The Positive Feedback Cycle in the Electricity Market.

Residential Solar PV Adoption, Falling Electricity Demand and Increasing Electricity Prices.

15th IAEE European Conference – Vienna

Presenter: Dr. Jim Hanly

The Positive Feedback Cycle in the Electricity Market: Residential Solar PV Adoption, Falling Electricity Demand and Increasing Electricity Prices.

15th IAEE European Conference - Vienna 3rd- 6th September

Presenter: Dr. Jim Hanly
Authors: Michael Chesser, Dr. Jim Hanly, Dr. Nicholas Apergis, Dr. Damien Cassells.

CONTENTS

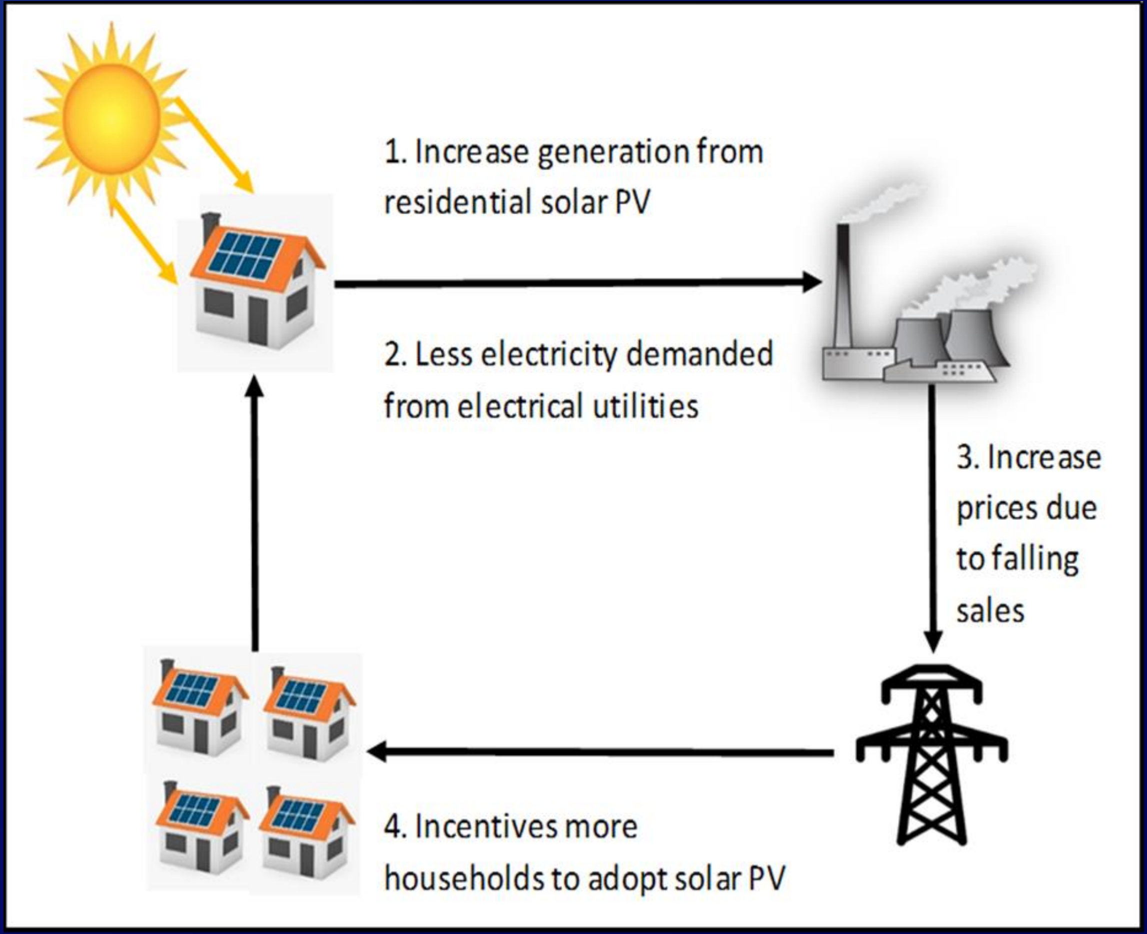
INTRODUCTION

- Environmental Policies
  - Renewable Energy Systems (RES)
  - Centralised model,
  - Delivered economies of scale and reliability
  - Electricity supply losses of 51% and 63% in Ireland and UK for 2014.
- Decentralized model & Micro RES
  - examples include Solar Photovoltaic (PV), Solar Thermal, Micro Wind Turbines, etc.
  - could provide 30 to 40% of the UK’s electricity needs by 2050.
- However…

Positive Feedback Cycle and Death Spiral

A positive feedback cycle is a situation where, action A generates more of action B which in turn generates more of action A. In economics a positive feedback cycle results in a systemic risk to the system

Residential Solar PV Market could induce a positive feedback cycle….
…which could result in Utility Death Spiral.



LITERATURE

- Cai et al.(2013) – that the positive feedback cycle reduces the time it takes to reach 15% of peak demand by up to 4 months.
- Laws et al. (2017) - results indicate that a utility ‘death spiral’ requires a perfect storm of high intrinsic adoption rates, rising utility costs, and favourable customer financials.
- Eryilmaz and Sergici (2016) - increasing residential electricity prices are associated with an increase in solar PV installations and in a future scenario where there is a 25% solar PV penetration by 2020, about 1.2% of the projected growth of the electricity sales to the residential customers will be taken over by rooftop solar PV.

STUDY

- Motivations
  - To model the positive feedback cycle.
- Countries
  - United Kingdom, Ireland and Australia
- Monthly Time Period from 2010 -2015
- Data Sources
- Model - Simultaneous Equations Model (SEM).
- Estimation Techniques – Three Stage Least Squares regression (3SLS).
- Objectives are to find:
  1) if increasing residential electricity prices will lead to higher installation rates of residential solar PV
  2) whether residential solar PV installations lead to higher residential electricity prices,
  3) whether residential solar PV installations negatively affect residential electricity demand.

THE MODEL

- Studies examining the effects of renewable energy systems on electricity prices. (Kaufmann and Vaid, 2016)

$$\boldsymbol{P_t = \alpha + \beta_1 Load_t + \beta_2 RE_t + \beta_3 NRE_t + \beta_4 PFF_t + \beta_5 Dum_t + \varepsilon_t}$$

- The prices of electricity is a function of; electricity load, quantity of electricity from renewable sources, electricity from traditional energy sources, the price of fossil fuels, dummy variables that represents time periods.

SOLAR ENERGY

THE SIMULTANEOUS EQUATION MODEL

Equation 1: $\boldsymbol{lnPV_t = \propto_0 + \propto_1 lnPElec_t + \propto_2 Scheme_t + \propto_3 lnSunlight_t + \propto_4 lnAvrCostPV_t + D_y^{year} + D_m^{month}}$

The Residential Solar PV Uptake Equation is a function of*;* Residential Price of Electricity, Solar PV Government Scheme, Average Sunlight Hours, Average Cost of Solar PV.

THE SIMULTANEOUS EQUATION MODEL

Equation 2: $\boldsymbol{lnPElec_t = \beta_0 + \beta_1 CoalShare_t + \beta_2 lnPElec_{t-1} + \beta_3 lnPV_t + D_y^{year} + D_m^{month} + \varepsilon_{2,t}}$

The Residential Price of Electricity Equation is a function of Coal Share used in Electricity Production, Lagged Residential Price of Electricity, and Residential Solar PV Uptake.

THE SIMULTANEOUS EQUATION MODEL

Equation 3: $\boldsymbol{lnE_t = \theta_0 + \theta_1 lnPElec_t + \theta_2\, lnPV_t + \theta_3 lnNG_t + \theta_4 lnTemp_t\ + \theta_6 lnWages_t + D_y^{year} + D_m^{month} + \varepsilon_{3,t}}$

The Residential Electricity Demand Equation is a function of Residential Price of Electricity, Residential Solar PV Uptake, Price of Natural Gas, Average Temperature, Average Income.

DESCRIPTIVE STATISTICS

Variable	Country	Mean	Std. Dev	Min	Max
Monthly residential solar PV average capacity installed (kW)	Ireland	3.7	1.5	0	7.6
	UK	2.9	0.4	1.0	3.3
	Australia	3.6	0.6	2.6	4.5
Average Residential Electricity Demand 2010 (Gw/h)	Ireland	2,253	313	1,914	2,681
	UK	9,901	2,366	7,521	14,548
	Australia	5,036	28	4,994	5,081
Average Residential Electricity Demand 2015 (Gw/h)	Ireland	2,088	256	1,803	2,493
	UK	8,915	1,542	7,130	11,436
	Australia	4,975	48	4,857	5,038
Average Residential Electricity Prices 2010 (€/kWh)	Ireland	0.20	0.02	0.18	0.23
	UK	0.17	0.03	0.14	0.21
	Australia	0.14	0.01	0.13	0.16
Average Residential Electricity Prices 2015 (€/kWh)	Ireland	0.24	0.01	0.21	0.25
	UK	0.19	0.03	0.14	0.23
	Australia	0.17	0.02	0.14	0.19

SOLAR ENERGY

SOLAR ENERGY

3SLS REGRESSION RESULTS

Equation		Obs	Parms	RMSE		"R-sq"	chi2	P
Solar PV Uptake		211	20	0.191		0.494	195.13	0.00
Residential Electricity Price		211	19	0.096		0.698	530.43	0.00
Residential Electricity Demand		211	21	0.451		0.448	234.06	0.00
Equation1 :Solar PV Uptake	***Est.***	***T-stat***	***Equation2: Residential Electricity Price***	***Est.***	***T-stat***	***Equation3: Residential Electricity Demand***	***Est.***	***T-stat***
PElec	0.46***	3.49	CoalShare	-0.003***	-7.06	PElec	-2.82***	-5.94
Scheme	0.08	1.27	$Pelec_{t-1}$	0.53***	10.16	PV	-1.6*	-1.37
AvrCostPV	-0.11	-0.82	PV	0.17**	2.05	NG	0.21	0.92
Sunlight	0.05**	1.81				Temp	-0.14*	-1.51
						Wage	-1.24**	-2.39
2011	0.24***	4.73	2011	-0.01	-0.4	2011	0.56**	1.71
2012	0.22***	3.4	2012	0.05*	1.58	2012	0.98***	2.53
2013	0.34***	4.37	2013	0.03	0.74	2013	1.21**	2.21
2014	0.35***	4.11	2014	0.03	0.69	2014	1.23**	2.16
2015	0.35***	4.13	2015	0.01	0.12	2015	1.26***	2.78
February	0.07	1.13	February	0.06**	1.78	February	0.3*	1.45
March	0.02	0.23	March	0.02	0.7	March	0.26*	1.41
April	0.07	1.07	April	-0.03	-0.99	April	0.10	0.51
May	0.03	0.45	May	0.02	0.54	May	-0.01	-0.02
June	0.08	1.18	June	0.02	0.49	June	0.10	0.45
July	-0.04	-0.63	July	0.03	0.97	July	-0.07	-0.38
August	0.00	0.04	August	0.04	1.24	August	0.08	0.41
September	0.08	1.17	September	-0.004	-0.12	September	0.07	0.33
October	0.07	1.05	October	0.04	1.15	October	0.24	1.13
November	0.08	1.17	November	0.08**	2.29	November	0.44**	2.01
December	0.16**	2.28	December	0.02	0.61	December	0.52**	1.94

Equation 1: Solar PV Uptake	Coefficient	T-Statistics
Residential Electricity Price	0.46***	3.49
Sunlight Hours	0.05**	1.81
Equation 2: Residential Electricity Price	Coefficient	T-Statistics
Solar PV Uptake	0.17**	2.05
Lagged Electricity Price	0.53***	10.16
Coal Share	-0.003***	-7.06
Equation 3: Residential Electricity Demand	Coefficient	T-Statistics
Residential Electricity Price	-2.81***	-5.94
Solar PV Uptake	-1.59*	-1.37
Temperature	-0.14*	-1.51
Wage	-1.24*	-2.39
Statistically Significant at *** 1% ** 5% *10%		

Results found;

- a positive relationship found between electricity prices and solar PV uptake.
- a positive relationship found between solar PV uptake and electricity price.
- a negative relationship found between electricity prices and electricity demand.
- also a negative relationship was found between solar PV and electricity demand.

SUMMARY

Evidence of the positive feedback cycle in an electricity market could raise issues for electricity utilities, transmission system operators and government energy departments, as some have suggested that it could result in a utility ‘death spiral’.

It would seem that Australia and the UK would be more at risk due to the larger cumulative capacity of residential solar PV systems added to the grid.

To tackle this issue there needs to be a restructuring of current renewable energy policies. If environmental goals are too be achieved, then stakeholders in the electricity market will have to support solar PV adoption in a sustainable way while also not punishing non-adopters with higher electricity rates.

SOLAR ENERGY

Thank You For Your Attention