resilience May Not Always Be a Good Thing: Lessons in Ecosystem Restoration from Glen Canyon and the Everglades*, 87 NEB. L. REV. 893 (2009); Suzanne Bostrom, Note, *Halting the Hitchhikers: Challenges and Opportunities for Controlling Ballast Water Discharges and Aquatic Invasive Species*, 39 ENVTL. L. 867 (2009).

68. Pete Harrison, *Once-Hidden EU Report Reveals Damage from Biodiesel*, REUTERS (Apr. 21, 2010), http://www.reuters.com/article/idUSTRE63K2CB20100421 ("[B]iofuel production soaks up grain from global commodity markets, forcing up food prices and encouraging farmers to clear tropical forests in the quest for new land. Burning forests releases vast quantities of carbon dioxide and often cancels out many of the climate benefits sought from biofuels."); *see also* John A. Sautter, James Landis & Michael H. Dworkin, *The Energy Trilemma in the Green Mountain State: An Analysis of Vermont's Energy Challenges and Policy Options*, 10 VT. J. ENVTL. L. 477, 502 (2009) ("A least-cost life-cycle standard means that the value of any energy production unit is calculated by projecting the future value of all resource commitments to producing energy from the generating unit."); Fitri Wulandari, *Unilever to Review Buying CPO if Sinar Mas Cleared*, REUTERS (Apr. 8, 2010), http://www.reuters.com/article/idUSLDE6371JS20100408 ("Unilever . . . , the world's top palm oil buyer, will consider reviewing its suspension of palm oil purchases from Indonesia's PT SMART . . . if independent auditors clear the firm over alleged forest destruction, a company spokesman said on Wednesday.").

69. *See* IRENA, http://www.irena.org/ (last visited Dec. 20, 2010); *see also* Kate Connolly & David Gow, *UK Looks on from Sidelines at Green Energy Summit*, GUARDIAN (Jan. 26, 2009), http://www.guardian.co.uk/environment/2009/jan/26/irena-renewable-energy-summit ("A new international body to promote renewable energy is to be established today, in a move that its supporters insist has the potential to replace the global dominance of conventional power with wind, solar and other sustainable sources within a matter of years.").

70. *America's Biofuel Muddle: Coming up Empty*, ECONOMIST (Mar. 25, 2010), http://www.economist.com/node/15773820?story_id=15773820&fsrc=rss ("Ethanol, which is used mainly as an additive to petrol, is not a particularly good fuel: it offers only about two-thirds as much energy as petrol and can corrode pipelines and car engines."). For a history of the energy crisis and U.S. government regulation, see Bruce A. McCarl & Fred O. Boadu, *Bioenergy and U.S. Renewable Fuels Standards: Law, Economic, Policy/Climate Change and Implementation Concerns*, 14 DRAKE J. AGRIC. L. 43 (2009); see also Energy Independence and Security Act of 2007, Pub. L. No. 110-140, 121 Stat. 1492 (codified as amended at 42 U.S.C. § 17001 and other scattered sections as described therein (2006 & Supp. 2008)).

> leased, making the fuel theoretically zero-carbon, although processing and transporting the fuel requires some energy.[71]

The Environmental Protection Agency (EPA) has stated that algae-based diesel lowers greenhouse gas emissions by over fifty percent compared to traditional diesel.[72]

These innovative transdisciplinary public-private collaborations hope to bring bioenergy into widespread sustainable use. Yet, they are the exception not the norm. Necessity may be the mother of invention but it remains unclear how to spark a paradigm shift from exclusivity to shared knowledge communities that can ramp up climate-technology innovation, diffusion, and capacity building. Legal and policy reform in relation to intellectual property rights can significantly increase timely, widespread diffusion of environmentally sound technology.

IV. UNIVERSITIES AND GLOBAL DIFFUSION LEADERSHIP

While universities receive $1 billion annually in return for licensing patents,[73] Mark Lemley notes that, "[u]niversity technology transfer ought to have as its goal maximizing the social impact of technology, not merely maximizing the university's licensing revenue."[74] Universities should be amenable to situations in which environmentally sound, climate-friendly technology transfer should not be patented or be willing to license without royalty requirements. Alternatively, universities can limit durations of exclusivity or grant field-specific exclusive licenses. Universities can also make a distinction as to whether a technology will be used commercially or require diffusion targets in return for exclusivity.[75]

Michael Gollin speaks of the benefits of an accessible domain of knowledge from which innovation arises, recognizing an "invisible infrastructure of innovation."[76] He highlights the importance of intellectual property that (1) strengthens the incentive to create, (2) establishes exclusive rights with which groups can share and invest in creative works and within innovative communities control dissemination to society at large, yet (3) limits such exclusive rights in a manner that enables other creative actors to access and build upon existing innovations.[77]

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71. Goldenberg, *supra* note 49.

72. *Id.*

73. Mark A. Lemley, *Are Universities Patent Trolls?*, 18 FORDHAM INTELL. PROP. MEDIA & ENT. L.J. 611, 614 (2008); *see also* LEE, ILIEV & PRESTON, *supra* note 66, at 7 ("Universities increasingly license the use of their research or form a spin-off business. A variety of business models is used, including in-house models (primarily used by large, well-resourced universities), pooling resources through a regional partnership or small conglomerate of similar-sized institutions, partnering with a specialist IP organization or a corporatization model which sees a university's technology transfer office turned into a private (and often listed) corporation.").

74. Lemley, *supra* note 73, at 611.

75. *Id.* at 612.

76. GOLLIN, *supra* note 9, at 1, 5.

77. *Id.* at 4. "In the public health context, patient advocates seek greater access to patented drugs while pharmaceutical companies seek stronger intellectual property rights. At the same time,

Universities hold roughly one percent of all patents and a significant eighteen percent of biotechnology patents.[78] Furthermore, sixty percent of university licenses are exclusive.[79] The commercialization theory suggests that the investment needed to bring a product to market requires exclusive patent licensing and its validity is industry and technology specific.[80] Lemley points out that "we have seen an enormous number of technologies commercialized out of universities throughout the 20th Century without need of university patents. Think of the computer, the world wide web, search engines, relational databases, and any number of software programs."[81] Integrating university-licensing offices into broader university initiatives can facilitate optimal technology transfer policy mindful of university public service mandates.[82] University missions encompass teaching, research, and public service.[83] Universities can play a vital role in facilitating global climate mitigation and adaptation.

U.S. universities obtain patents for inventions resulting from federal funds under the U.S. Bayh-Dole Act of 1980.[84] Based on empirical research of university patents, Jay P. Kesan explains that "University tech transfer activities continue to be predominantly patent-centric and revenue driven with a single-minded focus on licensing income and reimbursement for legal expenses," rather than embracing "alternative technology transfer methods—such as open collaborations, free participant use agreements, increased focus on commercialization activities, and royalty-free licensing—that would result in university innovations being adopted and disseminated throughout society."[85] The Association of University Technology Managers can provide leadership in determining optimal public domain versus accessible domain dissemination options for climate-crucial technologies. While many such technologies have wide-ranging applications across digital, medical, and a wide array of other fields, time is of the essence to determine and implement a workable balance between innovation and dissemination of environmentally sound technologies.

The World Intellectual Property Organization (WIPO) notes that "[p]rotection of intellectual property is not an end in itself: it is a means to encourage creative activity, industrialization, investment, and honest

nations from which medicines are derived insist those who remove biological material ask permission and pay for the privilege." *Id.* at 1.

78. Lemley, *supra* note 73, at 615.

79. *Id.* at 617.

80. *See id.* at 621–623.

81. *Id.* at 624.

82. *See id.* at 628 ("The National Institutes of Health ('NIH') has, at various times in the past, imposed mandates requiring universities to grant certain types of licenses to their work.").

83. GOLLIN, *supra* note 9, at 102 ("[A]bout 40 universities have been in continuous operation for more than 500 years. Indeed, universities can outlast the nations in which they were founded, and some would say their purposes are more important to humanity.").

84. Bayh-Dole Act, 35 U.S.C. §§ 200–212 (2006) (applying to inventions made with federal funding).

85. Jay P. Kesan, *Transferring Innovation*, 77 FORDHAM L. REV. 2169, 2207 (2009).

trade."[86] Ideally, intellectual property rights can facilitate public disclosure of new creative works as well as investment and transfer of innovation.[87] Yet, they can keep crucial innovations out of the public domain and raise the cost of technology.[88] Intellectual property rights can focus industry efforts "on what can be protected, not what's best" and can lead innovators to compete rather than cooperate.[89] University research is hidden until post-patent application filing as a result of technology transfer office mandates to work with a system of licenses and material transfer agreements limiting public-private collaborations. In contrast, copyleft public licenses use intellectual property to facilitate open information sharing and can become a model for climate innovation collaboration.[90] Multinational corporations have a distinct advantage given the complexity and expense of obtaining and maintaining such intellectual property rights as patents.[91] This has come to be known as the "tragedy of the anti-commons."[92]

Poor countries cannot afford to invest in developing intellectual property. They struggle to comply with requirements set forth by the international Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS)[93] to establish and fund a patent and trademark office as well as operate a judicial system with the capacity to enforce intellectual property rights.[94] Despite these drawbacks, limited intellectual property rights can increase access to information that would otherwise be hidden. "The innovation cycle can be seen as a flow of information from the public domain to an exclusive domain, to accessibility, and back into the public domain."[95] Gollin further notes that

> Commercial and research practices and ethical standards have continued to evolve over the past 15 years, with the [Convention on Biological Diversity (CBD)], the TRIPS Agreement, the International Treaty on Plant Genetic Resources, and the open access movement. . . . [W]e are witnessing a rebalancing of the legal framework to provide incentives not just for innovation, but also for conserving the raw materials of innovation in the accessible domain.[96]

86. GOLLIN, *supra* note 9, at 36 (quoting WIPO).

87. *Id.* at 39.

88. *Id.* at 40–41 ("Antitrust laws can be used to keep IP rights from causing excessive concentrations of power in a monopoly.").

89. *Id.* at 42.

90. *Id.* at 42, 254. "[T]he U.S. Patent and Trademark Office began a pilot program for 'open peer review . . . .'" *Id.* at 113.

91. *Id.* at 42.

92. *Id.* at 44. Gollin points out that sectors of civil society see it as "immoral to impose property rights on something that should remain freely available." *Id.* at 43.

93. Agreement on Trade-Related Aspects of Intellectual Property Rights, Apr. 15, 1994, 1869 U.N.T.S. 299 (entered into force Jan. 1, 1995) [hereinafter TRIPS], *available at* http://www.wto.org/english/docs_e/legal_e/27-trips_01_e.htm.

94. GOLLIN, *supra* note 9, at 43.

95. *Id.* at 46.

96. *Id.* at 52.

The strengthening of intellectual property rights under TRIPS continues to be exceedingly controversial. The expanded use of patents, copyrights, trademarks, and trade secrets has led to tension among cultures divided between older communal traditional knowledge systems and the benefits of World Trade Organization (WTO) membership.[97]

Similarly contentious, the international climate change negotiations circle between expanding intellectual property rights, status quo, and limiting intellectual property rights for climate crucial technologies.[98] While the U.N. Framework Convention on Climate Change (UNFCCC)[99] and Agenda 21[100] have provided guidance since the early 1990s, international legal standards have yet to be codified with regard to which technologies qualify as environmentally sound.[101]

Basic solar cookers utilizing cardboard and aluminum foil are already being diffused broadly round the globe. In contrast, thin film PV flexible solar panel innovation has yet to come into widespread use due to high costs associated with mass production and intellectual property rights. Similarly, basic rainwater harvesting can be done with ancient traditional knowledge yet could be more effective at managing water if

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97. *Id.* at 53.

98. *Id.* at 56–57.

99. UNFCC, *supra* note 8.

> 5. The developed country Parties and other developed Parties included in Annex II shall take all practicable steps to promote, facilitate and finance, as appropriate, the transfer of, or access to, environmentally sound technologies and know-how to other Parties, particularly developing country Parties, to enable them to implement the provisions of the Convention. In this process, the developed country Parties shall support the development and enhancement of endogenous capacities and technologies of developing country Parties. Other Parties and organizations in a position to do so may also assist in facilitating the transfer of such technologies.

Id.

100. *Agenda 21*, *supra* note 1.

> 34.1. Environmentally sound technologies protect the environment, are less polluting, use all resources in a more sustainable manner, recycle more of their wastes and products, and handle residual wastes in a more acceptable manner than the technologies for which they were substitutes.
> 34.2. Environmentally sound technologies in the context of pollution are "process and product technologies" that generate low or no waste, for the prevention of pollution. They also cover "end of the pipe" technologies for treatment of pollution after it has been generated.
> 34.3. Environmentally sound technologies are not just individual technologies, but total systems which include know-how, procedures, goods and services, and equipment as well as organizational and managerial procedures. This implies that when discussing transfer of technologies, the human resource development and local capacity-building aspects of technology choices, including gender-relevant aspects, should also be addressed. Environmentally sound technologies should be compatible with nationally determined socio-economic, cultural and environmental priorities.
> 34.4. There is a need for favourable access to and transfer of environmentally sound technologies, in particular to developing countries, through supportive measures that promote technology cooperation and that should enable transfer of necessary technological know-how as well as building up of economic, technical, and managerial capabilities for the efficient use and further development of transferred technology. Technology cooperation involves joint efforts by enterprises and Governments, both suppliers of technology and its recipients. Therefore, such cooperation entails an iterative process involving government, the private sector, and research and development facilities to ensure the best possible results from transfer of technology. Successful long-term partnerships in technology cooperation necessarily require continuing systematic training and capacity-building at all levels over an extended period of time.

Id.

101. The creation of a Technology Mechanism under the UNFCCC could help flesh out what technologies should be transferred and under what terms.

recent innovations to stop and channel the flow of water were more widely available. Be it enzymes used for cellulosic ethanol, a high-oil content strand of algae, or breakthrough battery innovation—the international community has the capacity to follow through on UNFCCC and WTO commitments to diffuse environmentally sound technologies.

In the absence of an international patent, technology transfer recommendations range from expanding compulsory licensing to waiving patent infringement for scientific research.[102] India and other countries have already required patent applicants "to identify the source of any genetic material or traditional knowledge used in the invention."[103] Momentum is building to respond to climate change with open source licensing for environmentally sound, climate crucial technologies, expanding the open access movement.[104]

Given renewable innovation stimulus programs in the wake of global economic crisis, innovation and diffusion can make a substantial contribution to addressing both climate mitigation and adaptation. Be it access to solar panels or dengue and malaria drugs, technology transfer is an important component of climate treaty negotiation and implementation. Frederick Abbott notes that,

> There are a number of lessons that can be drawn from the public health-related negotiations, at the WTO and other forums, that may be useful to developing country negotiators addressing IPRs and climate change. Some of these lessons are relatively straightforward: economic and political power substantially influences the outcome of negotiations; the involvement of NGOs and other stakeholders is essential; it is important to shape public opinion through effective communication.[105]

Developing country and NGO efforts to complement the Doha Declaration on the TRIPS Agreement and Public Health with a similar declaration on intellectual property rights and climate change can build upon current technology transfer flexibilities designed to balance innovation and diffusion.

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102. GOLLIN, *supra* note 9, at 57.

103. *Id.* "India and other countries are establishing national systems to register and reward traditional knowledge, but the task is extremely difficult for many reasons. Traditional knowledge is not well documented. It may be collective, not individual. It may be old, not new." *Id.* at 78.

104. *Id.* at 57.

105. FREDERICK M. ABBOTT, INNOVATION AND TECHNOLOGY TRANSFER TO ADDRESS CLIMATE CHANGE: LESSONS FROM THE GLOBAL DEBATE ON INTELLECTUAL PROPERTY AND PUBLIC HEALTH ix, 1 (2009), http://www.frederickabbott.com/uploads/innovation-and-technology-transfer-to-address-climate-change.pdf ("Although highly capitalized corporations in the developed countries may be the best positioned to develop new technologies in certain fields, farmers in least developed countries (LDCs) may well develop agricultural techniques that reduce resource consumption and/or improve crop yields and reduce strains on agricultural land. Innovation must take into account different geographic, wealth and environmental conditions because technologies suitable for implementation only in wealthy developed countries may result in a shift of greenhouse gas output to less wealthy regions. While improvement will result from addressing greenhouse gas output in the developed countries, it is important that the situation be addressed on a global basis because 'global warming' is not limited to a particular geographic region. This will require development and transfer of suitable technologies.").

Access to information is also playing out in regional legal disputes. Public health remains a strong driver of environmental regulation. For instance, toxicity disclosure requirements may risk the loss of trade secrets.[106] That said, the risk that competitors deduce the chemical process used to extract natural gas is outweighed by the public's interest in safe drinking water. The names and physical properties of twenty percent of the 84,000 chemicals in commercial use in the United States are kept secret from all but a handful of EPA officials to protect trade secrets in a highly competitive industry.[107] As a result, regulators are hindered from controlling dangers, and citizens have no access to their toxic substance exposure rate. The 1976 Toxic Substances Control Act requires manufacturers to report new chemicals intended for market.[108] Trade secrecy provisions should accommodate the need for state regulators to access toxicity information with which to regulate such developments as natural gas extraction of Marcellus Shale. While co-generation that combines wind and natural gas production to optimize use of renewables with the reliability of natural gas generally makes sense, ramping up natural gas production must be done in a manner mindful of groundwater safety.

Be it local drinking water or multilateral climate debates, communities large and small can make difficult decisions in an inclusive manner, involving stakeholders in gathering and evaluating information. Technical expertise may be required for advanced chemical reactions, but moral decisions can be made irrespective of specialized training.

When it comes to patenting, "[e]xtracts are less controversial than whole organisms [and] [n]onreplicating materials like small chemicals are less controversial than replicating materials like DNA or microbes," Gollin explains.[109] With respect to such innovations as algae-to-fuel, it is worth noting that under Article 27(3) of the TRIPS Agreement, microbes are patentable in all WTO countries, potentially creating an internal conflict with the plain language of TRIPS Article 27(2), that appears to encompass exclusion of environmentally sound technologies from patentability.[110] Together TRIPS Articles 27(2), 66, and 67 set forth

106. GOLLIN, *supra* note 9, at 335.

107. Lyndsey Layton, *Use of Potentially Harmful Chemicals Kept Secret Under Law*, WASH. POST (Jan. 4, 2010), http://www.washingtonpost.com/wp-dyn/content/article/2010/01/03/AR2010010302110.html.

108. 15 U.S.C. § 2605 (2006); *cf.* Layton, *supra* note 107 ("A week after he arrived at the agency in July, Steve Owens, assistant administrator for the EPA's Office of Prevention, Pesticides and Toxic Substances, ended confidentiality protection for 530 chemicals. In those cases, manufacturers had claimed secrecy for chemicals they had promoted by name on their Web sites or detailed in trade journals.").

109. GOLLIN, *supra* note 9, at 304.

110. TRIPS, *supra* note 93, art. 27(2) ("Members may exclude from patentability inventions, the prevention within their territory of the commercial exploitation of which is necessary to protect *ordre public* or morality, including to protect human, animal or plant life or health or to avoid serious prejudice to the environment, provided that such exclusion is not made merely because the exploitation is prohibited by their law."); *see also id.* art. 2(1) (incorporating Articles 1 through 12 and Article 19 of the Paris Convention of 1883, including Article 5's compulsory licensing provision). The 173 member states to the Paris Convention of 1883 have committed to its intellectual property rights rules. *See* Par-

that WTO members should share environmentally sound technologies to least developed countries[111] as well as engage in broad technological cooperation.[112]

While certain states have lacked the domestic political awareness and will to provide leadership regarding emerging public international law, the WTO has benefited from strong country commitments to cooperate on free trade measures. Building international consensus is an arduous task across many sectors, yet momentum is building to try to resolve key areas of international concern—including transfer of environmentally sound technologies to least developed countries. This collective effort can translate into binding treaty language with which to address post-2012 climate coordination at the international level. The U.S. EPA has upped the ante for U.S. engagement in resolving a post-2012 regime, announcing on December 7, 2009, that "greenhouse gas emissions pose a threat to public health and welfare."[113] This announcement represents a game changer, clarifying that the EPA is willing to regulate greenhouse gas emissions under the federal Clean Air Act.[114]

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is Convention for the Protection of Industrial Property, Mar. 20, 1883, 21 U.S.T. 1583, 828 U.N.T.S. 305; *see also* Todd R. Miller & Dawn M. Amos, *Cleantech Innovators Should Be Aware of Certain Global Intellectual Property Issues*, INTELL. PROP. & TECH. L.J., May 2010, at 1–3 (discussing TRIPS Articles 30 and 31 on emergency use); ICTSD, ICTSD'S INITIATIVE ON CLIMATE TECHNOLOGY AND TRADE (n.d.), http://ictsd.org/downloads/2009/12/climate-technology-and-trade_brochure_02dec1.pdf. *See generally* SUSTAINABLE DEVELOPMENT IN WORLD INVESTMENT LAW (Marie-Claire Cordonier Segger, Markus Gehring & Andrew Newcombe eds., Kluwer Law International 2011).

111. TRIPS, *supra* note 93, art. 66 on Least-Developed Country Members states that

> 1. In view of the special needs and requirements of least-developed country Members, their economic, financial and administrative constraints, and their need for flexibility to create a viable technological base, such Members shall not be required to apply the provisions of this Agreement, other than Articles 3, 4 and 5, for a period of 10 years from the date of application as defined under paragraph 1 of Article 65. The Council for TRIPS shall, upon duly motivated request by a least-developed country Member, accord extensions of this period.
>
> 2. Developed country Members shall provide incentives to enterprises and institutions in their territories for the purpose of promoting and encouraging technology transfer to least-developed country Members in order to enable them to create a sound and viable technological base.

112. *Id.* art. 67 on Technical Cooperation states that

> In order to facilitate the implementation of this Agreement, developed country Members shall provide, on request and on mutually agreed terms and conditions, technical and financial cooperation in favour of developing and least-developed country Members. Such cooperation shall include assistance in the preparation of laws and regulations on the protection and enforcement of intellectual property rights as well as on the prevention of their abuse, and shall include support regarding the establishment or reinforcement of domestic offices and agencies relevant to these matters, including the training of personnel.

113. Miller & Amos, *supra* note 110, at 1; *see also* Endangerment and Cause or Contribute Findings for Greenhouse Gases Under Section 202(a) of the Clean Air Act, 74 Fed. Reg. 66,495 (Dec. 15, 2009) (to be codified at 40 C.F.R. ch. I), *available at* http://www.epa.gov/climatechange/endangerment.html.

114. Endangerment and Cause or Contribute Findings for Greenhouse Gases Under Section 202(a) of the Clean Air Act, 74 Fed. Reg. at 66,500; *see also* Clean Air Act, 42 U.S.C. §§ 7401–7671 (2006); Miller & Amos, *supra* note 110, at 4 (noting that the Clean Air Act's mandatory licensing provision can be found at 42 U.S.C. § 7608 and that "when a patent is being used or is intended for public or commercial use and is not otherwise reasonably available and is necessary to enable someone to comply with other provisions of the Clean Air Act, a mandatory license may be granted. There must be no reasonable alternative methods available to accomplish the same purpose, and the unavailability of the right to use it must result in 'a substantial lessening of competition or tendency to create a mo-

Policy indecision has left those involved in energy innovation and diffusion with unclear signals, delaying decision making across the board. This ripple effect can be reversed through non-state actor cooperation. Todd Miller and Dawn Amos note that "[v]oluntary diffusion reduces or eliminates the need for government bodies to step in and use tools such as compulsory licensing,[115] royalty free patent pooling, and the like. Voluntary diffusion is also a quicker mechanism in contrast to forced diffusion that involves politics and red tape."[116] Voluntary approaches that innovators can implement include technology sharing,[117] licensing to scale,[118] and direct foreign investment.[119]

Responding to climate change should involve maximizing the capacities of public innovation communities—including global innovation initiatives, multinational research consortia, and ad hoc arrangements such as open innovation communities.[120] These organizations coordinate with the United Nations and related international organizations. The international community can combine international law, best practices, innovation prizes, patent pools,[121] standardized licensing arrangements, compul-

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nopoly.' While this compulsory licensing provision was much hyped after passage of the Clean Air Act, it has not quite lived up to the original excitement as there have been no known attempts to use it").

115. "A compulsory license is one that is granted without the patent holder's consent or against the patent holder's will. A government may issue a compulsory license for its own use or grant one to a third party." Miller & Amos, *supra* note 110, at 2.

> The Bayh-Dole Act also provides for march-in rights. Even when title has been retained, the funding agency may require the title owner or its licensee to license the invention on terms reasonable under the circumstances. The agency may itself also grant such a license if the inventor or licensee refuses to do so if the agency determines that the patent holder has not taken effective steps to achieve practical application of the invention or the action is necessary to alleviate health or safety needs that are not being satisfied. Because the government is authorized to license to third parties, march-in rights are broader than the license the government has under 35 U.S.C. § 202(c).

Id. at 3.

116. *Id.* at 5.

117. *Id.* ("The Eco-Patent Commons was launched in January 2008 by IBM, Nokia, Pitney Bowes, and Sony in partnership with the World Business Council for Sustainable Development. More than 100 eco-friendly patents have been pledged by 11 companies that covenant not to assert their rights against those using technologies in the Commons for environmental benefit. The Creative Commons is also planning to launch a green commons called the Green Xchange in early 2010.").

118. *Id.* at 5–6. Licensing to scale involves setting a lower price while selling more of a given product, an approach that can accelerate diffusion of environmentally sound technology in a manner that benefits everyone.

119. For a discussion of forced technology diffusion through compulsory licensing see *id.* at 5 ("One example of successful direct foreign investment involves the General Electric Company and Shenhua Group, China's biggest coal producer, partnering to build integrated gasification combined cycle (IGCC) facilities across China.").

120. GOLLIN, *supra* note 9, at 97.

121. *See* Miller & Amos, *supra* note 110, at 4–5 ("Patent pooling usually refers to a private agreement between two or more patent holders privately to cross license their patents relating to a particular technology. A patent pool is said to be 'closed' when it restricts access. In contrast, an 'open' patent pool allows access by any party to the technologies covered. Option 2 of the Negotiating Text provides for the creation of a Global Technology Pool for Climate Change to promote access to climate friendly technologies for developing countries, 'including on non-exclusive royalty-free terms.' Option 2 also states that steps need to be taken to ensure sharing of publicly funded technologies and related know how, including doing so 'to developing countries on royalty free terms.'").

sory licensing for public emergencies, equitable royalties, and dispute resolution to address climate change.[122] All of these, particularly the latter, can be implemented remaining mindful of the scarcity of time with which climate stabilization must occur. In a joint report, energy and environment research institutes from across India, China, Indonesia, Malaysia, and Thailand note that "compulsory licensing of technology, in the absence of access to equipment, know-how and human skills to adapt and implement the technology, would not be able to translate to effective transfer."[123] Technology funds[124] can be a powerful means of diffusing climate technology, but cannot be a magic bullet where markets are dominated by a few sellers hesitant to license given technologies.[125] Patent buy-outs can be "diplomatic alternative[s]" to compulsory licensing.[126] Yet buy-outs and mandatory price negotiations for patented products could prove to be more complex in the climate context than in relation to pharmaceutical products since climate technologies often involve numerous intellectual property rights in each product.[127]

The World Intellectual Property Organization[128] and the U.N. Department of Economic and Social Affairs have promoted patent prizes,[129]

122. GOLLIN, *supra* note 9, at 112.

123. ENERGY & RES. INST., EMERGING ASIA CONTRIBUTION ON ISSUES OF TECHNOLOGY FOR COPENHAGEN 39 (2009), http://www.teriin.org/div/Paper_AEI.pdf ("Some of the hurdles in technology transfer of climate relevant technologies can also be addressed through tackling anti-competitive practices. Article 31(c) of TRIPS provides that a country can use such a measure 'to remedy a practice determined after judicial or administrative process to be anti-competitive.'").

124. *Id.* ("The inspiration for such a fund comes from the financial mechanism under the Montreal Protocol for inter alia licensing fees of alternative technologies . . . .").

125. *Id.* at 40. Licensing should be forthcoming as developing countries become TRIPS compliant. *Id.* at iv.

126. *Id.* at 40.

127. *Id.* ("Price regulation can be imposed even as a competition-remedy measure. Since countries are empowered to act under their competition regimes such a mechanism is legally possible. However, for many developing countries, it would not be easy to enforce when the companies in question could be big trans-national companies from a powerful country." (citation omitted)).

128. *Id.* at 40–41 (noting that WIPO facilitates voluntary sharing arrangements including: patent commons (pledging patented technology for broad use without royalty payment), patent pools (patent holders agree to license technologies to one another), humanitarian or preferential licensing, reducing fees for patent holders who agree to make their patented technology available to anyone seeking a license, putting technologies in the public domain, and open innovation); *see also* Charles R. McManis, *Teaching Current Trends and Future Developments in Intellectual Property*, 52 ST. LOUIS U. L.J. 855, 856 (2008) ("The TRIPS Agreement essentially thrust the protection of intellectual property into the heart of international trade law by obligating all members of the WTO to comply with a detailed set of international minimum standards for intellectual property protection and enforcement, and provided that any member disputes over TRIPS implementation were to be submitted to the WTO dispute settlement process. Suddenly, the WIPO, which had unsuccessfully sought to develop a consensus among its members on international minimum standards for intellectual property protection, found itself cast in a new international role as the international agency responsible for keeping pace with rapid technological developments, identifying emerging intellectual property law issues, and developing appropriate international law and policies to deal with those emerging issues, while leaving it to the WTO to obtain compliance with the TRIPS international minimum standards for intellectual property protection and enforcement." (footnotes omitted)).

129. "A cheap solar cooker has won first prize in a contest for green ideas. [It] is made from cardboard and can be used for sterilising water or boiling or baking food." Richard Black, *Prize for "Sun in the Box" Cooker*, BBC NEWS (Apr. 9, 2009), http://news.bbc.co.uk/2/hi/science/nature/7991654.stm. Another innovation featured in the competition's final was "a feed additive for live-

pools, commons, and other models of shared intellectual property rights.[130] Noting that such approaches will remain "severely constrained unless more players come on board, willing to share a greater number of 'valuable' patents," India, China, Indonesia, Malaysia, and Thailand conclude their report by recommending that developed nations allocate some of their research and development (R&D) budget for developing climate technologies available to developing countries pursuant to Article 4.3 of the UNFCCC.[131]

Both climate change and biotechnology are multisectoral concerns, encompassing agriculture, public health, and industry.[132] Biotechnology has significantly challenged international intellectual property policy.[133] Kerstin Mechlem and Terri Raney note that food security includes "the availability, accessibility, safety, nutritious quality, and acceptability of food, as well as the degree of sustainability with which that food is grown . . . ."[134] Mechlem and Raney conclude that since "technology is

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stock, derived from garlic, which can cut methane emissions from cows and sheep by at least 5%." *Id.* ("The Climate Change Challenge competition was also supported by the Financial Times newspaper and technology company HP.").

130. ENERGY & RES. INST., *supra* note 123, at 41.

131. *Id.* at 43–44. Article 4.3 of the UNFCCC Report states that

> The developed country Parties and other developed Parties included in annex II shall provide new and additional financial resources to meet the agreed full costs incurred by developing country Parties . . . . They shall also provide such financial resources, including for the transfer of technology, needed by the developing country Parties to meet the agreed full incremental costs of implementing measures . . . .

Rep. of the Intergovernmental Negotiating Comm. for a Framework Convention on Climate Change, 5th Sess., Apr. 30–May 9, 1992, U.N. Doc. A/AC.237/18 (Pt. II)/Add.1 (May 15, 1992) [hereinafter UNFCCC Report], http://unfccc.int/resource/docs/a/18p2a01.pdf.

132. *See* Kerstin Mechlem & Terri Raney, *Agricultural Biotechnology and the Right to Food*, *in* BIOTECHNOLOGIES AND INTERNATIONAL HUMAN RIGHTS 131, 132 (Francesco Francioni ed., Hart Publ'g 2007).

133. McManis, *supra* note 128, at 857. McManis notes that

> [T]he 2001 WTO Ministerial Conference, in its Doha Declaration, specifically directed the TRIPS Council to examine the relationship between the TRIPS Agreement and the Convention on Biological Diversity, as well as the protection of traditional knowledge and folklore. Likewise, in 2000, the WIPO established an Intergovernmental Committee on Intellectual Property and Genetic Resources, Traditional Knowledge and Folklore to facilitate discussion of intellectual property issues that arise in the context of access to genetic resources and the fair and equitable sharing of benefits arising out of the utilization of same, as well as the protection of traditional knowledge, innovations, creativity, and expressions of folklore. As these actions by the WTO and WIPO illustrate, a second fundamental emerging legal issue in international intellectual property law is the growing interface with international environmental law. . . . Finally, the TRIPS requirement that WTO members protect plant varieties either by patents or by an effective *sui generis* system or some combination thereof, together with the recent promulgation and entry into force of the FAO International Treaty on Plant Genetic Resources for Food and Agriculture, highlights the growing interface between international intellectual property and agricultural law.

Id. at 867–68 (footnotes omitted); *see also* Convention on Biological Diversity, June 5, 1992, 1760 U.N.T.S. 142 (discussing technology involved in protecting biological diversity).

134. Mechlem & Raney, *supra* note 132, at 132. Mechlem and Raney note that

> The Green Revolution demonstrated that technological innovation—higher yielding seeds and the inputs required to make them grow—can play an important role in increasing food availability. Between 1960 and 2000, global cereal production more than doubled on virtually the same amount of land. As a consequence, an additional two billion people are being fed, and fed much better. The share of the world's chronically hungry population fell by half during the same period . . . .

embodied in the seed, it is scale-neutral and easily transferable," benefiting small-scale and resource-poor farmers.[135] They note that food safety concerns regarding genetically modified (GM) crops, and foods derived from them, include toxins, allergens, and antibiotic resistance and that long-term effects should be monitored but that research to reduce allergens in GM crops is underway.[136] Existing GM crops that require less insecticide than conventional crops can reduce chemical residue on food.[137] Yet, concern mounts regarding the trend toward privatization of research as the top ten bioscience companies shell out $3 billion annually on agricultural biotechnology R&D.[138] Drought and salinity tolerance are crucial areas of research that remain underfunded.[139]

In contrast, renewable energy innovation has become diffused around the globe.[140] The World Resources Institute highlights the need for policy and technical capacity building—"[s]killed people, who understand the technologies are necessary to develop, install, maintain and adapt technologies to local circumstances."[141] While innovation has yet to occur at a rate necessary to address climate change, a coordinated strong technology push can mobilize public funding of innovation, demonstration, diffusion, and capacity building.[142] International technology

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> High-yielding GM crops could offer similar opportunities to grow more food on the same amount of cultivated land. Until now, however, biotechnological innovations have focused mainly on crops grown with large-scale farming methods in developed countries, not on those of greatest importance to developing countries.

Id. at 137.

135. *Id.* at 138.

136. *Id.* at 139–140.

137. *Id.* at 140–141.

138. *Id.* at 145.

139. *Id.* at 146.

140. For example, the Village Energy Project (VE) is involved in widespread diffusion of a small-scale anaerobic digestion process (waste to biogas) using a microbial process. Demonstration and deployment of these units is accompanied by training and seed money for socially responsible local production. VILLAGE ENERGY, http://www.villageenergy.org/projects-overview.html (last visited Dec. 20, 2010). "1.6 billion people today have no access to electricity. 2.4 billion rely on primitive biomass for cooking and heating." Press Release, Int'l Energy Agency, Energy and Poverty: IEA Reveals a Vicious and Unsustainable Circle (Aug. 21, 2002), *available at* http://www.iea.org/press/pressdetail.asp?PRESS_REL_ID=64. "[F]our out of five people without electricity currently live in rural areas of the developing world." *Id.*

141. Deborah Seligsohn, Lutz Weischer, Shane Tomlinson & Pelin Zorlu, *Key Functions for a UNFCCC Technology Institutional Structure: Identifying Convergence in Country Submissions* 5 (World Res. Inst., Working Paper, 2009), *available at* http://pdf.wri.org/working_papers/key_functions_for_a_unfccc_technology_institutional_structure.pdf ("Enhanced capacity is necessary to speed up the development, deployment and transfer of technology. Countries need to increase their absorptive capacity and the strength of their innovation systems.").

142. *See id.* at 1 (noting that World Resources Institute's seven critical functions include: (1) "[t]echnology development; i.e. the innovation and production of new technologies," (2) "[t]echnology transfer and diffusion; i.e. the actual arrangement by which either the knowledge or the ownership of the knowledge is transferred from one actor to the other," (3) "[s]trategic planning and needs assessment," (4) "[c]oordination," (5) "[i]nformation sharing," (6) "[c]apacity building," and (7) "[m]onitoring and assessment").

entities can facilitate technology transfer by funding start-ups and lowering costs by sharing best practices.[143]

The G77 + China group has proposed a new technology mechanism under the UNFCCC with an executive body consisting of experts on technology transfer and government officials (with balanced regional representation) that would execute a technology action plan to accelerate invention and diffusion.[144] The technology mechanism would also have a secretariat, strategic planning committee, verification group, and technical panels.[145] These entities would support new national and regional technology excellence centers.[146] A new technology fund under the UNFCCC could augment venture capital funding for innovation, leveraging further private capital via public investment in emerging climate-friendly technologies. The fund would support the process from innovation to diffusion and capacity building. China further suggests linking public investment, capital market, carbon market, and technology market.[147]

The Ad Hoc Working Group on Long-term Cooperative Action under the UNFCCC is considering a new technology mechanism that would consist of (1) a "Technology Executive Committee" and (2) a "Climate Technology Centre."[148] The text currently has two options with regard to intellectual property rights—option one would be to refrain from addressing intellectual property rights in the text while option two would state:

> Any international agreement on intellectual property shall not be interpreted or implemented in a manner that limits or prevents any Party from taking any measures to address adaptation or mitigation of climate change, in particular the development and enhancement of endogenous capacities and technologies of developing countries and transfer of, and access to, environmentally sound technologies and know-how;
>
> Specific and urgent measures shall be taken and mechanisms developed to remove barriers to the development and transfer of technologies arising from intellectual property rights protection, in particular:

143. *See id.* at 5 ("Enabling environments refer to policies and measures to support deployment and diffusion. These policies and measures could be 'direct' actions, such as increases in R&D funding, deployment schemes, or procurement plans and 'enabling' actions, such as market reforms, carbon pricing, and training of experts. They also involve a technical component, for example investment in grids.").

144. *Id.* at 6.

145. *Id.*

146. *Id.*

147. *Id.*

148. Chair of the Ad Hoc Working Grp. on Long-term Coop. Action Under the Convention, *Text to Facilitate Negotiations Among Parties* Annex I ¶ 43 (Ad Hoc Working Group on Long-term Cooperative Action Under the Convention, Paper No. FCCC/AWGLCA/2010/6, 2010), *available at* http://unfccc.int/resource/docs/2010/awglca10/eng/06.pdf.

(a) Creation of a Global Technology Intellectual Property Rights Pool for Climate Change that promotes and ensures access to intellectual property protected technologies and the associated know-how to developing countries on non-exclusive royalty-free terms;

(b) Take steps to ensure sharing of publicly funded technologies and related know-how, including by making the technologies and know-how available in the public domain in a manner that promotes transfer of and/or access to environmentally sound technology and know-how to developing countries on royalty-free terms;

Parties shall take all necessary steps in all relevant forums to exclude from Intellectual Property Rights protection, and revoke any such existing intellectual property right protection in developing countries and least developed countries on environmentally sound technologies to adapt to and mitigate climate change, including those developed through funding by governments or international agencies and those involving use of genetic resources that are used for adaptation and mitigation of climate change;

Developing countries have the right to make use of the full flexibilities contained in the Trade Related Aspects of Intellectual Property Rights agreement, including compulsory licensing;

The Technology Executive Committee shall recommend to the Conference of the Parties international actions to support the removal of barriers to technology development and transfer, including those arising from intellectual property rights.[149]

Much of this negotiating text remains heavily bracketed, indicating that it is still subject to dispute.[150] Delegates to the international climate negotiations need to remove the brackets and agree upon draft outcome text. This process is at the crux of the chaotic global debate. It is increasingly clear that innovation and technology transfer are core components of the international climate negotiations.[151]

Breakthrough innovations often result from interdisciplinary collaboration.[152] "[I]nventions in the energy sector have generally taken two to three decades to reach the mass market," according to a study conducted by Bernice Lee, Ilian Iliev, and Felix Preston, while similar lag time has

149. *Id.* Annex III ¶ 11.

150. For an analysis of the climate negotiations, see Elizabeth Burleson, *Climate Change Consensus: Emerging International Law*, 34 WM. & MARY ENVTL. L. & POL'Y REV. 543 (2010).

151. LEE, ILIEV & PRESTON, *supra* note 66, at 3 (noting the importance of "compulsory licensing, patent pools of publicly funded technologies and using the precedent set by multilateral action such as the Doha Declaration on the World Trade Organization's Agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS) and Public Health").

152. *Id.* at vii ("[I]nnovation in solar PV technologies has benefited from developments in consumer and industrial electronics, and advances in CSP derive from aerospace and satellite technologies.").

been required for later inventions to use such patented technology.[153] They note that the "diffusion time for clean technologies globally will need to be halved by 2025 to have a realistic chance of meeting climate goals."[154] This can be done through targeted policies that accelerate demonstration and deployment, as has occurred with wind and solar since the 1990s.[155] Developing country deployment of climate technologies may initially require foreign technologies but should be done in coordination with facilitating indigenous innovation.[156] Using data on the patents registered by researchers to protect their technological inventions, Lee, Iliev, and Preston conclude that

> High-carbon companies control some of the key knowledge assets needed for the low carbon economy. Seven out of the top 20 owners of cleaner-coal patents are from the steel sector. Carbon capture and storage (CCS) technologies originate in a range of applications in the petrochemical, fertilizer and enhanced oil-recovery sectors. The use of advanced alloys is critical for the next generation of wind, PV, CSP and cleaner-coal power generation.
>
> The key question is how to identify the assets in high-carbon industries and harness them for low carbon technologies, in developing and developed countries alike. It is also important to ensure that climate policies offer sufficient incentives for innovation among important technology players. The current trend towards excluding heavy industry from climate-change regulations (e.g. by issuing free emission permits) may reduce these incentives, with negative spillover effects on the rest of the economy.[157]

Concentration of patent ownership can sometimes delay innovation and diffusion.[158] Patent rights are viewed as "currency" that can lure venture capital, insulate from litigation, and lead to entry into important collaborations and mergers and acquisitions.[159] Industrial heavyweight perceptions of developing countries influence diffusion rates via licensing, funding, or knowledge sharing.[160]

Enhancing global cooperation is requisite to accelerate innovation and technology diffusion in order to adequately address climate change.[161] This can be done by expanding knowledge networks that faci-

153. *Id.*

154. *Id.*

155. *See id.* at vii–viii.

156. *Id.* at viii.

157. *Id.* This study is based on close to 57,000 patents across six key technology sectors covering a span of over thirty years. *Id.* at vii. "Many energy technologies are also dependent on innovation in advanced materials, e.g. alloys." *Id.* at ix.

158. *Id.* at viii.

159. *Id.* at ix.

160. *See id.* ("One worrying trend is the increase in patent-related litigation in fast-maturing technologies. While it is understandable that patent owners seek to assert their right to protect their inventions and markets, protracted lawsuits can slow the diffusion of key technologies by decades.").

161. *See id.* at ix–x ("By adopting advanced technologies—and strengthening their innovation capabilities—developing countries have an opportunity to leapfrog the resource-intensive, highly polluting growth phase experienced by Western countries . . . . While there is [currently] some collabora-

litate ramped up collaboration regarding inventions across sectors and countries.[162] Options include joint ventures, cross-training and licensing, trade tariff exemptions, and joint manufacturing.[163] Governments have a crucial role to play in facilitating global demonstration programs, optimal technology standards entities, and open innovation.[164] The latter can include a range of climate-technology prizes.[165] Similarly, fiscal and investment incentives established by governments encourage the establishment of cross-licensing schemes and patent pools. Knowledge-sharing can be sped up by showcasing and using model R&D cooperation agreements between developing/developed countries and minimizing patent-related conflicts.[166] Such agreements can be made available as part of a global database set up by WIPO, featuring best practices and useful licensing information.[167] Knowledge-intensive, climate-friendly technology can most effectively be broadened to developing countries through combined transfer and capacity building. The latter involves "learning by doing," assisted by individuals familiar with the technology, as mere ownership of technology does not guarantee its use.[168] The clearinghouse, or database approach, can complement governmental push/pull incentives for innovation by clarifying targeted R&D investment (technology push) as well as bringing products to market via regulatory standards and/or pricing mechanisms (market pull).[169]

Climate technology innovation and diffusion suffer from market imperfections. Governmental market intervention in the form of offering intellectual property right protection can increase incentives to innovate since R&D investments can be recovered through commercialization of products. Yet companies under-invest in climate-related R&D when they view a lack of ability to make a profit above initial investments. What might make sense for a given company's bottom line does not make sense on a societal level. Governments engaged in correcting

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tion among OECD countries, only two per cent of joint patents are shared between companies and institutions from developed and developing countries.").

162. *Id.* at x, 58 ("In designing global solutions it will be necessary to strike a careful balance between private interests and the delivery of global public goods, and to take into account the social and economic needs of developing countries. New incentive systems and collaborative mechanisms at bilateral, regional and international levels will be essential to encourage technological innovation, demonstration and diffusion.").

163. *Id.*

164. *Id.*

> Technology standards bodies are industry associations administering key technology standards on behalf of the market. Typically the entrants will contribute IP for mutual use, which means cross-licensing agreements are often part of these associations. All members can use IP within agreed boundaries and may be required to pay royalties into a common pool.

Id. at 7.

165. *Id.* at x.

166. *Id.* at xi.

167. *Id.* The authors note that in an effort to increase knowledge networks, the global community should "[i]nvest in sectoral mapping. Existing efforts by WIPO, such as geographic patent mapping, should also be extended . . . ." *Id.* at 59.

168. *Id.* at 4.

169. *Id.*

market failures of this nature can be more nuanced in the means by which they reward innovation. Market pull approaches beyond simple patent protection can involve reciprocity that intellectual property protection will come with a commitment to invest in research crucial to sustaining public goods, such as a stable climate.[170] Governments can also address a second market failure by adjusting market prices to recognize the social benefit of climate mitigation and adaptation. Subsidies and regulations can make it profitable to diffuse socially beneficial technologies.[171]

Strong patent portfolios are often prerequisites for attracting investment:[172] "A patent portfolio is a currency—for attracting venture capital, entry into strategic alliances, protection against litigation, as well as opening opportunities for mergers and acquisitions," according to Lee, Iliev, and Preston.[173] Their research indicates that early leaders of new innovations become dominant due to their intellectual property portfolio, involvement in standard setting, and influence over distribution.[174] Patents encourage innovation but do not necessarily lead to timely diffusion.[175]

V. THE INTERNATIONAL CLIMATE NEGOTIATIONS

The international community is engaged in a collective struggle to respond to its scientific understanding of climate change with an effective and equitable legal framework. Wet regions of the world will become wetter and dry regions will become dryer, according to the Intergovernmental Panel on Climate Change.[176] Expansion of water as oceans absorb heat from the atmosphere contributes to sea-level rise, as does melt water from ice caps and glaciers.[177] Deep cuts in global greenhouse gas emissions are needed to avert further climate destabilization.[178] "You can expect that as you have droughts, as you have scarcity of re-

170. *See id.* ("Market 'push' incentives can include research grants, tax credits, and direct or partnership-based research by governmental agencies. Making these incentives accessible to new entrants is critical.").

171. *Id.* at 5.

172. *Id.* at 6.

173. *Id.* at 57.

174. *See id.* at 9.

175. *Id.* at 44.

176. Intergovernmental Panel on Climate Change, *Technical Paper on Climate Change and Water*, 28th Sess., Apr. 9–10, 2008, at 32, U.N. Doc. IPCC-XXVIII/Doc.13 (Apr. 9, 2008), http://www.ipcc.ch/meetings/session28/doc13.pdf.

177. Anna Vigran, *With Climate Change Comes Floods*, NPR (Jan. 14, 2008), http://www.npr.org/templates/story/story.php?storyId=18229027. The ten cities at the highest risk for flooding are: Mumbai, Guangzhou, Shanghai, Miami, Ho Chi Minh City, Calcutta, greater New York City, Osaka-Kibe, Alexandria, and New Orleans. *Id.*

178. Chair of the Ad Hoc Working Grp. on Long-term Coop. Action Under the Convention, *Negotiating Text*, Annex ¶ 3 (Ad Hoc Working Group on Long-term Cooperative Action Under the Convention, Paper No. FCCC/AWGLCA/2009/8, 2009) [hereinafter *Negotiating Text*], *available at* http://unfccc.int/resource/docs/2009/awglca6/eng/08.pdf.

sources . . . it will increase tensions and it will increase conflict," according to the U.N. Deputy High Commissioner for Refugees, L. Craig Johnstone.[179] He explains that climate change is likely to displace 6 million people each year, forcing up to 250 million people to become refugees by 2050.[180] Climate change, acting as a "multiplier of existing health risks,"[181] necessitates coordinated efforts to increase the efficiency of water use, both to deal with infectious disease transmission caused by the presence of dams and to address food security impacts of rapid development of biofuels.[182]

The 1992 UNFCCC commits member states to "common but differentiated responsibilities"[183] and the 1997 Kyoto Protocol sets mandatory emission-reduction goals.[184] The Kyoto Protocol entered into force in 2005 and currently has 190 parties.[185] Member states to both the original convention and the subsequent protocol meet annually, gathering in forums that bring together perspectives from governments, intergovernmental organizations, nongovernmental organizations, and individual members of civil society. The U.N. Environment Programme (UNEP) predicts that more than eight thousand Clean Development Mechanism projects will be operational "or in the pipeline by 2012," making $25–30 billion available to developing countries.[186] Tim Gore of Oxfam International notes that countries "are now walking in the right direction, but they need to start running."[187] MIT's John Sterman observes that the offers on the table will result in a global temperature increase of 3.9°C (7°F) above preindustrial levels.[188] Ban Ki-moon calls upon the interna-

179. Megan Rowling, *U.N. Says Climate Change May Uproot 6 Million Annually*, REUTERS (Dec. 8, 2008), http://www.reuters.com/article/idUSTRE4B773G20081208; *see also Climate Change Could Force Millions from Homes*, REUTERS (Oct. 8, 2008), http://www.reuters.com/article/idUSTRE497BQK20081008.

180. *See* Rowling, *supra* note 179; *see also Climate Change Could Force Millions from Homes*, *supra* note 179 (noting that it is more likely that low-income persons will be displaced and human trafficking networks could benefit from the serious environmental situations).

181. WORLD HEALTH ORG., PROTECTING HEALTH FROM CLIMATE CHANGE: GLOBAL RESEARCH PRIORITIES 6 (2009), http://whqlibdoc.who.int/publications/2009/9789241598187_eng.pdf.

182. *See id.* at 12.

183. UNFCCC Report, *supra* note 131, Annex I art. 4.

184. U.N. Framework Convention on Climate Change, *Kyoto Protocol*, art. 3, U.N. Doc. FCCC/CP/1997/L.7/add.1 (Dec. 10, 1997), http://unfccc.int/resource/docs/convkp/kpeng.pdf. The treaty addresses the following greenhouse gasses: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6). *Id.* Annex A; *see also* Elizabeth Burleson, *A Climate of Extremes: Transboundary Conflict Resolution*, 32 VT. L. REV. 477 (2008); Elizabeth Burleson, *Multilateral Climate Change Mitigation*, 41 U.S.F. L. REV. 373, 379–80 (2007).

185. *Status of Ratification of the Kyoto Protocol*, UNFCCC, http://unfccc.int/essential_background/kyoto_protocol/status_of_ratification/items/5524.php (last visited Dec. 20, 2010).

186. Anna Mudeva & Michael Szabo, *U.N. Climate Talks to Speed CO2 Offset Approval*, REUTERS (Dec. 13, 2008), http://uk.reuters.com/article/idUKTRE4BA60S20081213 (describing "emissions-cutting projects" under the "clean development mechanism" agenda set forth in the Kyoto Protocol).

187. Jeff Tollefson, *Last-Minute Deal Saves Climate Talks*, NATUREWS (Dec. 13, 2010), http://www.nature.com/news/2010/101213/full/468875a.html.

188. Stu Seidel, *Climate Accord in Hand, Obama Turns to Senate*, NPR (Dec. 19, 2009), http://www.npr.org/templates/story/story.php?storyId=121669686&ft=1&f=1001.

tional community to "think big, connecting the dots between poverty, energy, food, water, environmental pressure and climate change."[189] The floods in Pakistan and fires in Russia are the latest bells tolling an alarming wake up call. Donne's wisdom grows ever more timely:

> No man is an island, entire of itself; every man is a piece of the continent, a part of the main. If a clod be washed away by the sea, Europe is the less, as well as if a promontory were, as well as if a manor of thy friend's or of thine own were: any man's death diminishes me, because I am involved in mankind, and therefore never send to know for whom the bells tolls; it tolls for thee.[190]

The spoken and unspoken calls of children, women, and men, of forest beings and marine life are coalescing. Time will not gain patience—we must channel the urgency into collective action to address climate change. "I was born in 1992. You have been negotiating all my life. You cannot tell us that you need more time," Christina Ora of the Solomon Islands challenged a collection of 193 countries gathered at the Cancun climate negotiations.[191] Despite interminable shuttles between surreal resorts along the "Riviera Maya," it seems the multilateral climate process has regained momentum. At its core the Cancun Agreements set forth: (1) greenhouse gas mitigation by all countries; (2) an Adaptation Framework; (3) A Technology Transfer Mechanism to facilitate environmentally sound technology and capacity building; (4) a new U.N. Green Climate Fund; (5) measurable, reportable, and verifiable inspections for the United States, China, and other major emitting countries; (6) scientific review after five years; and (7) forestry consensus to fund countries to avert deforestation.

VI. RECOMMENDATIONS

Climate-resilient communities can be achieved with the support of global research, development, deployment, and diffusion of environmentally sound energy technologies and processes.[192] Averting catastrophic climate-security risks can be accomplished if the international community substantially strengthens its commitment to mitigate, adapt, fund, and innovate.

Legal measures that respond effectively and equitably to climate change can facilitate sustainable development, security, and energy inno-

189. Wangari Maathai, *Cancún Must Be About More than Climate Change*, GUARDIAN.CO.UK (Nov. 26, 2010), http://www.guardian.co.uk/commentisfree/cif-green/2010/nov/26/cancun-climate-change-conference.

190. JOHN DONNE, *Mediation*, *in* DEVOTIONS UPON EMERGENT OCCASIONS XVII (Ann Arbor Paperback 1959), *available at* http://www.gutenberg.org/ebooks/23772.

191. Alister Doyle, *Analysis: Climate Talks: 18 Years, Too Little Action?*, REUTERS (Dec. 12, 2010), http://www.reuters.com/article/idUSTRE6BB0DS20101212.

192. CLIMATE ACTION NETWORK INT'L, SUBMISSION TO AWG-LCA ON FINANCE FOR MITIGATION AND LOW CARBON AND CLIMATE-RESILIENT DEVELOPMENT (2009), http://unfccc.int/resource/docs/2008/smsn/ngo/093.pdf. Public financing must also be utilized to support and encourage private financing. *Id.*

vation. *Our Common Future* defined sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs."[193] Energy security and innovation can be enhanced through laws that address climate change.

A. *Energy Security and Innovation*

Several important ingredients of energy security include: diversity of energy sources, security of infrastructure, stable investment in sustainable technologies, and security of transit.[194] Much of the global oil trade navigates such strategic points as the Strait of Hormuz,[195] leading to heavy protection of corridors through which oil is transported.[196] As global energy demand rises, the need to facilitate energy cooperation among consuming, exporting, and transit jurisdictions has become crucial. At the same time, there is an equally vital need to enhance energy efficiency and expand use of renewable energy. The international community can agree upon an Energy Cooperation Framework Convention,[197] based on the potential of the European Energy Charter Treaty (ECT).[198] The ECT focuses on energy investment, trade, and transit.[199] The treaty seeks to balance the concerns of importing and exporting nations by preserving "sovereignty over natural resources and guaranteeing protection of investment in exploration and production."[200] Such legal frameworks can balance economic, environmental, and social elements of energy trade.

Reducing energy imports and diversifying global energy supply can be accomplished by reducing use of fossil fuels, making more efficient use of remaining fossil fuel products, enhancing the efficiency and securi-

193. WORLD COMM'N ON ENV'T & DEV., OUR COMMON FUTURE, at 43, U.N. Doc. A/42/427 (1987), *available at* http://www.un-documents.net/ocf-02.htm.

194. *See* SANAM S. HAGHIGHI, ENERGY SECURITY: THE EXTERNAL LEGAL RELATIONS OF THE EUROPEAN UNION WITH MAJOR OIL AND GAS SUPPLYING COUNTRIES 419 (Hart Publ'g 2007).

195. COUNCIL ON FOREIGN RELATIONS, NATIONAL SECURITY CONSEQUENCES OF U.S. OIL DEPENDENCY: REPORT OF AN INDEPENDENT TASK FORCE 23 (2006), http://www.cfr.org/publication/11683/national_security_consequences_of_us_oil_dependency.html?breadcrumb=%2Fissue%2F18%2Fenergy_security.

196. *Id.* at 30.

197. HAGHIGHI, *supra* note 194, at 422.

198. Energy Charter Treaty, Dec. 17, 1994, 34 I.L.M. 381 (1994), *reprinted in* THE ENERGY CHARTER TREATY AND RELATED DOCUMENTS: A LEGAL FRAMEWORK FOR INTERNATIONAL ENERGY COOPERATION 21 (2004), http://www.encharter.org/fileadmin/user_upload/document/EN.pdf.

199. The Energy Charter Treaty guarantees protection of foreign investment. It offers energy-producing countries essential energy technologies and upgrading of energy exploration and production mechanisms. The Treaty eventually guarantees the uninterrupted flow of energy through secure transit routes. One major obstacle in the path of the ECT's development, however, is the lack of adequate membership of the major energy-producing countries (only three important countries, namely Turkmenistan, Azerbaijan, and Kazakhstan have joined). THE ENERGY CHARTER TREATY AND RELATED DOCUMENTS: A LEGAL FRAMEWORK FOR INTERNATIONAL ENERGY COOPERATION, *supra* note 198, at 13–17.

200. HAGHIGHI, *supra* note 194, at 423.

ty of energy infrastructure, and significantly ramping up environmentally sound energy investment.[201] Countries can use energy, materials, and labor that optimize efficiency in energy generation. For instance, hybrid-electric vehicles can reduce fossil fuel use as long as the base electricity load is not based on such fossil fuels as coal. Conversely, transport of coal by rail, truck, barge, or pipeline results in air pollution, herbicide use on rights of way, and dredging of waterways.[202]

Worldwide, approximately $235 billion annually subsidizes coal, oil, natural gas, and nuclear energy, yet renewable energy is seen as uncompetitive in contrast to traditional energy sources. Richard Ottinger, Lily Mathews, and Nadia Elizabeth Czachor note that

> Subsidies for production, R & D, and insurance for fossil and nuclear energy go to the most affluent corporations in the world, granted primarily because of political pressures, often induced by political contributions. . . . Renewable energy in the United States is being inhibited today by direction of 95 per cent of the subsidies and R & D funding to the established energy companies . . . .[203]

Energy subsidies should align with efforts to genuinely address climate mitigation and adaptation.

"[A]llowing independent power producers to sell their power onto the grid" is an important means by which to diversify the energy sector and establish an even playing field for renewable resources.[204] High transmission access rates and standby rates as well as fixed unavoidable charges constitute unreasonable interconnection requirements of utilities on new producers. Ottinger, Mathews, and Czachor explain that intermittent-generator exit fees are often fictitious commitments of availability and fees are unrealistic for intermittent energy producers.[205] Similarly, government approval requirements, such as for liability insurance or performance of payment guarantees, are not adequately geared toward interconnection by renewable energy producers.[206] At the same time, intermittent resources are not given credit for increasing security via energy diversity, emissions reductions, reducing peak-load, and helping to prevent power surges.[207]

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201. COUNCIL ON FOREIGN RELATIONS, *supra* note 195, at 31.

202. George (Rock) Pring, Alexandra Suzann Haas & Benton Tyler Drinkwine, *The Impact of Energy on Health, Environment, and Sustainable Development: The TANSAAFL Problem*, *in* BEYOND THE CARBON ECONOMY: ENERGY LAW IN TRANSITION 13, 19 (Donald N. Zillman et al. eds., 2008).

203. Richard L. Ottinger, Lily Mathews & Nadia Elizabeth Czachor, *Renewable Energy in National Legislation: Challenges and Opportunities*, *in* BEYOND THE CARBON ECONOMY: ENERGY LAW IN TRANSITION, *supra* note 202, at 183, 186 ("Indeed, political reform is one of the major imperatives for elimination of unjustified subsidies. Where there are no effective limits on lobbying or campaign contributions, as in the United States, the powerful can readily corrupt the political process with contributions, gaining unjustified direct subsidies and favorable financing, depreciation, and tax treatment that result in policies that favor them but harm the general public.").

204. *Id.* at 189.

205. *Id.*

206. *Id.*

207. *See id.* at 189–190.

Broader use of renewable energy can be facilitated through such market incentives as subsidies and cap-and-trade programs. Government programs can encourage deployment of renewables, while utility regulatory requirements and programs can avoid advantaging fossil fuel sources to the exclusion of intermittent energy producers. A twenty percent renewable standard by 2020 can result in the development of significant renewable energy capacity, as can citizen-suit enforcement measures.[208] Net-metering provisions support the expansion of small renewable energy producers since each is able to feed the grid, allowing their electricity meters to run backward when they can produce more energy than they consume.

Feed-in tariffs, such as those pioneered by Germany, require utilities to grant renewable energy producers access to the grid.[209] They also force energy utilities to purchase energy produced at a fixed price, which can depend on the source of the renewable energy.[210] As a result, certain technologies can receive support based upon maturity and cost of production, encouraging renewable energy development.[211] While such an approach helps small local energy producers enter the market, it can be difficult to identify optimal feed-in tariff levels that are neither too low to support production nor too high to result in windfall profits.[212]

In contrast, renewable portfolio standards can mandate a set quantity of renewable energy that will be produced.[213] Renewable portfolio standards requiring twenty percent renewable energy by 2020 can facilitate the requisite transition from coal to more efficient and environmentally sound energy sources. Programs, such as the U.S. Energy Star system, that highlight efficient consumer options can help individuals and organizations make conscientious energy decisions.[214] Labeling programs work effectively in helping countries transition to goods and services that are equitable and environmentally sustainable. Legislatures can facilitate stable, large-scale R&D that rises above bringing special interest funds home to given jurisdictions.[215]

Denmark has reduced its greenhouse gas emissions by fourteen percent since 1990—over the same time frame, it has raised gross domestic product by over forty percent while keeping energy consumption con-

208. *See id.* at 192–193.

209. *Id. See generally* SMARTGRID.GOV, http://www.smartgrid.gov/ (last updated Dec. 6, 2010) ("Government-sponsored Smart Grid projects are transforming electric power systems in communities across the country.").

210. Ottinger, Mathews & Czachor, *supra* note 203, at 192.

211. *Id.* ("Ideally the tariffs are guaranteed for a certain period of time and then reduced, allowing time for investors to earn returns but ultimately providing incentives for cost reduction. The cost of the tariffs is usually spread among all energy consumers as an electricity surcharge.").

212. *Id.* at 193–194.

213. *Id.* at 197. "Production tax credits are another common method of subsidizing renewable energy production, in which tax benefits are tied to the amount of renewable energy produced. Alternatively, production payments may be given per unit of renewable energy produced." *Id.* at 194.

214. *See generally* ENERGY STAR, http://www.energystar.gov (last visited Dec. 20, 2010).

215. COUNCIL ON FOREIGN RELATIONS, *supra* note 195, at 45–46.

stant.[216] It has done so through: cap-and-trade, energy/carbon taxes, environmentally sound building codes, and labeling.[217] Energy tax revenues return to industry subsidizing environmental innovation in addition to supporting, mass transit, and energy efficiency. Energy technologies constitute eleven percent of Danish exports while renewables supply thirty percent of Denmark's electricity mix.[218]

Like Denmark, Texas has recently established laws that facilitate renewable energy capacity. Enabling environments—such as existing energy infrastructure and expertise in the case of Texas, and a socialist political bent in Denmark—may have facilitated the ramping up of the wind energy sector in each of these jurisdictions. Texas passed a renewable portfolio standard in 1999 that required the state's competitive electric providers to bring 2000 megawatts (MW) of new renewable energy capacity online by 2009.[219] This standard was achieved in a little over six years, prompting the Texas legislature to increase the renewable portfolio standard to 5880 MW by 2015 and 10,000 MW by 2025.[220] A renewable energy credit trading program will operate through 2019.[221] Requiring electricity providers to include such renewables as wind, solar, biomass, hydropower, and geothermal power in the energy mix that they sell to retail customers significantly facilitates the increase in renewable energy generation.[222] Texas also requires its public utility commission to designate competitive renewable energy zones and mandates the construction of electric transmission infrastructure with which to bring renewable energy from these zones to areas of high demand.[223]

Comprehensive energy innovation programs can be enhanced by a central figure at the national level focused on facilitating the transition to greater efficiency and environmentally sound energy innovation. This can place energy on equal footing with defense policy and international economic directorates. The Council on Foreign Relations' Independent Task Force argues that

> Global dependence on oil is rapidly eroding U.S. power and influence because oil is a strategic commodity largely controlled by regressive governments and a cartel that raises prices and multiplies the rents that flow to oil producers. These rents have enriched and emboldened Iran, enabled President Vladamir Putin to undermine Russia's democracy, entrenched regressive autocrats in Africa, forestalled action against genocide in Sudan, and facilitated Venezuela's

216. Thomas L. Friedman, Op-Ed., *The Copenhagen that Matters*, N.Y. TIMES (Dec. 22, 2009), http://www.nytimes.com/2009/12/23/opinion/23friedman.html.

217. *Id.*

218. *Id.*

219. S.B. 7, 76th Leg., Reg. Sess. (Tex. 1999).

220. S.B. 20, 79th Leg., 1st Called Sess. (Tex. 2005).

221. *Texas Renewable Portfolio Standard*, STATE ENERGY CONSERVATION OFFICE, http://www.seco.cpa.state.tx.us/re_rps-portfolio.htm (last visited Dec. 20, 2010).

222. In the solar context, see generally Sara C. Bronin, *Solar Rights*, 89 B.U. L. REV. 1217 (2009).

223. *See* S.B. 79th Leg., 1st Called Sess. (Tex. 2005).

> campaign against free trade in the Americas. Most gravely, oil consumers are in effect financing both sides of the war on terrorism.[224]

Strengthening energy security and mitigating climate change require a focus upon legal and technological measures to facilitate a transition to renewable energy sources. Environmentally sound energy sources are geographically broadly available while producing few greenhouse gas emissions. Yet legal barriers and lack of funding have hindered technological advances that can lower costs. Approximately twenty percent of future emissions can be eliminated by switching to renewables for cooling/heat, electricity, and transport.[225] Beyond regenerative braking, vehicles can store electricity through onboard batteries. Antony Froggatt and Michael Levi note the need for "rapid and widespread diffusion of renewable technologies and the introduction of new energy systems and infrastructures that are more suited to the more dispersed and intermittent generation associated with renewable energy."[226] Yet, they go on to caution that, "if managed poorly, intermittent renewable electricity sources could degrade power supplies. And some express concerns that the long-distance power transmission required for some renewable energy schemes (such as solar generation for Europe based in North Africa) would introduce infrastructure-related security vulnerabilities."[227] Energy diversity sustains resilience, while its absence decreases security. Patrice Kunesh notes that "[r]esilience is weakened or lost when systems lose the ability to foresee and adapt to external variability. . . . The ability to withstand destabilizing forces and the development of foresight potential are critical facilities of resilient systems."[228] Energy innovation cooperation can increase resilience around the globe.

B. Committing to Sustainability

While sustainable development is widely respected as a goal, the international community continues to struggle with the legal complexities of maintaining international peace and security generally and addressing climate change in particular. Until recently, attention focused upon Blackwater and waterboarding to the exclusion of water insecurity and climate change. While natural resources are at the core of many of the world's armed conflicts, the environmental components of security have yet to be sufficiently integrated into efforts to define and maintain security. The role of reciprocity cannot be overestimated in building consensus

224. COUNCIL ON FOREIGN RELATIONS, *supra* note 195, at 60.

225. Antony Froggatt & Michael A. Levi, *Climate and Energy Security Policies and Measures: Synergies and Conflicts*, 85 INT'L AFF. 1129, 1134 (2009), *available at* http://www.cfr.org/publication/20922/climate_and_energy_security_policies_and_measures.html?breadcrumb=%2Fpublication%2Fby_type%2Fjournal_article.

226. *Id.*

227. *Id.* at 1135.

228. Patrice H. Kunesh, *Constant Governments: Tribal Resilience and Regeneration in Changing Times*, 19 KAN. J.L. & PUB. POL'Y 8, 13–14 (2009).

on climate and energy policy. Applying customs of peace to such global public goods as climate can lead to reciprocal commitments to mitigate and adapt to climate change.

Energy, environmental, and economic concerns can as easily draw us together as splinter us into factions. Both for ill and for good, the last several decades have seen recognition of the growing importance of non-state actors. Although terrorism continues to rattle the international framework of decision making and threatens the emergence of open societies, access to information has expanded, and this development has enabled civil society to speak on behalf of sustainable development generally and on ecological integrity in particular. Good governance depends upon a free press and an informed citizenry. Good governance also depends upon a culture in which news is not first and foremost entertainment. Access to information is also a key to economic development. It is equally critical to protecting human rights and the environment. Regrettably, access to information about ordinary citizens has increased while, at times, access to information about government has been curtailed.

Over the past decade, much ink has been spilled debating the balance between participation and surveillance. Distinguishing between potential transnational terrorists and individuals displaced by climate change will likely be difficult. Irrespective of the legal status of people who have fled, recent experiences of U.S. Gulf Coast residents and Darfur villagers indicate that we are not presently prepared for the scale of humanitarian response that is likely to be requisite over the next several decades. The term "climate refugee" has yet to become a legal term at international law, and the absence of a legal framework with which to address climate displacement will likely further threaten international peace and security.[229]

The institutional integrity of the United Nations and nongovernmental organizations that have been working with countries can continue to lead to broad ratification of treaties that can play a role in conflict prevention. Rod Beckstrom notes that, "[w]hen a fairly centralized player gets attacked by a decentralized force, like al-Qaeda, the first reaction is to centralize further, and that's usually a strategic mistake."[230] Governments have wavered in their commitment to the absolute prohibition of torture and the minimization of counterterrorism measures' encroachment upon human rights. Discussing the flow of information between government and civil society, Beckstrom notes that, "[t]he people living in any community have the best sense of what is really going on in that community. They have local intelligence."[231] Local wisdom and in-

229. *See generally* Elizabeth Burleson, Essay, *Climate Change Displacement to Refuge*, 25 J. ENVTL. L. & LITIG. 19 (2010).

230. Elizabeth Williamson, *Follow the Leader, or Think Like a Starfish?*, WASH. POST (Jan. 1, 2007), http://www.washingtonpost.com/wp-dyn/content/article/2006/12/31/AR2006123100832.html.

231. *Id.*

formation regarding local events remains valuable to governments during armed conflicts. If governments use violent means by which to acquire information, violence will be sustained. Facilitating access to education and employment across the Middle East could break the cycle of violence if pursued with mutual respect.[232] "When cultures feel insulted, people can become radicalized," Beckstrom points out.[233] Building consensus between cultures requires an exchange of perspectives and a genuine search for common ground.

Post-conflict peace building is vital to achieving sustainability.[234] Armed conflict has negatively impacted the international effort to achieve sustainable development. Civil wars have generated or intensified poverty and contributed to the global drug problem, the rise of terrorist organizations, and the spread of diseases such as AIDS and malaria.[235] The World Bank notes that while the number of civil wars has declined worldwide,

> [e]ighty percent of the world's 20 poorest countries have suffered a major war in the past 15 years. On average, countries coming out of war face a 44 percent chance of relapsing in the first five years of peace. Even with rapid progress after peace, it can take a generation or more just to return to pre-war living standards.[236]

In contrast, June Fletcher has noted that there exists a McMansion glut in the United States that has left few people able to afford $5000 a year to heat and cool a 5000-square-foot house: "[n]ationwide, electricity rates have risen 12% over the past three years, while the price of natural gas for heating has risen 43% in the same period . . . ."[237] As Henry David Thoreau once observed: "What is the use of a house if you haven't got a tolerable planet to put it on?"[238]

But what is a "tolerable planet?" What can be tolerated? We are a highly adaptable species but that does not mean that individuals or even nation-states are highly adaptable in short timeframes. Undoubtedly, ac-

232. *Id.*

233. *Id.*

234. *Peacebuilding Efforts Producing Results on the Ground, Security Council Told*, UN NEWS CENTRE (Oct. 21, 2008), http://www.un.org/apps/news/story.asp?NewsID=28659&Cr=peacebuilding&Cr1=commission ("The United Nations peacebuilding arm is making steady progress and has produced concrete results in the four post-conflict countries placed under its direction in the two years since its work started, the Security Council was told in a briefing today. In the wake of the 2005 World Summit, the UN set up the 31-member Peacebuilding Commission (PBC), which currently has four countries—Burundi, Sierra Leone, Guinea-Bissau and Central African Republic (CAR)—on its agenda. . . . Areas such as youth employment, rural private sector, justice and peace need to be addressed so that the countries under the Commission's consideration can successfully surface from their individual conflicts.").

235. *See Work in Fragile and Conflict-Affected Countries*, WORLD BANK, http://web.worldbank.org/WBSITE/EXTERNAL/NEWS/0,,contentMDK:20042303~menuPK:34480~pagePK:64257043~piPK:437376~theSitePK:4607,00.html (last updated Sept. 2010).

236. *Stimulating Good Governance in Fragile States*, WORLD BANK, http://go.worldbank.org/6GS91MWG50 (last visited Dec. 20, 2010).

237. June Fletcher, *The McMansion Glut*, WALL ST. J., June 16, 2006, at W1.

238. Letter from Henry David Thoreau to Harrison Blake (May 20, 1860), *in* FAMILIAR LETTERS OF HENRY DAVID THOREAU 416 (F.B. Sanborn ed., 1894).

celerating climate change will be tolerated by some life on Earth. Yet which species will tolerate it, and for how long, should not be the question.[239] A far better question is how to avert catastrophic climate change through sustained legal cooperation that will achieve environmentally sound sustainable development. This requires the largest greenhouse gas emitters to come together and agree to collective action. China and the United States are the two most strategic players in this process. As permanent members of the U.N. Security Council, both countries hold the unilateral power with which to address sustainability and security in a legally integrated manner.

All avenues of cooperation should be used at once. The following do not need to occur in any given order. The Security Council should agree to act to address the threat that migration, loss of sovereignty, and a wide range of climate change ramifications have on international peace and security. A resolution that recognizes that climate change threatens human security on the scale of warfare is crucial. Such a resolution can facilitate a legal response to displacement, statelessness, and a host of other climate induced security dilemmas for individuals and nation-states alike.

In addition to Security Council leadership, negotiations culminating in effective and equitable mitigation, adaptation, funding, and technology transfer should continue. Civil-society participation is crucial to achieving international agreement in keeping with scientific climate consensus.[240] Combining mitigation, adaptation, funding, and environmentally sound technology transfer in an effective and equitable manner can jumpstart genuine sustainable development on a global scale. Doing so requires political will on the part of nation-states to commit to numerical targets, as well as to follow through on sufficient funding and technology assistance. These are not new debates. While nations and non-state actors alike have become preoccupied, international agreements such as the UNFCCC, Agenda 21, and others demonstrate that the international community has known for quite some time what should be done. Moving beyond normative pronouncements to positive commitments is a legal process long overdue.

239. Even if it were the question, humans as a species are unlikely to find the outcomes favorable.

240. United Nations Framework Convention on Climate Change Bali, Indonesia, Dec. 3–15, 2007, U.N. Doc., FCCC/CP/2007/6 (Mar. 14, 2008), http://unfccc.int/resource/docs/2007/cop13/eng/06.pdf; *see also* Tomilola Akanle, Asheline Appleton, Douglas Bushey, Kati Kulovesi, Chris Spence & Yulia Yamineva, *A Brief History of the UNFCCC and the Kyoto Protocol*, EARTH NEGOTIATIONS BULL. (Int'l Inst. for Sustainable Dev., 12 IISD 395, New York, N.Y.), Dec. 15, 2008, at 1, 2, http://www.iisd.ca/download/pdf/enb12395e.pdf ("This roadmap includes 'tracks' under the Convention and the Kyoto Protocol. Negotiations on the follow-up to the Convention Dialogue resulted in agreement on a Bali Action Plan that established the AWG-LCA, which was mandated to launch a comprehensive process on long-term cooperative action under the Convention. The Bali Action Plan identifies four key elements: mitigation, adaptation, finance and technology. The Plan also contains a non-exhaustive list of issues to be considered under each of these areas and calls for articulating a 'shared vision for long-term cooperative action.'").

To date, global attention has been drawn to energy security. The United States, for instance, does not have enough domestic oil supply to satisfy its rapidly growing demand for energy. This geopolitical problem has led to a focus upon the Middle East. Wars were once fought over salt for lack of awareness of salt's abundant availability in the earth's crust.[241] Similarly, armed conflicts over fossil fuels can be averted by timely investment in environmentally sound renewable energy sources, storage, and transport. The international community possesses the requisite capacity to craft a framework convention addressing energy and a Manhattan Project Plus commitment to research, development, and deployment of environmentally sound energy technologies. U.N. Development Programme (UNDP) notes that, "[t]he United States has successfully used tax incentives to encourage the development of a vibrant wind power industry. However, while the rapid growth of renewable energy has been encouraging, overall progress falls far short of what is possible—and of what is required for climate change mitigation."[242] To date, one of the best ways to increase the efficiency of lighting and appliances as well as the use of renewable energy is to make sure that building codes facilitate efficiency, new technologies become readily available, and tax incentives help bring efficiency and environmentally sound technology into mainstream use. A comprehensive mix of regulations and market incentives can facilitate efficiency and environmentally sound technologies. Doug Struck notes that more than one-third of all energy used in the United States goes to heat, cool, and power buildings:

> Federal, state and local governments can set standards for more efficient buildings, for example, or more efficient cars or appliances. Lawmakers can require industries to curb greenhouse gas pollution. Subsidies, taxes, incentives and fees can be structured by governments to change the economic equations . . . to end tax breaks for fossil fuel exploration in favor of subsidies for alternative energy development.[243]

Careful but timely legal and technological action can strengthen security of energy supply, mitigate greenhouse gas emissions, and provide jobs.

C. International Innovation Cooperation

Technology collaboration offers an important means by which the international community can find middle ground in climate negotiations. Resolution in the following areas could be instrumental to addressing climate change:

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241. *See generally* MARK KURLANSKY, SALT: A WORLD HISTORY 12–13 (Walker & Co. 2002).

242. UNITED NATIONS DEV. PROGRAMME, HUMAN DEVELOPMENT REPORT 2007/2008: FIGHTING CLIMATE CHANGE: HUMAN SOLIDARITY IN A DIVIDED WORLD 11 (2007).

243. Doug Struck, *A Big Drop in Emissions Is Possible with Today's Technology*, WASH. POST (Jan. 21, 2008), http://www.washingtonpost.com/wp-dyn/content/article/2008/01/20/AR2008012001171.html.

(a) Promote joint R&D activities in the context of South–South, North–South and triangular cooperation;

(b) Promote the transfer of environmentally sound technologies to developing country Parties;

(c) Stimulate capacity-building, in particular for endogenous technologies;

(d) Improve access to information on existing and new technologies;

(e) {Promote the sharing of IPRs}.[244]

Intellectual property rights remain one of the many areas in need of greater dialogue. Funding the establishment of licenses to place key technologies in the public domain can be part of a technology action plan. A global technology action plan can encompass "specific policies, actions, and funding requirements for technologies in the public domain, patented technologies and future technologies."[245] Parties can also facilitate innovative, environmentally sound technologies and international cooperation by sharing national technology road maps.[246]

Similarly, voluntary technology agreements could enhance "cooperative R&D and large-scale demonstration projects, technology deployment projects, cooperation on specific sectors or gases, and cooperation on climate observation and warning systems for enhancing resilience."[247] Technology information could be distributed through the development of an international database housing green technologies and best practices.[248] A new body on technology transfer could also implement technolo-

244. *Negotiating Text*, *supra* note 178, ¶ 197.

245. *Id.* ¶ 183.

246. *Id.* ¶ 185. National technology roadmaps can include: "(a) Identification of technological options for specific sectors; (b) Obstacles to the development and transfer of identified technological options; (c) Policy instruments and infrastructure required for the deployment, diffusion and transfer of identified technological options; [and] (d) Capacity-building needs . . . ." *Id.*

247. *Id.* ¶ 192. The Text further notes that

> For the purpose of meeting its quantified emission limitation and reduction commitments and requirements for monitoring, reporting and verification, a Party may transfer to, or acquire from, other Parties emission reduction units resulting from projects and programmes that accelerate the diffusion or transfer of environmentally sound technologies, provided that:
>
> (a) Voluntary participation is approved by each Party involved;
>
> (b) Any such project results in measurable, reportable and verifiable reductions of GHG emissions by sources or enhancements of removals by sinks;
>
> (c) The project contributes to the achievement of the technology targets and objectives of the host Party;
>
> (d) The host Party has allocated assigned amount units or environmentally sound technology rewards (ESTRs) to the project or programme;
>
> (e) The project/programme is registered under the Convention;
>
> (f) Participants in the ESTR mechanism may involve private and public companies.

Id. ¶ 191.

248. *Id.* ¶ 195.

gy transfer mechanisms and such related enabling activities as technical training, capacity-building, and R&D cooperation.[249] Such a technology body could facilitate sectoral technology cooperation by sharing best practices and best available technologies, both current and emerging.[250] It could also help diffuse and transfer environmentally sound technologies to all relevant sectors.[251]

VII. CONCLUSION

Establishing a technology mechanism, Climate Technology Centre, and Technology Executive Committee is within political reach. The Technology Executive Committee can consider and recommend actions to promote environmentally sound technology transfer; provide guidance on policy and program priorities; facilitate collaboration between governments, the private sector, NGOs, and academic and research communities; recommend actions to address barriers to technology transfer; and catalyze development and use of technology road maps or action plans. The Climate Technology Centre can facilitate existing networks, organizations, and initiatives in order to provide assistance to developing countries on technology need identification, technology implementation, and deployment of existing technologies. Technology transfer can be combined with strengthened capacity building support via networks for sharing communication, education, information, public awareness, training, and stakeholder participation.

The international community is facilitating a culture of legal dialogue regarding climate change. This consensus building process is unprecedented in scope. Procedural and substantive issues continue to be hashed out in intensive rounds of negotiations. Yet middle ground remains elusive, as sand sifts through the hourglass. Can we turn it around? How can we optimize public-private support for climate technology innovation?

The international community can achieve global production and consumption transformation to a climate stabilizing energy pathway. International cooperation is key to diffusing current and future climate friendly innovations. The international climate negotiations can help deliver a global system for international technology cooperation.[252] Given the urgency with which we need to address climate change, governments should facilitate accelerated development of new innovation as well as broad diffusion of existing climate-friendly technologies.[253] We can bring

249. *See id.* ¶ 196.
250. *Id.*
251. *Id.*
252. Seligsohn, Weischer, Tomlinson & Zorlu, *supra* note 141, at 2.
253. *See id.* at 3.

energy and environmental law closer together.[254] Public sector involvement in ramping up climate friendly technology is at the core of international climate negotiations and international strategizing to address climate change. Yet no single actor will be able to solve this collective action challenge. University, individual innovator, private firm, civil society, government, and United Nations system collaboration can achieve the requisite technological paradigm shift needed to address climate change.

This Article has analyzed the means by which legal, scientific, engineering, and a host of other public and private actors can collaborate to bring environmentally sound energy innovation into widespread use to achieve sustainable development. The algae-to-fuel case study has illustrated the opportunities and challenges of bioscience contributions to an emerging bioenergy sector. Universities in particular stand at the crossroads of global innovation and diffusion leadership. They should stand up to the plate and facilitate transdisciplinary international climate technology sharing.

Universally shared values provide a foundation for dialogue and a means by which a lasting culture of cooperation can take root.[255] Genuine security hinges upon our commitment to transnational, interdisciplinary, inclusive decision making. Innovation cooperation can help the international community achieve sustainable development.

254. *See* Lincoln L. Davies, *Alternative Energy and the Energy-Environment Disconnect*, 46 IDAHO L. REV. 473, 504–506 (2010).

255. *Dialogue Among Civilizations*, UNESCO, http://www.unesco.org/dialogue (last updated Sept. 30, 2005).