NASA Energy Management
Stakeholder Ideation Workshop

Diverse Challenges for the Energy Sector

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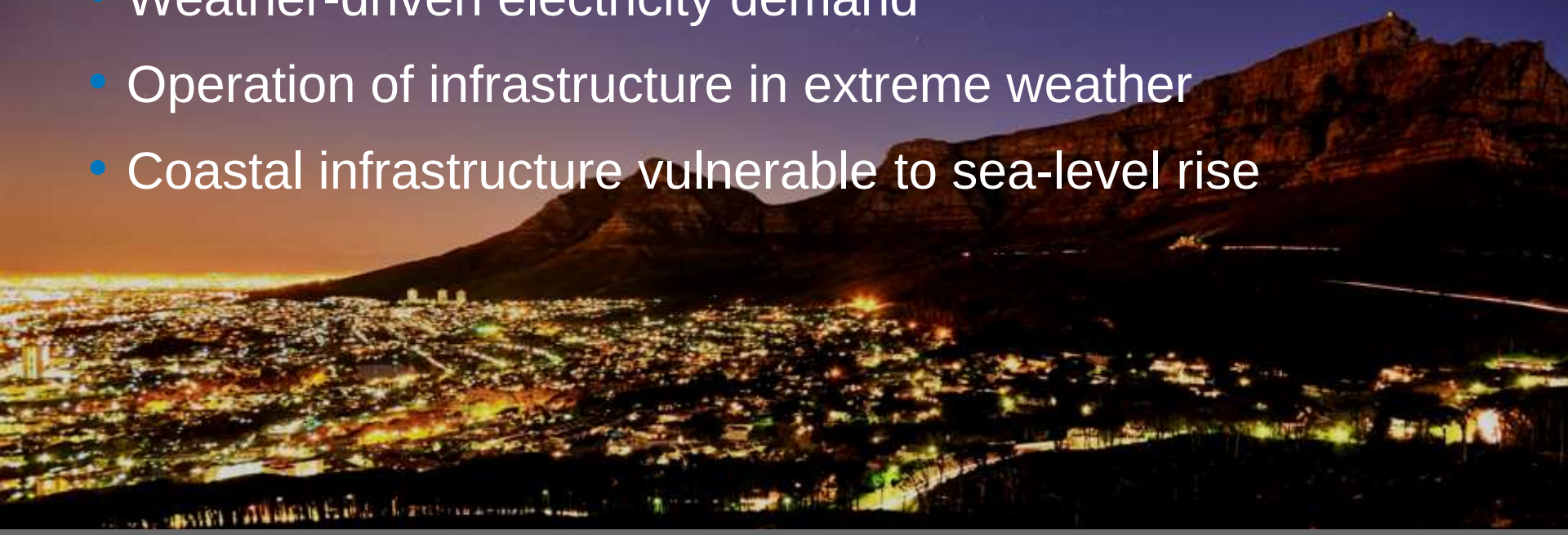
Challenges to the Energy Sector

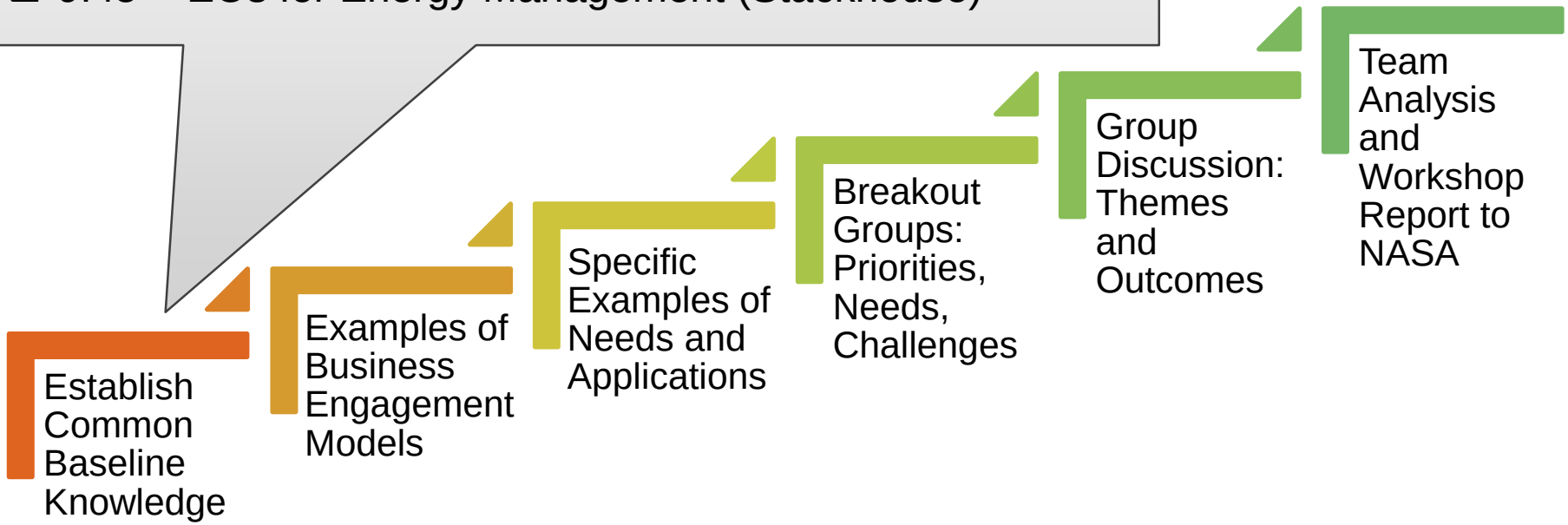
Most challenges to the energy sector can be informed by Earth observations.

- Renewable resource availability (solar, wind, hydropower)
- Weather-driven electricity demand
- Operation of infrastructure in extreme weather
- Coastal infrastructure vulnerable to sea-level rise



Towards Ideation Workshop Outputs

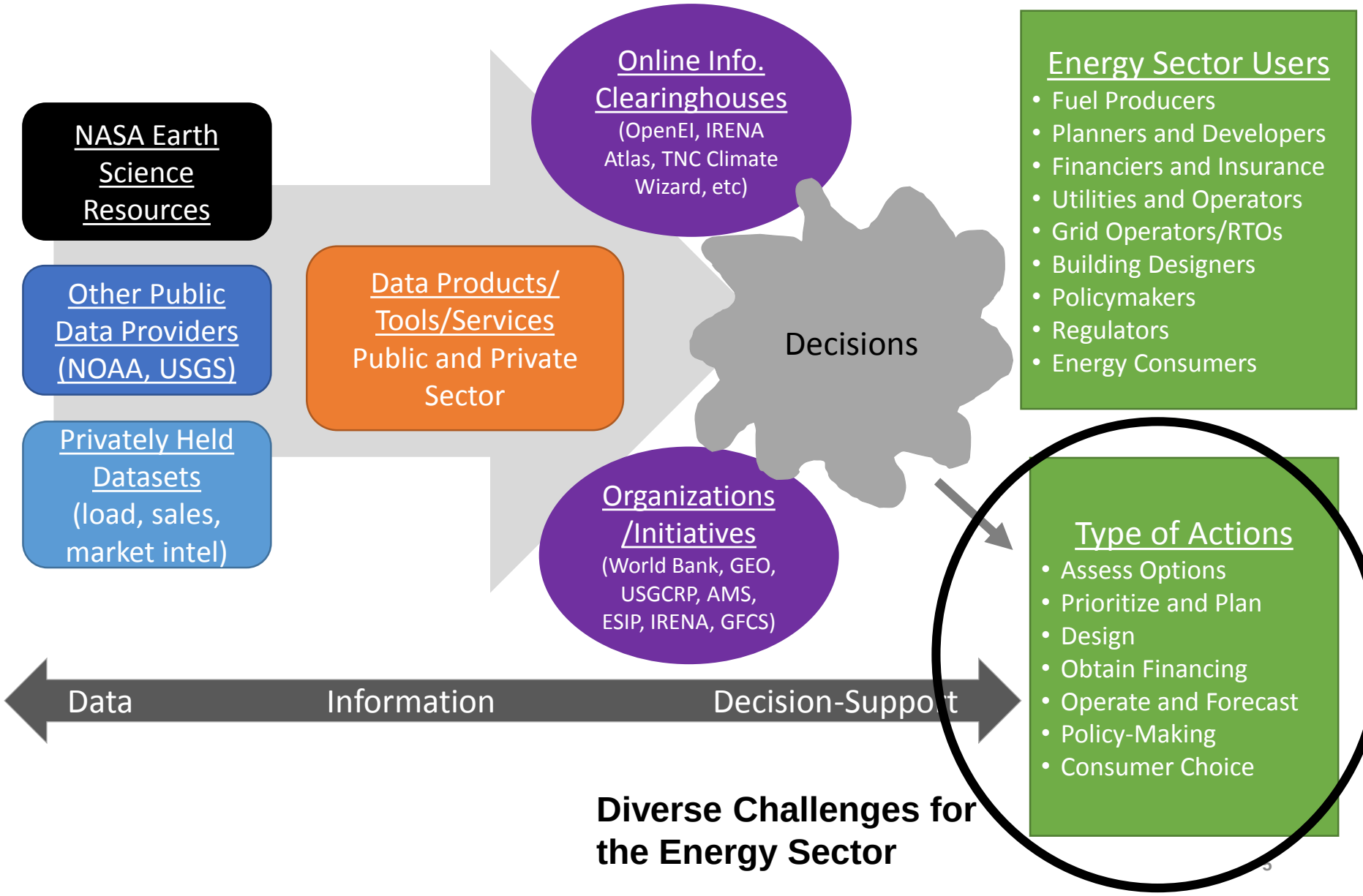
- ❑ 9:20 - **Diverse Challenges for Energy Sector (Zell)**
- ❑ 9:45 - EOs for Energy Management (Stackhouse)



Linking Energy Sector Challenges with Earth Observations

- Provide common starting point for afternoon breakout discussions on:
  - Current applications of Earth observations for Energy Management which could be improved/expanded:
    - By NASA
    - By other space and meteorological agencies
  - Unmet needs that could benefit from NASA Earth observations:
    - Low-hanging fruit
    - Mid-term to longer-term opportunities
- By the nature of your organization and experience, you will know about different categories of the above….

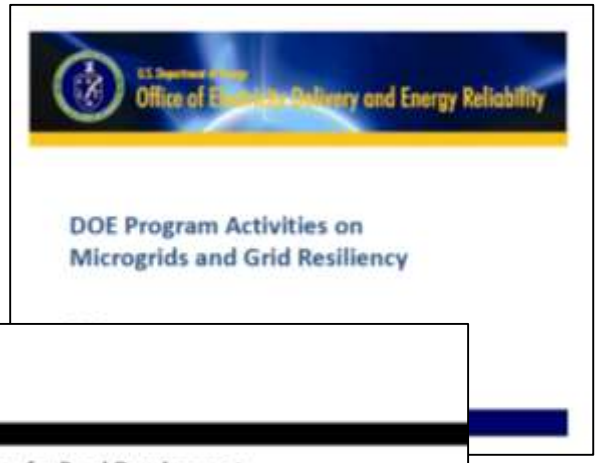
Energy Sector Decision Support Data Flow

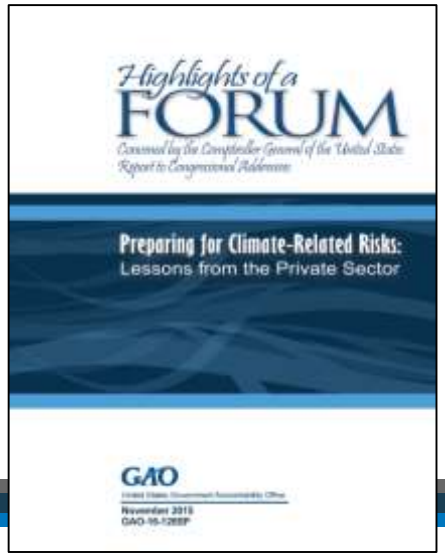


Diverse Challenges for the Energy Sector

Our Methodology

- Refined energy sub-topics based on rapid changes or expansions, new EOs
- Online literature search (reports, journal articles, presentations)
- Attendance at relevant workshops, committees
- Consultations with 8 speakers
- Pre-workshop questionnaire responses (11)



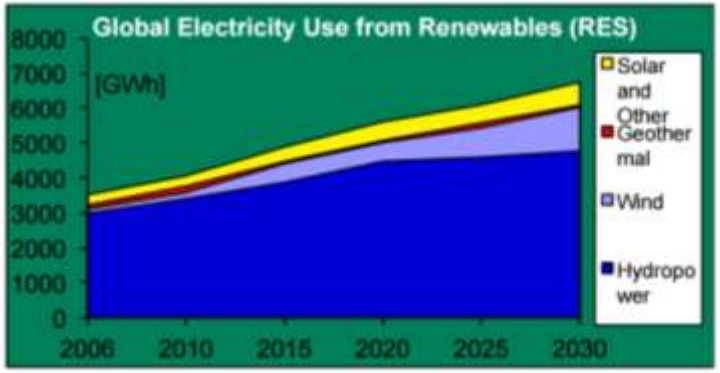


Sub-topic 1: Renewable Energy (RE)

Relevant EOs:

Weather, solar, water cycle parameters

For country resource assessments for policy-making, pre-feasibility studies, project siting, design, and operations



Source: Space-Tec 2013

Example priority needs: (solar)

- Real-time clouds for solar forecasting, especially 0-30 min (nowcasting)
- Predict significant ramping events from sudden wind and solar changes
- Need to increase confidence in solar forecast accuracy

Sub-topic 1: RE (cont.)

Example Stakeholders and Decision Support Systems:

- Power plant developers, financers, and insurers, electric utilities, electric grid operators, technology developers, researchers, policymakers, and regulators
- Resource assessment specialists
  - Value-added providers contribute specialized expertise in data analysis and validation, visualization, and other services
  - Clean Power Research, GeoModel, Viasala
- International Renewable Energy Agency (IRENA) Global Solar and Wind Atlas

Sub-topic 2: Building Energy Efficiency

- Approximately 41% of total U.S. energy consumption in 2014 was used for building heating, cooling, and lighting. (Source: EIA)
- Emphasis on reduction of GHGs has increased attention on building energy efficiency.

Relevant EOs:

Especially surface weather, climate, and solar resource data

Historical data (climatology), potentially near-real time data for applications with Smart Grids

Example priority needs:

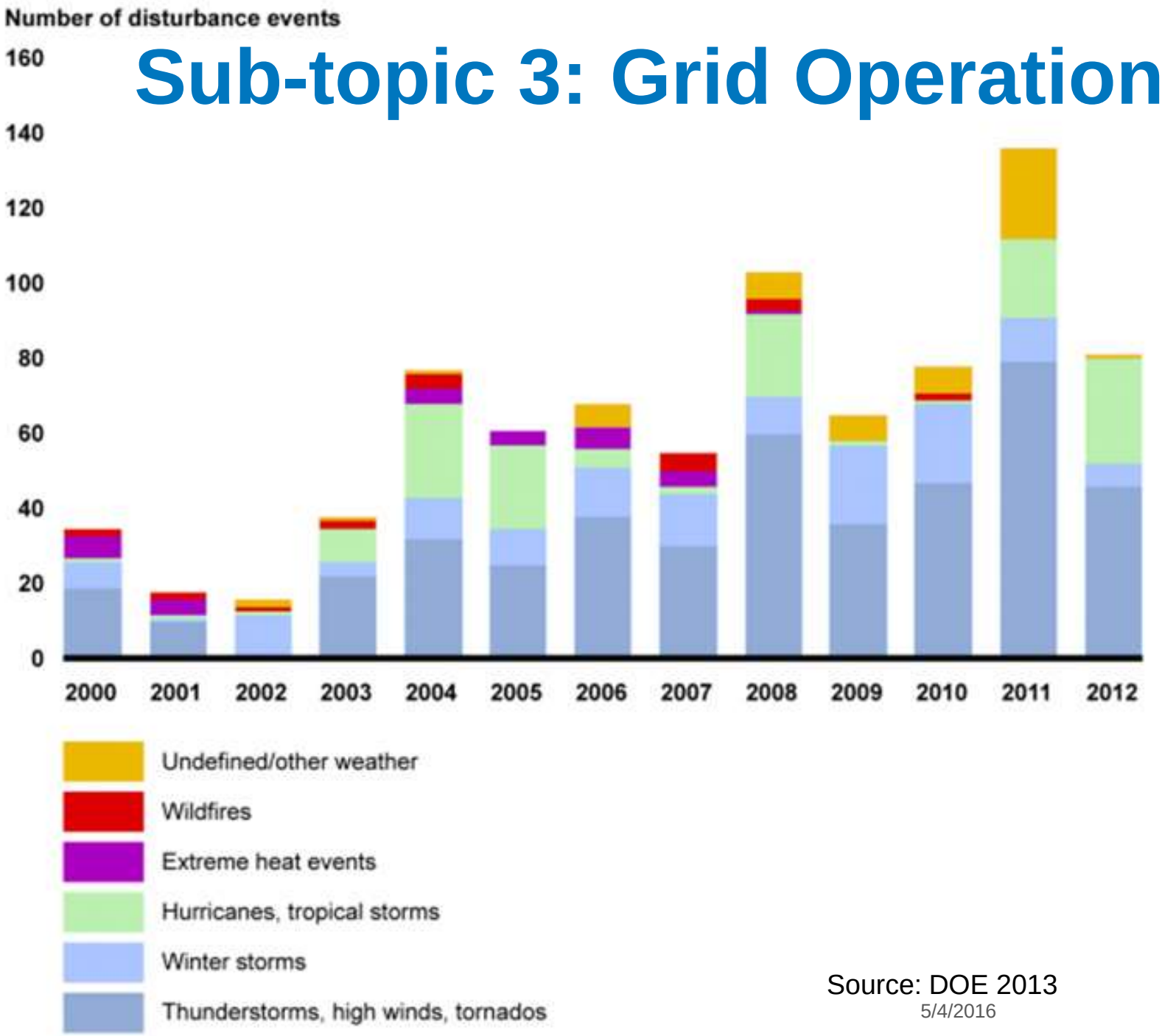
Climate Zones, and heating and cooling degree days (including any shifts from climate change)

Sub-topic 2: Energy Efficiency (cont.)

Example Stakeholders and Decision Support Systems:

- City governments- focused on improving building energy efficiency to reduce GHGs
- Building design software and other software (e.g., RETScreen Clean Energy Management)
- National Renewable Energy Laboratory's EnergyPlus Simulation Program which incorporates weather data and ASHRAE Design Conditions Design Day Data file
- DOE's Building Performance Index on energy-related characteristics of commercial and residential buildings
- State and Local Energy Efficiency Action Network

Sub-topic 3: Grid Operation



Source: DOE 2013

Sub-topic 3: Grid Operation

Relevant EOs:

Surface weather forecasts: temp, rainfall, wildfires, ice accumulation, wind speed, wind and solar forecasting, severe weather

In the U.S., imperfect weather forecasts can have an impact on the electricity generation industry by as much as US$1 million per degree Fahrenheit (missed) per day.
Source: Letendre et al 2014

Land surface information: high-resolution aerial photography, high resolution orthophotos, oblique imagery and LiDAR

Example priority needs:

Distributed solar generation output integrated with load forecasting software

Vegetation around transmission lines

Sub-topic 3: Grid Operation (cont.)

Example Decision Support Systems:

- Value-added providers - software and services for grid studies, smart grids, load balancing, renewable integration
  - E.g., ETAP Smart Grid Solutions Software, Gridquant Software Tools
- Transmission siting and planning tools and methods:
  - Public web map services such as Google Earth
  - Electric Power Research Institute-GTC Siting Methodology
  - Corridor Analyst 9, an extension to ArcGIS designed by Photo Science
  - eTAMIS, an online software built on ESRI's ArcGIS platform that supports high-voltage transmission line facilities management
  - Transmission Business Line tool - Bonneville Power Administration

Sub-topic 4: Energy Sector Climate Vulnerability and Resilience

U.S. energy supply chain includes:
- 6,600 operational power plants
- 144 operable refineries
- 2.6 million miles of pipelines
- 160,000 miles of transmission lines

Executive Order 13653: (2013) Preparing the United States for the Impacts of Climate Change
Instructs Federal agencies to provide the information, data, and tools that local, state, and private sector leaders need to improve preparedness and resilience in critical systems.

Relevant EOs: Climate, etc.

Example priority needs:

- Extreme weather event information
- Shifts in weather-related electricity demand and supply (near-real time, to seasonal, decadal)
- Sea-level rise, increased storm surge projections
- Water availability and surface water temperature

Sub-topic 4: Vulnerability & Resilience

Example Priority Needs: (cont).

- Updated design criteria for warming permafrost and more intense storms
- Thermal predictive models into reservoir level forecast
- Improved forecasts of snowmelt
- Extreme temperature scenarios for electric grid planning
- Better assessment of flooding and wildfire prone areas
- Agreed-upon set of down-scaled climate change and impact scenarios available for local or regional use

Sub-topic 4: Vulnerability & Resilience

Example Decision Support Systems:

- Data sources and tools are generally cited as lacking or misunderstood, or are being borrowed from other related energy sector planning data sources, utilized before climate resilience entered the picture

Example of Needs Assessment:

2015 DOE Report: ***Climate Change and the U.S. Energy Sector: Regional Vulnerabilities and Resilience Solutions***

- **Lack of relevant information:** Available information is insufficient to identify vulnerabilities and support informed decision making.
  - "Climate Scenarios" for inputs to decision-making (with uncertainties)
  - 30-year planning horizon, flexible risk-based planning methods
- **Poor understanding of costs and benefits of resilience technologies and practices**

Sub-topic 5: Modern Energy Access in Developing Countries

Sustainable Development Goal 7:
Ensuring access to affordable, reliable, sustainable, and modern energy for all."

Approximately 1.3 billion people worldwide have no access to modern energy services, including no consistent access to electricity (frequent blackouts) and no access to modern, clean cooking fuels.
Source: IEA 2014

Relevant EOs:

Satellite-based resources for international development broadly (World Bank, NASA/USAID SERVIR Program)

Example Priority Needs:

EO needs related to universal energy access are not clearly identified

(Primarily a funding and policy issue)

Sub-topic 5: Modern Energy Access in Developing Countries

Example Decision Support Systems and Applications:

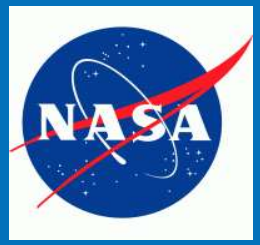
- Renewable resource mapping (World Bank ESMAP, NASA SSE, USAID Power Africa)
- Electric grid and distributed energy system design (HOMER Energy Microgrid Modelling Software, RETScreen)
- Tool - *Targeting Villages for Rural Development Using Satellite Image Analysis* to enable microgrid developers to analyze rural sites and plan infrastructure (Varshney 2015)
- Japan Aerospace Exploration Agency providing EOs for planning large dams and pipelines
- Satellite-based nighttime lights for electrification, blackouts

Take-away Messages

- Many of the needs are step improvements or expansions on current applications
- Climate vulnerability and resilience has a newer set of needs and less developed decision support systems to ingest EO data
- Modern energy access:
  - Needs (and datasets) highly developed in terms of renewable resource assessment, micro-grids, and hydropower
  - Needs less identified for large-scale grid design, expansion

Questions and Comments

Battelle
The Business of Innovation



Earth Observations for Energy Challenges

- Digital elevation models
- Land cover type and change, surface roughness/texture
- Offshore wind data and wave/current data (wave height, tides, bathymetery, current)
- Precipitation
- Cloud cover (cloud index)
- River and lake parameters (near-surface water temperature and sea-surface temperature, river flow, water run-off)
- Snow cover extent and snow water equivalent
- Soil moisture
- Groundwater storage
- Evaporation
- Solar irradiance (GHI, DNI, DHI, inclined plane radiation, circumsolar ratio
- Atmospheric composition including ozone, aerosol optical depth, and water vapor
- Wind speed, direction, shear, turbulence, and air pressure (e.g., at 10m, 50m 80m, 120m above ground level)
- Synthetic aperture radar images
- Temperature (land surface and air)
- Numerical weather prediction models and cloud imagery analysis (solar forecasting)
- Seasonal to inter-annual to decadal and longer climate projections, particularly solar irradiance, precipitation, and wind

EO data to address the challenges

- Some “needs” are for Earth observation (EO) data itself
  - Other “needs” are for specialized products with high/er certainty
  - Some “needs” are for model outputs that rely on EOs
  - Other “needs” require integration of EOs into cost-benefit studies
- Some “needs” simply require connecting users with data, or customizing datasets and increasing accessibility
- Other “needs” require more basic research, or initial test applications to assess potential benefit

Example EO- Energy Applications

- Application of weather and climate data and projections along with satellite-derived land cover analysis for **energy efficiency and electric load forecasting and planning**
- Application of cloud, aerosol, water vapor, and other datasets and models for **solar resource assessment**, site selection and project design, forecasting, and operations support
- Application of numerical weather forecasts, cloud information, and other datasets for **wind resource assessment**, site selection and project design, forecasting, and operations support
- Application of satellite imagery, snow and ice products, and water resource data and modelling for **hydropower applications**
- Application of heliosphere measurements for **solar storm forecasting** as it impacts the electric grid

Example Applications (cont.)

- Application of weather and climate data and projections along with satellite-derived land cover analysis for **energy efficiency and electric load forecasting and planning**
- Emerging applications for energy sector **climate vulnerability analysis**, including sea-level rise and coastal change data and projections, shifts in climate zones, increased variability of renewable resources, extreme weather impacts to operations

(OUT OF SCOPE FOR TODAY)

- Application of climate, land, and vegetation parameters for **bioenergy assessment and forecasting**
- Application of land imagery and geologic datasets for **fossil fuel exploration and production** and **geothermal resource assessment**
- Applications on **environmental impacts** of energy production and use