



Capacity and Energy Markets for Stable Renewable Economy

Mohammad Rasouli and Demosthenis Teneketzis

University of Michigan

June 2016



Toward Stable Renewable Economies

- * Current supportive policies for investment on renewable energies is not sustainable with increase in their share.
(Hobbs 2015, Hogan 2015)
- * Current market mechanisms are not ready for introducing renewables.
(Hogan 2015, Joskow and Tirole 2007)

Challenges and Policy Response

Origin of Underinvestment in Electricity Industry? Missing Money

- × Price caps by regulator ← Market power
- × Reliability criteria by regulators ← Short term and long term uncertainties
- × Rare scarcity pricing for investment cost recovery ← Forced demand reduction, No Storage

What Renewables Add to the Investment Problem?

- × More reliability criteria ← More uncertainty
- × Longer investment cost recovery ← Low marginal production cost
- ✓ adjustable plans to uncertainties ← Shorter construction time
- ✓ Market power reduction ← Greater number of large producers
- ✓ Price responsive demand ← Smart grid

Policy Response (Hoggan 2015, Hobbs 2015, California Market Surveillance Committee 2014, Winkler 2012, Joskow 2006)

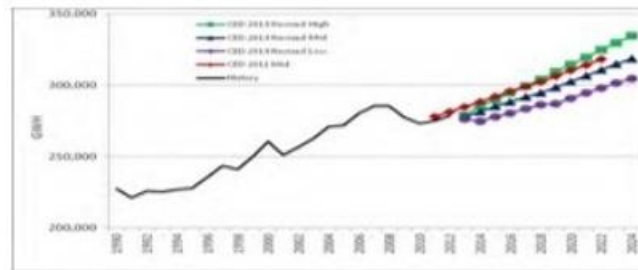
- * Correct the spot generation market (the center of the economy)
- * Rethink the operating reserve market
- * Add forward capacity market for expansion

Forward Moving Approach with Real-Time Compensation

Contribution: Designing **spot market** and **capacity market** for stable renewable economy with **short construction time** considering strategic producers with private information

Expansion, X X_1
 Generation, e e_1
 Payment, R p_1e_1+
 $(P_1E_1-p_1e_1)$

FORWARD MOVING APPROACH



Time

Demand
 Message
 Outcome

“A Methodology for Generation Expansion Planning for Renewable Energy Economies”,
 M. Rasouli, D. Teneketzis, Submitted

Properties of the market mechanism

- ✓ Strong Nash implementation: Implements social welfare maximizing investment and generation meeting long term reliability criteria
- ✓ Price efficiency: Equilibrium price equals marginal costs
- ✓ Individually rationality: Producers participate voluntarily

Discussion and Future Directions

The mechanism:

- ❑ **addresses** market power & price caps, long term uncertainty, market interventions, and low marginal cost of production
- ❑ **does not address** short term uncertainty, storage and demand response, and network effects
 - Future: modeling reserve market, multiple technology specific capacity mechanisms, and modeling network
- ❑ **despite existing capacity markets** (e.g. Joskow 2006) does not pay ahead for expansion
 - Future: Design inelastic capacity markets with payments

Questions?

Jobs in Renewable Energy



Bioenergy
(Biomass, Biofuels,
Biogas)



Geothermal



Hydropower
(Small-scale)ⁱ



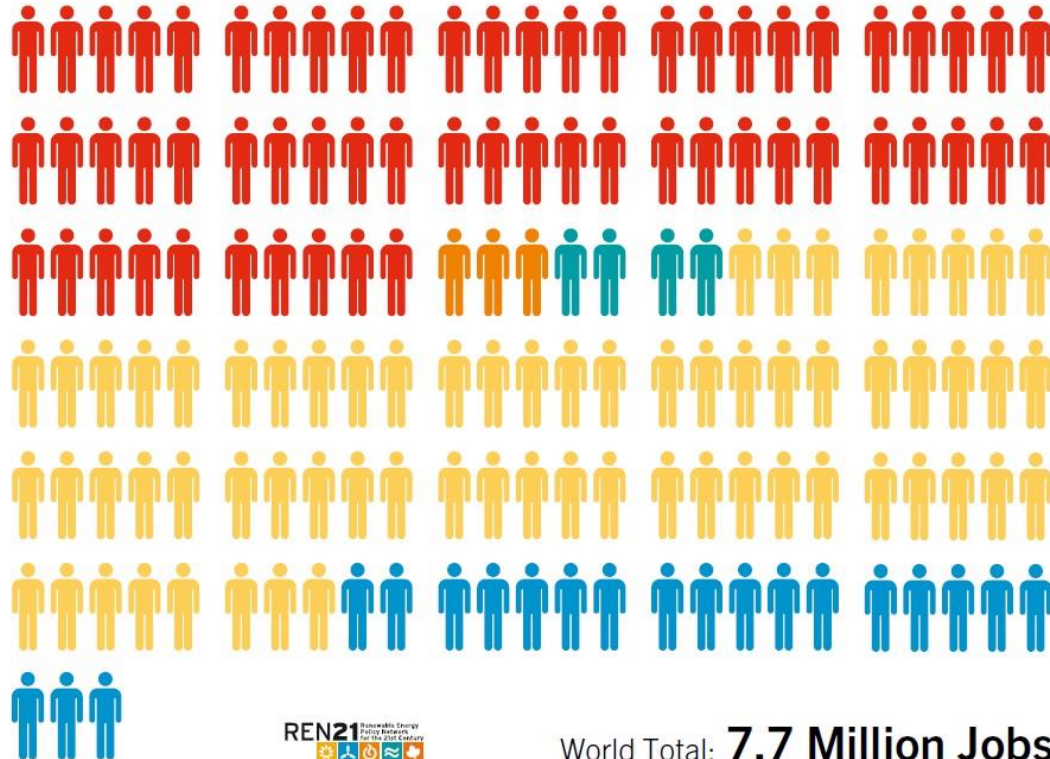
Solar Energy
(Solar PV, CSP,
Solar Heating/Cooling)



Wind Power



= 50,000 jobs



i - Employment information for large-scale hydropower not included.

- [1] **Joskow, P.L., 2006.** Competitive electricity markets and investment in new generating capacity. AEI-Brookings Joint Center Working Paper, (06-14).
- [2] **Joskow, P. and Tirole, J., 2007.** Reliability and competitive electricity markets. The Rand Journal of Economics, 38(1), pp.60-84.
- [3] **Hobbs, B. F., 2015.** Designing and Modeling Power Markets to Support Optimal Decisions. Workshop on Optimization and Equilibrium in Energy Economics, IPAM, UCLA.
- [4] **Hobbs, B.F., et al., 2015.** The Evolution of the Market: Designing a Market for High Levels of Variable Generation. *Power and Energy Magazine, IEEE*, 13(6), pp.60-66.
- [5] **Hogan, W.W., 2015.** A Cleaner Energy System: Renewable Energy and Electricity Market Design [In My View]. *Power and Energy Magazine, IEEE*, 13(4), pp.112-109.
- [6] **Winkler, D.V.J., 2012.** Market designs for a completely renewable power sector. *Zeitschrift für Energiewirtschaft*, 36(2), pp.77-92.