EAAERE2019
Beijing University
August 4, 2019

OUTLINE AND PURPOSE OF THE SESSION

Modelling Innovation to Transition Industry, Transport and Residential Heating Systems Towards a Sustainable, Low Carbon Future in East Asia

Presented by

Soocheol Lee

(Meijo University)

1.Outline and Purpose of the Session

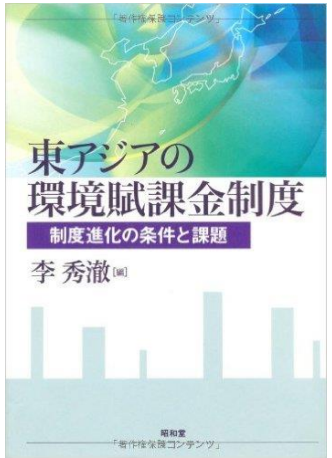
REEPS

Research Group for East Asia Environmental Policy Studies

http://www.reeps.org/

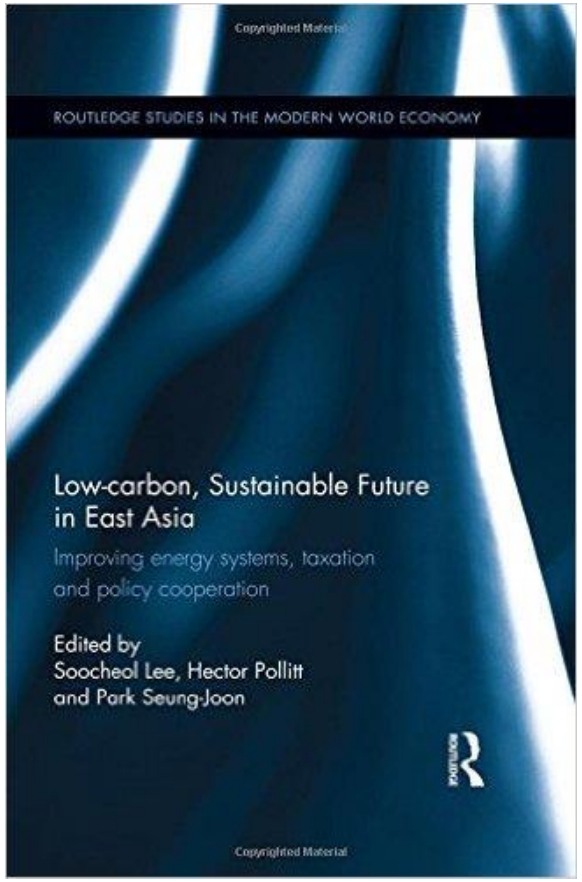
Since 2014, supported by

Grants-in-Aid for Scientific Research, Japan
<KAKENHI>



Environmental Charge System in East Asia
Showado Publishing(2010)

Energy and Environmental Policy in East Asia
Showado Publishing(2014)



ROUTLEDGE Publishing(2015)

Environmental and economic Sustainability in East Asia

Policies and Institutional Reforms

Edited by

Soocheol Lee, Hector Pollitt and Kiyoshi Fujikawa

Forth coming(October 2019)

- The aim of this session is to assess how we might achieve carbon emission reductions through the diffusion of new technologies across the whole economy, for each East Asian country by 2050. We use a modelling approach, specifically the global macro-econometric E3ME model (www.e3me.com).

- E3ME is linked to a full set of bottom-up technology transformation sub modules (FTT:Future Technology Transformation) namely: FTT:Steel, FTT:Transport and FTT:Heat.

- The session looks in detail at a scenario in which a combination of policies is used to achieve the 2050 2℃ target across East Asia.

- As well as a carbon tax for Steel Sector(P1), there are sector-specific policies, for example fuel taxes, EV subsidies and a biofuel mandate in the Transportation Sector(P2), or renewable subsidies in the Household Heating Sector(P3). We assess both the environmental and economic impacts of the policies.

- We will show that carbon taxes with a policy mix of regulations and subsidies applied to the steel, transport and heating sectors boost the uptake of low-carbon technologies.
- Paper 1 focuses on the policies needed to decarbonize the steel sector, leading to the uptake for example of electric and hydrogen-based furnaces.
- Paper 2 considers measures to promote the uptake of hybrid and electric vehicles.
- Paper 3 discusses how households might be encouraged to use heat pumps and solar thermal water heaters.
- These three sectors are important end users of energy in East Asia. Their decarbonization is crucial for meeting overall carbon targets.

Energy, and Environmental and Economic Sustainability in East Asia

Policies and Institutional Reforms

Edited by Soocheol Lee, Hector Pollitt and Fujikawa Kiyoshi

PART I Building low-carbon power generation while simultaneously reducing the role of nuclear

PART II Innovating to reduce CO^2 emissions in industry, transport and buildings

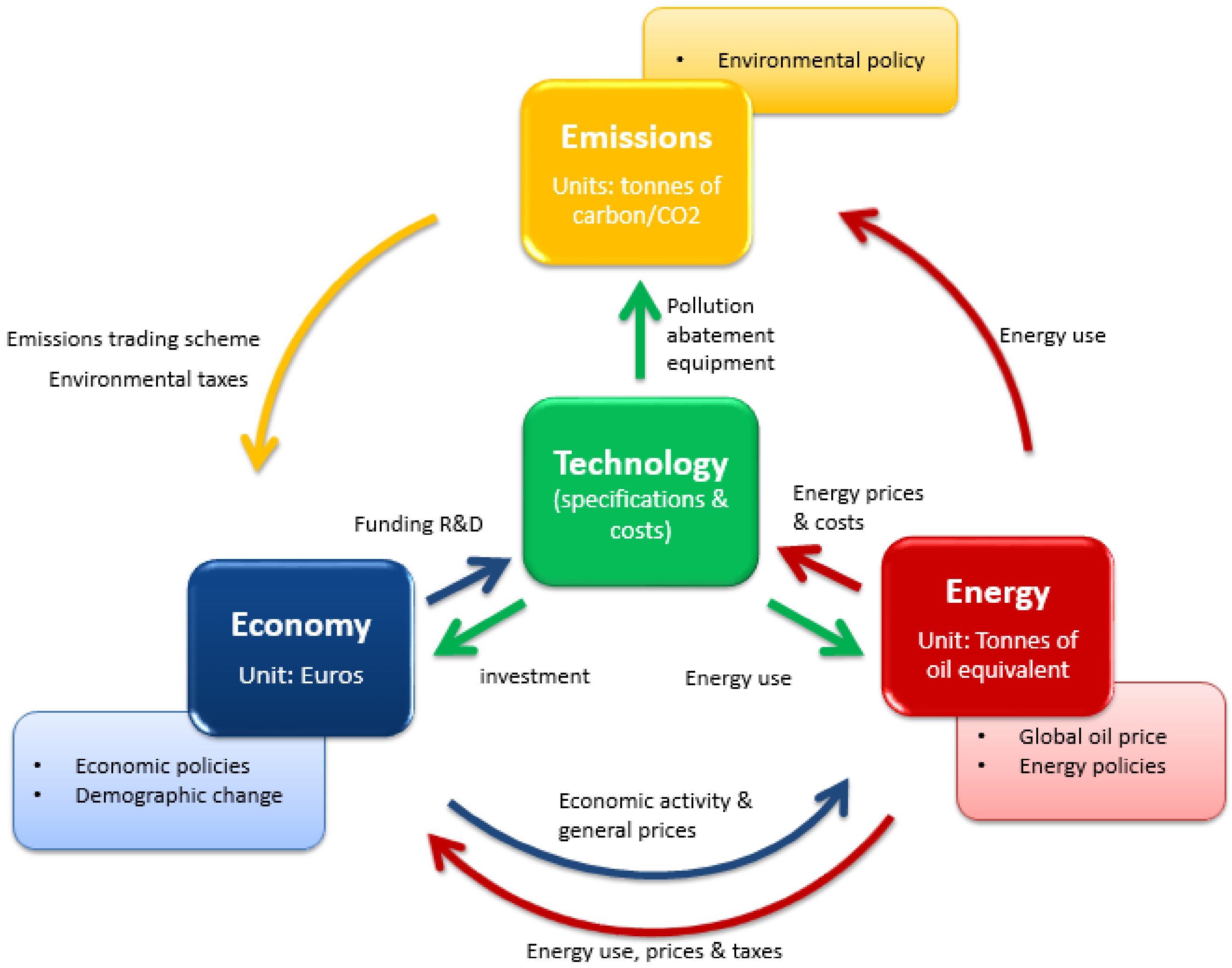
PART III Wider sustainability issues: reducing water and material consumption, and improving air quality

2.E3ME Description

The E3ME model: Dimensions

- Econometric model
  - cover world 59 regions, including explicit representation of all G20 countries and all EU Member States. The model has recently been expanded to cover many East Asia and South East Asia regions explicitly including Japan, China, Korea, Taiwan and Indonesia. Other ASEAN countries are grouped together.
  - based on the system of national accounts
    - includes intermediate and all components of final demand
    - detailed treatment of the labor market
    - 22 stochastic equation sets, also covering energy and prices
  - large sectoral disaggregation: 42 industries, 28 consumption categories
  - 12 different fuel types, and 23 separate fuel user groups ,24power technologies
  - 14 atmospheric emissions
  - long and short-term specification
  - annual solutions to 2050
- For more details see www.e3memodel.com

Simple structure of The E3ME Simulation Model

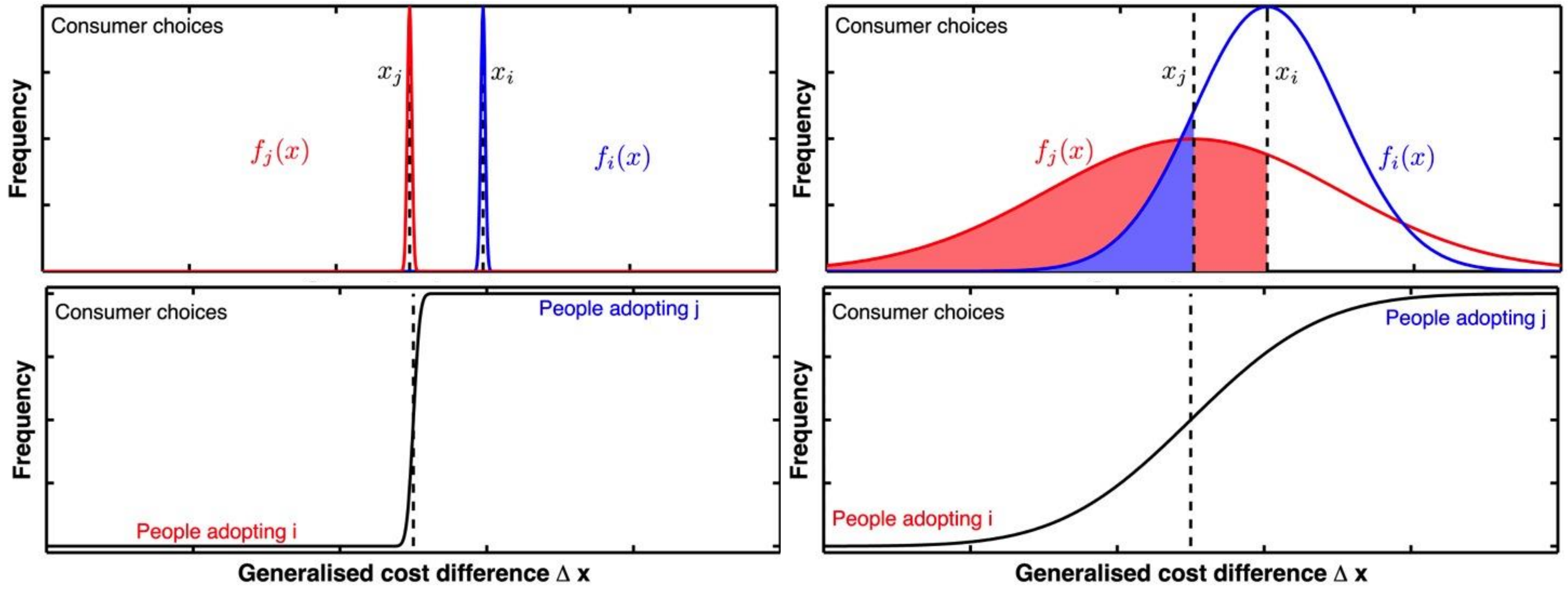


3.FTT Description and its Linkage to E3ME

J.-F. Mercure, Energy Policy 48, 799-811 (2012)

Choice probability distribution depends on cost distribution

Choice probability represents diversity of investors



※$\Delta x = x_i - x_j$ 0 0

- Power sector replace their generation systems in time intervals related to technical lifetimes
- Choices are based on **Levelised Costs of power Generation (LCOG):** combined measure of investment costs, fuel costs, and maintenance costs
- Calibration of these costs to observed preferences and trends: accounts for lead times of constructions, different comfort levels, local variations, existing policies etc.

FTT: Power Link between E3ME and FTT

FTT is a **micro-model of technology choice and substitution**, given economic/policy context

Post-Schumpeterian (evolutionary)

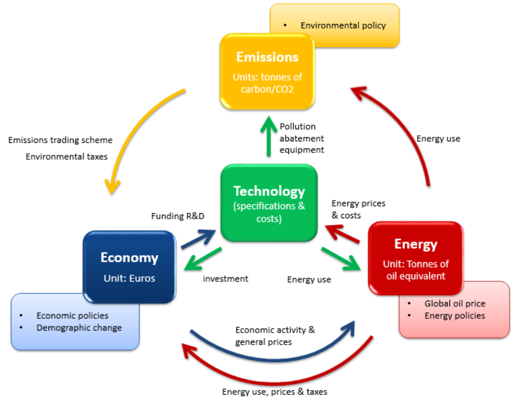
FTT

- Electricity demand
- Fuel demand

- Fuel consumption
- Investment in new power source
- Electricity price

Post-Keynesian,

E3ME =



- CO_2 emission
- Investment spill over
- GDP, Employment

Post-Schumpeterian (evolutionary)

FTT

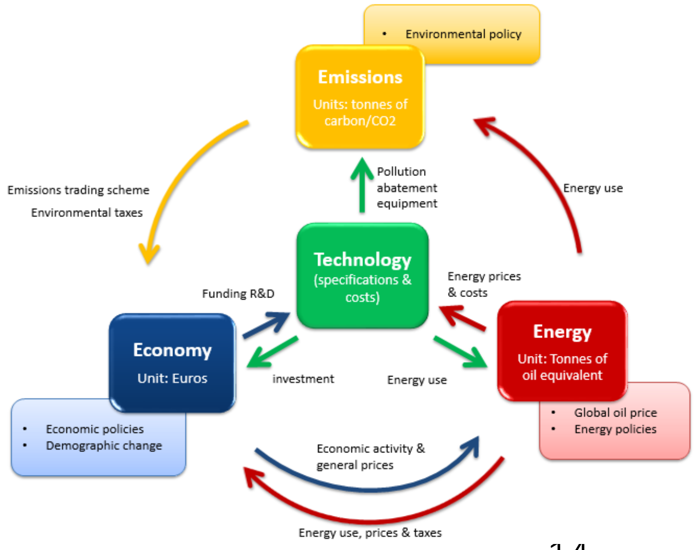
- Fuel demand
- Electricity demand

- Fuel consumption
- Investment in new technology
- price of each technology

Post-Keynesian (effective demand)

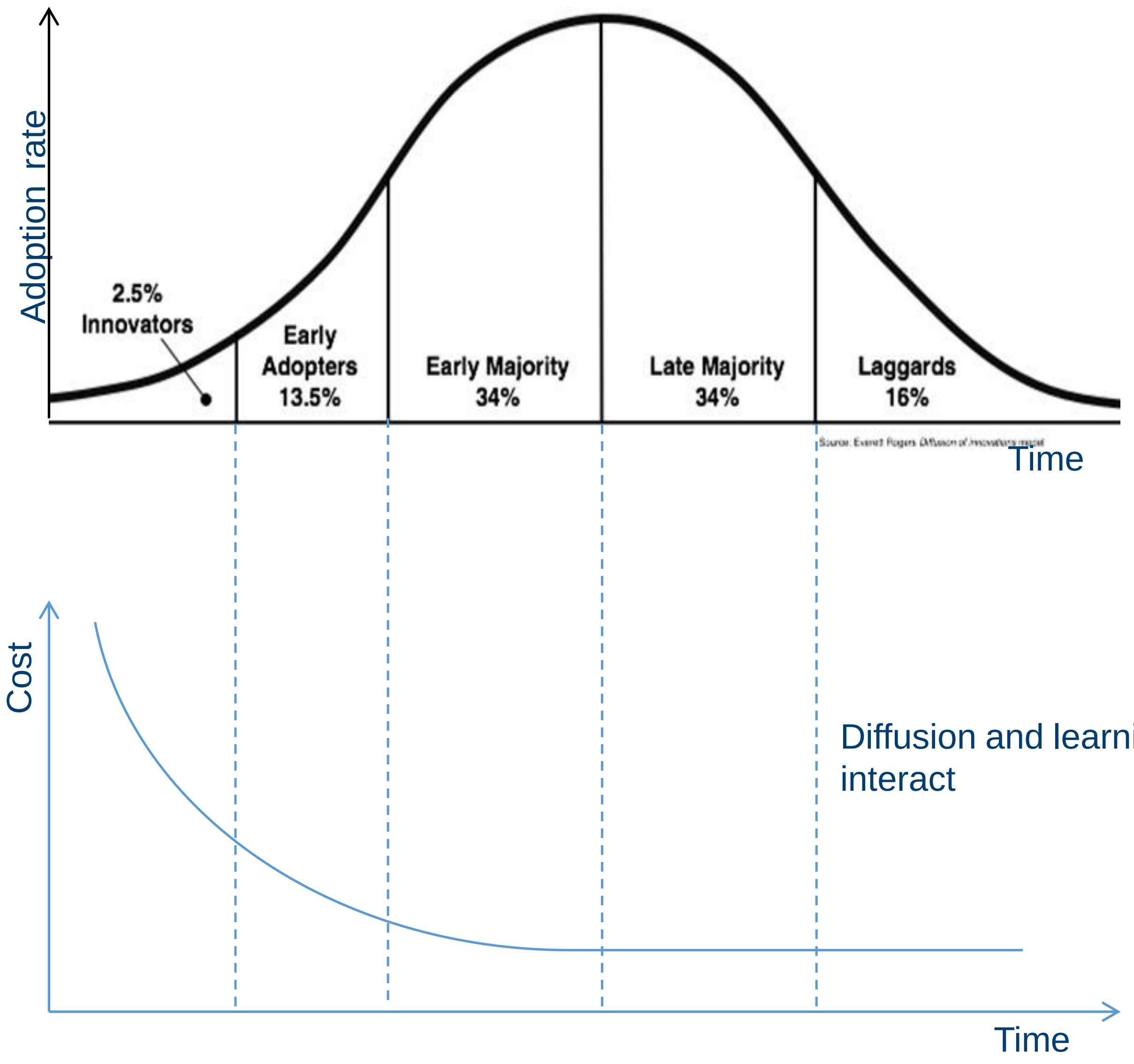
E3ME

=



- CO_2 emission
- Investment spill over
- GDP, Employment

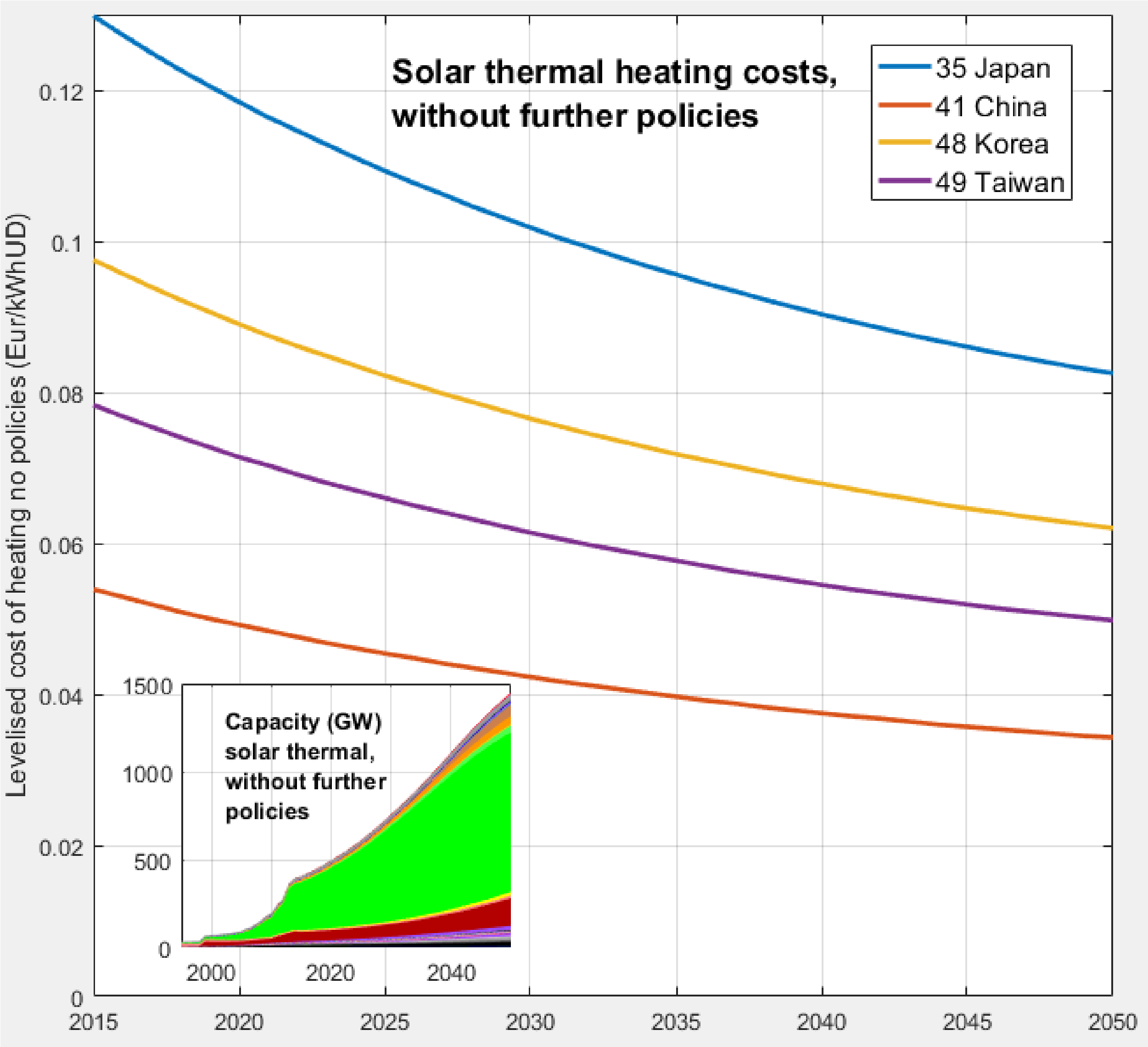
Technological learning and cost impact



Diffusion and learning interact

Technological learning and cost impact

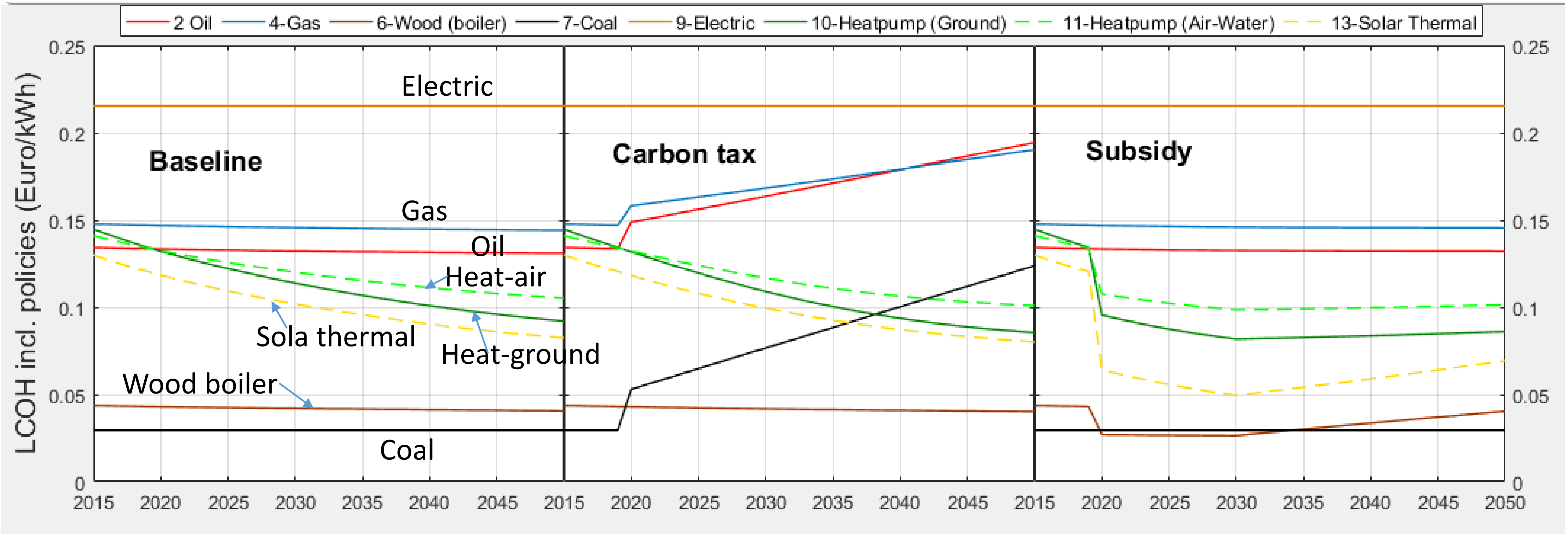
By Florian Knobloch



FTT:Heat simulation of future solar thermal heating costs, by country (assuming a continuation of current policies).

Policy effects on heating costs in Japan

By Florian Knobloch



Technological learning mainly reduces cost of
solar thermal, heat pumps and modern biomass.

The carbon tax increases the cost of coal, oil
and gas-bases heating.

The subsidy decreases the cost of renewables. Although
it is phased out after 2030, costs remain at a much lower
level, due to technological learning in the meantime.

FTT: Power

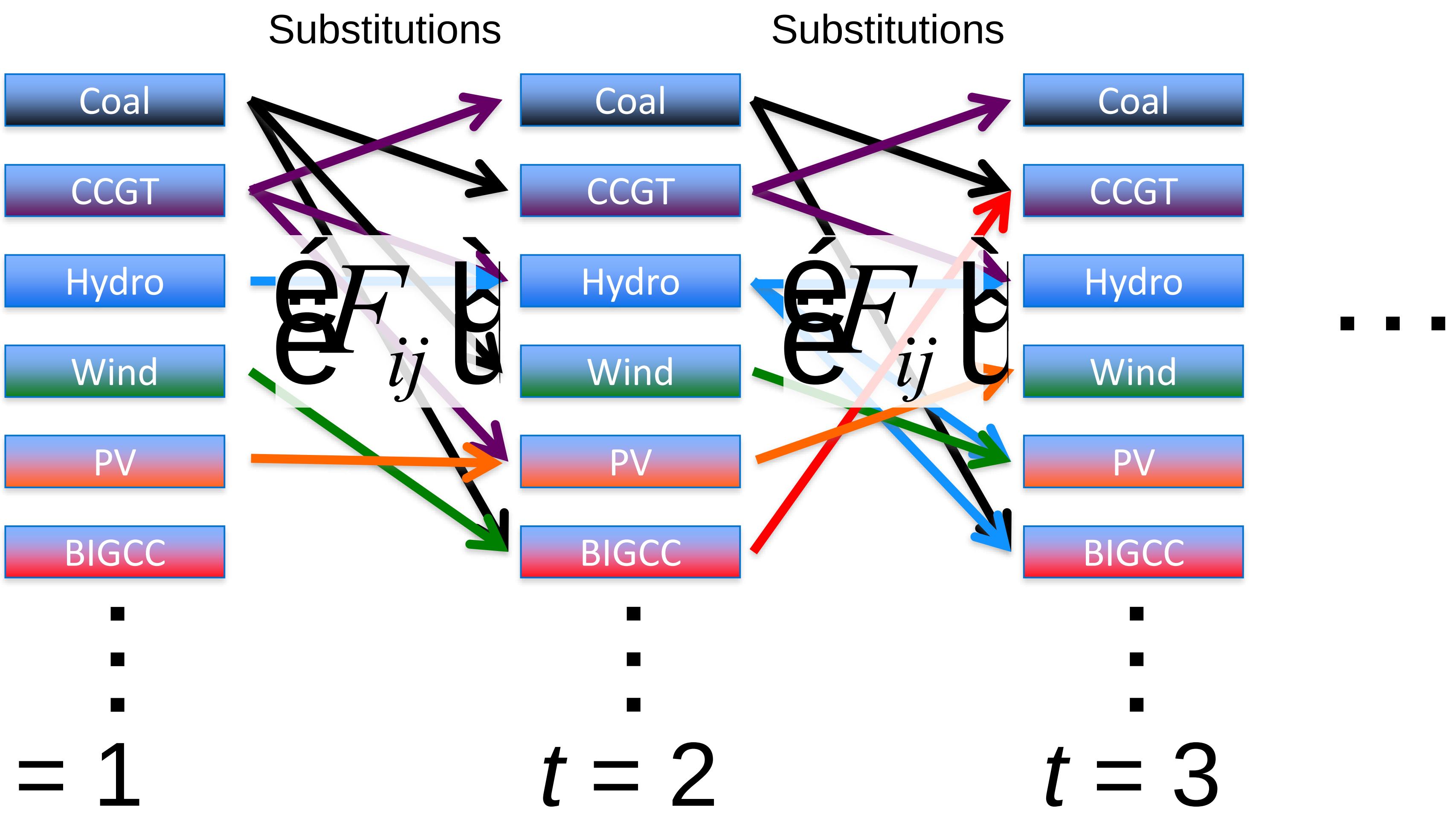
Modeling technology substitution

53 regions, 24 power generation technologies

Simulates:

- The future replacement and diffusion
- Of power technologies
- By power generation sectors worldwide (59 world regions)
- Based on dynamical shares equations (the FTT method – no optimisation)

- Useful energy demand by country as an exogenous driver (depending on future levels of construction/gereration)



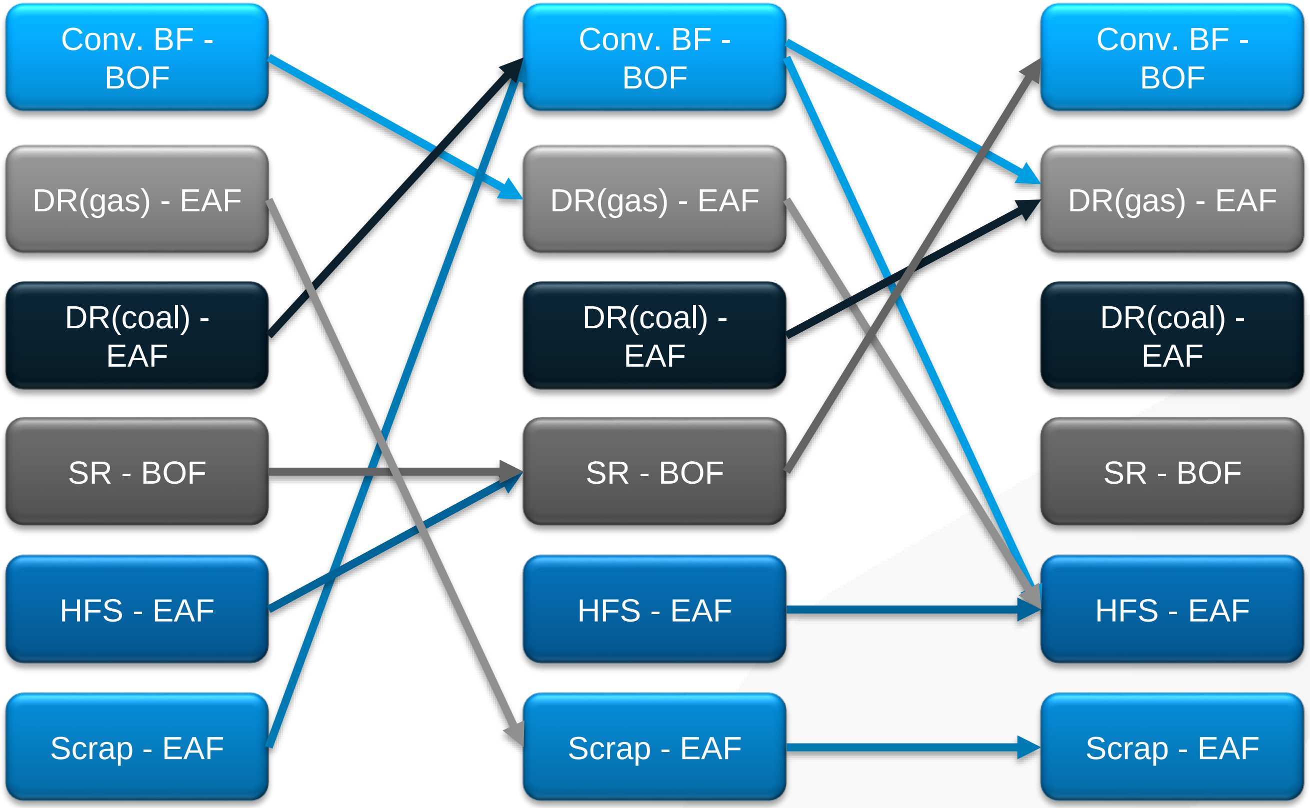
J.-F. Mercure, Energy Policy 48, 799-811 (2012)

FTT-Power (LCOE – IEA 2016)

0	From: IEA Projected costs of generating electricity																	
	p.103	p. 62-63							p.43									
	Discount rate	10%	Rate increase price of carbon		1%	Starting price of carbon ($/t)			22.10	dD/D	15%	Es/D:	1%	Upeak/Utot	30%	Us/Utot	1%	Negative allo
	Carbon Costs	std	Overnight	std	Fuel	std	O&M	std	Lifetime	Lead Time	Load Factor	Type	LCOE	std	Fuel CO2	Efficiency	Emissions	Learning rat
	$/MWh	$/MWh	$/kW	$/MWh	$/MWh	$/MWh	$/MWh	$/MWh	years	years		0,1,2,3	$/MWh	$/MWh	kgCO2/GJ	%	tCO2/GWh	b
uclear	0	0	4896.00	1525.05	9.60	2.33	11.00	6.15	60	7	85%	1	109.95	34.41	0.0	100%	0.0	-0.086
il	0	0	1227.84	1033.63	223.66	239.52	22.13	5.69	40	4	85%	1	265.34	256.04	73.3	45%	586.4	-0.014
oal	0	0	2292.95	775.01	25.62	11.23	7.41	6.02	40	4	85%	1	69.54	25.08	99.4	43%	832.2	-0.044
oal + CCS	0	0	4224.69	1172.55	22.43	10.23	15.02	4.55	40	4	85%	1	104.72	29.87	99.4	37%	96.7	-0.074
GCC	0	0	3829.06	1705.94	20.05	1.57	10.09	1.51	40	4	85%	1	91.11	29.34	99.4	42%	852.0	-0.044
GCC + CCS	0	0	4521.14	1523.05	19.96	7.50	12.87	0.52	40	4	85%	1	104.83	31.77	99.4	37%	96.7	-0.074
CGT	0	0	1067.00	336.75	66.46	16.52	5.82	2.80	30	2	85%	1	88.23	21.79	56.1	57%	354.3	-0.059
CGT + CCS	0	0	2446.53	520.63	71.20	1.47	6.42	0.40	30	2	85%	1	114.19	9.31	56.1	47%	43.0	-0.074
olid Biomass	0	0	4007.00	2587.47	93.24	72.94	18.55	26.53	40	4	85%	2	175.59	118.82	0.0	43%	0.0	-0.074
Biomass CCS	0	0	5938.74	2985.00	93.24	72.94	18.55	26.53	40	4	85%	2	206.35	125.15	-112.0	37%	-980.8	-0.105
IGCC	0	0	3829.06	1705.94	93.24	72.94	10.09	1.51	40	4	85%	2	164.30	100.12	0.0	42%	0.0	-0.074
IGCC + CCS	0	0	4521.14	1523.05	93.24	72.94	12.87	0.52	40	4	85%	2	178.10	97.19	-112.0	37%	-980.8	-0.105
iogas	0	0	3733.00	3519.63	0.00	36.62	60.52	5.84	30	2	85%	2	116.32	89.69	0.0	57%	0.0	-0.074
iogas + CCS	0	0	5112.53	3703.50	0.00	36.62	60.52	5.84	30	2	85%	2	136.94	92.44	-54.6	47%	-376.4	-0.105
mall Hydro	0	0	2782.50	3538.98	0.00	0.00	38.40	6.45	80	7	85%	3	89.04	70.86	0.0	100%	0.0	-0.020
arge Hydro	0	0	2492.50	2499.96	0.00	0.00	9.86	10.43	80	7	85%	3	55.21	55.92	0.0	100%	0.0	-0.020
nshore	0	0	1841.00	443.49	0.00	0.00	21.38	8.67	25	1	30%	0	98.50	27.25	0.0	100%	0.0	-0.105
ffshore	0	0	5000.00	579.58	0.00	0.00	40.71	19.82	25	1	42%	0	190.32	37.17	0.0	100%	0.0	-0.136
olar PV	0	0	1833.50	552.90	0.00	0.00	22.80	15.57	25	1	14%	0	187.39	65.20	0.0	100%	0.0	-0.269
SP	0	0	4901.00	1859.10	0.00	0.00	17.38	22.10	25	1	55%	0	129.37	64.58	0.0	100%	0.0	-0.152
eothermal	0	0	5822.50	2036.63	0.00	0.00	17.28	34.10	40	4	85%	3	109.99	66.53	0.0	100%	0.0	-0.074
Vave	0	0	5142.07	2414.85	0.00	0.00	55.91	36.58	20	1	46%	0	207.34	107.70	0.0	100%	0.0	-0.218
uel Cells	0	0	5884.82	5459.00	58.71	54.56	53.70	49.81	20	2	85%	1	205.17	159.93	15.3	80%	68.9	-0.234
HP	0	0	2000.00	4358.28	65.74	15.21	15.93	31.85	40	2	85%	1	76.82	124.79	15.3	80%	68.9	-0.044
																	1 GWh = 3600 GJ	
requency Matrix Aij = 10/lifetime*10/BuildTime																		
	Nuclear	Oil	Coal	Coal + CCS	IGCC	IGCC + CCS	CCGT	CCGT + CCS	Solid Biom	S Biomass (	BIGCC	BIGCC + CCS	Biogas	Biogas + CCS	Small Hydro	Large Hydro	Onshore	Offshore

FTT: Steel

53 regions, 26 steel production technologies



FTT calculates the Levelised Cost of Steelmaking (LCOS) → (imperfect) Investor preferences → Can be affected by:

- Learning-by-doing
- Prices of raw materials
- (Un)availability of scrap
- Emissions (when carbon taxes are applied)

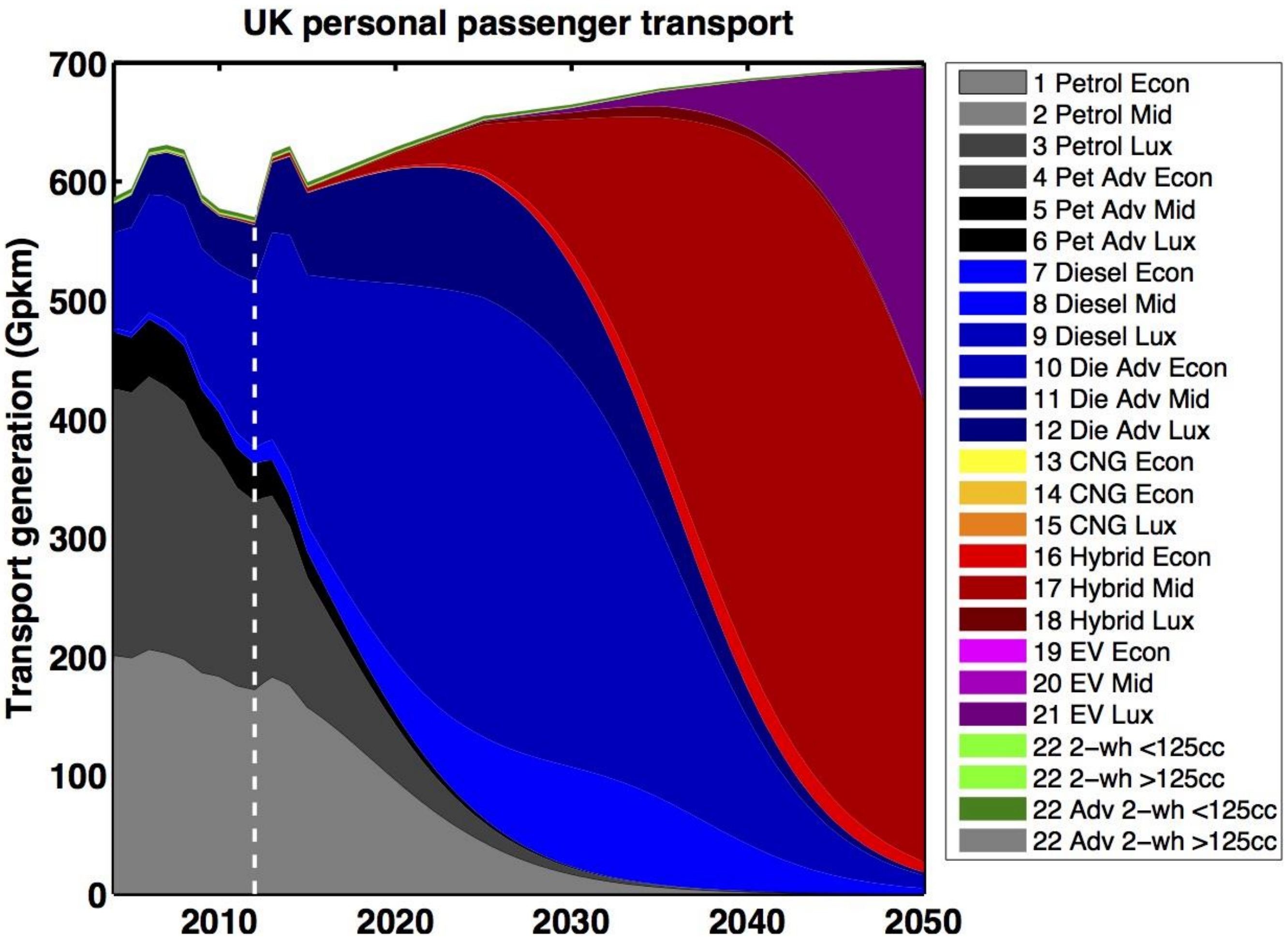
Market share changes are then proportional to investor preferences, and technological and sectoral constraints

e3me
e3me.com

FTT:Transport

53 regions, 25 transport technologies

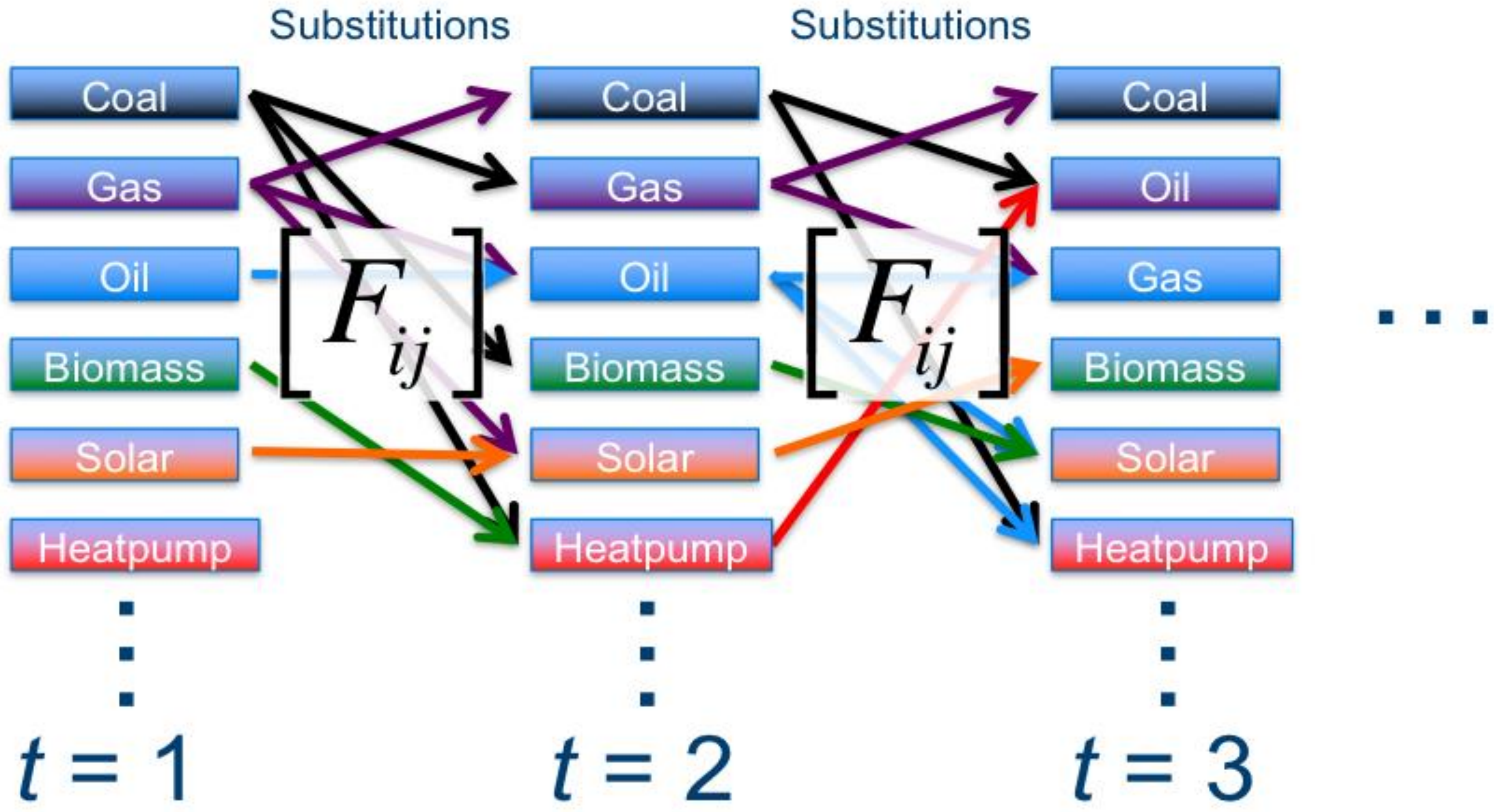
15.$UK	Prices'of'cars'(	Std'of'price''	fuel'cost'(US[	std'fuel'cost	O&M'costs'(U	O&M'costs'(s	Discount'rate	lifetime	energy'us							
Petrol$Econ	18683.00	4396.00	0.095	0.013	0.038	0.020	15%	12	1.5							
Petrol$Mid	32185.00	8164.00	0.123	0.014	0.051	0.030	15%	12	2.(							
Petrol$Lux	99538.00	49455.00	0.202	0.057	0.064	0.030	15%	12	3.3							
Advance$Petrol$Econ	18683.00	4396.00	0.076	0.013	0.038	0.020	15%	12	1.4							
Advance$Petrol$Mid	32185.00	8164.00	0.110	0.014	0.051	0.030	15%	12	1.8							
Advance$Petrol$Lux	99538.00	49455.00	0.161	0.057	0.064	0.030	15%	12	3.(							
Diesel$Econ	22608.00	3297.00	0.069	0.010	0.038	0.020	15%	12	1.3							
DieselMid	33755.00	7065.00	0.077	0.015	0.051	0.030	15%	12	1.5							
Diesel$Large	54793.00	14601.00	0.118	0.025	0.064	0.040	15%	12	2.1							
Advance$Diesel$Econ	22608.00	3297.00	0.084	0.010	0.038	0.000	15%	12	1.2							
Advance$Diesel$Mid$	33755.00	7065.00	0.095	0.015	0.051	0.000	15%	12	1.4							
Advance$Diesel$Large	54793.00	14601.00	0.095	0.025	0.064	0.000	15%	12	1.8							
CNG$Econ	21485.45	1000.00	0.048	0.055	0.039	0.020	15%	12	1.5							
CNG$Mid	37012.75	3000.00	0.071	0.069	0.056	0.030	15%	12	2.2							
CNG$Large	114468.70	5000.00	0.082	0.076	0.066	0.040	15%	12	2.5							
Hybrid$Econ	29202.00	2826.00	0.084	0.003	0.039	0.030	15%	12	1.4							
Hybrid$Mid	34540.00	6594.00	0.073	0.009	0.056	0.040	15%	12	1.2							
HybridLux	78343.00	9263.00	0.124	0.017	0.066	0.040	15%	12	2.(							
EV$Econ	10990.00	157.00	0.000	0.000	0.046	0.040	15%	12	0.2							
EV$Mid	44745.00	1256.00	0.000	0.000	0.065	0.050	15%	12	0.5							
EV$Lux	89961.00	2355.00	0.000	0.000	0.080	0.060	15%	12	0.5							
2$Wheelers$Motorcycle$Econ$	3808.00	1326.00	0.040	0.003	0.030	0.030	15%	7	0.6							
2$Wheelers$MotorcycleLux>	14932.00	5760.00	0.127	0.039	0.030	0.030	15%	7	2.124	6052	0.55	3328.6	0.906978	147.159745	2	R0.0144996
Adv$Mot	3808.00	1326.00	0.040	0.095	0.030	0.030	15%	7	0.676	6052	0.55	3328.6	2.2693	46.8324621	2	R0.0144996
AdvMot	14932.00	5760.00	0.095	0.095	0.030	0.030	15%	7	2.124	6052	0.55	3328.6	0.906978	147.15[illegible]	2	[illegible]



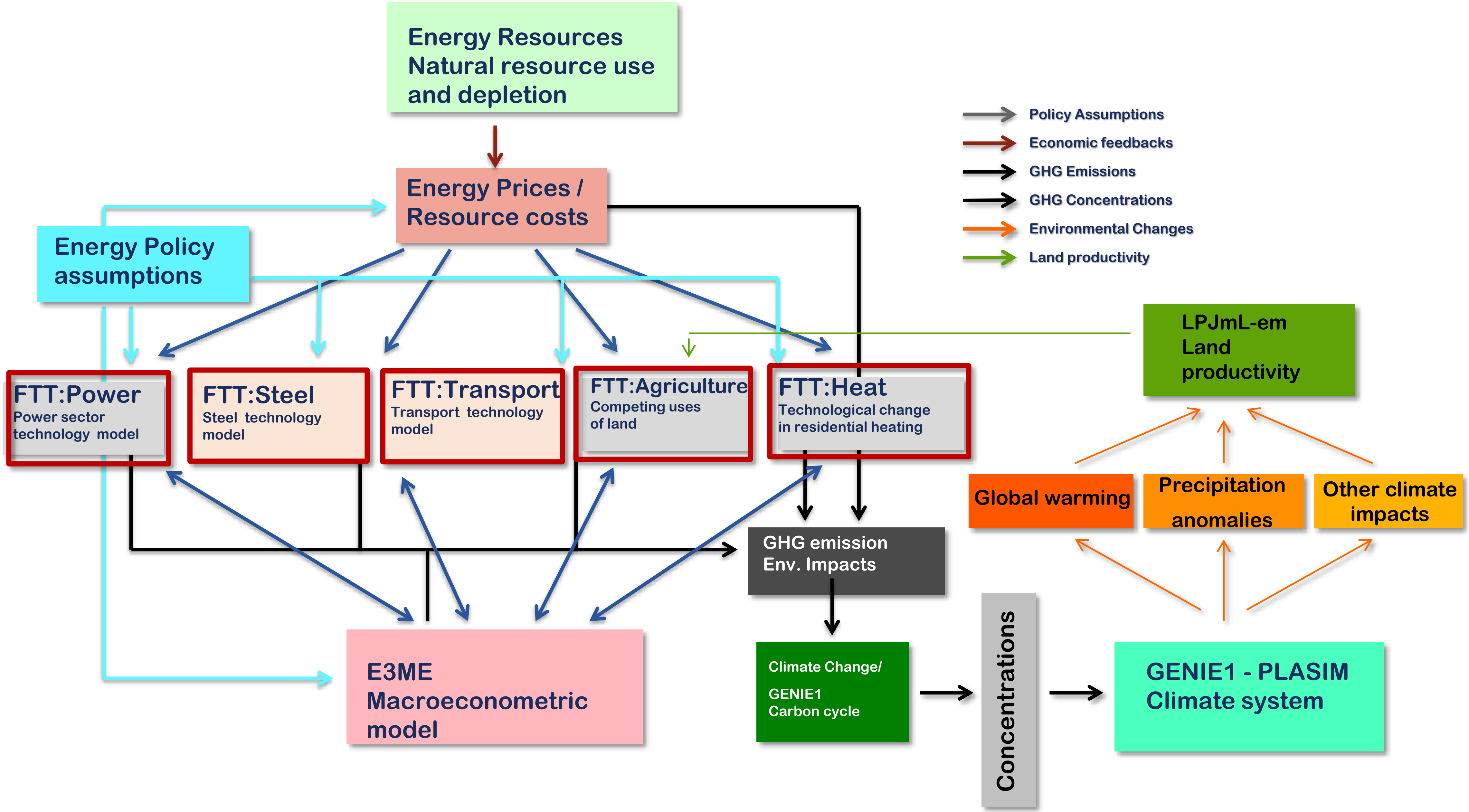
Mercure & Lam, *in preparation* (2016)

FTT:Heat

53 regions, 12 heating technologies



J.-F. Mercure, Energy Policy 48, 799-811 (2012)



Energy Resources
Natural resource use and depletion
Energy Prices / Resource costs
Energy Policy assumptions
Policy Assumptions
Economic feedbacks
GHG Emissions
GHG Concentrations
Environmental Changes
Land productivity
LPJmL-em
Land productivity
FTT:Power
Power sector technology model
FTT:Steel
Steel technology model
FTT:Transport
Transport technology model
FTT:Agriculture
Competing uses of land
FTT:Heat
Technological change in residential heating
Global warming
Precipitation anomalies
Other climate impacts
GHG emission
Env. Impacts
E3ME
Macroeconometric model
Climate Change/
GENIE1
Carbon cycle
Concentrations
GENIE1 - PLASIM
Climate system