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The Distributed Generation (DG) Phenomena

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THE DISTRIBUTED GENERATION (DG) PHENOMENON

by

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I. INTRODUCTION

This essay makes some observations about the phenomenon of the emergence of a fundamentally new and different business and operational infrastructure model for providing electricity around the world (for example, in the United States, China, Germany, the United Kingdom, and Denmark) that potentially may have profound significance for the future of the global economy. The new emerging model is termed Distributed Generation (DG). The DG model has been characterized variously as creating a "death spiral" for investor owned electric utilities[1], causing a "paradigm shift" in the production and use of electricity[2], potentially creating an "energy revolution,"[3] and a "new era in electricity."[4] In addition, legislation has recently been introduced in the U.S. House and Senate to take steps toward integrating clean energy DG into the U.S. electricity grid.[5] New distributed generation capacity is projected to surpass new central station generation capacity by 2018 in the United States and other countries around the world.[6]

If fully implemented, the DG model will have a significant impact not only on electric utilities that make electricity, but also on existing and new electric consumers. This impact will affect small businesses and multinational corporations providing products and services or rural and urban residential populations using electricity for lighting, heating, and cooling. The DG model will also affect the future role of local and national governments in the electric sector.

The global electric sector in which the DG model is emerging is quite significant. In 2011, the global electric market had total revenues of over 2.2 trillion dollars.[7] In 2012, the

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[1] *See generally* Elisabeth Graffy & Steven Kihm, *Does Disruptive competition Mean a Death Spiral for Electric Utilities?*, 35 ENERGY L.J. 1(2014).

[2] *See generally* Charlie Coggeshall, *Utilities and the Distributed Energy Paradigm Shift* (Energy Blog), http://blog.cleanenergy.org/2013/0603/utilities-and-the-distributed-energy-paradigm-shift/.

[3] Joel B. Eisen, *Distributed Energy Resources, "Virtual Power Plants," and the Smart Grid*, 7 ENVT'L & ENERGY L. & POL'Y 191(2012).

[4] *See generally* European Commission, "New Era for Electricity in Europe" (2003), http://www.smartgrids.eu/documents/New-Era-for-Electricity-in-Europe.pdf.

[5] The proposed "Clean Distributed Energy Grid Integration Act" was introduced in the House (H.R. 4393) on January 25, 2016 and in the Senate (S.1201) on May 5, 2015.

[6] Jan Vrins *et al*, "From Grid to Cloud", 153 PUB. UTIL. FORT., Oct. 2015. https://www.navigantresearch.com/blog/from-grid-to-cloud-a-network-of-networks-in-search-of-an-orchestrator.

[7] *Global Electricity*, Research and Markets (October 2012), http://www.researchmarkets.com/research/3eda04/global_electricity.

total world-wide production of electricity exceeded 21.5 trillion kilowatt-hours (kWh).[8] The average household in the U.S. uses roughly 1000 kWh a month. Global electric production is estimated to increase annually until at least 2030.[9] In addition, as of 2011, roughly 1.3 billion people live without access to electricity, mostly in sub-Saharan Africa, developing Asia, and in mostly rural areas.[10] The United Nations and the World Bank have development initiatives to achieve sustainable universal electric access in the future.[11] Recently, the United States enacted the Electrify Africa Act of 2015 (EAA) to partner with the governments of sub-Saharan African countries, international financial institutions, and African regional economic communities, cooperatives, and private sectors to, among other things, help provide electricity access for all.[12] However, the EAA leaves unaddressed the operational infrastructure and business model that will be used to electrify sub-Saharan Africa.[13]

There is, of course, a link between electricity and gross domestic product (GDP)—the monetary value of total goods and services—in the sense that affordable and reliable electric service is vital to providing light, heat, manufacturing, operating motors and computers, etc. and is different from other products in the marketplace because it provides an essential service unlike say, jeans or perfume. For developing economies to develop and for developed economies to sustain economic growth, business and growth requires the use of electricity. The manner and method of the production and availability of electricity remains equally as important.

This essay offers some of the reasons for the emergence of the DG model, describes some of the major benefits of the DG model, and identifies some of the significant issues posed by the DG model going forward that are in the process of being addressed.

II. THE EMERGENCE OF THE DG MODEL

For over 100 years, the dominant model for the production and use of electricity has been the large central station model. This model typically involves natural monopoly utilities of one sort or another, constructing and operating large electric power plants fueled by burning coal and natural gas, or using enriched uranium in nuclear power plants or by falling water from large hydroelectric dams, like the Hoover Dam. The power plants typically are located far from the electric consumer and electricity is carried long distances over high voltage transmission lines and then distributed to the electric consumer over low voltage electric lines.[14] Under this model, electricity flows one way from the central station power plant to residential, commercial, and large industrial consumers. Some of the reasons for the dominance of the large central station model were the development of alternating current which allowed transport of electricity to reach broader and more distant markets, economies

[8] *Int'l Energy Statistics*, U.S. ENERGY INFORMATION ADMINISTRATION (EIA), http://www.eia.gov/cfapps/ipdbproject/iedindex3.cfm?tid=2&pid=2&aid=12&cid=regions&syid=2010&eyid=2012&unit=BKWH.

[9] *Electricity Industry*, ECONOMY WATCH (June 29, 2010), http://www.economywatch.com/world-industires/energy/electricity-industry.html.

[10] *Energy Poverty*, INT'L ENERGY AGENCY, http://www.iea.org/topics/energypoverty. (last visited Oct. 27, 2015).

[11] *Overview*, WORLD BANK (Sept. 16, 2015), http://www.worldbank.org/en/topic/energy/overview.

[12] Electrify Africa Act of 2015, S. Res. 2152, 114th Cong. (2015) (enacted).

[13] *Id.*

[14] *Centralized Generation*, U.S. ENVTL. PROTECTION AGENCY, http://www.epa.gov/energy/centralized-generation. (last visited Feb. 16, 2016).

of scale achieved by constructing large power plants to serve a large base of customers, falling electric prices, and a governmental policy that accepted electric operators as natural monopolies subject to regulation.[15]

By contrast, the DG model emphasizes electric generation facilities that are small, numerous, operated near the consumer, more often than not, by consumers themselves. They involve:

> a range of smaller-scale and modular devices designed to provide electricity, and sometimes also thermal energy, in locations close to [electric]consumers. They include fossil and renewable energy technologies (e.g., photovoltaic arrays, wind turbines, microturbines, reciprocating engines, fuel cells, combustion turbines, and steam turbines); energy storage devices (e.g., batteries and flywheels); and combined heat and power systems [cogeneration].[16]

Viewed expansively, DG may involve energy efficiency measures, conservation, and demand response behavior (curtailing and shifting electric use by consumers in peak periods of demand for electricity to off-peak periods).[17] DG employs an array of electricity technologies associated with electric generation or with savings realized near the point of use or "behind the meter" of the customer.[18] DG includes rooftop solar panels, micro-wind turbines, small diesel or natural gas generators, and even electricity stored in electric powered vehicles.[19] Excess electricity generated may flow into the electric grid and may be used by others. The DG model operates by handling electricity that flows both ways and not just one way as in the large central station model.

Among the notable developments that arose roughly during the later decades of the 20th Century that help explain the rise of the DG model in the United States are: the introduction of competition into electric markets; the growth in domestic and international laws and policies addressing air and atmospheric pollution from fossil fuel use; and the development of technologies that made the DG model feasible.[20]

A. The Introduction of Competition in Electric Generation in the United States

Apart from a token measure of yardstick competition provided by publicly-owned utilities, the central station model involved natural monopolies of regulated investor-owned utilities operating in exclusive geographic franchise markets.

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[15] James E. Hickey, Jr., *Regulation of Electric Rates in the US: Federal or State Competence,* 8 J. ENERGY & NATURAL RESOURCE & L. 105, 107-10 (1990).

[16] *Distributed Energy,* OFFICE O ELECTRICITY DELIVERY & ENERGY RELIABILITY, http://energy.gov/oe/technology-development/smart-grid/distributed-energy. (last visited Apr. 19, 2016).

[17] *See A Review of Distributed Energy Resources,* DNV GL (Sept. 23, 2014), http://energy.gov/oe/technology-development/smart-grid/distributed-energy.

[18] *Distributed Energy, supra* note 16.

[19] *Distributed Generation,* U.S.ENVTL. PROTECTION AGENCY, http://www.epa.gov/energy/distributed-generation. (last visited Feb. 16, 2016).

[20] Large central station nuclear power plants are arguably clean air energy generation sources. However, decreasing public support, concerns about safety and accidents (like Three Mile island, Chernobyl and Fukushima), regulatory delays and rising costs make their future a bit uncertain.

In 1978, competition was introduced by federal legislation into electric generation in the form of the Public Utilities Regulatory Policy Act (PURPA).[21] PURPA was part of President Jimmy Carter's national energy plan to respond to the energy crisis at the time.[22] Section 210 of PURPA imposed for the first time an obligation on electric utilities to buy electricity from two new sorts of electric generators – cogenerators (combined heat and power producers) and small power producers (using renewable sources of electric generation like, solar, wind, geothermal, and biomass at the full avoided cost to the utility of producing the next unit of electricity). Small power producers were called qualifying facilities (QFs). In 1996, the Federal Energy Regulatory Commission (FERC) in Order 888 further facilitated wholesale competition by requiring utilities to provide "open access" to their transmission lines on a non-discrimination basis to alternate generators of electricity.[23]

At the state retail level, electric generation competition has been further facilitated by both renewable portfolio standards (RPS) and, in some states, by feed in tariffs (FITs).[24] A majority of state governments have some form of RPS programs.[25] Although primarily aimed at increasing clean sources, RPSs and FITs also may, along with other incentives, facilitate the market entrance of new electric generators. Typically, a RPS mandates that electric utilities maintain a required percentage of its electricity provided at retail from renewable energy sources by generating the percentage themselves or by buying some renewable generation from others.[26] This mandate helps to stimulate entrance into electric generation markets by renewable energy developers.[27] A FIT is a fixed favorable price (tariff) guaranteed ahead of time for a long period to a generator of electricity from renewable sources who is also assured of interconnection with the utility.[28] There is no differentiation whether or not the electric generator is a QF. This helps the renewable energy developers secure financing and encourages developers to get into the electric generation market. FITS are prominently used in Germany.

B. The Rise of Domestic and International Environmental Regulation of Air and Atmospheric Pollution from Fossil Fuel Use in Large Central Station Power Plants

The emergence of environmental regulation of air and atmospheric pollution from large central station power plants has also contributed to the efficacy of the DG model by discouraging the burning of fossil fuels and encouraging the use of renewable sources of electricity.

In the 1970's, federal domestic environmental efforts began in earnest with the passage of the National Environmental Policy Act (NEPA) in 1969 which, among other

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21 Public Utility Regulatory Policies Act of 1978, Pub. L. 95-617, 92 Stat. 3117 (1978).

22 Jon Wellinghoff & Steven Weissman, *The Right to Self-Generate as a Grid Connected Customer*, 36 ENERGY L. J. 305, 316-317 (2015).

23 18 C.F.R.§ 35 & 385 (1996).

24 JOEL B. EISEN, *et al.*, ENERGY, ECONOMICS AND THE ENVIRONMENT, CASES AND MATERIALS 750-67 (4th ed. 2015).).

25 *Id.* at 758.

26 *Id.* at 758-67.

27 *See* U.S. P'ship for Renewable Energy Fin., Ramping up Renewables: Leveraging State RPS Programs amid Uncertain Federal Support (2012).

28 Sonia Aggarwal et al., Renewable Energy Policy Experience (Sept. 2012), http://energyinnovation.org/wp-content/uploads/2014/11/Renewable-Energy-Policies-Japan.pdf.

things, imposed environmental responsibilities on all federal agencies of government.[29] During that time, the Environmental Protection Agency (EPA) was established by Congress[30] and the 1955 Clean Air Act (CAA)[31] was amended to significantly expand federal authority over air pollution. The new amendment required the EPA to establish National Ambient Air Quality Standards (NAAQS) and performance standards for stationary air pollution sources (NSPS) like central station electric power plants.[32] In 1977, the CAA was amended to require reductions in particulates (coal dust), sulfur dioxide (a component of acid rain), and nitrogen oxide (smog) from burning fossil fuels.[33] In 1990, the CAA was amended to institute a program (Title IV) to deal with acid rain sources from major stationary sources like fossil fuel electric power plants through a market-based cap and trade mechanism[34]

In 2007, the U.S. Supreme Court ruled that carbon dioxide and other atmospheric greenhouse gases constituted an "air pollutant" under the CAA.[35] The federal government responded with the Clean Power Plan under the CAA to reduce carbon pollution emissions (CO_2) from electric power plants.[36]

The international effort to address climate change and the curtailment of man-made greenhouse gases (GHGs), including carbon dioxide and methane from large central station power plants, began in the late 1970s.[37] In 1992, the United Nations Framework Convention on Climate Change (UNFCCC) was adopted.[38] This Convention sets out a framework for action aimed to stabilize atmospheric concentrations of GHGs to avoid dangerous anthropogenic interference with the climate system.[39] This was followed in 1997 by the Kyoto Protocol.[40] In subsequent decades, a series of Conferences of the Parties (COP)[41] have taken a

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[29] *See* Pub. L. No. 91-190, 83 Stat. 852 (1970); U.S ENVTL. PROTECTION AGENCY, *What is the National Environmental Policy Act?*, https://www.epa.gov/nepa/what-national-environmental-policy-act (last visited Apr. 21, 2016).

[30] *See* Reorganization Plan No.3 of 1970, 35 Fed. Reg. 15623 (1970); *see* 84 Stat. 2086 (1970).

[31] *See* Pub. L. No. 91-604, 84 Stat. 1676 (1970).

[32] *See id.*

[33] *See* Pub. L. No. 95-95, 91 Stat. 685 (1977).

[34] *See* ROY S. BELDEN, CLEAN AIR ACT, BASIC PRACTICE SERIES 115-26 (2d ed. 2011).

[35] *See generally* Mass. v. EPA, 549 U.S. 497 (2007).

[36] *See* U.S ENVTL. PROTECTION AGENCY, *Regulatory Actions*, https://www.epa.gov/cleanpowerplan/regulatory-actions#regulations (last visited Apr. 21, 2016).

[37] For a complete timeline see *Background on the UNFCC: The international response to climate change*, U.N. FRAMEWORK CONVENTION ON CLIMATE CHANGE, http://unfccc.int/essential_background/items/6031.php (last visited Mar. 22, 2016); *see also* James E. Hickey Jr., *Some Legal Impacts of the Emerging International Climate Change Regime on Energy Prices*, 4 GLOBAL BUS. L. REV. 1 (2013), http://unfccc.int/essential_background/items/6031.php.

[38] *The Secretariat*, U.N. FRAMEWORK CONVENTION ON CLIMATE CHANGE, http://unfccc.int/secretariat/items/1629.php (last visited Apr. 18, 2016). This is the United Nations body responsible for climate and based in Bonn, Germany. *Id.*

[39] *Id.*

[40] Kyoto Protocol to the United Nations Framework Convention on Climate Change, Dec. 10, 1997, U.N. Doc FCCC/CP/1997/7/Add.1, 37 I.L.M. 22 (1998).

[41] Conference of the Parties (COP) is an annual meeting of all nations that make up the United Nations Framework on Climate Change (UNFCCC) – 195 nations in total. This is the 21st meeting (thus COP21), with the first occurring in Berlin in 1995. *See* Brandon Miller, *Five Things You Need to Know About COP21*, CNN (Oct. 30, 2015, 2:49 p.m.), http://www.cnn.com/2015/10/30/world/cop21-paris-conference-five-things.

rather tortured path of efforts culminating most recently in COP21[42] held in Paris at the end of 2015. COP21 set goals to limit global warming and to reach net zero man-made GHG emissions by mid-century.[43]

The international climate change efforts have long influenced, to varying degrees domestic laws and policies. For example, over two decades ago in 1992, the Wisconsin Public Service Commission tackled the problem of putting a dollar amount in electric rates in anticipation of international climate change regulation:

> Because of widespread concern about the risks of global warming at state, national and international levels, future regulations are likely to require the utility industry to limit its release of these gases. If so, utilities would incur real economic cost in order to comply with these regulations.
>
> * * *
>
> A national and international consensus to regulate greenhouse gas emissions is emerging. When the likelihood of future regulation is high, it is reasonable to estimate the cost of compliance to utilities. Ignoring this financial risk would be imprudent.
>
> * * *
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> Monetizing the risk of greenhouse gas regulation is a prudent means of reducing utility business risk by hedging against the future...[and] considering the likelihood of...international greenhouse gas regulations.[44]

The GHG reduction goals favor laws and policies to reduce reliance on large central station fossil fuel power plants, to internalize the pollution externalities of large fossil fuel power plants, and to increase non-polluting renewables sources of electricity. In turn, this favors a DG model over the traditional central station model.

C. Advancements in DG Technology

Existing technologies, like small natural gas and diesel generators and cogeneration facilities (combined heat and power), provide DG capacity. In addition, over the past several decades, significant new advancements in both generation technology and in operational technologies are working to increase noticeably the reliability and efficiency of DG while decreasing the costs to make, install, operate, and maintain DG facilities.

For example, the PV solar power costs (primarily roof top solar panels) have been reduced significantly over the past twenty or so years.[45] Efficiencies in sunlight conversion

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[42] The Paris Climate Conference is officially known as the 21st Conference of the Parties (COP21) to the United Nations Framework Convention on Climate Change (UNFCCC). The Conference will also serve as the 11th Meeting of the Parties to the Kyoto Protocol. *See* UN Climate Change Conference Paris 2015, UNITED NATIONS http://www.un.org/sustainabledevelopment/cop21.

[43] COP21 will, for the first time in over 20 years of UN negotiations, aim to achieve a legally binding and universal agreement on climate, with the aim of keeping global warming below 2°C. Find Out More About COP21, SUSTAINABLE INNOVATION FORUM, http://www.cop21paris.org/about/cop21.

[44] *Advance Plans for Constr. Of Facilities*, 136 P.U.R. 4th 153 (Wi.P.S.C. 1992); *see generally* James E. Hickey, Jr., *The Globalization of Domestic Environmental Law*, 14 NYSBA Env'tl L. Section J. 16 (1994).

[45] *Solar*, U.S. DEP'T. OF ENERGY, http://energy.gov/science-innovation/energy-sources/renewable-energy/solar (last visited Apr. 18, 2016).

have improved, manufacturing techniques and materials are better, and installation and maintenances have become easier with such developments as modular solar panels. Those technological improvements have made the cost of DG solar per kWh more competitive with central station generation. One projected solar PV cost is now between 12.3 cents and 19.3 cents/kWh.[46] And, this does not include any net metering sales of excess solar power to the distribution grid or any applicable IRS investments tax credits.[47]

Wind DG (less than 100kW) is used by farmers, home owners, small businesses like car dealers and manufacturing operations and are either interconnected to the distribution grid or are stand-alone turbines "off the grid". Technological progress has been made to reduce the costs of the components of wind DG like the generators and alternators, the turbine tower and the gear box. A recent key technological breakthrough is the low-cost production of advanced turbine blades using injection-molded plastic.[48]. From 2013 to 2014, the average installed cost of small wind turbines is estimated to have decreased over $700 per kW. Efforts to have a reliable certification process regarding turbine designs, performance, and safety have increased confidence in the deployment of DG wind.[49]

An emerging, very promising, key technology for DG is the fuel cell. The fuel cell may potentially replace a significant portion of central station electric generation. A fuel cell is a very efficient and clean technology that uses an electrochemical process to convert hydrogen into electricity and heat, leaving harmless water vapor as a by-product.[50] Small fuel cells between 1kW and 10kW may one day in the not too distant future be widely used for residential electricity in the DG model and larger fuel cells could have commercial application.[51] Investments in stationary fuel cell technology used in the DG model are significant and fuel cell markets are growing in the United States and even more so outside the United States.[52]

Another rapidly developing technology needed for the DG model is energy storage. PV solar and wind technologies (the dominant generation sources for DG) do not produce the same electric product as does the central station model, which produces electricity on call 24/7/365. The sun doesn't shine and the wind doesn't blow all the time so the electricity made is variable and not constant. To make it a firm product like central station electricity, wind and PV solar DG electricity must be capable of being stored. In recent years, there have been great technology advances in electricity storage with lithium-ion batteries that have enhanced battery performance and in a more cost effective way than in the past.[53] There are some "294

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[46] James Conca, *Which Is Cheaper – Rooftop Solar Or Utility-Scale Solar*, FORBES (July 30, 2015, 6:26 a.m.), http://www.forbes.com/sites/jamesconca/2015/03/30/which-is-cheaper-rooftop-solar-or-utility-scale-solar/#b4899fa4f6d1.

[47] *Distributed Wind*, U.S. DEP'T. OF ENERGY, http://energy.gov/eere/wind/disributed-wind (last visited Apr. 18, 2016).

[48] U.S. DEP'T OF ENERGY, 2014 DISTRIBUTED WIND MARKET REPORT (Aug. 2015), http://energy.gov/sites/prod/files/2015/08/f25/2014-Distributed-Wind-Market-Report-8.7_0.pdf.

[49] *Id. at 28.*

[50] ENERGY AND THE ENVIRONMENT, PAUL SCHERRER INSTITUTE, https://www.psi.ch/info/MediaBoard/Energie_und_Umwelt_e.pdf.

[51] *See generally* A. Elgowainy & M.Q. Wang, *Fuel Cell Comparison of Distributed Generation Technologies*, CTR. FOR TRANSP. RES., ARGONNE NAT'L LABORATORY (Nov. 2008), https://www1.eere.energy.gov/hydrogenandfuelcells/pdfs/fuel_cycle_comparison_report.pdf.

[52] DNV GL, *supra* note 17, at 3.

[53] *Id.* at 36; Richard Fiora Vanti, *Storage Grows Up*, 153 PUB. UTIL. FORT., Sept. 2015, at 48.

advanced electric storage projects totaling 546MW" already operating in the United States and worldwide some 611 projects operating totaling 1.163 GW.[54] Investment in electric storage technology should reach $13 billion by 2020.[55]

In addition to electric generation technology, new operational technologies are emerging to enable electric operations to operate with a diversified power supply and two-way flow of electricity that complement the DG model. Developments like the "Smart Grid" use computer and internet technology to operate organically by monitoring power plants and generation sources, customer demands, and electric use preferences with real time information that help to instantly balance electric demand and supply.[56] Smart meters and net metering allow DG producers to sell excess DG that they do not use themselves to others.[57] There is even emerging an "energy cloud" enabling technology.[58]

III. THE BENEFITS OF THE DG MODEL

The DG model provides embedded and potential benefits variously to the public, to electric consumers, to transmission and distribution service providers, and to DG and other producers of electricity.[59]

Some of the benefits of the DG model may be summarized as follows:

1. To the extent that DG relies on renewable sources, it is, on balance, a cleaner electricity supply by producing less air pollution (particulate matter, sulfur dioxide, nitrogen oxides) than large central station power plants using fossil fuels. It also results in less air and water pollution from related reductions in fossil fuel production of coal and natural gas including fracking activities.
2. Related to the first benefit, a DG model helps to reduce GHG emissions of carbon dioxide and methane into the upper atmosphere consistent with the emerging climate change regime goals and objectives by displacing emissions from central station fossil fuel plants.
3. The DG model is more efficient than the central station model because it does not suffer inefficiencies from "line losses" of electricity incurred in the central station model from high voltage long distance transmission

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[54] Richard Fioravanti, *Energy Storage: Out of the Lab and Onto the Grid*, 153 PUB. UTIL. FORT., Apr. 2015, at 30, 31.

[55] Anissa Dehamna, "Energy Storage Technologies", Navigant Research, (March 2015).

[56] *See* U.S. DEP'T OF ENERGY, THE SMART GRID: AN INTRODUCTION, http://energy.gov/sites/prod/files/oeprod/DocumentsandMedia/DOE_SG_Book_Single_Pages%281%29.pdf.

[57] Under Section 1251 of the Energy Policy Act of 2005, Public Law 109-58, public utilities offer net metering to customers that request it.

[58] Jan Vrins et al., *supra* note 6.

[59] *See generally* U.S. DEP'T OF ENERGY, THE POTENTIAL BENEFITS OF DISTRIBUTED GENERATION AND RATE-RELATED ISSUES THAT MAY IMPEDE THEIR EXPANSION: A STUDY PURSUANT TO SECTION 1817 OF THE ENERGY POLICY ACT OF 2005 (Feb. 2007) https://www.ferc.gov/legal/fed-sta/exp-study.pdf; MARK RAWSON, DISTRIBUTED GENERATION COSTS AND BENEFITS ISSUE PAPER, Cal. Energy Comm'n (July 2004); Gina S. Warren, *Vanishing Power Lines and Energy Distributed Generation*, 4 Wake Forest J. L. & POL'Y 347 (2014).

lines. It also adds to the overall efficiency of power production to the extent cogeneration (combined heat and power) is relied upon, which uses waste heat applications in the same electric production process.

4. The DG model by making electricity at, or near, the point of consumption helps to reduce congestion on long distance transmission facilities (lines and substations).

5. A diversified DG model is also more secure because a large number of smaller, geographically dispersed production sources are less attractive as terrorist attack targets than large central station power plants, especially nuclear power plants.

6. A DG model reduces impacts on land use by large central station model infrastructure like power plants and transmission lines. In turn, this also should reduce the number and nature of formal and informal NIMBY siting or nuisance complaints.

7. The DG model potentially should help meet regulatory requirements of renewable portfolio standards (RPS) to the extent that renewable sources of DG are relied upon and to the extent that central station model utilities do not construct large central station renewable energy projects, like wind and solar farms, to meet their RPS requirements.

8. The DG model helps to make the overall electric grid more resilient to the effects of natural disasters predicted to increase as a result of climate change.

9. The DG model empowers the electric consumer to participate in making electricity and to benefit from reducing electric demand (and bills) by self-generation and by demand response activities.

IV. SOME SIGNIFICANT ISSUES IN NEED OF RESOLUTION

There are several significant and interrelated issues currently being addressed or in need of being addressed by regulators, generators, and consumers that will have an impact on the degree to which the DG model replaces the central station model and the speed at which that potential displacement occurs. Taken individually most pending issues, viewed broadly, seem capable of resolution in a way that enhances the spread of the DG model around the world. Taken together, however, those issues, if not resolved, could pose significant roadblocks to the growth of adoption of the DG model. Some of those issues include the following:

A. Stranded costs of Central station infrastructure

The emergence of the DG model, accepting predictions of future slowing increases in electric demand, will result in stranded costs of central station model infrastructure and facilities. Central station system facilities (power plants, transmission lines, substations, distribution lines, etc.) typically are financed, built, and maintained on the predicate that costs will be recovered over several decades from a pool of electric consumers in the form of rates. The growth and spread of the DG model inevitably, given current electric demand forecasts, will result in less demand for central station electricity and fewer consumers in the pool to pay for facilities that now have become overbuilt and underused. Those costs now become "stranded." Depending on one's policy stance (fairness, equity, efficiency, etc.) and energy political viewpoint (growth, no growth, transition growth policy advocates, etc.), those stranded costs will be borne by some or all stakeholders involved. For example, taxpayers could be forced to pay using a variety of methods. Shareholders of investor-owned central station utilities could pay for stranded costs through lower dividends and stock prices. Remaining central station system customers, who do not participate in the DG model, could pay through higher electric rates. DG consumers themselves could be required to pay some sort of fee or premium to help offset stranded costs occasioned by their self-generation.

B. Prices/costs affecting the DG model

What is the price to be paid to the DG generator if there is an overall net excess of electricity generated beyond the DG generator's own electric use that is sold to others nearby or sent into the central station system?[60] Should those DG generators receive payment from the central station provider for that excess? If so, should payment be at the same rate that the central station provider charges to its customers; that is, a price that bundles all costs of generation, transmission and distribution together. Or, should they get a lower price that reflects the value of the DG generation only? In any event, how is that value to be calculated?

An additional issue is the charge for any standby services provided under the DG model. These are "back up" services and commitments by the central station provider in the event of DG outages and the like from storms, equipment failures etc. Should the DG generator be required to pay standby charges and, if so, at what price? If these are prohibitively high, they could be a disincentive to adopt the DG model.

Another issue is whether any exit fees should be charged to the DG generator who reduces or stops taking electric service (going "off grid") as result of using on-site generation. That is, the argument goes, the central station provider invested in facilities to serve its customers and recovers those costs in its rates. An exit fee would help defray the costs of those facilities borne by the remaining pool of central station consumers after the DG generator becomes a partial customer or ceases being a central station customer altogether.

C. Net Metering

Net metering takes into account that under the DG model electricity flows two ways and not one way as under the central station electricity model. That is, DG consumers may purchase and consume electricity (albeit a reduced amount) which is registered by the traditional one way meter but also they may generate excess electricity at other times that offsets their use "behind the meter" or that is sold to others nearby or even sent back into the transmission grid. Net metering allows DG consumers/generators to in some way net the electricity that comes to them and the electricity they generate that flows to others or flows back to electric grid by measuring the electricity flow both ways with two way meters. This could be done by simply allowing existing meters to "run backwards" or by some form of "net billing." The absence of net metering of one sort or another is a barrier to the development of DG model.

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[60] *See* David B. Ruskin, *The Regulatory Challenge of Distributed Generation*, 4 HARV. BUS. L. REV. ON LINE 38 (2013) (discussing the growth of distributed generation in a U.S. regulatory context).

Apart from the physical aspects of net metering, several controversial issues arise from a policy perspective. One such issue involves a "free rider" perception held by some that a DG generator may be able to pay nothing for the electricity they take from a central station provider if, during a billing period, they also generate the same amount of electricity and send back into the grid thereby having a zero net electric use. The free rider perception is that by netting zero the DG generator/consumer does not pay for the value of the grid for which other non-DG consumers pay. DG supporters stress that the electric grid benefits by having less need for central station generation and purchased power to meet system demands, by reducing demand for transmission line space (congestion) and by other savings and benefits.

D. Safety and Reliability

The emergence of a new DG model that depends on a wide variety of technologically evolving electric generation methods and diverse generators (home owners, communities, hospitals, industries, etc.) operating over a wide geographic area presents safety and reliability issues that need to be addressed. These include concerns about the safety and reliability of the installation, maintenance and operation of DG generation sources like solar panels, wind turbines, natural gas and diesel generators, geothermal facilities, etc. There are also safety concerns about the physical interconnections of these myriad electric sources to local distribution lines and transmission lines. Those concerns raise related long term legal liability and insurance issues which, if not addressed satisfactorily, will inhibit the adoption of the DG model.

One unique safety and reliability concern about the DG model which is a "major impediment to widespread adoption" of the DG model is unintentional "islanding."[61] Islanding happens when a local portion of an electric system grid loses central station power but remains energized through its own DG sources. Islanding, done intentionally, is a benefit by ensuring reliability of electric supply especially in rural areas around the world and in developing countries with unreliable intermittent central station service. However, when islanding occurs unintentionally, it is "undesirable" and can endanger electric line workers who are maintaining lines or working on lines downed in an emergency like a storm or natural disaster. Here, electric lines which are assumed to be shut down may still be energized because DG sources are still operating.[62]

E. The role of government regulators

Partial displacement, or full replacement, of the central station model with the DG model requires substantial rethinking and adjustment of the role of government in regulating electricity. Depending on the country involved in the transformation, the DG model could require more or less government involvement in the production, transmission, distribution and consumption of electricity, and with the activities of all the stakeholders involved along the way.

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[61] CHRIS GREACEN ET AL., *A Guidebook on Grid Interconnection and Islanded Operation of Mini-Grid Power Systems Up to 200 KW*, LAWRENCE BERKLEY NAT'L LABORATORY, 28-30 (April 2013), http://www.cleanenergyministerial.org/Portals/2/pdfs/A_Guidebook_for_Minigrids-SERC_LBNL_March_2013.pdf.
[62] *Id.*

In the U.S., this requires reconsideration of both state regulation and federal government regulation that has evolved over the past 100 years of the central model as reflected in statutes, court decisions and administrative regulations. The 50 states, of course, each have regulatory authority over electricity within their borders. To the extent each state addresses the DG model to a different degree and with different rules, on a host of legal, policy and administrative issues, including those mentioned above, the transaction costs to develop and implement the DG model in each state are raised significantly. From a federalism perspective, there are also government regulatory issues raised about the traditional bright line between state retail regulatory authority and federal wholesale regulatory authority. Fundamentally, the emergence of the DG model raises new and unique questions that need to be resolved with clarity "with respect to who regulates these [DG] transactions".[63]

V. CONCLUSION

In some form, it appears the DG model is here to stay. To a greater or lesser degree all stakeholders – electric utilities, consumers (homeowners, small businesses and large industries), communities, governments (local, regional and national) etc. – will be affected by its emergence and evolution in the decades ahead. The embedded and potential benefits of the DG model are considerable along with the difficult and challenging issues that remain to be resolved. The degree to which the DG model is adopted around the world, both in areas yet to be electrified and in areas where it may displace the traditional large central station model, remains uncertain. In the latter case, one plausible scenario beginning to emerge, here and there, is the transformation of central station model generators into a service industry for DG – as consultants, as facilities manufacturers (solar panels, wind turbines etc.), as installers, as maintenance and repair providers, and as back-up service providers. In any event, the DG model potentially will have a significant, if not dominant, future role to play in providing more affordable, more reliable, safer, cleaner, electricity to do work in the global economy for the remainder of the 21st Century.

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[63] Robert R. Nordhaus, *The Hazy "Bright Line": Defining Federal and State Regulation of Today's Electric Grid*, 36 ENERGY L. J.203, 207-09 (2015); Sam Kalen, *Muddling Through Energy Policy, forthcoming in* 24 N.Y.U. ENV'TL L. J. (2016).