Sustainable energy scenarios for the 21st century: the role of systems analysis

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“integrated assessment is an attempt to combine information, analysis and insights from the physical and social sciences to address the nature of climate change and to develop possible policy responses to it”


• Examples of global integrated assessment and energy-economy models (cost-effectiveness analysis):
  – AIM, GCAM, IMAGE, MESSAGE, REMIND, TIAM, WITCH, …

• Insights fed into IPCC AR5 WG3 in a big way, via model inter-comparisons (AMPERE, LIMITS, EMF27, …)
Energy Supply

Energy Demand

Transport
Industry
Buildings

Agriculture, economy, geo-politics,…

Climate, environment
195 countries have agreed, by consensus, to reduce their greenhouse gas emissions “as soon as possible” and to do their best to keep global warming “to well below 2 degrees C”.

Image sources: GIY(www.globalinstituteforyouth.org/2015/09/less-than-100-days-left-are-youth-ready-for-cop-21-paris/); COP21 (www.cop21paris.org/)
United Nations’
Post-2015 Sustainable Development Goals (SDGs)

Source: https://sustainabledevelopment.un.org/
‘Sustainable development’ means overcoming several energy challenges.

- Energy Poverty
- Energy Security
- Food Security & Biodiversity
- Climate Change
- Water Scarcity
- Air Pollution

Energy Security

Affordability of Energy Services

Increased diversity; reduced imports

Air quality guidelines (e.g., PM2.5 35 µg/m³)

Climate Change

2°C warming

Air Pollution

Affordability of Energy Services

Energy Security

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Climate Change

2°C warming

Air Pollution
Modeled policies of varying stringency

Global warming

Energy imports and diversity

Air pollution framework (PM, SO₂, NOₓ, BC, …)

> 4°C
3°C
2°C
1.5°C

Increasing stringency

Business-as-usual
Weak effort
Moderate effort
Stringent effort

39 levels

Increasing stringency

No further improvement
Current legislation
Stringent legislation
Maximum feasible reduction

4 levels

4 levels
IIASA Integrated Assessment Framework

**Scenario Storyline**
- demographic change
- economic development
- technological change
- policies

**Population**

**Economy**

**National level Projections**

**G4M**
- spatially explicit forest management model

**GLOBIOM**
- integrated agricultural, bioenergy and forestry model

**MESSAGE**
- systems engineering model (all GHGs and all energy sectors)

**GAINS**
- GHG and air pollution mitigation model

**MACRO**
- Aggregated macro-economic model

**MAGICC**
- simple climate model

**Socio-economic drivers**
- consistency of land-cover changes (spatially explicit maps of agricultural, urban, and forest land)
- carbon and biomass price
- agricultural and forest bioenergy potentials, land-use emissions and mitigation potential
- emissions
- air pollution emission coefficients & abatement costs
- demand response
- iteration
- energy service prices
- socio-economic drivers

Graphic courtesy of Volker Krey (IIASA)
Generated a large scenario ensemble

>600 unique scenarios spanning the feasible scenario space (energy-climate-pollution-security futures)

Synergies of energy efficiency and decarbonization accrue in multiple dimensions

1. Co-benefits for air pollution and human health
   → improved air quality
   (22-32 million fewer disability-adjusted life years globally in 2030)

2. Synergies for improved energy security
   → more dependable, resilient, and diversified energy portfolios

3. Cost savings and spillovers
   → up to $600 billion/yr globally in reduced pollution control and energy security expenditures by 2030 (0.1-0.7% of world GDP)
An integrated approach saves >$5 trillion (~0.5% of GDP)

Global costs rise with the ambition of the mitigation goal

Source: Figure 6.21, Table SPM.2
Questions?
Comments?

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