Pathways to Sustainable Energy Project
Project Kick-off and Scenario Scoping
14 June 2017, Astana
Agenda

- Project Overview
- Modeling Approach, Models
- Review: Storylines, Scenarios and Target Definition
Project Overview

• Objectives and approach
• Implementation phases
• Stakeholder engagement
Project Overview
Pathways to Sustainable Energy

- Timeframe: May 2017 – Dec 2018
- Expected accomplishments
  - (1) Modelling of Sustainable Energy Scenarios
    *Enhanced understanding of the UNECE member States of alternative pathways for transitions to a sustainable energy future.*
  - (2) Conceptualisation of an early-warning system
    *Enhanced knowledge of member States to apply early-warning indicators and a mechanism to track implementation of national contributions towards reaching common goals.*
  - (3) Policy Dialogue and Formulation of Adaptive Policy Pathways
    *Increased capacities of national energy ministries to develop, implement and track national sustainable energy strategies.*
- Key deliverables
  - Energy scenarios modeled based on UNECE-SSP merged storylines
  - Definition of adaptive policy pathways
  - Development of policy and technology options / technology portfolio, roadmap
  - KPIs to conceptualize early-warning system to track progress
  - 2-4 energy expert workshops to define and discuss policy options
  - High-level policy dialogue planned for 2018
Project Stakeholders
Pathways to Sustainable Energy

- **Project Steering**
  - CSE Bureau; Advisory Board

- **Project Coordination**
  - ECE SED Secretariat

  - **Independent expert community**

  - **Technological Zoom-In**
    - Full technology portfolio & technology zoom-ins

  - **Geographical Zoom-In**
    - Global & selected sub-regions (subset 1)
    - Global & selected sub-regions (subset 2)

Subset one is for North America (in addition to a global model that is required).
Subset two is for the Eurasian part of the UNECE region including Western and Central Europe, Eastern Europe, Southeastern Europe, Caucasus, Central Asia, Russian Federation, Turkey, Israel (in addition to a global model that is required).
Global Modelling
Regional subsets
- North America
- Western Europe
- Central and Eastern Europe
- Southeast Europe
- Caucasus
- Central Asia
- Ukraine, Belarus, Moldova
- Russian Federation
- Turkey
- Israel

See countries in each cluster here: [http://data.ene.iiasa.ac.at/message-globiom/message_globiom/overview/spatial.html](http://data.ene.iiasa.ac.at/message-globiom/message_globiom/overview/spatial.html)
**UNECE**
- Overall project coordination
- Policy dialogues
- Project steering (CSE)

**IIASA**
- World Model (MESSAGE)
- Regional and thematical zoom-ins

**PNNL**
- World Model (GCAM)
- Regional and thematical zoom-ins

**Fraunhofer**
- Full technology portfolio survey
- Technological zoom-in for system integration technologies
- International coordination of modelers
Pathways to Sustainable Energy
Project Implementation Phases

**Trends**
May 2017 – Dec 2017

- **Sustainable Energy Storylines**
  - Definition of trends & uncertainties
  - Narrative Descriptions

- **Research Questions (Case Studies, Deep Dives)**
  - Definition of particular thematic or sub-regional aspects, policies
  - Definition of research questions

- **Technology Assessment**
  - Trends and cost evaluations for sustainable energy technology options

- **Energy Policies Research**
  - Current policies
  - Other policies (NDCs, energy related)

**Analysis**
June 2017 – Oct 2018

- **Modelling / Assessment**
  - Energy scenarios: energy supply, demand, technology mix, costs, climate budget, etc.
  - Modelling / testing of policy options
  - Topical / Sub-regional deep dives

- **Policy options**
  - 2-3 Policy energy expert workshops

**Results**
Nov 2017 – Dec 2018

- **Adaptive Policy Pathways**
  - Policy Briefs
  - Policy dialogues

- **Case Studies / Deep Dives Results**
  - 3-5 selected SE Scenarios

- **Technology Pathways**
  Portfolio, Roadmap

- **Early-Warning System**
  - Defining KPIs
  - Concept development

**Engagement of Energy Expert Community**

- Storylines
- Technology trends
- Policies

- Defining assumptions / indicators
- Developing policy options
- Policy energy expert workshops

- Outreach
- Policy dialogues

May 2017 – Dec 2017
June 2017 – Oct 2018
Nov 2017 – Dec 2018
Project Timeline

Engagement with the Expert Community

May 2017

- Modeler Kick-off Workshop
  Oberhausen, May 2017

- Kick-off & Expert Workshop at 8th IFESD
  Astana, Jun 2017

Dec 2018

- Policy Dialogue at CSE
  Discuss policy options & pathways
  Geneva, Sep 2018

- Expert Workshop - tbc
  Discuss technology & policy options
  tbd, Q1 2018

- Expert Workshop at 9th IFESD
  Derive / discuss policy options / pathways
  Ukraine, Q3 2018

- High-level Political Dialogue
  Russia (tbc), Q1 (2019)

CSE = Committee on Sustainable Energy
Modeling Approach, Models
Project Outline
Technological Portfolio and Zoom-In (2017)

Technology Portfolio
• Nuclear energy, hard/soft coal, natural gas, oil, biomass, wind, solar, CCS/ CDR, energy efficiency technologies in final energy uses etc.
• Description of state of the art
• Key parameters (Fuel costs, Capex, Efficiency (energy output/input))

Data input:
• Literature (meta-analysis); comparison of results with data used in models

Data output:
• Market share, global / regional energy demand & consumption, CO2 emissions
Project Outline
Technological Portfolio and Zoom-In (2017)

Technology Zoom-In

- Energy Storage, Power2X, CCS / CDR technologies
- Energy Efficiency

Data input:
- Literature (meta-analysis); comparison of results with data used in models

Data Output:
- State of the art (Power2X, storage)
- **Overview** on CCS/CDR technologies & energy efficiency potentials by sectors: buildings, industry, appliances, transport
- Expected development of currently available technologies plus cutting edge technologies with the potential to play a significant role in future energy systems
- **Technological relevance**: regional case studies, global/regional technology demand, market penetration/spatial share of technologies
- **Technology cost**: Current and future cost figures, Capex evolution, Development of marginal abatement cost curves
Disaggregation of the FSU region into Russian Federation, Central Asia, Caucasus and sub-region Ukraine, Belarus and Moldova.

- Base year energy flows and generation mix calibration
- Add and aggregate current and expected national policies
- Make sub-regions consistent with SSP2 scenario (2015-2050/2100)

- Update technology portfolio to reflect imminent deep technology dives (input Fraunhofer) for all 14 IIASA model regions
- Ensure consistency/harmonization of technology and scenario assumption among PNNL/IIASA & Fraunhofer
- Modelling and testing of ‘Research Questions’
- Testing adaptive policy pathways as well as KPIs
- Present to, and discuss with, UNECE and stakeholders, initial set of scenario outcomes (1st Q 2018)
- Based on feedback received refine workplan for 2018
MESSAGE is a dynamic, multi-period optimization model. It is a bottom-up systems engineering model designed for medium- to long-term energy system planning, energy policy analysis, and scenario development. MESSAGE currently features 11 world regions covering the entire globe. It is a scenario-oriented energy system model; scenarios are developed through minimizing model total discounted energy system costs under a set of engineering and user defined constraints imposed on the energy system. Future demands for energy services is one of the key scenario inputs. MESSAGE provides information on the utilization of domestic resources, energy imports & exports, investment requirements, technologies selected, pollutant emissions, etc. It informs the user if policies imposed on the model are ‘technically’ and financially feasible (and if, at what costs and trade-offs). The model takes into account existing installations, their vintage and retirement schedules. The optimisation process, then determines the need for new generating capacity and the investment requirements.
As part of IIASA’s Integrated Assessment Framework

MESSAGE

IIASA Integrated Assessment Framework

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

National level Projections
Population
Economy

MAGICC
simple climate model

GAINS
GHG and air pollution mitigation model

GLOBIOM
integrated agricultural, bioenergy and forestry model

G4M
spatially explicit forest management model

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

MACRO
Aggregated macro-economic model

MESSAGE-Access
consumer fuel-choice model

socio-economic drivers

socio-economic drivers

carbon and biomass price

agricultural and forest bioenergy potentials, land-use emissions and mitigation potential

consistency of land-cover changes (spatially explicit maps of agricultural, urban, and forest land)

emissions

air pollution emission coefficients & abatement costs

demand response

iteration

energy service prices

Slides: IIASA
**MESSAGE**

**Inputs and Outputs**

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**INPUT**

- Energy system structure (including vintage of plant and equipment)
- Base year energy flows and prices
- Energy demand projections (e.g. MAED)
- Technology and resource options & their techno-economic performance profiles
- International fuel market prices
- Technical and policy constraints
- Subsidies, taxes and feed-in tariffs
- ...and much more

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**OUTPUT**

- Primary and final energy mix by fuel
- Electricity generating mix by technology and fuel
- Capacity expansion/retirement
- Emissions & waste streams
- Resource use (energy, water, land, etc.)
- Trade & import dependence
- Investment requirements
- Prices
- .... and much more

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Mathematical Formulation behind MESSAGE:
GCAM - The Global Change Assessment Modeling Framework

GCAM: a global integrated assessment model

- Links economic, energy, land use, water, and climate systems
- 32 geopolitical regions
- 283 land-use regions
- 233 water basins
- Runs through 2100 in 5-year time steps
- Emissions of 24 GHGs and short-lived species
- Used to analyze consequences of interdependencies between human and Earth systems
  - Energy, climate, and other policies
  - Socioeconomic development
  - Technology and resource changes
  - Climate impacts and adaptation
- Community model
- Developed and housed at the Joint Global Change Research Institute, research collaborations

Slides: PNNL
## Scenario Assumptions

- Socioeconomic development
- Energy, land use, and water technologies
- Policies
- Resources

### Scenario Outputs

- Prices, quantities
- Energy production
- Agricultural demand and production
- Land use
  - Crop (by type)
  - Pasture
  - Forest
  - Unmanaged
- Water demand
- Greenhouse gas emissions
- Economic indicators
  - Income transfer
  - Policy costs

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**GCAM Inputs and Outputs**

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<td>Socioeconomic development</td>
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<td>Policy costs</td>
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Data Inputs from countries
Seeking support

- National energy statistics, energy and electricity balances (if different from IEA)
- Current national policies (energy, environment, NDCs, other relevant development policies)
- (Large) energy projects under construction, advanced planning
- A contact person for potential future interaction

please send to lisa.Tinschert@unece.org
Review: Storylines, Scenarios, and Target Definition

• UNECE Sustainable Energy Storylines
• Key challenges of defining Sustainable Energy
Visionary Storylines (narratives)

Overview

A

- Energy service-based business models with innovative enabling technologies
- Low amount of cooperation in meeting sustainable development goals

B

- Energy service-based business models with innovative enabling technologies
- High amount of cooperation in meeting sustainable development goals

C

- Traditional energy commodity business models with slow technological innovation
- Low amount of cooperation in meeting sustainable development goals

D

- Traditional energy commodity business models with slow technological innovation
- High amount of cooperation in meeting sustainable development goals

Middle of the Road

SSP 2: (Intermediate Challenges)
**Visionary Storylines (narratives)**

**DRAFT Summaries**

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| **A** | Innovative but less cooperative  
Technology development and innovation in home markets, with service-based business models and decarbonisation of fossil fuels and system-wide efficiency. |
| **B** | Innovative, collaborative and green  
Service-based business models with emergence of energy “prosumers”, increased decentralisation, increased trade and interconnection, aggressive application of innovative low-carbon technologies. |
| **C** | Focusing inward: Energy independence fueled by fossil energy  
Strong acceleration of energy efficiency measures from source to use; focus on domestic energy sources and energy independency / security. |
| **D** | The conservatives: Progress step by step  
Sustained high penetration of fossil fuels in the energy system with increased application of decarbonisation approaches based on technology transfer; extension of networks and collaboration |
Shared Socio-Economic Pathways (SSPs)

Overview

- **2007-2013:**
  Development of narrative socio-economic scenarios, to derive emissions scenarios without and with climate policies

- **Purpose:**
  Integrated analysis of future climate impacts, vulnerabilities, adaptation, and mitigation

- **2013-2016:**
  Quantified datasets for Population and GDP Growth, Urbanisation

Full SSP database available online: [https://tntcat.iiasa.ac.at/SspDb/dsd?Action=htmlpage&page=welcome](https://tntcat.iiasa.ac.at/SspDb/dsd?Action=htmlpage&page=welcome)
SSP2: Middle of the Road
Overview

• SSP2 does not imply a simple extrapolation of recent experience, but rather a development pathway that is consistent with typical patterns of historical experience observed over the past century. Social, economic, and technological trends follow historical patterns:

• Global population growth is moderate and levels off in the second half of the century;

• **Moderate population growth**, persisting income inequality

• Most economies are politically stable; Globally connected markets function imperfectly. **Medium economic growth**

• **Slow progress in achieving SDGs**

• Environmental systems degrade, overall resource & energy intensity declines.

• Even though fossil fuel dependency decreases slowly, there is no reluctance to use unconventional fossil resources.

• Technological progress continues without major slowdowns or accelerations.
Target Definition: Sustainable Energy
Draft: 3 Components

Energy Security

- Supply to meet demand (but differing conceptualisations)
- ...

Sustainable Energy

- Air pollution control
- Climate commitments
- ...

Quality of Life

- Energy affordability
- ...

Environmental Sustainability
Building the Scenarios, based on SSP2

Drivers (Inputs)

- **Meta Drivers** (underlying characteristics of energy system)
  - International Cooperation (degree of openness to trade)
  - Innovation (technology costs development, changes in efficiency, business models)

- **Drivers (Range definitions)**
  - Energy efficiency (end-use, conversion)
  - Energy Storage
  - Electric Vehicles
  - Abundance of fossil fuels (all types), extraction costs
  - CCS (incl. BECCS)
  - Power to X (efficiency, CapEx)
  - Nuclear
  - Renewable energies (BM, non-BM, system integration, CapEx, efficiency)

- **Policies**
  - Subsidies (carbon price, taxes, etc.)
Building the Scenarios, based on SSP2
Indicators (Outputs)

- **Indicators**
  - Final energy intensity (SDG7)
  - Carbon intensity (SDG13)
  - Carbon budget (temperature change)
  - Energy prices
  - Share of RE (SDG7)
  - Investment requirements (SDG7)
  - Energy imports and exports
  - Food prices / consumption (SDG2)
  - Energy access (energy use?) (SDG7)
  - Water use of energy sector (SDG6)
  - Pollutants (SDG9)
Focal question: How can countries attain sustainable energy?

- Role of FF in a future sustainable energy system
- Methane leakage from extraction, transmission, distribution
- Competitiveness of RE compared to FF; synergies of RE & FF; RE grid-integration; RE and Gas
- Energy efficiency policies as enabler for other policies / holistic approach
- Investment requirements to attain certain level of RE, changing of investment patterns for transition towards SE system
- Quantum leap of technologies: Technologies as game changer
- Sub-regional topics to be defined
- Others
Thank you!

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Date 14 I 07 I 2017, Astana