Uncertainty related modelling activities at UCL Energy Institute

ADVANCE Expert Workshop on modelling uncertainty,
Fondazione Eni Enrico Mattei, Milan, May 14th 2014

Ilkka Keppo

UCL Energy Institute

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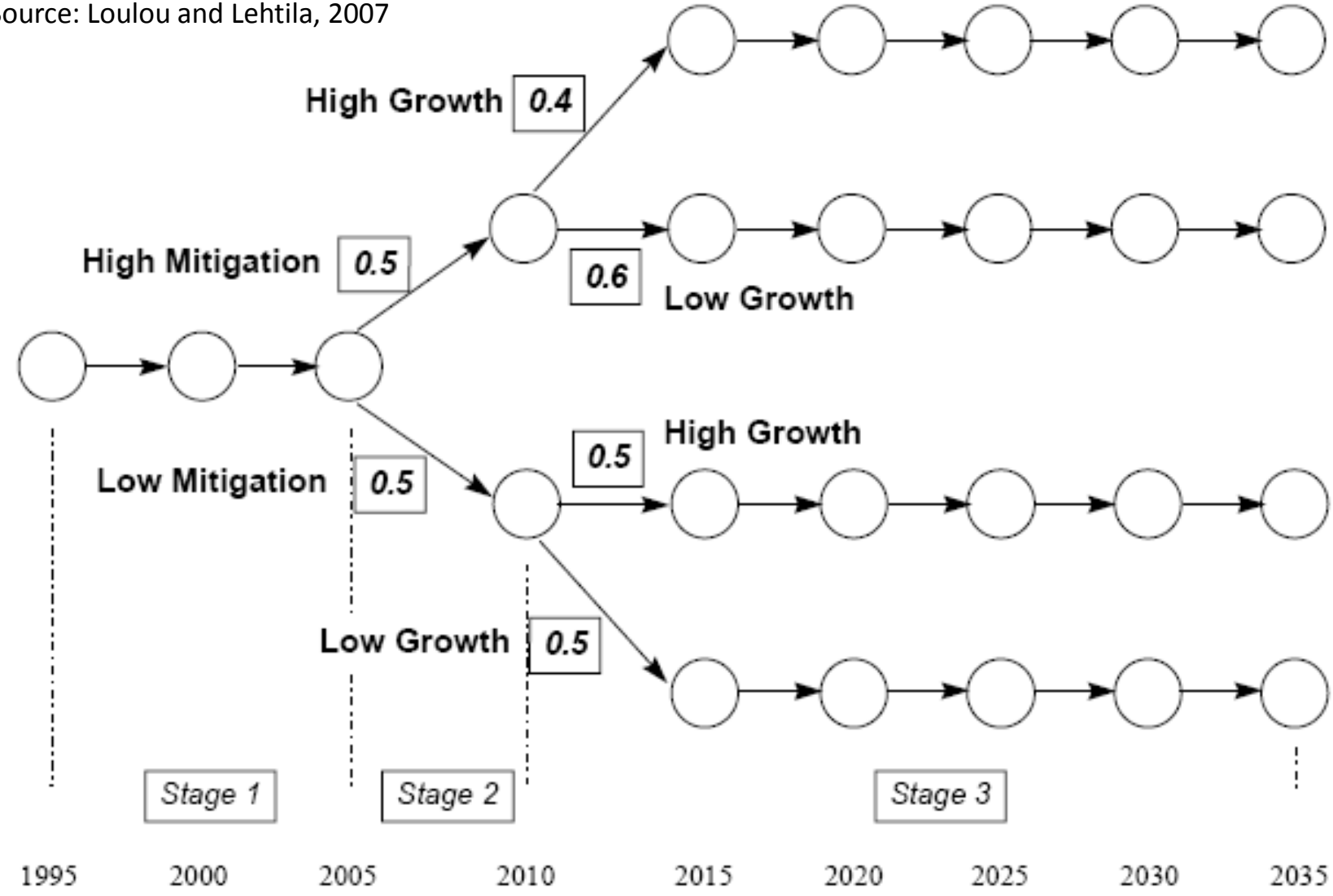
Presentation overview

- Stochastic programming
  - For large energy system models (MARKAL, TIMES)
  - Action dependent uncertainty for R&D investments
- Energy systems modelling + Monte Carlo(ESME)
- Exploration of near optimal scenario space
- Other activities

Source: Loulou and Lehtila, 2007

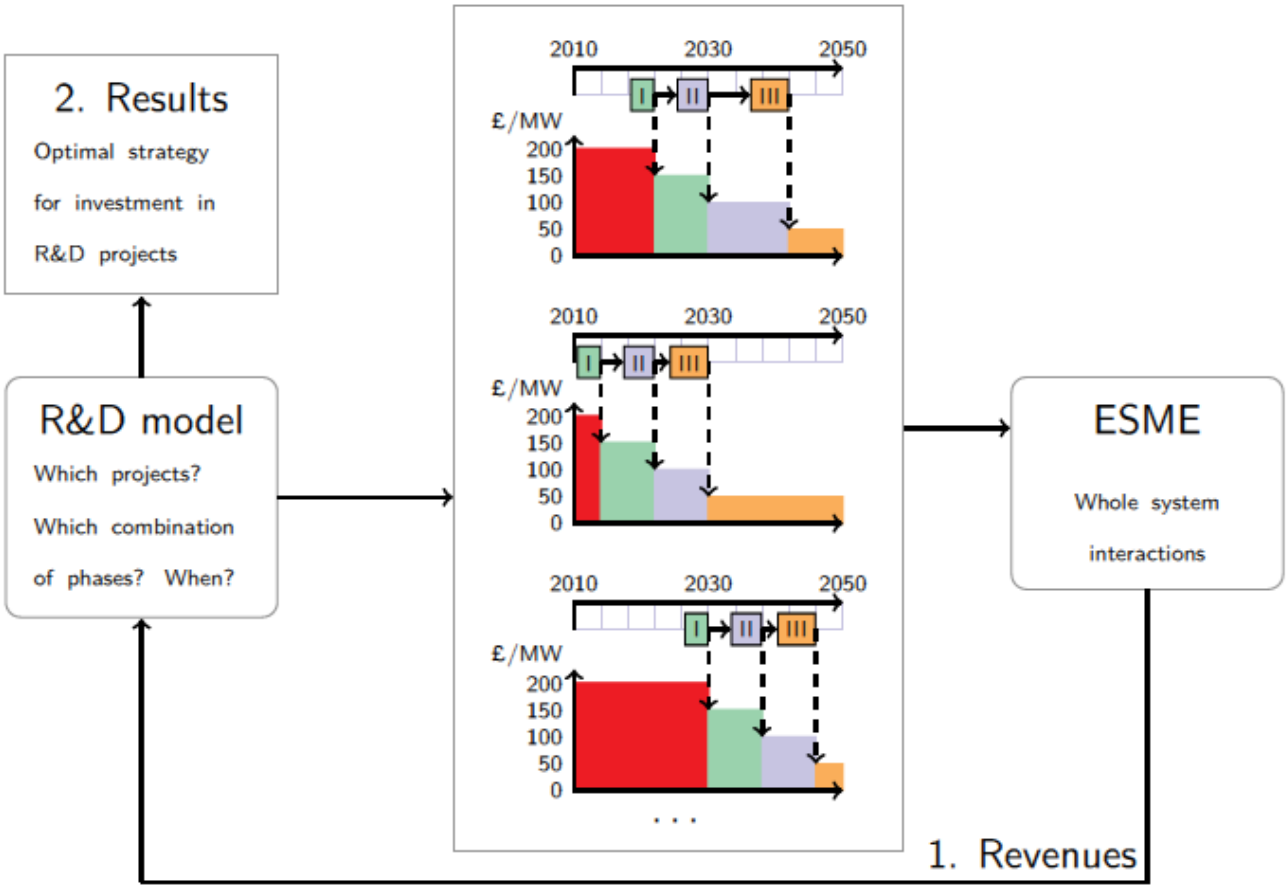


Ilkka Keppo, Bob van der Zwaan. 2012. The Impact of Uncertainty in Climate Targets and CO2 Storage Availability on Long-Term Emissions Abatement. Environmental Modeling & Assessment, 17(1-2), pp 177-191

Usher, W. and N. Strachan. 2012. Critical mid-term uncertainties in long-term decarbonisation pathways, Energy Policy, 41, 433-444.

Stochastic programming, Action dependent uncertainty

- Phased R&D projects
  - outcome of each phase uncertain (success or fail)
  - next phase possible only with success
  - each successful phase reduces technology costs and thus brings revenues
  - Revenues determined through linkage to an energy systems model (ESME)
- Uncertainty depends on decisions about entry to projects & phases, timing -> endogenous uncertainty
- The consecutive nature of the phases reduces dimensionality problems
- A high number of ESME runs required to provide the revenue data for a scenario



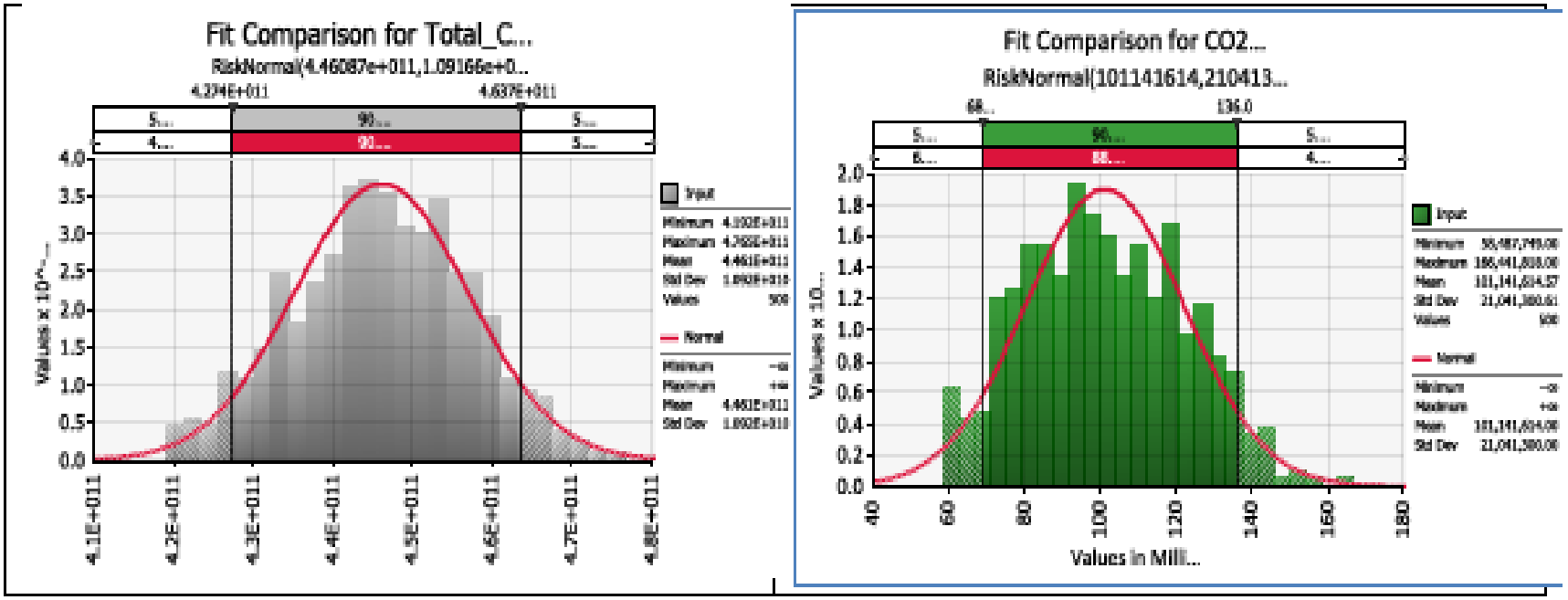
Source: Ongoing PhD work of Mr Will Usher

Energy systems modelling + Monte Carlo(ESME)

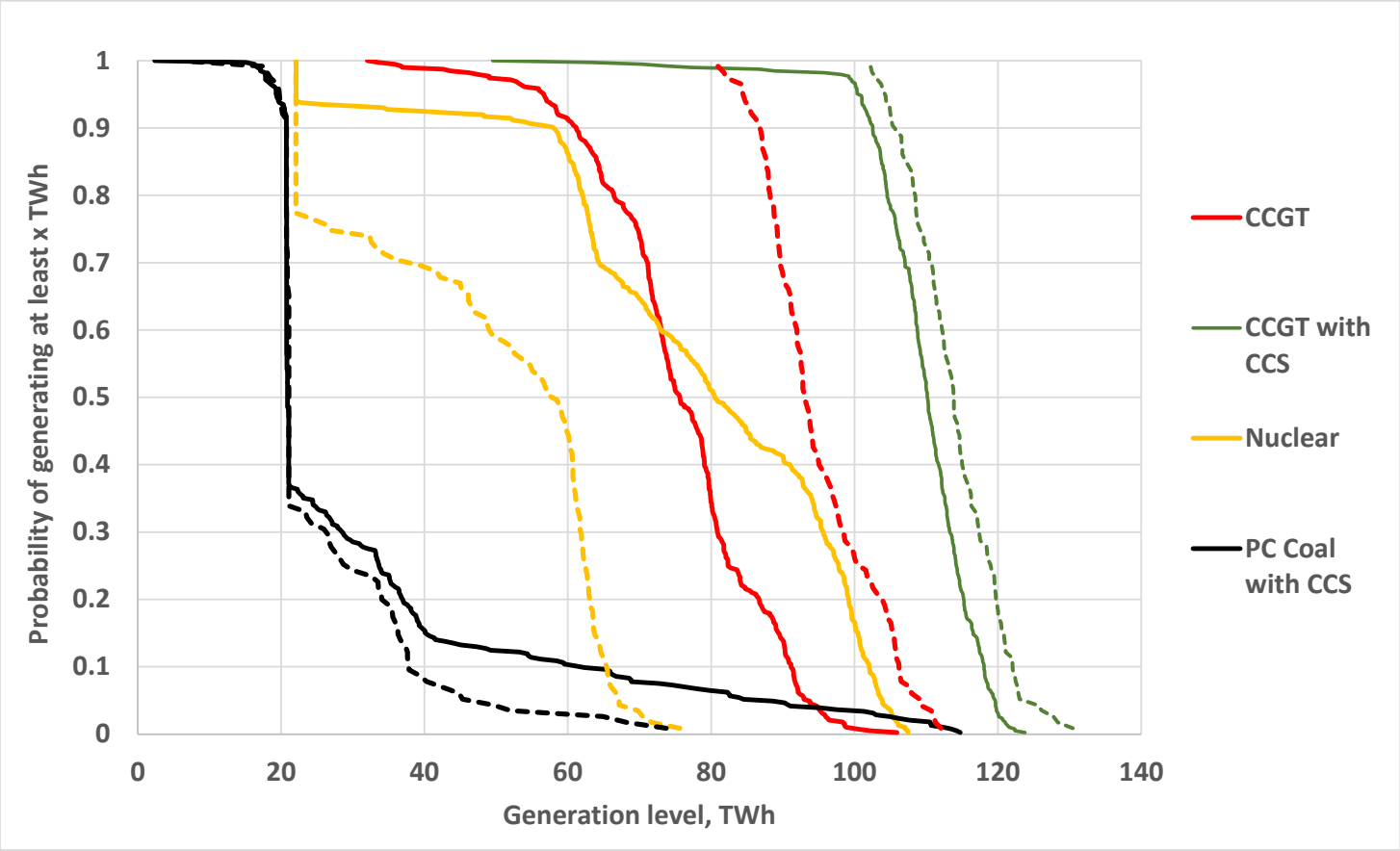
- ESME is a UK energy system model similar in principle to MARKAL/TIMES
- The main difference is that it is designed to run in a Monte Carlo mode, in which parameter values (usually costs) are sampled from predetermined distributions
- Correlations can also be provided, typical number of runs required is ~ 200-1000
- Most recent assessment by Pye et al., 2014 focused on the likelihoods of meeting targets with predetermined emission price trajectories, with 65 uncertain parameters (costs, prices, biomass availability, max build rates)

Pye, S., Sabio, N. and N. Strachan. 2014. UKERC Energy Strategy Under Uncertainties - An Integrated Systematic Analysis of Uncertainties in UK Energy Transition Pathways. UKERC working Paper. UKERC/WP/FG/2014/002

ESME, Probabilistic costs and CO2 emissions



ESME, Probabilistic power sector results



Likelihood of power production being at least as high as indicated in runs that a) reach (solid lines) or b) don't reach (dashed lines) the target

Pye, S., Sabio, N. and N. Strachan. 2014. UKERC Energy Strategy Under Uncertainties - An Integrated Systematic Analysis of Uncertainties in UK Energy Transition Pathways. UKERC working Paper. UKERC/WP/FG/2014/002

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- Derivation of distributions, consideration of uncertainty in decision making, uncertainty over time.

Pye, S., Sabio, N. and N. Strachan. 2014. UKERC Energy Strategy Under Uncertainties - An Integrated Systematic Analysis of Uncertainties in UK Energy Transition Pathways. UKERC working Paper. UKERC/WP/FG/2014/002

Exploration of near optimal pathways, D-EXPANSE

- Bottom-up, technology rich, cost-optimisation model for the UK power system
- Main focus the exploration of near-optimal pathways, e.g. that have up to 10% higher total system costs than the cost optimal trajectory
- A large number of pathways generated and a smaller set of maximally-different pathways is selected

Trutnevyte E., 2013. EXPANSE methodology for evaluating the economic potential of renewable energy from an energy mix perspective. Applied Energy 111; 593-601.
Trutnevyte E., Strachan N., 2013. Paper for the International Energy workshop, 19-21 June 2013, Paris, France
Trutnevyte E., 2014. Paper for the International Energy workshop, 4-6 June 2014, Beijing, China

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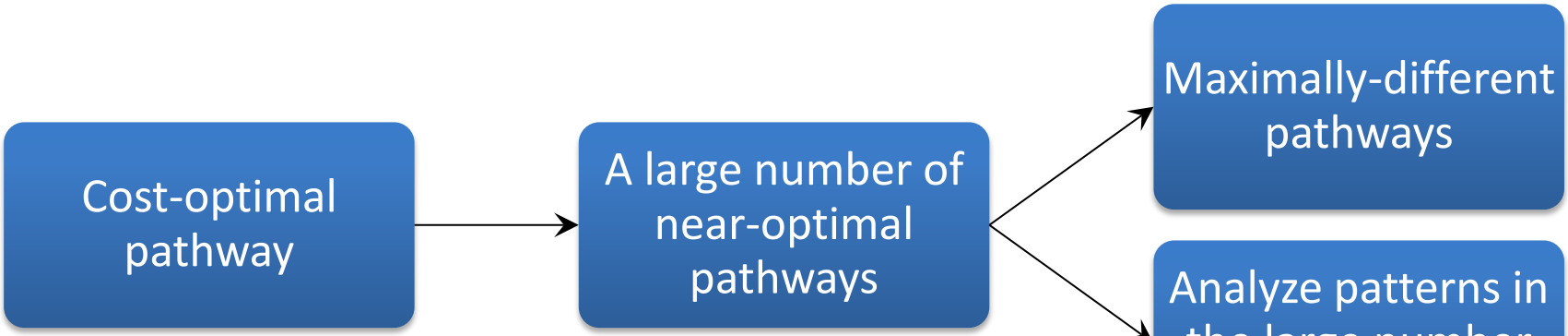

Minimize total system costs

➢ ***One set of deterministic inputs***

Slack

- e.g. 20% on total system costs

Efficient random generation technique
(Chang et al. 1982a,b)

- 1000 pathways

Adapted distance-to-selected technique (Tietje, 2005; Trutnevyte et al. 2012)

Descriptives and other methods

Trutnevyte E., 2013. EXPANSE methodology for evaluating the economic potential of renewable energy from an energy mix perspective. Applied Energy 111; 593-601.
Trutnevyte E., Strachan N., 2013. Paper for the International Energy workshop, 19-21 June 2013, Paris, France
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Other activities

- A UK expert elicitation on six national and international drivers of energy demand (Usher and Strachan, 2013)
- Meta-analysis on (model based) scenario construction, use, interpretation and communication, scenarios as reflections of the understanding of key uncertainties (McDowall et al., 2014)
- Model archaeology (Dodds et al., submitted)
- Some work on approximate dynamic programming in the energy system context

Usher, W. and N. Strachan. 2013. An expert elicitation of climate, energy and economic uncertainties, Energy Policy, 61, 811-821
McDowell, W., Trutnevyte, E., Tomei, J. and I. Keppo. 2014. Reflecting on Scenarios. UKERC working paper (in press)