Solar Energy for a Sustainable Future

World Green Energy Forum

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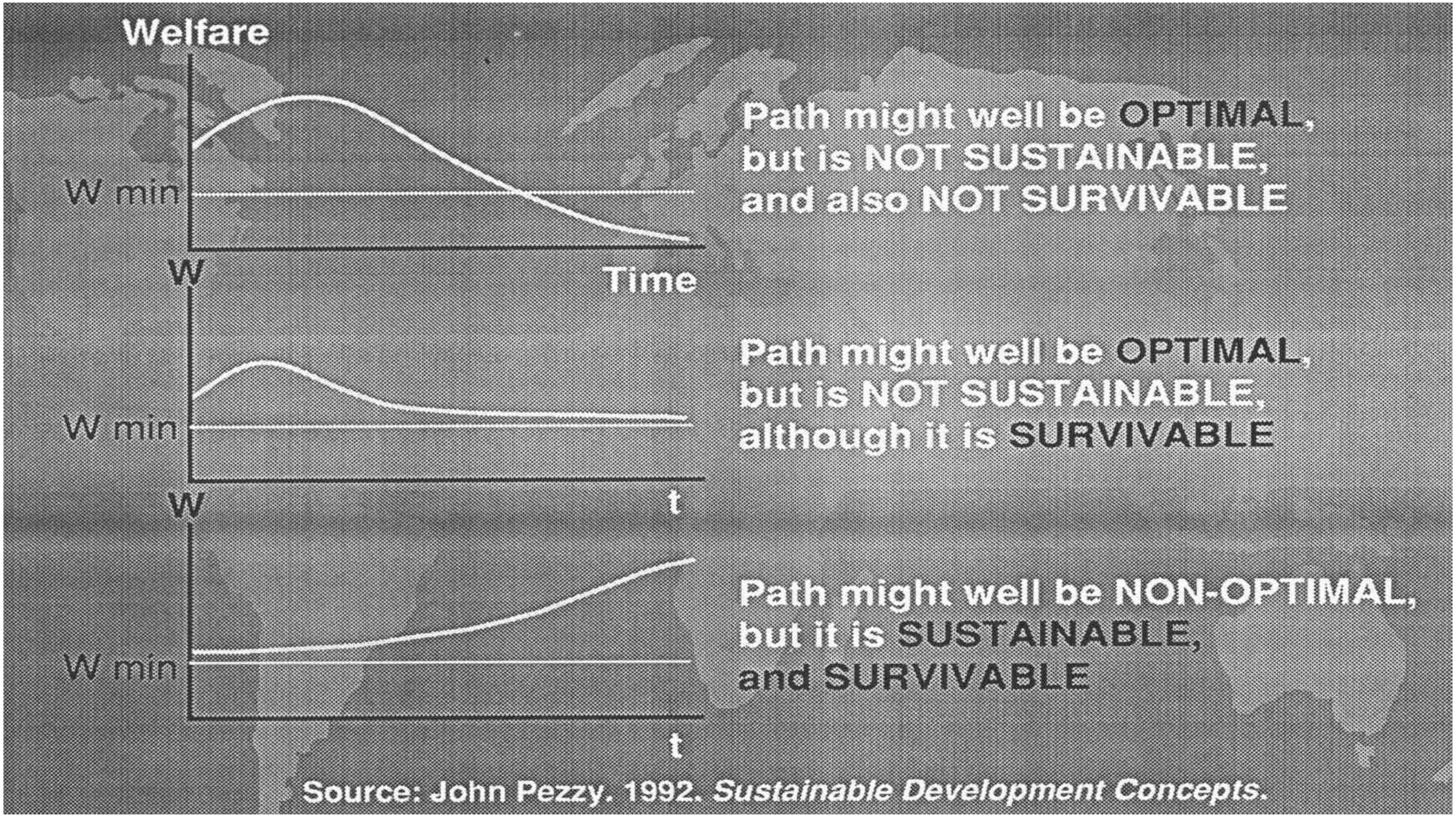
Optimality, Survivability and Sustainability



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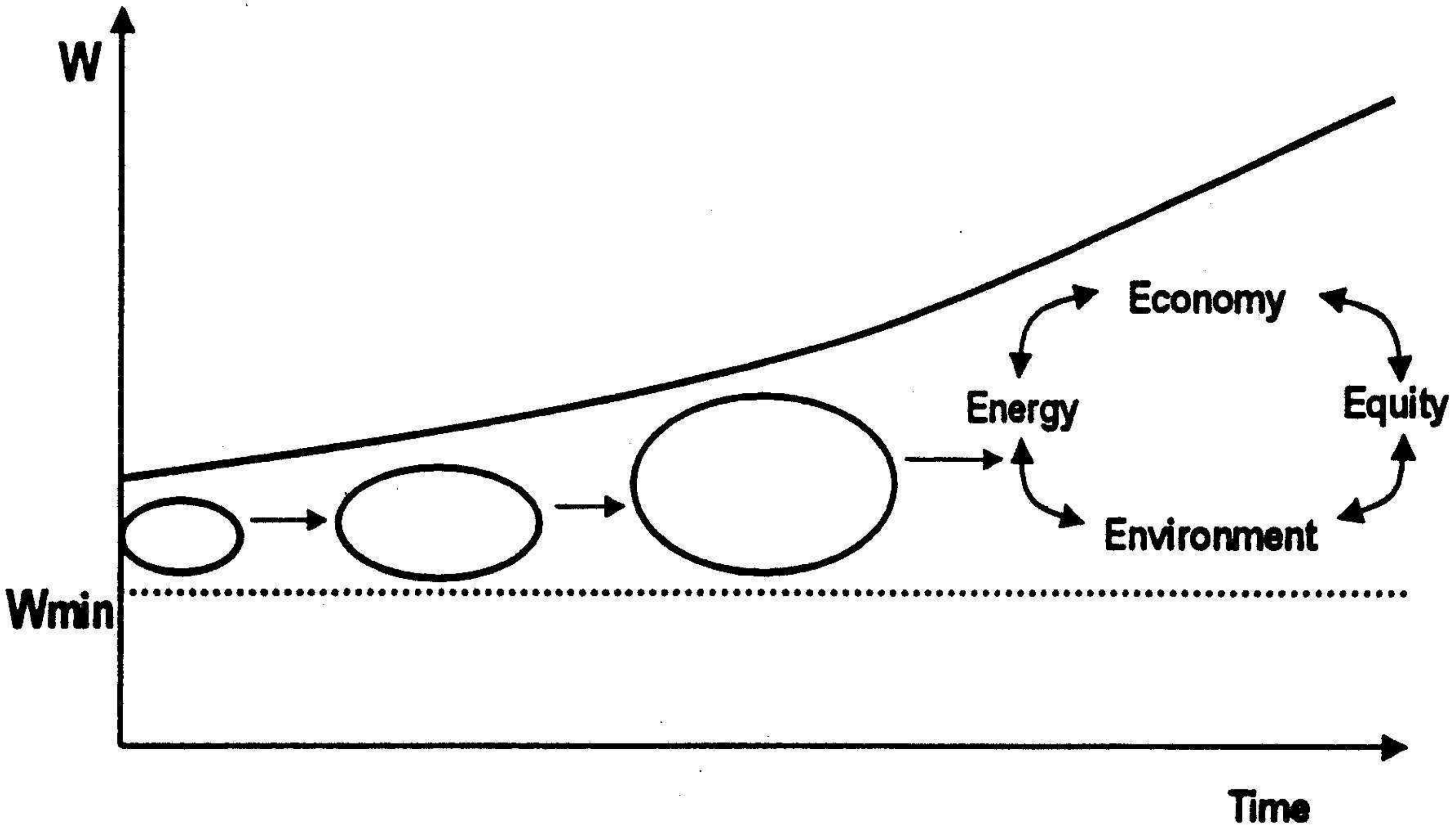
A Framework of Sustainable Development: Integration of Time and E^4

(Modified by Wang, 2001)



Sustainability: E^4

"The Linkages between Energy Systems and Economic Development, Social Equity, and Environmental Protection indicate that a Change in present Energy System is required if Sustainable Development Pathways are to be realized."

(Johansson, 2005)

Sustainable Development and Sustainable Energy System

Sustainable Energy System is an Instrument for Sustainable Development

AND

Sustainable Energy System cannot be Achievable without a Sustainable Development System

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Concerns About Conventional Fuels

Solution:

1.) Renewable Resources or Inexhaustible Resources;

2.) Energy Efficiency and Conservation

(Cassedy, 2000)

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Major Challenges of the Current Electricity Sector

- *Increasing Costs of Energy to produce Electricity*
- *Environmental Impacts (Regulatory Pressure to mitigate Carbon Emissions: Climate Change)*
- *Vulnerability (Thermal Power Plants: low-lying Coastal Areas)*
- *Generation & Transmission Inefficiency*
- *Aging T&D Infrastructure and Costly Grid Installation (lagging Investments)*
- *Needs for Dispersed Small-Scale Generation (Increasing the Resiliency and Flexibility of the System)*
- *Incapability to accommodate Demand for Modern Energy Services including On-Site Generation and Demand Response Program*
- *Accommodation of Major New End Uses such as Plug-In Vehicles*
- *Power System with continuously 'Perfect Balance'*
- *Unidirectional in Nature, suffering from Domino Effect Failures*

Energy Decentralization

Characteristics of the 21st Century Energy Economy may be Decentralization

- ***Hydrogen may become the Main Fuel for the 21st Century***
- ***As with Cellular Phones, Decentralized Energy Technologies could be less expensive Way of providing Energy***
- ***Fuel Cells: nearly as Economical on a Small Scale as on a Large One***
- ***Small-scale, Modular Technologies could be cheaper (Mass Production of a Model T)***
- ***Natural Gas could form a Kind of Bridge to Hydrogen***

(Flavin, 1999)

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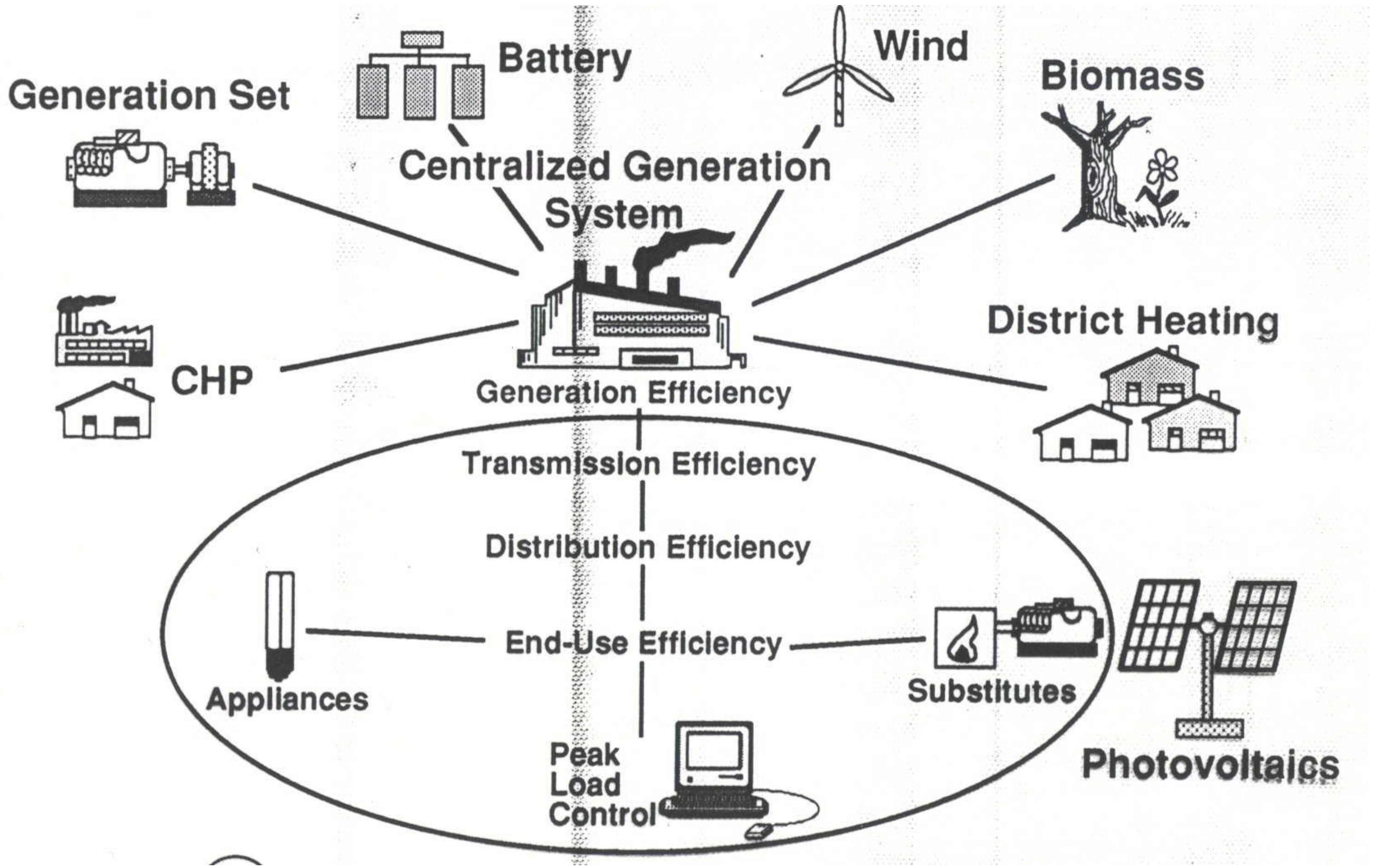
Framework of a Spatially Integrated Electricity Resources Planning



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German RE Electricity Production (GWh) and Shares (%): 1990 -2012

Year	Hydro	On-Shore Wind	Off-Shore Wind	Biomass	Solar PV	Geo-thermal	Total Renewable	Total Electricity Generated	RE Share
1990	15,580	71		1,434	1		17,086	551,148	3.1
1995	20,747	1,500		2,013	11		24,271	539,356	4.5
2000	24,867	9,513		4,737	64		39,181	576,191	6.8
2005	19,576	27,229		14,025	1,282	0	62,112	614,972	10.1
2010	20,958	37,619	174	33,866	11,729	28	104,374	610,373	17.1
2011	17,674	48,315	568	37,603	19,340	19	123,519	602,531	20.5
2012 **%**	**21,200** **3.6**	**45,325** **7.6**	**675** **0.1**	**40,850** **6.9**	**28,000** **4.7**	**25**	**136,075** **22.9**	**594,216**	**22.9**

Source: Morey & Kirsch, 2014

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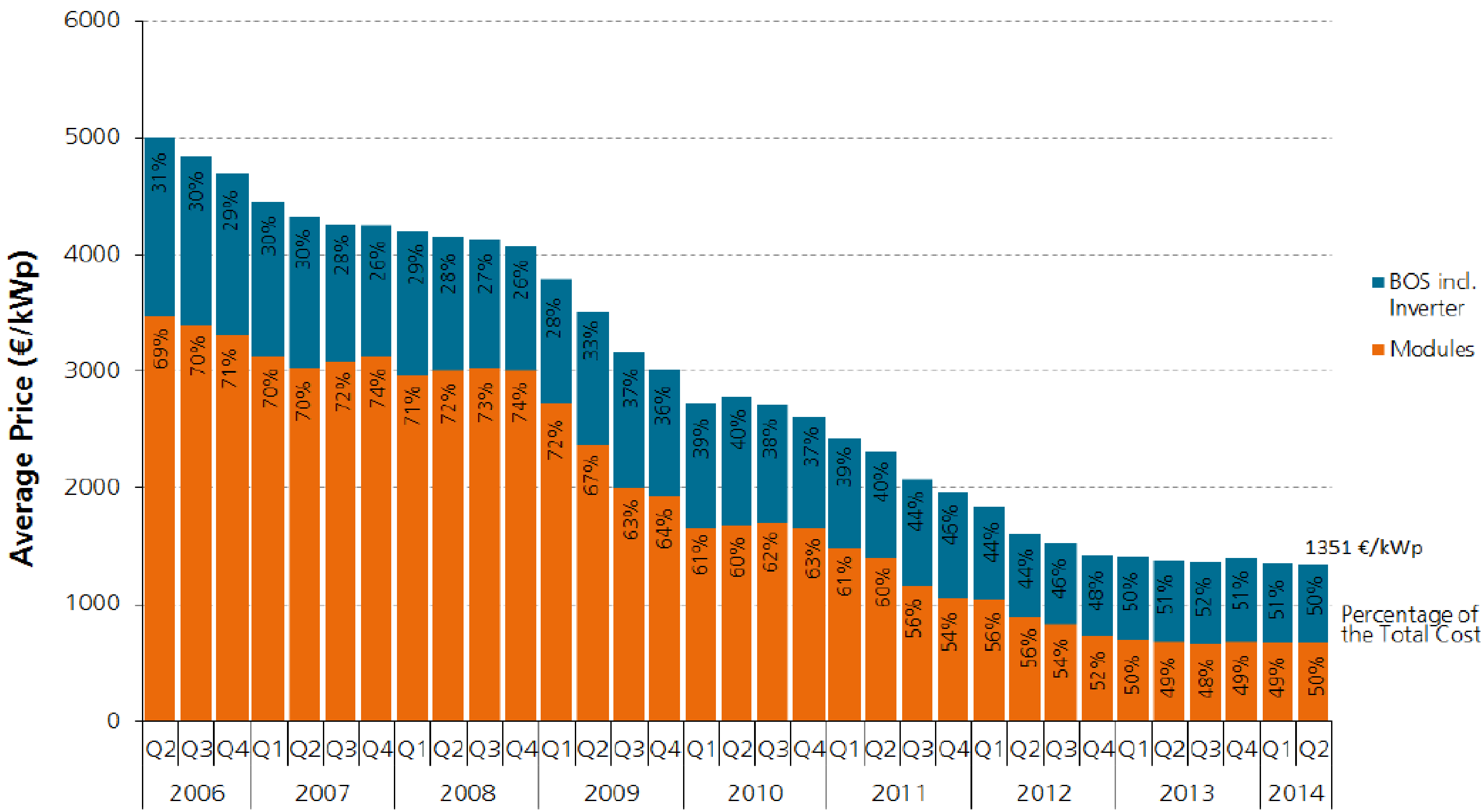
Average Price for PV Rooftop Systems in Germany (10kWp – 100kWp)
(Fraunhofer ISE)



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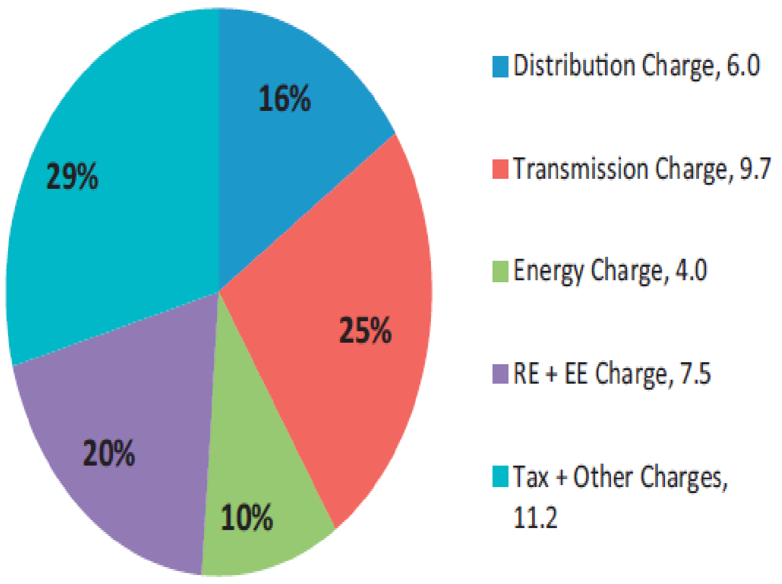
Germany: Policy Review

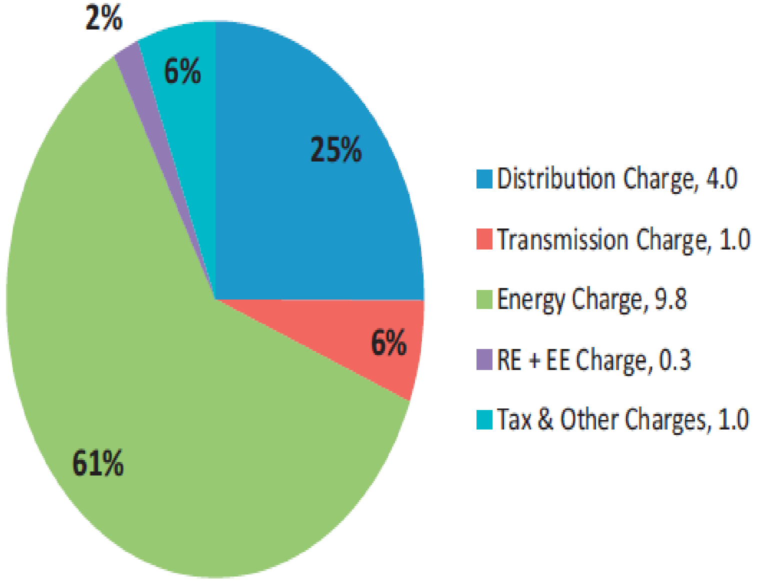
- *2000 FIT: 0.5 euro/kWh from PV; 20 years*
  - *New Installations after 2000: 5% decrease to stimulate R&D*
- *2004 Goal: 12.5% Renewable Electricity by 2010*
  - *Sooner than expected: 14.2% by 2007*
- *2008 Goal Adjustment*
  - *By 2020, Renewable Electricity from earlier Plan of 20% to 30%;*
  - *Lower the FIT Rate for PV; increase Rate for Wind*
- *2010 further Decrease of PV FIT Rate*
  - *To catch up with the Decrease of Product Price and stimulate further R&D*
  - *2011 New Installations were more than Twice the Forecasted (catch the last bus!)*
- *2012: -15% FIT; -29% within the Next Year*

Residential Electricity Price Composition for a Sample of Germany and U.S. Utilities

German Residential Electricity Price in 2013 (38.5¢ per kWh)



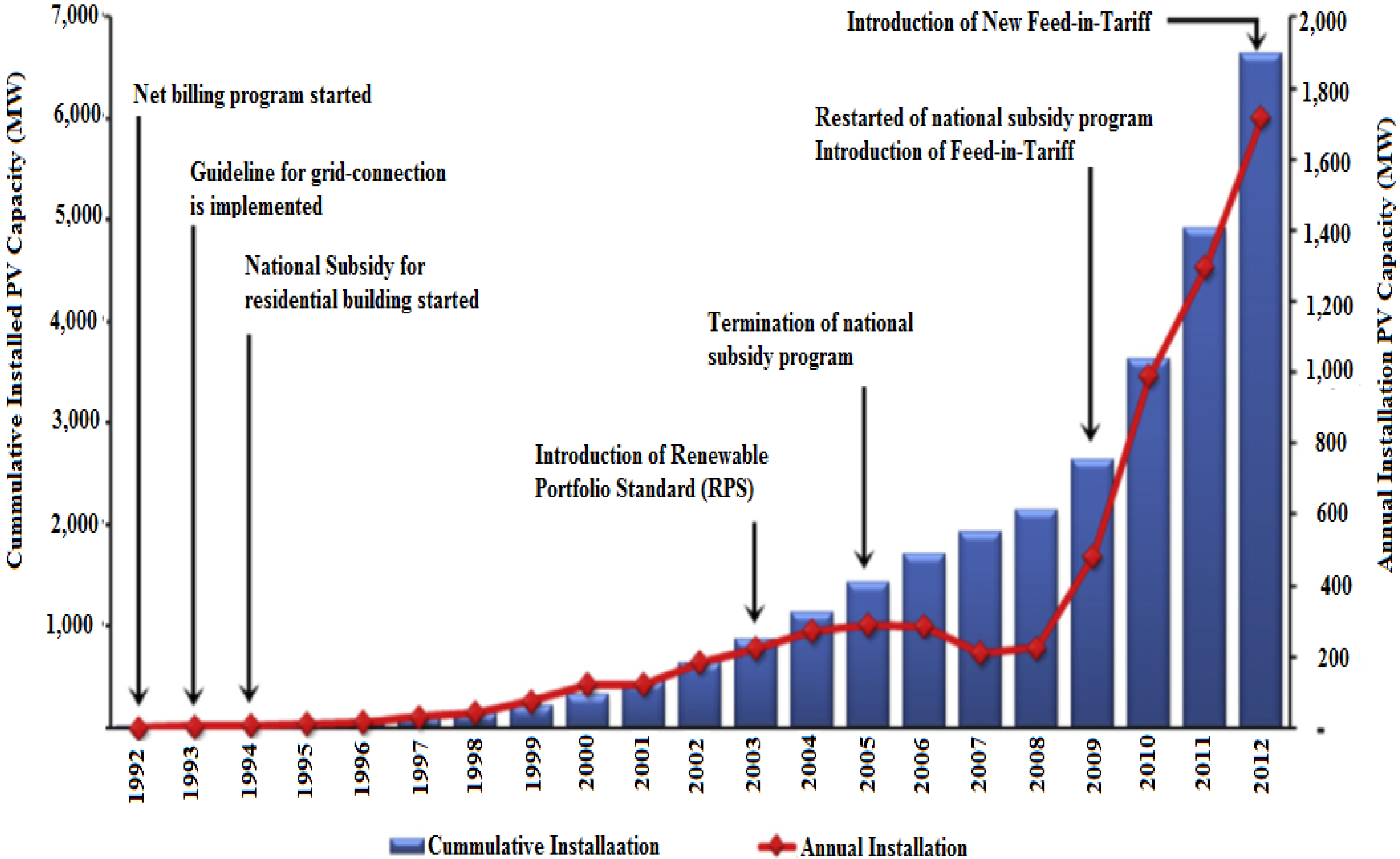
Sample of 16 U.S. Utilities for Residential Electricity Price in 2013 (16.1¢ per kWh on the average)



Average RE + EE Surcharge for the U.S case is about 2% in contrast to about 20% in the case of Germany suggests that Germany's enthusiastic embrace of RE is adding 10 times as much to its residential rate compared to the U.S.

Source: Morey & Kirsch, 2014

Japan's Solar PV Installations (1992 – 2012)



Source: Muhammad-Sukki, et al., 2014

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New Feed-In-Tariff Scheme: Japan

- *Before the New FIT (July 2012), Japan funded the Sunshine Project for the Residential Sector*
- *New FIT after the Fukushima Event incorporated Other Renewable Energy Sources besides Solar PV, namely Wind, Geothermal, Hydro and Biomass*
- *The Scheme is aimed at achieving between 20% and 35% of the Energy from the Renewables by 2030*
- *The Scheme is targeted at Non-Residential Segments, such as Large-Scale PV Projects, in the Commercial and Industrial Sectors*

70 MW Solar Plant Launched in Kagoshima Prefecture (Aerial view)

Launched by KYOCERA Corporation, this 70 MW solar plant of total cost of ¥27 billion covers an area of 1,270,000m^2 and expected to produce 78.8GWh annually

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Energy Transformation

The Interplay of Technology, Policy, and Finance has always determined the Rate at which Clean Technologies advance

- ***The Key to our Energy Future lies in exploiting two Opposing Forces without having them undermine each other: Silicon Valley's Free-Market Culture of Innovation and Washington's Power***
- ***Government needs to cultivate potentially Transformative Energy Ideas by creating an equivalent of the Pentagon's Defense Advanced Research Projects Agency (DARPA)***
- ***The Challenge is to establish European-Style Stability without constraining ourselves to anemic European Levels of Innovation.***

(Green, 2009)

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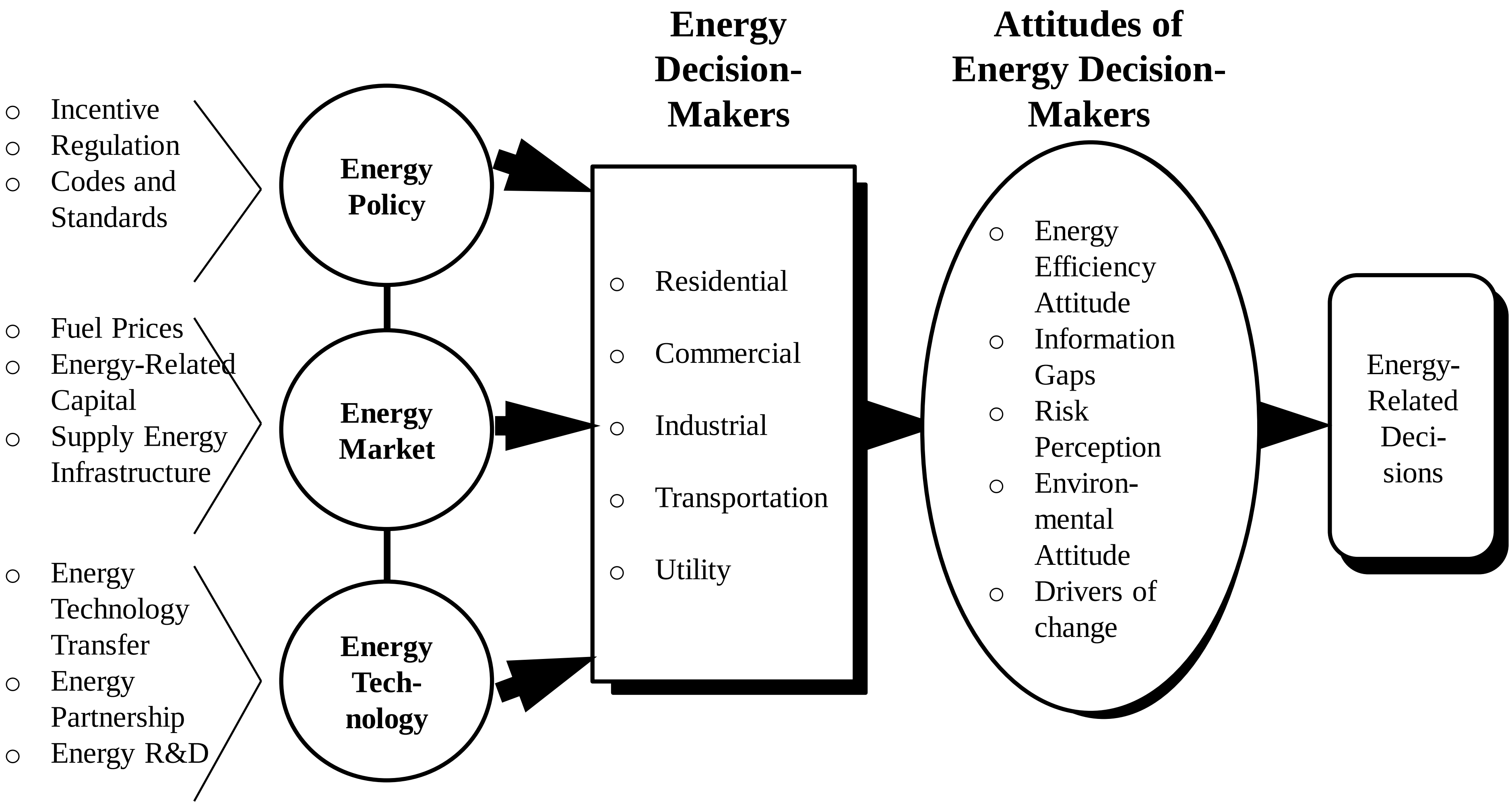
Direct and Internal Factors:
Affecting Energy Decisions of Energy Sectors



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Policy Interventions: DG Technology Focus

Policies to support Sustainable Energy Technology Innovation include:

- ***Front-end Technology Nurturing: RD&DD***
- ***Back-end Incentives: Tax Credits, Loan Guarantees, low-cost Financing, Price Guarantees, Government Procurement, etc.***
- ***Back-end Regulatory and Mandates: Emission Taxes, RPS, Fuel-Economy Standards***

(Weiss and Bonvillian, 2009)

Smart Grid:
The New Paradigm

- ***Upstream Smart Grid: To lessen the Likelihood and Severity of Blackouts and to operate the System more efficiently overall***
- ***Downstream Smart Grid: responding to Prices, smaller Local Generators (DG), and much greater Levels of Storage– Three Physical Landmarks***
- ***A System that previously flowed Power only from large Central Sources to Downstream Customers will flow in both Directions from locally-based Generation and Storage***

(Fox-Penner, 2010)

Strategies for Attitudinal Change

- ***Identify Opinion Leaders (Innovators and early Adopters)***
- ***Force of Law and enticing Incentives***
- ***Education and effective Communication***
- ***Through religious Beliefs***
- ***Small Group Management of Common Resources***
- ***Actions of Peers and direct Appeals***

(Modified from Gardner, 2001)

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Drivers of Change

Playing a Part in producing rapid Change toward Sustainability

- ***Civil Society:** crucial in Campaign*
- ***NGOs:** framing Issues*
- ***Private Business:** visionary Leadership*
- ***State Power:** political Base*
- ***Scientific Community:** information Base*
- ***Media:** information: pivotal Position*

(Gardner, 2001)

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Community Cooperatives: Electricity Generation

Germany

- *Utilities are responsible for purchasing electricity produced by civil renewable cooperatives for 20 years with fixed price*
- *100 Community Renewable Cooperatives are created each Year*
- *650 Community Renewable Cooperatives are responsible for 47% of total Renewable Investment in 2012*
- *Soft Loan (1%) for Renewable Investors by Utility Companies and 1.5% by Germany Reconstruction Bank*
- *370,000 Renewable Employees, contributing Regional Economic Development*
- *ROI (5-9%) is higher than Bank Interest Rate (around 1%)*

(Hankook Ilbo, September 29, 2014)

Sustainable Energy Revolution

Change is not easy, but possible

- ***The Abolition of Slavery***
- ***Nonviolent Movement in India***
- ***The End of Apartheid in South Africa***
- ***The Unification of West and East Germany***
- ***Communist Regime Collapse, etc.***

(Modified from Gardner, 2001)

Thank You