

System Dynamics in Industrial Ecology

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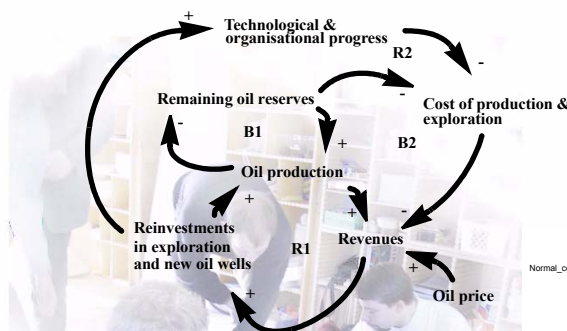
Introduction

System Dynamics was developed during the 50ies by Jay W. Forrester at MIT. Originally developed to solve complex management problems within industry, it turned out to be a general method that could be applied in many areas, from industrial management problems to global environmental problems, urban planning, energy planning etc. The most famous studies are Limits to Growth, Urban Dynamics and Industrial Dynamics. The theory itself draws upon control-, organisation- and decision theory.

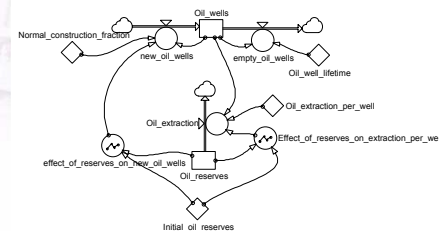
Mental model

Future development of Norwegian oil production.

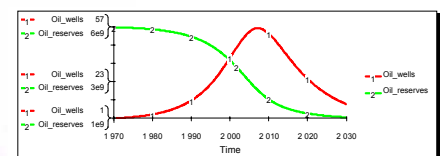
When Phillips struck oil in the North Sea in 1971, Norway started to explore the oil fields in the North Sea. Revenues from oil production were reinvested in new explorations and oil wells, increasing oil production and revenues that drive our fossil fuelled economy. In this process, new technologies, experience and organisational skills developed, improving production technology, reducing the costs of production and enabled us to dig even deeper into the fossil reservoirs. The remaining oil reserves are, however diminishing, but this effect is still being offset by the growth of investments and technology improvements of oil production and exploration. The figure below shows the yearly oil production in the North Sea. It seems that for the last four years, oil production has begun to peak. Authorities recently started to encourage the discovery of new oil resources to counter the anticipated decline in oil production over the next decade. Neither fluctuating oil prices in a volatile market nor new surprising discoveries can overshadow the long term trend of diminishing production due to resource scarcity and its effects on costs. When the costs of new exploration and production offset the revenue of production and technology improvements, oil production is bound to decline.



Formal model



From discussion of complex problems among stakeholders and decision makers... To causal loop diagrams for enhanced communication and clarification ...



...and formal modelling, simulation, synthesis, design of improvements and enhanced understanding.

Figure 1 From discussion of problems to formal modelling and synthesis

System dynamics and industrial ecology

Usually, technical, economic and social systems are analysed separately in science and real world, though these systems are heavily interdependent. This is also the case for industrial ecology, which is characterised by a set of tools that partially address economic, environmental and social relationships. System dynamics enables us to analyse problems involving environmental, economic and social factors within a common theory. Theories from other disciplines can be translated into the system dynamics language, where not only energy and material, but also capital, human resources and information are

viewed as stocks and flows forming multiple feedback nonlinear systems. The system dynamics method bridges the gap between different approaches in scientific disciplines and is therefore particularly suited for the interdisciplinary industrial ecology.

Goals of the course

The overall objective is to introduce the participants to the system dynamics method and its potential for use in industrial ecology by hands-on examples. The participants will learn causal loop diagramming for structuring problems in discussions and get some practical experience with stock & flow modeling and system dynamic simulation models applied on typical IE problems. Approximately one fourth of the participants should bring their Laptop with CD-rom. Software will be provided at the course.

Bibliography

Some example materials will be available at <http://www.stud.ntnu.no/~klausv/> under “Industrial Ecology” from February on

Counterintuitive behaviour of social systems (Forrester, J.W, 1971) available [online] <http://sysdyn.mit.edu/sdep/Roadmaps/RM1/D-4468-2.pdf>

World Dynamics (Forrester, J.W, 1970)

Limits to Growth (Meadows et al., 1972)

Business Dynamics, (Sterman, J.D, 2000)

Modeling the Environment (Ford, A., 1999) available [online]: <http://www.wsu.edu/~forda/AAOpen.html>

Several publications on system dynamic modeling and IE related problems, see Matthias Ruth's homepage <http://www.puaf.umd.edu/faculty/papers/ruth/ruth.html>

The Global Citizen: Celebrating the Life of Dana Meadows. System Dynamics Review Special Issue. vol 18, issue 2, 2002. (Contains system dynamic studies of environmental problems)