國立臺北大學自然資源與環境管理研究所

104 學年度第二學期『清潔生產與工業生態』

課程進度(16)：工業生態學之展望：系統分析與情境模擬

Thinking Ahead: Systems Analysis and Scenario Simulation

- INTRODUCTION TO SYSTEMS ANALYSIS (G&A, Chp.15)
  - □ Industrial Ecology = Systems Analysis + Life Cycle Assessment
  - □ The Systems Concept
    - ⇨ A General Definition of A System: A Group of interacting, interdependent parts linked by exchanges of energy, matter, and/or information
    - ⇨ Simple Systems vs. Complex Systems
    - ⇨ Linear Systems vs. Nonlinear Systems
    - ⇨ The "Butterfly Effect"
  - □ The Adaptive Cycle => Adaptive Management => Adaptation vs. Mitigation
  - □ "Holarchies"=> Holistic Hierarchies?
  - □ Adaptive Management of Technological Holarchies

- MODELING IN INDUSTRIAL ECOLOGY SCENARIOS (G&A, Chp.22)
  - □ Industrial Ecology Model
    - ⇨ Conceptual Models vs. Mathematical Models
  - □ Building the Conceptual Model
    - ⇨ Class 1 Industrial Ecology Model: "Sequential Process"
    - ⇨ Class 2 Industrial Ecology Model: "Multifold Considerations?"
    - ⇨ Class 3 Industrial Ecology Model: "System Dynamics Model?"
  - □ Running and Evaluating Industrial Ecology Models
    - ⇨ Implementing the Model
    - ⇨ Model Validation vs. Parameter Verification (Accreditation vs. Certification)
  - □ Examples and the Status of Industrial Ecology Models

- INDUSTRIAL ECOLOGY SCENARIOS (G&A, Chp.23)
  - □ Industrial Ecology Scenario
    - ⇨ Conceptual Scenarios vs. Mathematical Scenarios
  - □ Building the Scenario
    - ⇨ Evolutionary Behavior vs. Disruptive Behavior
    - ⇨ BAU – Business as Usual
    - ⇨ Decision Support vs. Decision Making
  - □ Examples and the Status of Industrial Ecology Scenarios
  - □ Describing Possible Future
    - ⇨ "Prediction" Models and Utility of Scenarios
    - ⇨ The ETP Scenarios (IEA: Energy Technology Perspectives 2016)

Figure ES.1 ▶ Key technologies for reducing CO_2 emissions under the BLUE Map scenario

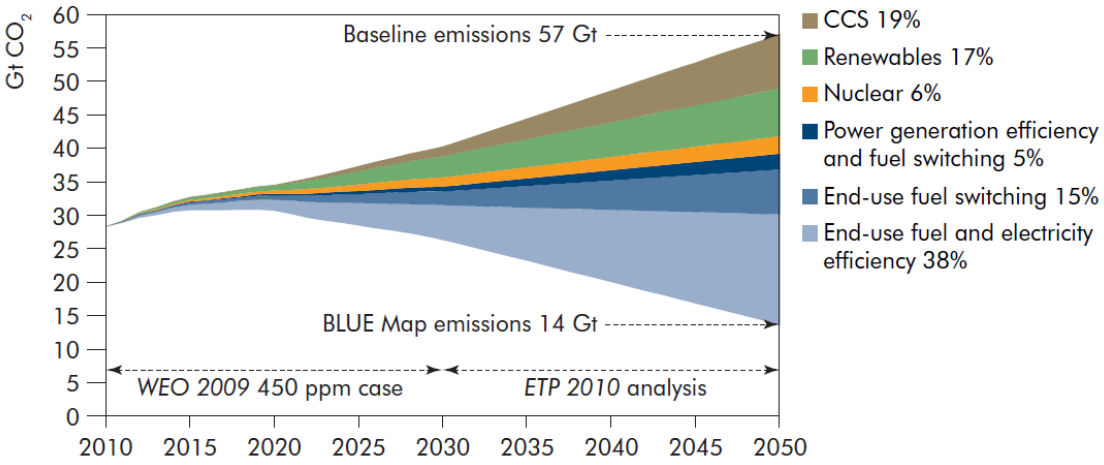

Table ES.1 ▶ Energy and emission trends under the Baseline and BLUE Map scenarios: 2050 compared to 2007

Baseline scenario	BLUE Map scenario
• Energy-related CO_2 emissions roughly double	• Energy-related CO_2 emissions reduced by 50%
• Primary energy use rises by 84%; carbon intensity of energy use increases by 7%	• Primary energy use rises by 32%; carbon intensity of energy use falls by 64%
• Liquid fuel demand rises by 57% requiring significant use of unconventional oil and synthetic fuels; primary coal demand increases by 138%; gas demand is 85% higher	• Liquid fuel demand falls by 4% and biofuels meet 20% of total; coal demand drops by 36%; natural gas falls by 12%; renewables provide almost 40% of primary energy supply
• CO_2 emissions from power generation more than double; CO_2 intensity of power generation declines slightly to 459 g/kWh	• CO_2 emissions from power generation are cut by 76%; its CO_2 intensity falls to 67 g/kWh
• Fossil fuels supply more than two-thirds of power generation; the share of renewable energy increases slightly to 22%	• Renewables account for 48% of power generation; nuclear provides 24% and plants equipped with CCS 17%
• Carbon capture and storage (CCS) is not commercially deployed	• CCS is used to capture 9.4 Gt of CO_2 from plants in power generation (55%), industry (21%) and fuel transformation (24%)
• CO_2 emissions in the buildings sector, including those associated with electricity use, nearly double	• CO_2 emissions in buildings are reduced by two-thirds through low-carbon electricity, energy efficiency and the switch to low- and zero-carbon technologies (solar heating and cooling, heat pumps and CHP)
• Almost 80% of light-duty vehicles (LDVs) sales rely on conventional gasoline or diesel technology; petroleum products meet more than 90% of transport energy demand	• Almost 80% of LDVs sales are plug-in hybrid, electric or fuel-cell vehicles; the share of petroleum products in final transport demand falls to 50%
• CO_2 emissions in industry grow by almost half, as industrial production increases	• CO_2 emissions in industry fall by around a quarter mainly thanks to energy efficiency, fuel switching, recycling, energy recovery and CCS
• Total investment in energy supply and use totals USD 270 trillion	• Investment is USD 46 trillion (17%) more than in Baseline; cumulative fuel savings are USD 112 trillion higher than in Baseline
• Non-OECD countries are responsible for almost 90% of growth in energy demand and account for nearly three-quarters of global CO_2 emissions	• Non-OECD countries achieve CO_2 emissions reduction of around 30% compared to 2007; OECD countries account for less than one-quarter of global CO_2 emissions, having reduced emissions by 70% to 80% below 2007 levels