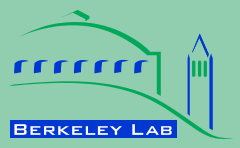

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Microgrid Policy Review of Selected Major Countries, Regions, and Organizations

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Environmental Energy Technologies Division

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Summary

A major challenge is posed by the limits of the centralized and conventional network paradigm, including climate change, unsustainable heat losses during energy conversion, as well as need to maintain and control the quality and reliability of the power supply. Many countries and regions around the world are increasingly looking for ways to tackle these challenges, with a major focus on the wider use and installation of sustainable distributed energy systems. “Grid Wise”, “Smart Grid” and “Intelligent Grid”, are examples of such efforts. Consequently, governments and energy regulation authorities worldwide have enacted and implemented a series of policies to increase the share of renewable energy and distributed generation.

The interconnection of distributed generation (DG) to the conventional network also brings technical challenges such as circuit protection, power quality and reliability and stability issues, which has led to a growing body of research on microgrids. The term microgrid is used loosely to refer to any localized cluster of facilities whose electrical sources (generation), sinks (loads), and possibly storage (both electrical and thermal) function semi-autonomously from the traditional centralized grid, or megagrid. Several developed countries and regions, as well as some international organizations, have engaged in research activities on microgrids, such as test beds and pilot projects, and have gradually enacted and implemented a series of policies and regulations related to microgrids development. These jurisdictions have accumulated valuable lessons from their experience, which can accelerate deployment elsewhere. Nonetheless, the incentives that stimulate deployment of microgrids are not readily apparent because they were often implemented for related purposes so identifying, quantifying, and capturing their benefits and establishing efficient markets poses some significant policy challenges. Interconnection rules, tariffs, and market mechanisms, together with power quality and reliability objectives will likely be the most potent drivers of microgrid development.

As for China, it currently has a goal of achieving 15% non-fossil energy by 2020. In 2011, China’s National Energy Agency (NEA) drafted its Management Methods for Distributed Energy document, which attempted to promote the microgrid concept and facilitate the expansion of renewable generation and other distributed energy resources. In the 12th Five-Year Plan, the NEA plans to use microgrids as the basis for 100 New Energy City pilots, and 30 microgrid pilot projects have also been proposed. But, being a new research and direction for China, learning from international experiences can be an effective vehicle for developing microgrids and breaking barriers.

This report collects and reviews policies and regulations related to microgrid development, and is intended as a reference. The material is divided into three parts under five dimensions:

interconnection, RD&D, tariff policy, other policies, and recommendations. The introduction presents limitations of the conventional electricity network, a definition of “microgrid”, and policy issues. Part Ⅰ provides a brief introduction to policies and regulations related to microgrid development in three major world areas, the Americas, Europe, and East Asia. With this basis, Part Ⅱ offers some policy recommendations for microgrid development in China.

It has to be noted that policies on microgrids are unavoidably related to policies on DG and renewables more generally, since microgrids are just one branch of DG and renewable utilization. Hence, microgrid policies covered in this report include related DG and renewables programs. In addition, a few of the policies covered have been repealed or replaced by new ones, but they are nonetheless included here because the purpose here is to list all efforts for which it will be useful to summarize experience and lessons.

Introduction

The major reason many economies are addressing the application of distributed generation and microgrids is that the conventional centralized megagrid paradigm is showing its limits. The centralized paradigm is currently coming under review because of multiple changes that are taking place in the industry.

To some extent, current policy objectives are contradictory. Expanding supply to meet expected growing demand is unavoidable, while it is also a priority to increase renewable generation penetration, and to develop and maintain competitive wholesale electricity markets. While all of the above objectives together with increasing difficulty siting new generation and transmission tend to work against a highly reliable high power quality system, at the same time, we seek to provide the same power quality and reliability (PQR) we enjoy today, or better. These contradictions have led some to question the traditional paradigm. Following is a short list of some of the key concerns that will challenge the traditional paradigm in the coming era.

Concerns about climate change and other environmental problems will result in increased penetrations of renewable generation in the fuel mix. Unfortunately, many of these new resources do not fit well into the traditional paradigm. Renewable generation is both variable and relatively unpredictable, compared to traditional fossil resources. Another problem with renewable generation is that much of it is expected to come from relatively small installations, e.g. residential rooftop photovoltaic (PV) systems. Controlling numerous, possibly millions, of small sources poses a significant new challenge, and has led analysts to consider alternatives that could manage these smaller scale and problematic sources locally. The residual system would continue to be managed centrally so it would operate with similar numbers and sizes of resources as are successfully controlled today.

Unsustainability of heat losses by energy conversion from fossil fuels to electricity is also a growing concern. While some modern technologies can achieve excellent efficiencies as measured by historic standards, the overall systemic efficiency of generation at remote sites, long distance transmission, and local radial distribution delivers barely a third of the initial fossil energy to ultimate devices. One partial solution to this problem is smaller-scale generation closer to loads, which increases the potential for combined heat and power (CHP), which can improve overall efficiency significantly. In many climates, using the waste heat to cool buildings can be attractive because doing so further reduces expensive on-peak electricity use and downsizes needed generating capacity.

Infrastructure interdependency has become a growing concern, especially because our current power delivery system is highly vulnerable to both natural and malicious threats. The consequences of blackouts are serious in large measure because so many other critical infrastructures, such as communications, transportation, water treatment, etc., depend upon it. To some extent, power generation independently and locally for key devices can reduce and tackle the possibility of this problem.

Reliability is costly even though customers do not usually see it as a line in their electricity bills. Maintaining high levels of reliability incurs two types of costs, both significant. First, equipment investments to improve PQR, such as underground versus overhead lines, impose direct costs on utility operations. Second, the paramount concern with maintaining high PQR leads to conservative operations, for example, potentially economic exchanges of energy are foregone. It

may be that sustaining high PQR across the board no longer makes economic sense. If we are now able to provide PQR locally more closely matched to the requirements of loads, the standards of the centralized grid can be rethought.
Based on the above limits of the centralized paradigm and the advent of new technology, the term “microgrid” has emerged. Commonly, the following two definitions of microgrid are often cited.

> *Microgrids are electricity distribution systems containing loads and distributed energy resources, (such as distributed generators, storage devices, or controllable loads) that can be operated in a controlled, coordinated way either while connected to the main power network or while islanded (CIGRÉ C6.22 Working Group).*
> *A microgrid is a group of interconnected loads and distributed energy resources within clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid. A microgrid can connect and disconnect from the grid to enable it to operate in both grid-connected or island-mode.*
> *(U.S. Department of Energy Microgrid Exchange Group, 2010).*

Above all, the term “microgrid” is used loosely to refer to any localized cluster of facilities whose electrical sources (generation), sinks (loads), and possibly storage (both electrical and thermal) function semi-autonomously from the traditional centralized grid, or macrogrid. Microgrids are one of three elements of emerging SmartGrid technology, the other more widely recognized two being: 1. improved operation of the traditional macrogrid, e.g. by deployment of phasor measurement, and 2. enhanced interaction between the grid and consumers, e.g. by deployment of advanced metering infrastructure. By contrast to these two recognized technological changes, microgrids are new entities that provide two-way benefits to their participants and the megagrid. The above two definitions have two basic requirements: 1. a microgrid must contain both sources and sinks under local control, and 2. a microgrid must be able to function both grid connected and as an island. Additionally, various types of microgrids might not only operate with quite different technologies and objectives, but might also fall under quite different regulatory regimes. Notably, microgrids can be wholly within one traditional utility “customer” site, and most existing demonstrations are of this type. Alternatively, a microgrid might involve several sites connected by a fragment of the legacy distribution network. The difference between these two types is critical from the regulatory and policy perspectives because the former is downstream of a single (or very few) meter(s) or point(s) of common coupling, which implies a regulatory environment distinct from the latter case, which implies a part of a regulated distribution utility is involved. Additionally, note that the key word identifying a microgrid, particularly, differentiating it from traditional distributed generation, is “controlled.” A microgrid must have semiautonomous capability. The U.S.DOE and CIGRÉ definitions, on the other hand, say nothing about the technologies involved, the scale, the motive, or the quality of power delivered to loads. The microgrid’s ability to present itself to the macrogrid as a controlled entity has two important implications: 1. it can provide complex services, e.g. levelizing variable renewable generation, and 2., it can coordinate with other entities in the network, such as other microgrids or sites with generation and/or controlled loads. Within the microgrid itself, in addition to the self-apparent potential benefits of potentially providing clean and affordable energy under local control,

consider that in stark contrast to the familiar universal homogeneous service from the macrogrid, microgrids provide an opportunity to control PQR locally tailored to meet load requirements. This might mean a local DC system for PV and storage microgrids, or in other circumstances, it may mean highly reliable and clean power for a site whose loads demand it, e.g. a telecom facility. However, being new, incentives related to stimulating deployment of microgrids are not readily apparent, and identifying, quantifying, and capturing their benefits and establishing efficient markets poses some significant policy challenges. The policy and regulatory environment has a profound effect on the adoption of microgrids, their composition, and their likelihood of sustained operation.

First and foremost, the economics of microgrids is driven by the incentives established by tariffs and other market opportunities. Creating effective mechanisms by which microgrids can exchange energy and services with the macrogrid, and hopefully capture a significant share of the benefits they bestow on the macrogrid, are a key policy priority. This problem is more complex that it seems for three reasons: 1. because microgrid economics are highly sensitive to details in tariffs and related agreements, 2. because the services that microgrids might provide to the macrogrid are either new, e.g. local voltage support, or have traditionally come from sources with very different characteristics, e.g. provision of grid ancillary services has come from large generating stations, so the way services are defined reflects large station capabilities, and 3. because many of the benefits are localized and quantifying them is not only a technical challenge but can raise significant equity issues. With respect to 3., a microgrid may merit compensation for providing local distribution network support in a certain location but the reason a problem exists in this one location may be the result of the somewhat arbitrary topology of the network. In other words, microgrids may be rewarded simply by virtue of quirks of the legacy network. As a second example, consider the benefits to the macrogrid by being buffered from variable renewable generation. This is a clear benefit, but not one that is readily estimated and compensated.

The rules, tariffs, and contracts on which payments are made, in both directions, will likely be the most potent driver of microgrid development, so a thorough policy analysis of their technical basis will be needed. To the extent that microgrids can provide benefits to the high voltage grid, e.g. by providing demand response and ancillary services, the markets for these too must be amenable to microgrid participation. One particular possibility of interest is that microgrids can serve as aggregators of potential ancillary service providers, e.g. by jointly controlling electric vehicle or stationary batteries and buildings equipment to offer a combined service to the grid. In this case, the contractual relationship between the vehicle owners and the microgrid also requires regulatory scrutiny.

Secondly, the technical rules by which microgrids interconnect and operate pose key policy questions. The costs of microgrid deployment can be significantly influenced by the details of technical rules, so their establishment has to be based on an open standards setting process, and their enforcement has to be evenhanded. In the U.S. considerable effort has ultimately led to passage of standards that are widely accepted by states.

Thirdly, as noted above, microgrids may or may not be subject to public utility codes, in various circumstances. In other words, under some circumstances microgrids might be considered public utilities, with severe regulatory and cost consequences. The rules under which microgrids become utiities, and the rules under which they must operate in each case needs to be carefully

examined. As with many aspects of microgrids, small such considerations can have major implications for economics and feasibility.

Fourthly, also as noted above, microgrids provide an opportunity to control PQR locally. The technical and regulatory environment will profoundly affect the way the technology is rolled out, in this regard. For example, can low-voltage DC networks be legally installed in buildings under existing codes, and what safety and other measures are required. Notably, could it emerge as a mechanism more geared towards exchange of low-carbon electricity that as a source of universal high PQR electricity, which has been the path followed by the currently industrialized countries. Ultimately, much of the benefit from microgrid technology may be that it enables the macrogrid to evolve differently. How policies enable or hamper such a diverse path will be one of the greater long-term research questions.

In this report, policies and regulations from the aspects of interconnection, RD&D, and tariffs on renewables, distributed generation, and microgrids are listed. These policies and regulations, show the experiences and lessons of major developed countries and regions on the development of renewable distributed generation and microgrids. The authors hope it can offer good references for policy-makers.

Part Ⅰ Policies on Microgrids or Related to Microgrids

1. Standards or Policies on Interconnection

Country/State	*Standard/Policy*	*path\filename on companion CD-ROM or Website*
US	1. IEEE1547	http://www.ieee.org/index.html
	2. IEEE1547.1	http://www.ieee.org/index.html
	3. IEEE1547.2	http://www.ieee.org/index.html
	4. IEEE1547.3	http://www.ieee.org/index.html
	5. IEEE1547.4	http://www.ieee.org/index.html
	6. FERC Order No.2006	http://www.ferc.gov/legal/maj-ord-reg.asp
California, US	1. Rule 21	http://www.energy.ca.gov/distgen/interconnection/RULE_21_MODEL_RULE_02-2006.PDF
	2. California Interconnection Guidebook	http://www.energy.ca.gov/reports/2003-11-13_500-03-083F.PDF
	3. Glossary and Resources Rule 21- Working Group	http://www.cpuc.ca.gov/NR/rdonlyres/88EEE026-B2E2-45DB-9252-8FF861212214/0/-FINALCPUCRule21 GlossaryandResources.pdf
	4. CEC 100-2005-003	http://www.cpuc.ca.gov
IEC	1. IEC/TS 62257.9.1	http://webstore.iec.ch/webstore/webstore.nsf/Artnum_PK/41866
	2. IEC/TS 62257.9.2	http://webstore.iec.ch/webstore/webstore.nsf/
Canada	1. CAN/CSA-C22.2 NO.257-06	http://shop.csa.ca/en/canada/general-standards/
	2. CAN/CSA-C22.3 NO. 9-08	http://shop.csa.ca/en/canada/
EC	1. Priority Interconnection Plan	http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2006:0846:REV1:EN:PDF
	2. REGULATION (EC) No 1228/2003	http://eur-lex.europa.eu/
	3. REGULATION (EC) No 714/2009	http://eur-lex.europa.eu/
EU Standards	EN 50438	http://www.en-standard.eu/
UK	1. ER G59/1	http://2010.energynetworks.org/distributed-generation/
	2. ER G83/1	http://www.ena-eng.org/ENA-Docs/EADocs.asp?WCI=MainMenu
	3. K/EL/00318/REP	http://www.energynetworks.org/ena_DG/FES_00318_v040211.pdf
	4. ETR 113	http://www.baxi-senertec.co.uk/documents/ETR_113.pdf

	5. CUSC (The Connection and Use of System Code)	**http://www.nationalgrid.com/uk/Electricity/Codes/systemcode/contracts/**
	6. The Electricity Act 1989, c.29	**http://www.legislation.gov.uk/ukpga/1989/29/contents**
Spain	**1. RD 1663/2000**	**http://www.boe.es/boe/dias/2000/09/30/pdfs/A33511-33515.pdf**
	2. RD 661/2007	**http://www.cne.es/cne/doc/legislacion/RD_661-2007-RE.pdf**
France	**1. Arrêté du 23**	**http://www.res-legal.de/en/**
	2. Loi n° 2000-108	**http://www.legifrance.gouv.fr/**
Germany	**1. EEG**	**http://www.bmu.de/files/pdfs/allgemein/application/pdf/eeg_2009_en.pdf**
	2. KraftNAV	**http://www.gesetze-im-internet.de/bundesrecht/kraftnav/gesamt.pdf**
Italy	**1. CEI 11-20 V1**	**http://www.ceiweb.it/webStore/**
	2. CEI 50160	**http://www.ceiweb.it/webStore/**

2. RD&D Activities on Microgrids

2.1 US and Canada

Country/State	*Program/Demonstration*	*Funded by*	*path\filename on companion CD-ROM or Website*
US	**1. Grid 2030**	**Recovery Act, DOE**	**http://energy.gov/sites/prod/files/oeprod/DocumentsandMedia/Electric_Vision_Document.pdf**
	2. IEEE1547.4(interconnection standard)	**DOE**	**http://www.ieee.org/index.html**
	3. Der-Cam	**DOE, LBNL**	**http://der.lbl.gov/der-cam**
	4. Dolan Technology Center CM test bed	**DOE, CERTS**	**http://certs.aeptechlab.com/; Nikos Hatziargyriou, Hiroshi Asano, Reza Iravani, Chris Marnay, 2007**
	5. Energy Surety Microgrid Projects	**DOE/FEMP**	**Merrill Smith, Office of Electricity Delivery and Energy Reliability, 2010**
	6. RESCO, San Diego	**DOE, CEC**	**http://www1.eere.energy.gov/deployment/communityre/resco.html**
	7. Santa Rita Jail Project	**Alameta County**	**http://www.acgov.org/srjp/caseStudy.PDF**
	8. New Mexico Project	**NEDO & the State**	**Kazuyuki Takada, NEDO, 2010; L. Dignard-Bailey et.al, 2010**
Canada	**1.Decentralized Energy Production program**	**Natural Resources Canada**	**http://canmetenergy-canmetenergie.nrcan-rncan.gc.ca/fichier.php/codectec/En/2004-148/2004-148f.pdf; Nikos Hatziargyriou, Hiroshi Asano, Reza Iravani, Chris Marnay, 2007**
	2. Canadian universities		**Nikos Hatziargyriou, Hiroshi Asano, Reza Iravani, Chris Marnay, 2007**
	3. Boston Bar	**BC Hydro**	**Farid Katiraei, CETC-V, 2007**
	4. BCIT Campus Microgrid	**BC gov., BMPIC**	**Hassan Farhangi, BCIT**

2.2 EU

Country/State	*Program/Demonstration*	*Funded by*	*path\filename on companion CD-ROM or Website*
EU	**1. Strategic Research Agenda for Europe's Electricity Networks of the Future**	**EU**	**http://ec.europa.eu/research/energy/pdf/smartgrids_agenda_en.pdf**
	2. FP5 (5th Framework Programme): the Microgrids	**EU**	**http://ec.europa.eu/research/fp5.html**
	3. FP6 (6th Framework Programme): More Microgrids	**EU**	**http://ec.europa.eu/research/fp6.html**
	4.IRED (Integration of Renewable Energy Sources and Distributed Generation into European Electricity Grid)	**EU**	**http://ec.europa.eu/**
	5. Sub Programmes: Dispower, EU-DEEP, FENIX, etc.	**EU**	**http://ec.europa.eu/**
	6. European Electricity Projects 2002	**EU**	**http://ec.europa.eu/**
	7. FP7 (7th Framework Programme)	**EU**	**http://ec.europa.eu/research/fp7.html**
Greece	**1.The Kythnos Island Microgrid**	**EU, ISET**	**Nikos Hatziargyriou, etc., 2007; Stathis Tselepis, 2010; http://www.microgrids.eu/index.php?page=kythnos**
	2.NTUA Power System Lab. Facilities	**EU**	**Nikos Hatziargyriou, etc., 2007; Meena Agrawal and Arvind Mittal, 2011**
Germany	**MVV Residential Demonstration**	**EU**	**Nikos Hatziargyriou, Hiroshi Asano, Reza Iravani, Chris Marnay, 2007**
Spain	**LABEIN**	**EU**	**http://www.microgrids.eu/**
Holland	**Continuon's MV/LV facility**	**EU**	**http://www.microgrids.eu/**
Italy	**CESI RICERCA test facility**	**Corp.**	**John Eli Nielsen, 2008**
Denmark	**Bornholm Island Multi-Microgrid**	**Corp.**	**John Eli Nielsen, 2008**
Portugal	**EDP's Microgeneration facility**	**Corp.**	**http://www.microgrids.eu/index.php?page=kythnos&id=3**
Scotland	**Eigg Island Project**	**Utility**	**http://islandsgoinggreen.org/about/eigg-electric/**

2.3 Japan

Country/State	*Program/Demonstration*	*Funded by*	*path\filename on companion CD-ROM or Website*
Japan	**1.Regional Power Grid with renewable Energy Resources Project**	**Ministry of Economy, Trade, and Industry**	**Nikos Hatziargyriou, Hiroshi Asano, Reza Iravani, Chris Marnay, 2007**
	2. Aichi Project	**NEDO**	**Nikos Hatziargyriou, etc., 2007; Satoshi Morozumi,2006; Mike Barnes, et.al, 2007**
	3. The Aomori Project in Hachinohe	**NEDO**	**Nikos Hatziargyriou, etc., 2007; Tomihiro Takano, Isolated Operation at Hachinohe Microgrid Project; Satoshi Morozumi, 2006; Mike Barnes, et.al, 2007**
	4.The Kyoto Project at Kyotango	**NEDO**	**Nikos Hatziargyriou, etc., 2007; Atsushi Denda, 2006**
	5. Sendai Project	**NEDO & Private**	**Nikos Hatziargyriou, etc., 2007; Mike Barnes, et.al, 2007**
Private Sector	**1. Shimizu's Microgrid**	**Shimizu Corp. & University of Tokyo**	**Nikos Hatziargyriou, etc., 2007; Mike Barnes, et.al, 2007; Atsushi Denda, 2006**
	2. Tokyo Gas Microgrid in Yokohama	**Tokyo Gas & University of Tokyo**	**Nikos Hatziargyriou, etc., 2007; Jianhua Zhang,et al., 2009**
	3. DoCoMo Building	**NTT**	**Chris Marnay**

2.4 Other Countries

Country/State	*Program/Demonstration*	*Funded by*	*path\filename on companion CD-ROM or Website*
Singapore	**Pulau Ubin Microgrid test bed**	**Energy Market Authority under the Ministry of Trade and Industry**	**http://www.ema.gov.sg/ubin-test-bed/**
Australia	**CSIRO Energy Centre**	**CSIRO**	**John K Ward, CSIRO Energy Technology, 2010**
Korea	**KEPRI Project, KERI Project, Jeju Project**	**KOEMA (Korea Electrical Manufacturers Association)**	**JongBo Ahn, 2010; Jaeho Choi, 2011**

3. Tariff Policies

Country/State	*Filename*	*path\filename on companion CD-ROM or Website*
California, US	**CEC300-2010-006**	**http://www.energy.ca.gov/2010publications/CEC-300-2010-006/CEC-300-2010-006.PDF**
Ontario, Canada	**Green Energy and Green Economy Act**	**http://www.ontla.on.ca/bills/bills-files/39_Parliament/Session1/b150ra.pdf**
Spain	**1. art. 27 Ley 54/1997**	**http://www.boe.es/aeboe/consultas/bases_datos/act.php?id=BOE-A-1997-25340&p=20110329&tn=1**
	2. RD 2818/1998	**http://www.boe.es/boe/dias/1998/12/30/pdfs/A44077-44089.pdf**
	3. RD 436/2004	**http://www.cne.es/cne/doc/legislacion/(36)RD436_2004.pdf**
	4. RD 661/2007	**http://www.cne.es/cne/doc/legislacion/RD_661-2007-RE.pdf**
	5. RD 1578/2008	**http://www.boe.es/boe/dias/2008/09/27/pdfs/A39117-39125.pdf**
Germany	**1. EEG**	**http://www.bmu.de/files/pdfs/allgemein/application/pdf/eeg_2009_en.pdf**
	2. BioSt-NachV	**http://erneuerbare-energien.de/inhalt/44655/40712/**
	3. AusglMechv	**http://erneuerbare-energien.de/files/english/pdf/application/pdf/englisch_ausglmechv_091019.pdf**
	4. SDLWindv	**http://erneuerbare-energien.de/files/english/pdf/application/pdf/sdl_windv_en.pdf**
UK	**FTO 2010**	**http://www.legislation.gov.uk/uksi/2010/678/contents/made**
France	**1. Loi n° 2000-108**	**http://www.legifrance.gouv.fr/affichTexte.do;jsessionid=D6C0EE051DEA138D0FF0DC94F4D3513F.tpdjo13v_3?cidTexte=LEGITEXT000005629085&dateTexte=20110111**
	2.Décret n° 2010-1510	**http://www.legifrance.gouv.fr/affichTexte.do;jsessionid=30ABC71A80251EF33E2BB621085A1691.tpdjo06v_1?cidTexte=JORFTEXT000023212761&dateTexte=20101214**
Italy	**1. ARG/elt 1/09**	**http://www.autorita.energia.it/it/docs/09/001-09arg.htm**
	2. L 244/07	**http://www.parlamento.it/parlam/leggi/07244l.pdf**
	3. DL 28/11	**http://www.governo.it/Governo/Provvedimenti/testo_int.asp?d=62612**
	4. AEEG 34/05	**http://www.autorita.energia.it/allegati/docs/05/034-05old.pdf**
	5. AEEG 280/07	**http://www.autorita.energia.it/it/docs/07/280-07.htm**
	6. AEEG 348/07	**http://www.autorita.energia.it/allegati/docs/07/tit.pdf**
	7. DM 05/05/11	**http://www.gse.it/attivita/ContoEnergiaF/servizi/TerzoContoEnergia/FtvConcentrazione/Documents/DM%205%20MAGGIO%20%282%29.pdf**

	8. AEEG 111/06	**http://www.autorita.energia.it/it/docs/06/111-06.htm**
Demark	**1.VE-Lov**	**http://www.ens.dk/en-US/Info/Legislation/Energy_Supply/Documents/Promotion%20of%20Renewable%20Energy%20Act%20-%20extract.pdf**
	2.Act on Electricity Supply	**http://www.ens.dk/da-DK/Info/Lovstof/Hoeringer/2009/Documents/Lovbekg_286.pdf**
Greece	**1. Law No. 3468/2006**	**http://www.ypeka.gr/LinkClick.aspx?fileticket=qtiW90JJLYs%3d&tabid=37**
	2. Law No. 2773/1999	**http://www.ypeka.gr/LinkClick.aspx?fileticket=VtweJAT%2fbGU%3d&tabid=277&language=el-GR**
	3. FEK 1079/2009	**http://www.ypeka.gr/LinkClick.aspx?fileticket=mz8ssdmgKhg%3d&tabid=541**

Net Metering

Country/State	Filename	path\filename on companion CD-ROM or Website
US	**1. H.R.729**	**http://www.gpo.gov/fdsys/pkg/BILLS-110hr729ih/pdf/BILLS-110hr729ih.pdf**
	2. H.R. 1945	**http://www.gpo.gov/fdsys/pkg/BILLS-110hr1945ih/pdf/BILLS-110hr1945ih.pdf**
California, US	**1. SB 656**	**http://www.leginfo.ca.gov/pub/95-96/bill/sen/sb_0651-0700/sb_656_bill_950804_chaptered.pdf**
	2. AB 1755	**http://www.leginfo.ca.gov/pub/**
	3. AB 918	**http://www.leginfo.ca.gov/pub/99-00/bill/asm/ab_0901-0950/ab_918_bill_20000930_chaptered.pdf**
	4. AB 29	**http://www.californiasolarcenter.org/legislation.html**
	5. SB 1	**http://www.californiasolarcenter.org/legislation_files/Legislation_PDF/SB1_MillionSolarRoofs.pdf**
	6.Introduction to the net energy metering cost effectiveness evaluation	**http://www.energy.ca.gov/**
Italy	**1. ARG/elt 74/08**	**http://www.autorita.energia.it/it/docs/08/074-08arg.htm**
	2. DL 387/03	**http://www.ambientediritto.it/Legislazione/Energia/2003/dlgs%202003%20n.387.htm**
	3. L 99/09	**http://www.parlamento.it/parlam/leggi/09099l.htm**
Denmark	**BEK 804/2010**	**https://www.retsinformation.dk/Forms/R0710.aspx?id=132740**

4. Other Policies

Country/State	*Filename*	*path\filename on companion CD-ROM or Website*
US	**1.2005 Energy Policy Act**	**http://energy.gov/oe/electricity-policy-coordination-and-implementation/transmission-planning/coordination-federal**
	2. Grid 2030	**http://energy.gov/oe/downloads/grid-2030-national-vision-electricity-s-second-100-years**
	3. 2010 Smart Grid Annual Report	**http://www.cpuc.ca.gov/NR/rdonlyres/A3D6019B-3620-44B5-95D5-5ADFDAD714C7/0/2010_Smart_Grid_Annual_Reportzafmjd_v5.pdf**
	4. A Policy Framework for the 21st Century Grid	**http://www.ferc.gov/industries/electric/indus-act/smart-grid/21st-century-grid.pdf#xml=http://search.atomz.com/search/pdfhelper.tk?sp_o=2,100000,0**
	5. National Action Plan on Demand Response	**http://www.ferc.gov/legal/staff-reports/06-17-10-demand-response.pdf#xml=http://search.atomz.com/search/pdfhelper.tk?sp_o=7,100000,0**
California, US	**1. AB 32**	**http://www.leginfo.ca.gov/pub/05-06/bill/asm/ab_0001-0050/ab_32_bill_20060927_chaptered.pdf**
	2. SB X1-2	**http://www.energy.ca.gov/portfolio/index.html**
	3. Executive Order S-3-05	**http://www.dot.ca.gov/hq/energy/ExecOrderS-3-05.htm**
	4. CEC 100-2009-003-CMF	**http://www.energy.ca.gov/2009publications/CEC-100-2009-003/CEC-100-2009-003-CMF.PDF**
	5. SGIP	**http://www.cpuc.ca.gov/PUC/energy/DistGen/sgip/aboutsgip.htm**
	6. CSI （California Solar Initiative）	**http://www.cpuc.ca.gov/puc/energy/solar/aboutsolar.htm**
	7. RPS Q2 2011	**http://www.cpuc.ca.gov/NR/rdonlyres/1D24680C-BDF1-4EE9-A43F-59B309602172/0/Q2ReporttotheLegislatureFINAL.pdf**
	8. Impacts of DG (Final Report)	**http://www.cpuc.ca.gov/NR/rdonlyres/750FD78D-9E2B-4837-A81A-6146A994CD62/0/ImpactsofDistributedGenerationReport_2010.pdf**
Ontario, Canada	**Long-Term Energy Plan**	**http://www.energy.gov.on.ca/docs/en/MEI_LTEP_en.pdf#page=22**
EU	**1. DIRECTIVE 2003/54/EC**	**http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2003:176:0037:0037:EN:PDF**
	2. DIRECTIVE 2003/55/EC	**http://eur-lex.europa.eu/**
	3. DIRECTIVE 2005/89/EC	**http://eur-lex.europa.eu/**
	4. DIRECTIVE 2009/72/EC	**http://eur-lex.europa.eu/**
	5. Energy 2020	**http://ec.europa.eu/energy/publications/doc/2011_energy2020_en.pdf**

	6. Energy Roadmap 2050	**http://ec.europa.eu/energy/strategies/2011/doc/roadmap_2050/20110503_energy_roadmap_2050_state_of_play.pdf**
	7. Smart Grid	**http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=SEC:2011:0463:FIN:EN:PDF**
Spain	**1. Energy Policy of IEA Countries Spain 2009**	**http://www.iea.org/textbase/nppdf/free/2009/spain2009.pdf**
	2. Spanish Renewable Energy Review	**http://www.erec.org/fileadmin/erec_docs/Projcet_Documents/RES2020/SPAIN_RES__Policy_review__09_Final.pdf**
Germany	**EEG**	**http://www.bmu.de/files/pdfs/allgemein/application/pdf/eeg_2009_en.pdf**
France	**France renewable energy policy review**	**http://www.erec.org/fileadmin/erec_docs/Projcet_Documents/RES2020/FRANCE_RES_Policy_Review_09_Final.pdf**
Italy	**Energy Policy of IEA Countries Spain 2009**	**http://www.iea.org/textbase/nppdf/free/2009/italy2009.pdf**
Denmark	**Law on the Promotion of Renewable**	**http://www.ens.dk/en-US/Info/Legislation/Energy_Supply/Documents/Promotion%20of%20Renewable%20Energy%20**
	Energy	**Act%20-%20extract.pdf**

5. Brief Introduction to Major Standards, Projects and Policies

5.1 Standards and Policies on Interconnection

IEEE1547: IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems.

IEEE1547.1: IEEE Standard Conformance Test Procedures for Equipment Interconnecting Distributed Resources with Electric Power Systems.

IEEE1547.2: IEEE Application Guide for IEEE Std 1547™, IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems.

IEEE1547.3: IEEE Guide for Monitoring, Information Exchange, and Control of Distributed Resources Interconnected with Electric Power Systems.

IEEE1547.4: IEEE Guide for Design, Operation, and Integration of Distributed Resource Island Systems with Electric Power Systems.

FERC Order No. 2006: Standardization of Small Generator Interconnection Agreements and Procedures (Final Rule).

Rule 21 (California): Rule 21 describes the interconnection, operating and metering requirements for generation facilities to be connected to a utility's distribution system, over which the California Public Utilities Commission has jurisdiction.

California Interconnection Guidebook: A Guide to Interconnecting Customer-owned Electric Generation Equipment to the Electric Utility Distribution System.

CEC 100-2005-003: Recommended changes to interconnection rules.

IEC/TS 62257.9.1: Small renewable energy and hybrid systems for rural electrification on micro power systems.

IEC/TS 62257.9.2: Specifies the general requirements for the design and the implementation of microgrids used in decentralized rural electrification to ensure the safety of persons and property and their satisfactory operation according to the scheduled use.

CAN/CSA-C22.2 NO.257-06: Interconnecting inverter-based micro-distributed resources to distribution systems.

CAN/CSA-C22.3 NO.9-08: Interconnection of distributed resources and electricity supply systems.

Priority Interconnection Plan: The purpose of this plan is to construct an internal energy market and to achieve the European Union's targets for sustainable development, competitiveness and secure energy supplies by rapid development of their interconnections. The Priority Interconnection Plan details the progress of the 42 projects of European interest listed in the Guidelines for trans-European energy networks adopted in 2006. And, it proposes five priority actions to ensure a stable environment favorable to investments.

REGULATION (EC) No 1228/2003: On conditions for access to the network for cross-border exchanges in electricity.

REGULATION (EC) No 714/2009: On conditions for access to the network for cross-border exchanges in electricity and repealing Regulation (EC) No 1228/2003.

EN 50438: Requirements for the connection of micro-generators in parallel with public low-voltage distribution networks.

ER G59/1: Recommendations for the connection of embedded generating plant to the regional electricity companies' distribution systems.

ER G83/1: Recommendations for the connection of small scale embedded generators (up to 16A per phase) in parallel with public low-voltage distribution networks.

K/EL/00318/REP: Technical Guide to the Connection of Generation to the Distribution Network.

ETR 113: Notes of guidance for the protection of embedded generating plant up to 5-MW for operation in parallel with public electricity suppliers' distribution systems.

CUSC (The Connection and Use of System Code): Regulating the conditions for the use of the British grid.

The Electricity Act 1989, c.29: The act opens the electricity and gas markets in Great Britain.

RD 1663/2000: Setting the conditions for the connection of photovoltaic installations to the low-voltage grid.

RD 661/2007: Establishing legal and economic provisions for electricity producers under "Régimen Especial".

Arrêté du 23: Art. 22 sets out the connection requirements for systems generating "unused" electricity (e.g. wind energy systems or photovoltaic systems).

Loi n° 2000-108: Modernizing and developing public electricity supply.

EEG (Erneuerbare-Energien-Gesetz): The Act regulates the obligation and process of system operator and grid operator on connection to grid.

KraftNAV: Ordinance on the connection of power plants to the grid; regulating the procedure for the connection of power plants with a capacity of at least 100-MW to high-voltage grids with a voltage of at least 110-kV.

CEI 11-20 V1: Power generation systems and uninterruptible power supplies connected to networks of I and II category (<20-kW without galvanic/metal isolation; >20-kW mandatory galvanic isolation).

CEI 50160: Voltage characteristics of electricity supplied by public distribution systems.

5.2 RD&D Activities on Microgrids

5.2.1 US and Canada

DER-CAM (Tool for Microgrid Deployment and Operation): LBNL's DER-CAM model can pick optimal combinations of equipment and operating schedules for microgrids and has been used

for 10 years internationally.

Dolan Technology Center CM test bed: Three Tecogen 60-kW gensets based on a production General Motors 7.5-L engine, with three 112.5-kVA inverter transformers which connect each Gen-set/inverter; the electrical panels include the load side breaker and visible disconnect switch for each Gen-set, the electrical breaker panel and 45-kVA transformer provides auxiliary power to equipment inside the gen-set and gen-set coolant system; three engine exhausts and sound suppressors are mounted on the roof with three ventilation exhaust fans; the main natural gas supply with gas pressure regulated from one 1,724-kPa source down to three individual 690-kPa sources, which are connected to each genset; a AC/DC surge module is connected to each genset and for this unit.

Energy Surety Microgrid Projects: A series projects cooperated by US army and Sandia Lab. Funded by DOE/FEMP, including Army Bases: Ft Sill, Ft. Bliss, Ft. Belvoir, Ft. Devens, Ft. Carson, IMCOM exploring two additional sites; Navy/Marines Bases: Indian Head, Camp Smith, Guam/Okinawa; Air Force Based: Maxwell AFB, Kirtland AFB, Schriever AFB, Vandenberg AFB.

RESCO (Renewable Energy Secure Communities), SAN DIEGO: The project consists of UC San Diego demonstrating integration of on-site renewable energy production. UC San Diego's campus-wide serves a 4.86-km^2, 450 building campus with a daily population of 45,000 running two 13.5-MW gas turbines, one 3-MW steam turbine and a 1.2-MW solar cell installation that together supplies 82 percent of the campus's annual power.

Santa Rita Jail Project: System size: 1.18-MW; annual power generated: 1,460,000-kWh; Power Light photovoltaic roof tiles 9,726; solar array size 12,077-m^2. The Alameda County solar project offers proof that solar electricity and energy efficiency are a robust blend of technological innovations well suited to respond to California's stressed power grid. Linking Santa Rita Jail's solar electric installation with energy efficiency upgrades and state-of-the-art energy management software, Alameda County is able to reduce its peak power consumption at Santa Rita Jail by 30%.

New Mexico Project: Los Alamos: 2-MW PV and 1-MW storage batteries on 2~5-MW distribution lines. EMS and ICT with changeable grid structure to switch the rate of PV power supply; distribution equipment with ICT capacity; smart house with 3-kW PV, 20-kW storage batteries, heat storage; Albuquerque: islanding operation at a commercial building with PV, fuel cell, natural gas reciprocating engine cogeneration, a thermal storage tank, storage batteries integrated into the building energy management system. Absorption of fluctuated output from other large scale PV system connected into the same distribution area by using both EMS of the grid and the building.

Decentralized Energy Production (DEP) program: The primary goals are the removal of

institutional barriers that prevent DEP installation (by 2010), and for 20% of new and replacement generation capacity to be met by DEP by 2025. Theme areas included in this program are: grid integration, renewable energy use, and fossil fuel conversion. Distributed generation production generally refers to on-site power generating plants of less than 1-MW capacity: however, for the scope of this program, highly efficient fossil fuel plants (up to 25-MW) and wind farms are also included. These systems will increase the reliability of, and reduce GHG and air emissions from Canada's electric power system at an acceptable economic cost to Canadians.

Boston Bar: Run-of-river hydro generation and two 3.45-MW (8.6-MVA) peak gensets, supplies 3-MVA peak load; the cable of 60-km with 69-kV link to BC Hydro's HV system.

BCIT Campus Microgrid: This demonstration includes co-generation power plants, an existing photovoltaic tower, capable of generating up to 8-kW, as well as three smaller PV systems elsewhere on the campus with a total generation capacity of around 14-kW. Work is also underway to equip the campus with a power boiler and a steam turbine-generator. Moreover, as part of the future expansion of this initiative, BCIT is planning to add two additional co-generation sources to its Intelligent Microgrid. The first of the future campus-based co-generators is an industrial-scale micro-wind turbine and generator which is based on a BCIT-developed wind-accelerator. Technology designed for areas where the wind intensity is normally insufficient for power generation. The second campus-based co-generation source would involve an additional boiler fueled by wood-waste. This will be used to develop and verify efficient and environmentally friendly ways of producing energy from beetle-infested timber.

5.2.2 EU

Strategic Research Agenda for Europe's Electricity Networks of the Future: The purpose of this program is to ensure that Europe's electricity networks develop, capture the benefits of collaboration and co-operation to address challenges, encourage imaginative solutions, build on previous RD&D thereby ensuring maximum benefit and elimination of duplication, fully utilize current infrastructure to ensure the most efficient use, provide a clear framework, goals and objectives for the research community and all stakeholders to focus on, and generate the momentum and support necessary from all stakeholders.

Vision and Strategy for Europe's Electricity Networks of the Future: In this vision, future electricity markets and networks must provide all consumers with a highly reliable, flexible, accessible and cost-effective power supply, fully exploiting the use of both large centralized generators and smaller distributed power sources across Europe. End users will become significantly more interactive with both markets and grids; electricity will be generated by

centralized and dispersed sources; and grid systems will become more inter-operable at a European level to enhance security and cost-effectiveness. This new concept of electricity networks is described as the 'Smart Grids' vision. It will enable a highly effective response to the rising challenges and opportunities, bringing benefits to all network users and wider stakeholders.

FP5 (5th Framework Programme) 1998-2002: the Microgrids: Within FP5, the Microgrids: large Scale Integration of Micro-Generation to Low Voltage Grids activity was funded, and led by 14 partners from 7 EU countries. The research objectives mainly focus on how to solve the issues on operation and control of microgrids.

FP6 (6th Framework Programme) 2002-2006: More Microgrids: The FP6 project is an extension of the Microgrids under FP5. It intends to deepen and spread the definition of microgrids, seek new microgrids control strategy and structure design solution, and develop tools being suitable for microgrids operation, in order to increase the ratio of DG in the whole networks.

The Kythnos Island Microgrid: It is an autonomous microgrid, composed of a 3-phase low-voltage grid, formed by battery inverters. The grid is composed of overhead power lines and a communication cable running in parallel to serve monitoring and control needs. The generation system comprises 10-kW of PV, a nominal 53-kWh battery bank, and a 5-kW diesel genset. A second PV array of about 2-kW connected to an SMA inverter and a 32-kWh battery bank on the roof of the control system building provides power for monitoring and communication. Three SMA batteries connected in a parallel master-slave configuration supply the power to the residents. And it electrifies 12 houses.

NTUA (National Technical University of Athens) Power System Lab. Facilities: The laboratory-scale microgrid system, installed at NTUA, comprises two PV generators, one wind turbine, battery energy storage, controllable loads and a controlled interconnection to the local LV grid. The battery unit, PV generators and wind turbine are connected to the AC grid via fast-acting DC/AC power converters. The battery converter in particular is suitably controlled to permit the operation of the system either interconnected to the LV network (grid-tied), or in stand-alone (island) mode, with a seamless transfer from one mode to the other.

MVV Residential Demonstration: Five PV systems, a total of 30-kW, and 1 CHP system have been installed by private investor. Grid structure is suitable for further microgrid option. The first goal of the experiment has been to involve customers in load management. Based on PV output availability information in their neighborhood, customers shifted their loads to times when they could use solar electricity directly.

LABEIN: PV installations: single-phase 0.6-kW, single-phase 1.6-kW and three-phase 3.6-kW; Diesel Generators: two 55-kW (one of them with a controllable rectifier); microturbine

MAGNETEK EG-50: 50-kW; wind turbine INCLIN NEO 6000: 6-kW, 4-m rotor. This network will be used to test centralized and decentralized control strategies in grid interconnected mode as well as communication protocols and components.

Continuon's MV/LV facility: Continuon operates a holiday-park with more than 200 cottages. A great number of these cottages are equipped with PV-generators, coupled to the grid by means of inverters. The total amount of installed PV-power is 315-kW. The cottages are connected to a MV/LV transformer using four LV-feeders. Each 3-phase feeder has a length of around 400-m. The main purpose of this microgrid is to establish: islanded operation of the microgrid, improving the voltage level and improving the voltage shape.

CESI RICERCA test facility: This facility is an automated grid with total electric power: of 350-kW, of which the total thermal power is 250-kW. The test facility will be able to operate with different voltage and frequency levels (45-Hz to 65-Hz, 360-V to 440-V) and under conditions of phase unbalance.

Bornholm Island Multi-Microgrid: The generation system comprises 55-MW peak load, 16 60/10-kV transformers, 39-MW diesel (Oil), 39-MW steam (Oil), 37-MW steam (coal/oil) CHP, 30-MW wind, four district heating systems, six heat generators. It can supply the electricity for 28,000 customers. The main objectives are to analyze of results including simulations against measurement, describe system's ability to balance active/reactive power, to blackstart and reconnect to main grid.

EDP's Microgeneration facility: The LV Microgrid integrates a micro-cogeneration of a natural gas station (NGS). The micro-cogeneration system is characterized by a complete cogeneration module, supported by a microturbine with an electric power of 80-kW. The electric power is generated in LV (400-V) and supplies the NGS and it is exported to the MV public grid. After some electrical reconfigurations it will be possible to supply a small LV rural public grid with this micro-source, in interconnected and islanded modes. The NGS recovery the thermal power from the microturbine and demands more or less 5-kW (the contracted power is 20.7-kVA), in normal operation. The remaining power is exported to the MV grid or possibly to the LV grid.

Eigg Island Project: The system consists of a hydroelectric generator, 4 small wind generators and an array of PV panels. The generations is sited at different locations around the island as determined by the availability of resources. The hydroelectric capacity is approximately 110-kW, the maximum output of the wind farm is 24-kW, and the PV panels can produce up to 10-kW. The total generating capacity of the whole system is approximately 144-kW. About 11-km of cable was laid for the grid, most of it on the surface. It is at the control building that the whole system is regulated, to ensure a continuous supply of electricity to the island. There are ninety-six 4-V batteries at the control building. Limited capacity, especially in the summer months when there is

little wind or rain is the biggest limitation. The decision was taken early in the design of the project to cap the supply to all outlets.

5.2.3 Japan

Aichi Project: This project now supplies a Tokoname City office building and sewage plant through a private distribution line. Its main feature is a combination of the following fuel cells as the main sources: 270-kW+300-kW MCFCs, 50-kW SOFC, four 200-kW PAFCs, 330-kW of PV, and 500-kW NaS battery. Garbage fermentation and gasification act as energy input to MCFC. Experiment results of intentional islanding mode have been obtained.

The Aomori Project in Hachinohe: The consumer load includes two 50-kW and three 10-kW PVs, wind turbines, battery energy storage and three 170-kW gas engines fed by sewage and waste gas by-product. Exhaust heat is reused by the gas fermentation process. The electricity is transmitted to schools, administrative and business buildings by a private distribution line more than 5-km and 6-kV feeder.

The Kyoto Project at Kyotango: This project includes five 80-kW biogas gensets, a 250-kW MCFC, and 100-kW led-acid battery bank, 50-kW PV and 50-kW wind turbine in remote areas. An energy control center communicates with micro generation units and the existing network by internet protocol to control demand and supply.

Sendai Project: This project includes its own solar photovoltaic array and gas-powered generators. Local generating and distribution systems such as this provide reliable electricity within their service areas and resilience to the main grid. The grid includes two 350-kW gas gensets, a 250-kW MCFC, and a 50-kW battery bank. The microgrid directly serves some DC loads and additionally supplies four different qualities of ac service to a university, a high school, and a sewage plant. The integrated system consists of a two-way mode power module, DC-AC inverter, and a battery bank. This project proved it is a true microgrid during the earthquake and tsunami. It functioned as an island for the two-day blackout that followed the disaster, and after reconnecting to the grid continued to function until natural gas supply was disrupted.

Shimizu's Microgrid: The system includes 90-kW+350-kW natural gas gensets, a 400-kWh NiMH battery bank, and four 100-kW 400 kJ double layer capacitors. The principle objective is to develop an optimum operation and control system.

Tokyo Gas Microgrid in Yokohama: The test facility includes two 25-kW and two 9.9-kW natural gas gensets, two 6-kW wind turbines, a 10-kW PV array, batteries and a biogas engine. The microgrid supplies three PQR levels to building of the Yokohama Research Institute.

DoCoMo Building: This project, which is also in Sendai, has engines and absorption chillers that supply a glycol cooling loop for a data center. Groundwater is pumped at the site and used to

precool the glycol, why rainwater and graywater is used for non-potable purposes.

5.2.4 Other Countries

Singapore-Pulau Ubin Microgrid test bed: Pulau Ubin will host a number of plug and play facilities for test-bedding various close-to-market clean and renewable energy solutions. The Microgrid test-bed will be powered by clean energy resources, including biodiesel and solar photovoltaic cells. The first phase will involve the construction of the Microgrid and the deployment of biodiesel and solar photovoltaic technology. In the second phase, EMA will invite proposals from companies interested to test-bed their clean and renewable energy solutions with the completed Microgrid infrastructure. This may include advanced solar photovoltaic, micro-wind turbine and biomass technologies. Construction of the Microgrid is targeted to commence in the first half of 2012 and be completed by the end of 2012.

Australia CSIRO Energy Centre: The system includes 3 microturbines, 4 wind turbines, 110-kW of PV, and 710-kWh of battery storage.

Korea- KEPRI Project: Develop core devices: EMS, GW, PCS, PQCC; grid-connected type site construction & performance evaluation.

KERI Project: Stand-alone type site construction & performance evaluation; develop engineering tech; support for standardization & mitigation of regulation. Target: construction of independent microgrid site (several 100-kW class), period: 2010-2012 (3 years).

5.3 Tariff Policies

CEC300-2010-006 (California, US): Feed-in tariff designs for California: implications for project finance, competitive renewable energy zones, and data requirements.

art. 27 Ley 54/1997 (Spain): Regulating the electricity sector. This law also applies to systems that generate electricity from renewable sources.

RD 436/2004 (Spain): Establishing the legal and economic framework for the operation of generators under “Régimen Especial”.

RD 661/2007(Spain) : Establishing legal and economic provisions for electricity producers under "Régimen Especial".

RD 1578/2008 (Spain) : Regulating photovoltaic electricity generation.

BioSt-NachV (Germany): Regulating the requirements for the sustainable generation of bioliquids.

AusglMechv (Germany): Furthering the development of the nationwide equalization scheme.

SDLWindv (Germany): Regulating the requirements for wind energy plants to improve grid integration and firing.

FTO 2010 (UK): To encourage the deployment of small-scale low-carbon electricity generation systems.

Decree NO. 2010-1510 (France): This decree suspends the feed-in tariff for solar energy installations with a capacity of more than 3-kWp for three months.

ARG/elt 1/09 (Italy): This regulation defines the modalities and economic conditions for the intake of renewable energy according to the incentive system known as “tariffa omnicomprensiva”.

L 244/07 (Italy): Article 2, paragraphs 143 to 176 of the Budget Act introduces fundamental changes in the promotion of electricity from renewable sources and its supply to the grid.

DL 28/11 (Italy): To define instruments, mechanisms, incentives and the institutional, financial and legal frameworks necessary for achieving the 2020 goals as regards the total quota of renewable energy in final consumption and in transports.

AEEG 34/05 (Italy): This resolution regulates the intake of electricity by the grid operator.

AEEG 280/07 (Italy): This resolution establishes indirect access to the market and a price regulation system.

AEEG 348/07 (Italy): Conditions on the transmission, distribution and metering of energy and the connection of systems to the grid.

DM 05/05/11 (Italy): Establishing a support system for PV systems.

AEEG 111/06 (Italy): Regulation of the distribution of energy in the national grid. Giving renewable energy priority access to the grid.

VE-Lov (Denmark): Promoting the generation of electricity from renewable sources.

Act on Electricity Supply (Denmark): Managing and organising the national electricity market. This Act stipulates binding guidelines for the promotion of electricity from renewable sources.

Law No. 2773/1999 (Greece): This law regulates the liberalization of the Greek electricity market. This law authorises the tax for renewable energy to finance the feed-in tariff. Provision for grid connection and grid development with regard to RES systems.

FEK 1079/2009 (Greece)： Promoting the installation of small PV systems (below 10-kW) on Rooftops.

Green Energy and Green Economy Act (Ontario, Canada): This Act enables the FIT program, which is available for renewable energy projects greater than 10-kW and is open to all types of generators, including developers, community groups and even individual homeowners. Under the Ontario FIT program, eligible applicants receive guaranteed prices for new projects that generate electricity using certain renewable fuels. The Act and associated legislation also provide eligible FIT projects with a priority to connect to the existing transmission and distribution system.

Net Metering

H.R.729 (US): HR-729 allows up to 2% net metering to H.R. 1945.

H.R. 1945 (US) : HR-1945 has no limit, but does limit residential users to 10-kW, a low limit compared to many states, such as New Mexico, with an 80,000-kW limit, or states such as Arizona, Colorado, and Ohio which limit as a percentage of load.

SB 656 (California, US): This bill is the first law for net metering in California. It simplified the grid interconnection rules for PV systems of 10-kW and offered standard contracts at retail prices to residential customers with a solar generating facility <1-MW from any utility in the state. (Wiser et al., 1998)

AB 1755 (California, US) adds small commercial customers (up to 10-kW) to net metering eligibility. It also modified the manner in which net metering would be accomplished, "using a single meter capable of registering the flow of electricity in two directions," and allowing for "an additional meter or meters to monitor the flow of electricity in each direction" to be installed. (M. Taylor, 2008)

AB 918 (California, US): AB-918 provides for customer-generators "taking service under tariffs employing 'baseline' and 'over baseline' rates" or "taking service under tariffs employing 'time of use' rates," to have the net kWh they produced or consumed priced accordingly under net metering. So-called "time-of-use" net metering has proven especially favorable to solar technologies, as these technologies often generate the most electricity at times of peak electricity demand. (M. Taylor, 2008)

AB 29 (California, US): AB-29 raises the eligible system size for net metering from 10-kW to 1-MW and expands the eligible customer-generators to include commercial, industrial, and agricultural customers. (M. Taylor, 2008)

SB 1 (California, US): The "Million Solar Roofs" bill, raises the cap on net metering from 0.5% of peak aggregate demand to 2.5%, while stipulating that to truly achieve 3,000-MW of solar power from roofs (the estimated capacity of a million roofs), 5% will be necessary (EIA, 2005). SB 1 also mandates that solar becomes a "standard option" for buyers of new homes by 2011, requires consideration by the CEC of mandating solar in all new construction, and reduces the CSI budget by $800 million to support municipal utilities in developing their own solar rebate programs. (M. Taylor, 2008)

Introduction to the net energy metering cost effectiveness evaluation (California, US): The report makes an analysis for the evaluation of distributed generation adopted by the CPUC by the cost-benefit methodology. Also, it provides a measure of the total incentive provided to solar PV participants through NEM (which until this point had not been estimated) but is not a measure of the overall cost-effectiveness of solar PV.

ARG/elt 74/08 (Italy): This regulation contains detailed provisions on net metering.

DL 387/03 (Italy): Implementing the EU directive 2001/77/EC and promoting renewable energy.

L 99/09 (Italy): This act aims to reform existing incentives and provide new incentives for enterprises, especially for enterprises in the energy sector.

BEK 804/2010 (Denmark): This law authorizes the exemption of certain producers from the surcharge on electricity.

5.4 Other Policies

A Policy Framework for the 21st Century Grid-Enabling Our Secure Energy Future (US, 2011): This report outlines policy recommendations that build upon the Energy Independence and Security Act of 2007 and the Obama Administration's smart grid investments to foster long-term investment, job growth, innovation, and help consumers save money. The report was prepared by the Subcommittee on Smart Grid of the National Science and Technology Council, Committee on Technology.

National Action Plan on Demand Response (US): The Plan intends to meet the following requirements specified: identify "requirements for technical assistance to States to allow them to maximize the amount of demand response resources that can be developed and deployed;" design and identify "requirements for implementation of a national communications program that includes broad-based customer education and support;" and develop or identify "analytical tools, information, model regulatory provisions, model contracts, and other support materials for use by customers, states, utilities, and demand response providers." To achieve this objective, it calls for two simultaneous, compatible paths of action: (1) enabling development of price-responsive demand response programs, products, technologies, and incentives and (2) facilitating market penetration of newly developing "smart grid" technologies and programs.

2005 US Energy Policy Act (US): This act declares that it is a national policy to enhance and, to the extent possible, increase the coordination and communication among Federal agencies with authority to site electric transmission facilities. Section 1221(a) of EPAct 2005 (which added section 216(h) to the Federal Power Act) stated that the U.S. Department of Energy (DOE) is to coordinate all Federal authorizations and related environmental reviews needed for siting interstate electric transmission projects, including National Environmental Policy Act of 1969 (NEPA) reviews. The purpose of this coordination is to streamline agencies' review processes and avoid duplication among Federal agencies.

Grid 2030-A National Vision for Electricity's Second 100 Years (US): The purpose of this document is to describe the common vision articulated at that meeting. The U.S. Department of Energy will use this vision to help implement President Bush's call for "…modernizing America's

electric delivery system" and the 51 recommendations contained in the National Transmission Grid Study. Various stakeholders, including industry practitioners, policy makers, and researchers, will use the vision as the coordinating foundation for actions leading to the construction of a 21st century electric system. The vision will guide the development of the National Electric Delivery Technologies Roadmap.

AB 32 (California, US) sets an absolute statewide limit on greenhouse gas emissions. The law confirmed California's commitment to transition to a sustainable, clean energy economy.

SB X1-2 (California, US) requires 1/3 State's electricity from renewable sources by 12/31/2020, increase 33% compared to 2010.

Executive Order S-3-05 (California, US): Executive Order S-3-05 calls for an 80% reduction in emissions from 1990 levels by 2050.

CEC 100-2009-003-CMF (California, US): The 2009 Report was prepared in response to Senate Bill 1389 (Bowen, Chapter 568, Statutes of 2002), which requires that the California Energy Commission prepare a biennial integrated energy policy report that contains an integrated assessment of major energy trends and issues facing the state's electricity, natural gas, and transportation fuel sectors and provides policy recommendations to conserve resources; protect the environment; ensure reliable, secure, and diverse energy supplies; enhance the state's economy; and protect public health and safety (Public Resources Code, Section 25301[a]). This report fulfills the requirement of SB 1389.

SGIP (California, US): AB 970 causes the CPUC to create the Self-Generation Incentive Program (SGIP) in 2001. This provides payments ranging from $1/W–$4.50/W to incentivize power production from systems larger than 30-kW (primarily businesses) (CEC, 2005).

CSI （California Solar Initiative）(California, US): In December 2005 CPUC Chair Michael Peevey issues a decision (05-12-044) on an "Interim Order Adopting Policies and Funding for the California Solar Initiative" (CSI). This increased the SGIP funding for 2006 by $300 million, using that money to reduce the PV waitlist (created at incentive levels of $3.50/W) by providing reduced incentives to waitlisted projects of $3.00/W and incentives to new applicants of $2.80/W, the same as in the Emerging Renewables Program.

RPS (California Renewables Portfolio Standard) (California, US): Established in 2002 under Senate Bill 1078 and accelerated in 2006 under Senate Bill 107, California's Renewables Portfolio Standard (RPS) is one of the most ambitious renewable energy standards in the country. The RPS program requires investor-owned utilities, electric service providers, and community choice aggregators to increase procurement from eligible renewable energy resources by at least 1% of their retail sales annually, until they reach 20% by 2010.

Impacts of Distributed Generation (Final Report) (California, US): A report on the impacts of

distributed energy generation on California's transmission and distribution systems. This report provides an overview of the current status of California's distributed energy generation resources and highlights some of the current challenges and activities around interconnecting these resources to the utility grid.

Common Rules for Internal Market:

DIRECTIVE 2003/54/EC (EU): concerning common rules for the internal market in electricity and repealing Directive 96/92/EC.

DIRECTIVE 2003/55/EC (EU): concerning common rules for the internal market in natural gas and repealing Directive 98/30/EC.

DIRECTIVE 2009/72/EC (EU): concerning common rules for the internal market in electricity and repealing Directive 2003/54/EC.

Electric Market Safety and Investment:

DIRECTIVE 2005/89/EC (EU): concerning measures to safeguard security of electricity supply and infrastructure investment.

Energy 2020 (EU): A strategy for competitive, sustainable and secure energy. The main goals of the plan include 20% energy-saving by 2020, to ensure the free movement of energy, to secure safe and affordable energy for citizens and businesses.

Ontario's Long-Term Energy Plan (Ontario, Canada): The Plan targets 19,700-MW of renewable generation capacity. In terms of generation, the plan projects renewables to account for 39% of Ontario generation by 2030. Also, in the Plan, the Ontario government identified five 'priority' transmission expansions to be completed within the next seven years to enable 4,000-MW of new renewable generation.

Part Ⅱ Recommendation

Since the mid-1980s, a series of market-oriented reform measures have been proposed in China's power sector, but due to the importance of this sector for the whole national economy growth and social stability, only limited reforms have been actually undertaken. The whole electricity market is still in the full control of the central government. Accordingly, the electricity sector management has been dominated by seven national grid companies in different areas, which are all stated-owned monopolies. As a result, electricity market policy-making is always apt to slant towards conventional industrial development and stakeholder benefits.

Rapid economic growth at a double-digit rate in the past two decades, has resulted in significantly increasing electricity demand. China is already ranked the world's second largest producer of electricity. At the same time, China has also become the biggest carbon emitter. In order to tackle the issue of climate change and in response to more and more heavy pressure of international markets that increase the price of primary energy, as well as electric power quality and reliability, China has enacted and implemented a series of policies and regulations to motivate renewable and distributed generation. These policies include:

• the Renewable Energy Law, implemented in January 2006.

• the Medium and Long Term Renewable Energy Development Plan, implemented in August 2007.

• the Management Methods for Power Grid Enterprises' Purchasing of Renewable Energy Electricity, implemented in September 2007.

• the 11th Five-Year Renewable Energy Development Plan, implemented in March 2008.

• the Management Methods for Distributed Energy, drafted in April 2011.

In addition, in the 12th Five-Year Plan, China's National Energy Agency plans to use microgrids as the basis for 100 New Energy City pilots, and 30 microgrid pilot projects have also been proposed.

Furthermore, the Technical Regulation on Distributed Generation Access to Grid has put into practice in August 2010.

Policies for promoting the deployment of renewable, distributed generation (DG), and microgrids still need to be managed and implemented. In this report, a series of policies and regulations in three major regions have been listed and analyzed from four aspects: interconnection, RD&D, tariffs, and other comprehensive policies. Based on developed countries' experiences and lessons, some basic policy suggestions are made:

(1) Shifting conventional market mechanisms and management systems, permitting more investors to participate the development of renewable, distributed generation and microgrids.

The successful experiences in developed countries have shown that competitive market mechanisms should be able to effectively promote the deployment of renewable distributed generation and trial microgrids activities. Commonly, to implement some deregulation policies (e.g. more investors access to electricity market, more competitive market) is not only able to facilitate the deployment and development, but also brings cost reductions, improved customer services, increased numbers of new products available, improved levels of service reliability, and added environmental benefits and so on. Of course, deregulation does not always bring net benefits for society. Under some situations, it also brings more negative side effects than positive ones. For example, the British deregulation experience estimates an overall benefit of € 6 to

€11.9 billion, which is equivalent to a permanent reduction of electricity prices of 3.2–7.5% from 1990 level ((Newbery and Pollitt, 1997). But, when California as a first state of US began to implement it, the result was catastrophic. Thus, any policy and regulation should combine with the current real features and situations of one country or region.

(2) Financial support for interrelated research on renewable distributed generation and microgrids.

In the EU, Americas, and Japan, a series of leading pilot microgrids projects and programs have been undertaken. Although there are many variations in adopting the microgrid architecture and design, and different countries' various strategies, microgrids are likely to play a role in promoting the evolution of smart grids. As ongoing research in this field in China, an abundant fund should be launched into the interrelated research of renewable, distributed generation, and microgrids, and the universities and research institutes should be encouraged to research these fields. The cooperation between corporation and university should be enhanced in order to improve the research. At the same time, international cooperation should be encouraged to improve domestic technology. Experience, learning, and national collaboration should expand RD&D activities and mitigate RD&D gaps and funding needs. Also, expanded international collaboration on RD&D offers additional benefits, including cost savings, accelerated learning, harmonization of standards and approaches, and elimination of duplication, etc.

(3) Incentives for renewable, distributed generation in microgrids deployment by tariffs policies. It has been proven in developed countries that tariff policies including feed-in tariffs, net-metering, and other incentives are able to effectively increase the development and deployment of renewable and distributed generation. Thus, under the guide policies at the macro level, to formulate the substantial and concrete policies and regulations in China is becoming the key to develop the new industry. And, it is must shift export-oriented policy into actively developing internal industrial deployment. In addition, interconnection standards compatible with IEEE and IEC standards should be researched and laid down as soon as possible, which is not only beneficial for the deployment of microgrids but can also enhance the competition of international electric sector. These measures will all probably be beneficial for increasing the development of microgrids in China.

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