Technological change in Long Term Transition Scenarios

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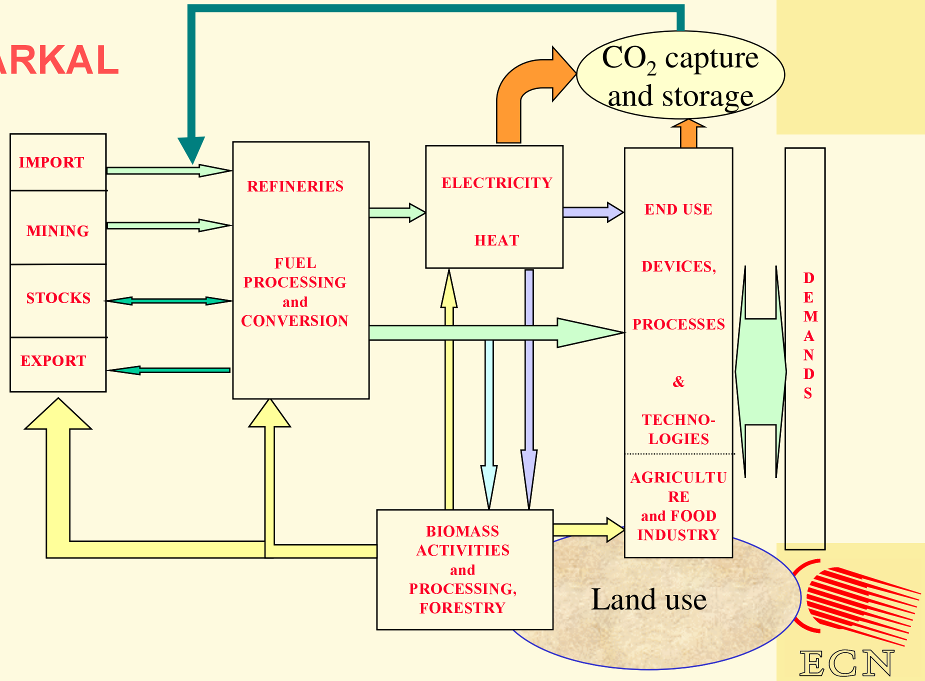
Technological change

- Model used
- What are technology clusters
- What is transition
- Results
- Conclusions

MARKAL



Clusters of technologies (1)

Definitions

- Cluster
  - = a group of technologies sharing a common essential (i.e. learning) component; therefore the learning behaviour of these technologies is linked
- Component
  - = the selected learning key technology shared by all technologies in a cluster
- Technologies are build by a number of components and a balance of system (infrastructure, non learning parts)

Clusters of technologies (2)

- Shared learning (SFLC)
  - $SC_{i,t} = a * \{\Sigma_T \alpha_{i,T} * CC_{T,t}\}^{-b}$
    - $SC_{i,t}$ = Specific investment cost
    - $\alpha_{i,T}$ = capacity fraction
    - $CC_{T,t}$ = cumulative capacity
  - $SC_{T,t}$ = N-ETL+ $\Sigma_T \alpha_{i,T} * SC_{i,t}$

Transition

- Definition:

  A transition is a gradual and lengthy process (25-50 years) of change in which a system changes fundamentally. The change concerns changes in various areas: technological and institutional changes, changes in behaviour, culture and intentions. The overall change encompasses changes in socio cultural, techno economical and environmental aspects.

- Terms like regime, niche markets, technology development and deployment are inherent to the use of MARKAL type models. The model is used to analyse a path or composition (future image) towards which the energy system is evolving over time, given the scenario constraints.
  (path dependency, lock-in lock-out, …)

Scenarios

- Purpose: to test radical future images in a long term and technology rich model
- Renewable electricity (green) target:
  - 100% by 2050, 2070 and 2100
  - optimal path and linear fixed path from 26% in 2010
- CO_2 less electricity production:
  - 0 Mton CO_2 in 2050, 2070 and 2100
  - optimal path and fixed linear path from 850 Mton in 2010
- No new investments in fission (LWR) reactors after 2000

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Results

Looking at technological change in different ways

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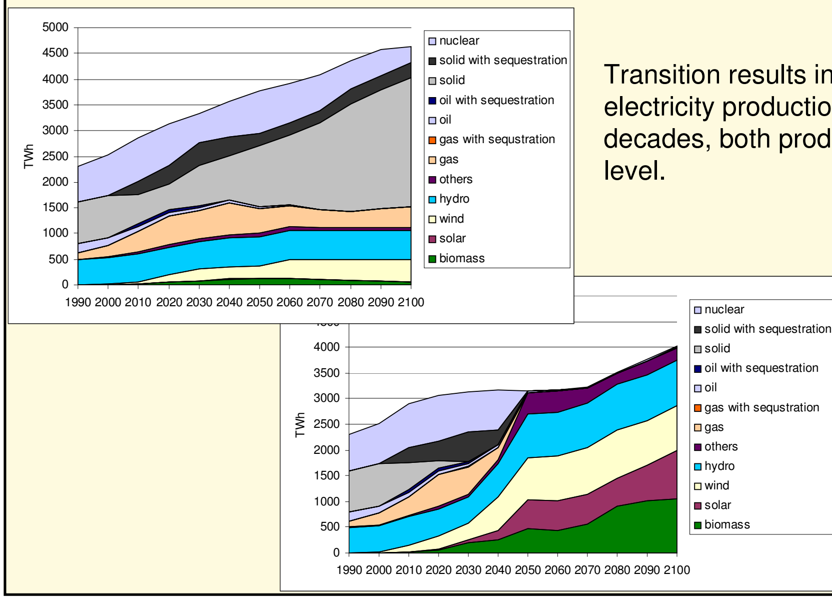
Results: (1)



Transition results in huge changes in electricity production in a couple of decades, both production mix and level.

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Results (2)

	1990	2000	2010	2020	2030	2040	2050	2060
biomass	0	0	-	+	+	+	+	+
solar	0	0	0	+	+	+	+	+
wind	0	0	+	+	+	+	+	+
hydro	0	0	0	-	-	+	+	+
others	0	0	0	+	+	+	+	+
gas	0	-	-	+	+	-	-	-
gas with sequestration	0	0	+	+	+	+	+	+
oil	0	-	+	+	0	0	0	+
oil with sequestration	0	0	-	-	-	+	+	+
solid	0	+	-	-	-	-	-	-
solid with sequestration	0	0	+	0	+	+	+	+
nuclear	0	0	+	-	-	-	-	-

The difference in electricity production per production type compared to the reference case (average represented here) shows that some power plant types have a robust trend (0, - or +) per period or even over the whole time horizon, while others vary over the different periods and scenarios.

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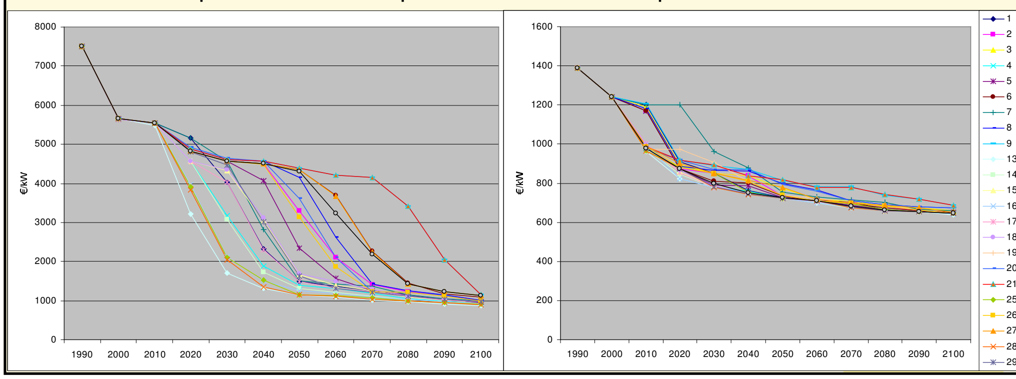
Results (3)

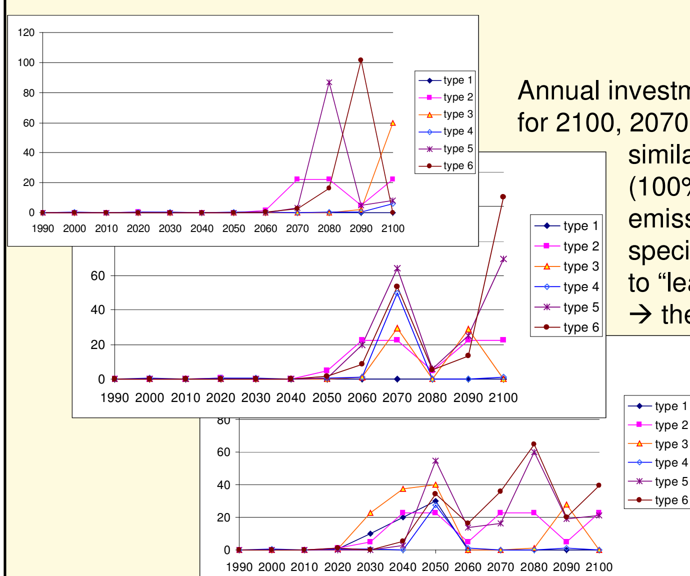
- Technology learning is very much scenario and scenario assumptions dependent (e.g. discount rate or fuel prices) as well as from the learning curve parameters (e.g progress ratio)

Specific Investment Costs [/kWel]

Component Solar PV panel   Component Wind turbine



Results (4)



Annual investments in Solar PV applications for 2100, 2070, 2050 (top to bottom) under similar scenario conditions (100% green electricity and emission free)

specific types move from “follower” to “leader” and vice versa

→ there is no pronounced winner, but there are robust ones and there are types that do not occur at all.

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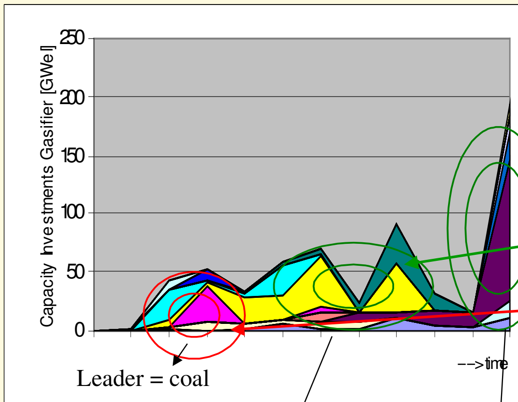
Results (5)



- Promising technology example: gasifier
- Capacity investments per technology in a cluster indicate which technology is leader and which is follower

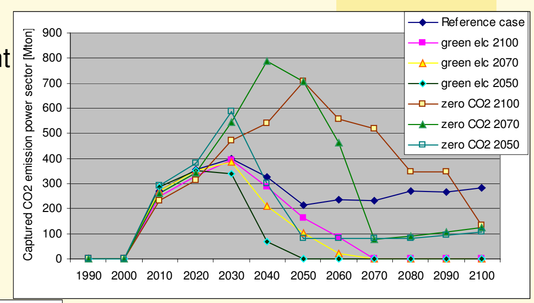
⇒preferential areas/technologies for (policy) intervention

Intermediate follower = coal with CO_2 capture and SOFC

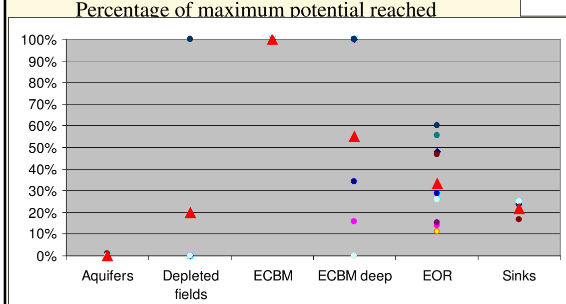
Last follower = biomass

Results (6)

CO_2 capture (and storage) is prominent part of the transition path, role later onwards is determined by scenario conditions



Percentage of maximum potential reached



Which storage option is used, varies considerably, but ECBM appears to be robust, together with EOR and the use of depleted fields

Conclusions

- Transition approach can be used to explore scenarios with far going implications.
- Implementation of transition scenarios in bottom up models can give valuable insights in technological changes and interactions.
- Technological change occurs e.g. through deployment switches towards alternatives or even towards competitors, technology train development (leaders and followers), cost reductions, …