The background of the slide is a grayscale photograph of a landscape. In the foreground, there are several palm trees. In the middle ground, a large, rounded mountain or hill rises against a bright, hazy sky. The overall scene is dimly lit, suggesting either dawn or dusk.

# **Access to Energy and its role in the WEF Nexus**

**66<sup>th</sup> Cairo Climate Talks**

# Overview

## Introduction

- Access to Energy
- Multi-tier framework of Energy Access

## The Nexus and the role of Energy

**Introduction**

**Access to Energy**

**&**

**Multi-tier framework**

# Access to energy – what does it encompass?

- **Proximity and availability** of modern energy sources, i.e. electricity, natural gas, liquid petroleum gas, biogas, ethanol
- **Availability of efficient end-user applications**, i.e. cooking units, lighting, water pumps, food processing, school & health facility appliances, energy-efficient housing/transport
- **Economy and security of supply**

*Access includes affordable and stable supply of clean energy, reliability of supply and quality*

# Broadening the view on access to energy

## Recent push to develop more comprehensive measures of energy access

- Capture the multidimensional and multi-tiered nature of Energy
  - (1) capacity
  - (2) duration and availability
  - (3) reliability
  - (4) quality
  - (5) affordability
  - (6) legality
  - (7) convenience
  - (8) health and safety

**1. Definition:** How to define affordable, reliable, and modern energy services

**2. Tracking:** How to measure the progress toward universal access

# Multi-tier framework of Energy Access

| Attributes of energy supply |                                | Tier 0                                                    | Tier 1         | Tier 2                   | Tier 3                                                           | Tier 4                                                | Tier 5    |  |
|-----------------------------|--------------------------------|-----------------------------------------------------------|----------------|--------------------------|------------------------------------------------------------------|-------------------------------------------------------|-----------|--|
| Capacity                    | Household electricity          | No electricity <sup>a</sup>                               | Very low power | Low power                | Medium power                                                     | High power                                            |           |  |
|                             | Household cooking              | Inadequate capacity of the primary cooking solution       |                |                          |                                                                  | Adequate capacity of the primary cooking solution     |           |  |
| Duration and availability   | Household electricity          | <4 hours                                                  | 4–8 hours      |                          | 8–16 hours                                                       | 16–22 hours                                           | >22 hours |  |
|                             | Household cooking              | Inadequate availability of the primary cooking solution   |                |                          |                                                                  | Adequate availability of the primary cooking solution |           |  |
| Reliability                 | Household electricity          | Unreliable energy supply                                  |                |                          |                                                                  | Reliable energy supply                                |           |  |
| Quality                     | Household electricity/cooking  | Poor quality of energy supply                             |                |                          | Good quality of energy supply                                    |                                                       |           |  |
| Affordability               | Household electricity          | Unaffordable energy supply                                |                | Affordable energy supply |                                                                  |                                                       |           |  |
|                             | Household cooking              | Unaffordable energy supply                                |                |                          |                                                                  | Affordable energy supply                              |           |  |
| Legality                    | Household electricity          | Illegal energy supply                                     |                |                          | Legal energy supply                                              |                                                       |           |  |
| Convenience                 | Household cooking              | Time and effort spent sourcing energy cause inconvenience |                |                          | Time and effort spent sourcing energy do not cause inconvenience |                                                       |           |  |
| Health and safety           | Household electricity          | Unhealthy and unsafe energy system                        |                |                          |                                                                  | Healthy and safe energy system                        |           |  |
|                             | Household cooking <sup>b</sup> | Level 0                                                   | Level 1        | Level 2                  | Level 3                                                          | Level 4                                               | Level 5   |  |

Source: World Bank, Spalding-Fecher et. Al. 2015

# The Nexus and the role of Energy

# The Nexus

A concept put forward to call for an integrated management of the three sectors by cross-sector coordination in order to

- reduce (unexpected) sectoral trade-offs
- promote the sustainable development of each sector

*--- Different from conventional decision-making practices in separate disciplines ---*

Coupled systems as a circle comprised of several subsystems

- Internal relationship analysis
- External impact analysis
- evaluation of the coupled system

→ **Resilience and Sustainability**



# The Nexus - interactions

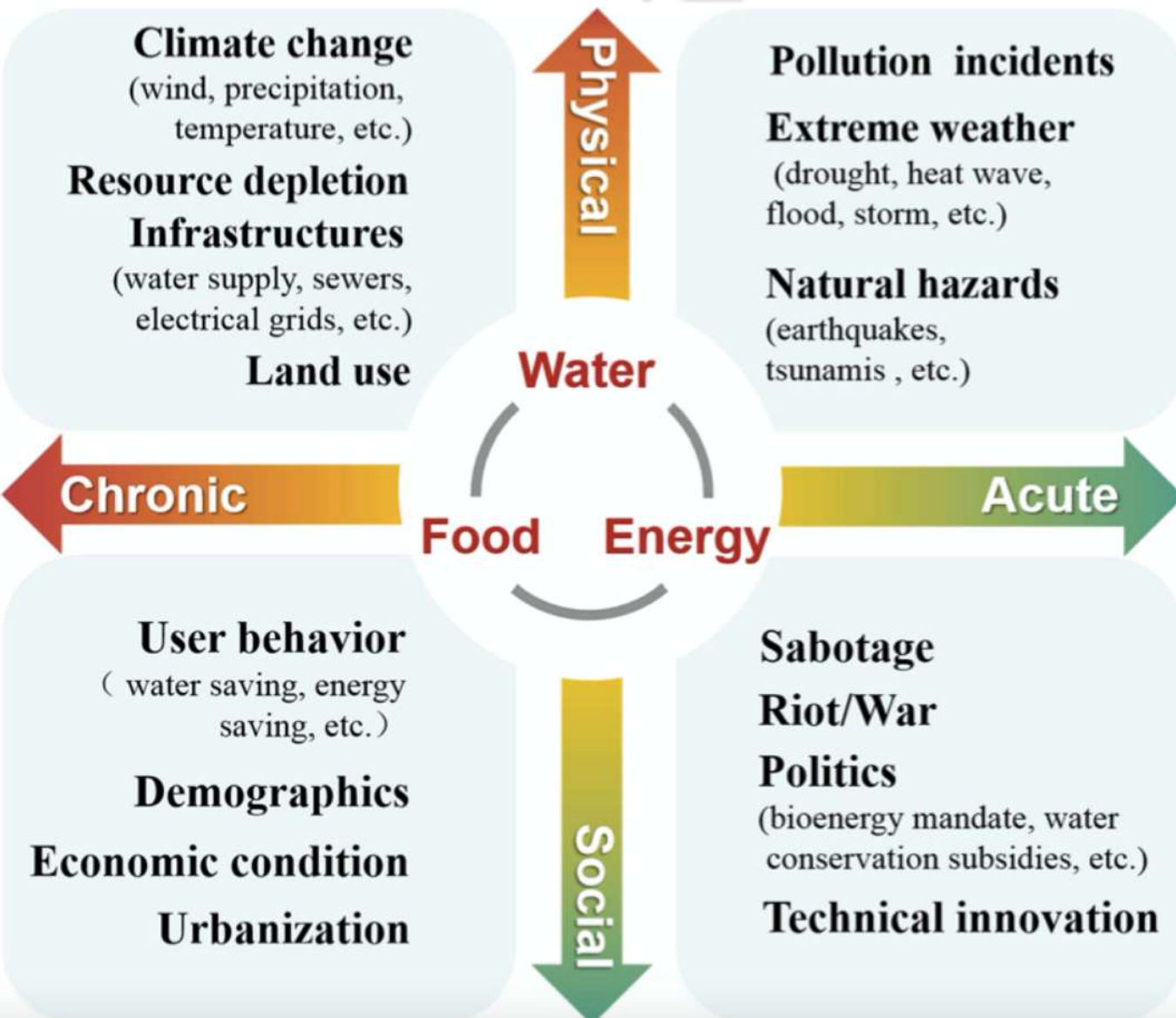
- Nexus system
  - Interdependencies between energy and water, as they are coupled in their supply, processing, distribution and use
  - System boundary extended to water-energy-food system (WEF)
  - Nexus can be defined as the interlink between water, energy and food
- Three perspectives to capture WEF interactions
  - The interconnected processes (e.g. physical and chemical)
  - The input-output relations during resource production
  - The interactions dominated by institutions, markets, and infrastructure

Security issues of these three sectors become more and more severe

→ Term emphasizes that failures in one sector may exert pressures on the other two

→ Requires a holistic management among these sectors

# Classification of external factors



## External Factors

- Population growth
- Climate change
- More extensive land use
- ...

Source: Zhang C, Chen X, Li Y, Ding W, Fu G, Water-energy-food nexus: Concepts, questions and methodologies

# Evaluation of the couple system

Except for internal and external impact analyses, assessment of the whole system performance

- **Resilience**
- **Sustainability**

→ field of current research

# Modelling approaches

| Research scale                     | Interdependency                                                                                                                                                                                                         | Research priorities                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Research methods                                                                                                                                                                                                                                 |
|------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Global scale                       | <ul style="list-style-type: none"> <li>• Water-energy</li> <li>• Food-energy-water</li> <li>• Climate-food-economy</li> <li>• Climate-water-energy-food</li> </ul>                                                      | <ul style="list-style-type: none"> <li>• Investigating impacts of consumption patterns (e.g. dietary shifts) and economic activities (e.g. trade)</li> <li>• Improving food/energy/water security given water-energy-food nexus</li> <li>• Climate change impacts and mitigation policy assessment and design</li> <li>• Ecosystem or sustainability valuation to help decision making</li> <li>• Development of integrated system modelling tools</li> </ul>                                                                                                                                         | <ul style="list-style-type: none"> <li>• Investigation and mathematical statistics</li> <li>• Computable general equilibrium model</li> <li>• Econometric analysis</li> <li>• Ecological network analysis</li> <li>• Integrated Index</li> </ul> |
| National scale                     | <ul style="list-style-type: none"> <li>• Water-energy</li> <li>• Food-water</li> <li>• Food -energy-water</li> <li>• Climate-energy-water</li> <li>• Climate-water-food</li> <li>• Climate-energy-water-land</li> </ul> | <ul style="list-style-type: none"> <li>• Investigating trade-offs underlying supply chains of water, energy, and food</li> <li>• Improving food/energy/water security given water-energy-food nexus</li> <li>• Climate change impacts and mitigation policy assessment and design</li> <li>• Demonstrating impacts of consumption patterns (e.g. dietary shifts) and economic activities (e.g. trade)</li> <li>• Promoting coherence in policy-making</li> <li>• Development of integrated system modelling tools</li> </ul>                                                                          | <ul style="list-style-type: none"> <li>• Investigation and mathematical statistics</li> <li>• Computable general equilibrium model</li> <li>• Econometric analysis</li> <li>• Life cycle analysis</li> <li>• System dynamics model</li> </ul>    |
| Basin scale                        | <ul style="list-style-type: none"> <li>• Water-energy</li> <li>• Energy-food</li> <li>• Energy-water-food</li> <li>• Climate-water-energy-food</li> </ul>                                                               | <ul style="list-style-type: none"> <li>• Manifesting nexus issues caused by resources allocation and promoting policy integration (e.g. expansion of biomass, water resource allocation between upstream and downstream countries, etc.)</li> <li>• Investigating trade-offs underlying supply chains of water, energy, and food</li> <li>• Improving resource use efficiency by resources recycle and novel technologies</li> <li>• Achieving long-term sustainability by managing trade-offs between water, energy, and food</li> <li>• Development of integrated system modelling tools</li> </ul> | <ul style="list-style-type: none"> <li>• Investigation and mathematical statistics</li> <li>• Life cycle analysis</li> <li>• Agent based model</li> </ul>                                                                                        |
| City scale<br>(or community scale) | <ul style="list-style-type: none"> <li>• Water-energy</li> <li>• Water-energy-food</li> <li>• Climate-food-energy-water</li> </ul>                                                                                      | <ul style="list-style-type: none"> <li>• Manifesting nexus issues inherent in urban metabolism</li> <li>• Revealing impacts of household uses (or end-use)</li> <li>• Identification of eco-friendly pathways to sustained economic growth</li> <li>• Improving resource use efficiency through resources recycle and novel technologies (e.g., renewable energy technologies, novel technologies in desalination and wastewater treatment, etc.)</li> <li>• Development of integrated system modelling tools</li> </ul>                                                                              | <ul style="list-style-type: none"> <li>• Investigation and mathematical statistics</li> <li>• Ecological network analysis</li> <li>• System dynamics model</li> <li>• Integrated Index</li> <li>• Physically based models</li> </ul>             |

# Modelling approach at community scale

- Social issues locally
- Contextual sensitivity possible to meet
- Community based approaches have the potential to be high in efficiency and high in impact given its tailored nature to the context (evidence from energy poverty)
- Allows to draw conclusions for higher levels, local policy to policy levels – from bottom-up approach to top levels
- Community-based approach builds capacities, leads to ownership, promises higher impact and sustainability

# Modelling approach – ABM

## Agent-based modelling

*“bottom-up” approach where every agent is a discrete autonomous entity with distinct goals and actions within a particular social context “*

- Modelling agents allows for the diversity that exists among agents/households in their attributes and behaviours at the bottom level
- System level can also be investigated through aggregation of all agents’ behaviours
- ABM breaks through the limitations of single-level and individual-perspective
  - provides a more realistic and effective modelling framework
  - describing and investigating complex systems by offering a way to model social systems
  - systems composed of numerous agents which can interact with and influence each other, learn from experiences, and adapt their behaviours to be better suited to their environment

# Agent-based modelling in practice

## **Decentralised energy supply**

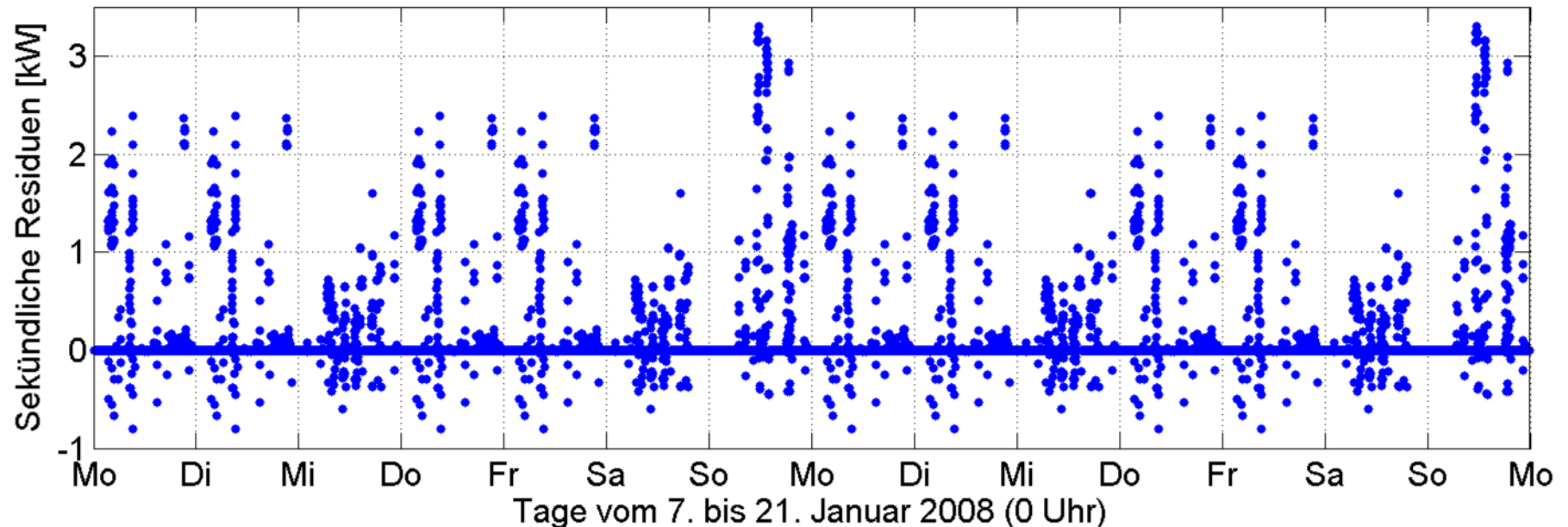
- Flexibility to adjust production to consumption of energy (more dynamic)
- Local production, closer to consumption, potential to use excess heat (higher efficiency, less losses in transport)
  
- Mass market for energy systems and reduced costs
- Higher number of energy systems lowers risk of outages (Resilience)
- Renewable advances in decentralized energy technology (Sustainability)

# Agent-based modelling in practice

What can a small energy production system in a household lead to?

→ Blue dot above the line – when there is too much energy produced for the household

→ Blue dot below the line – when there is too little energy produced for the household

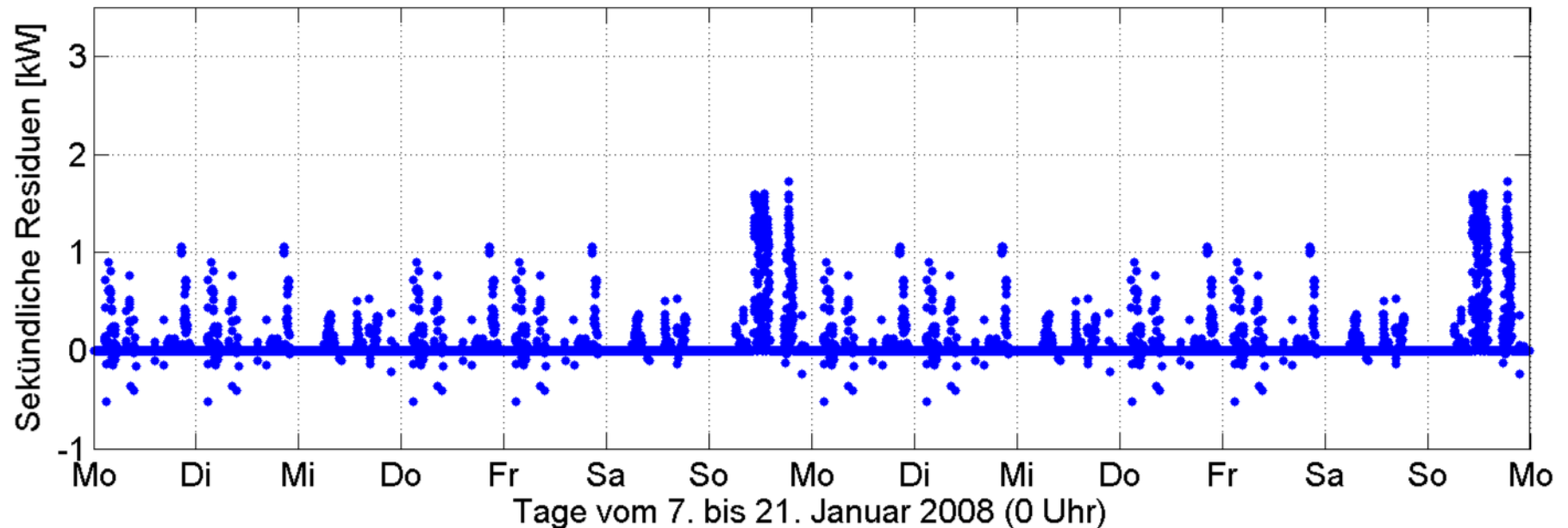




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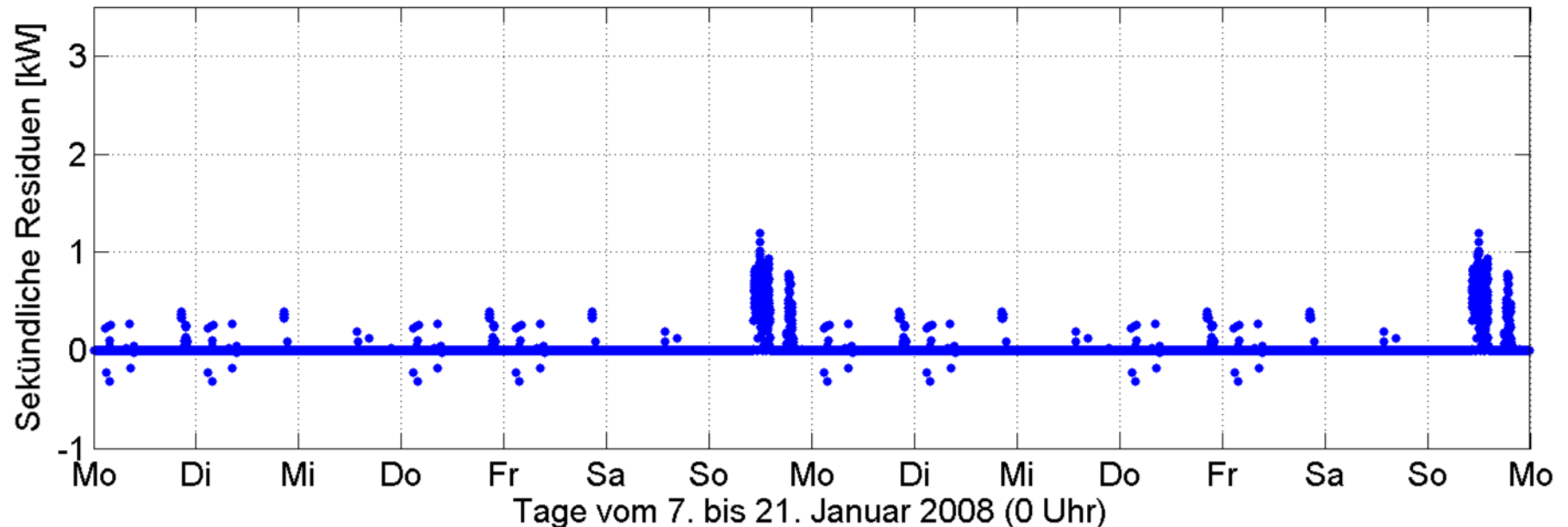


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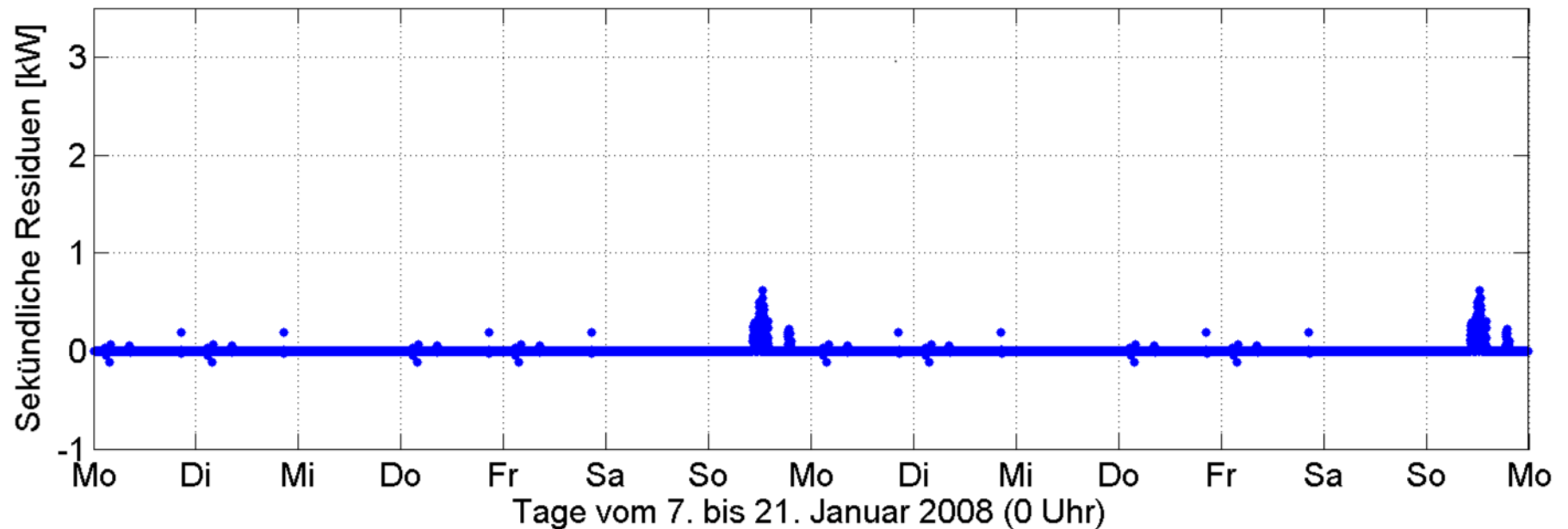


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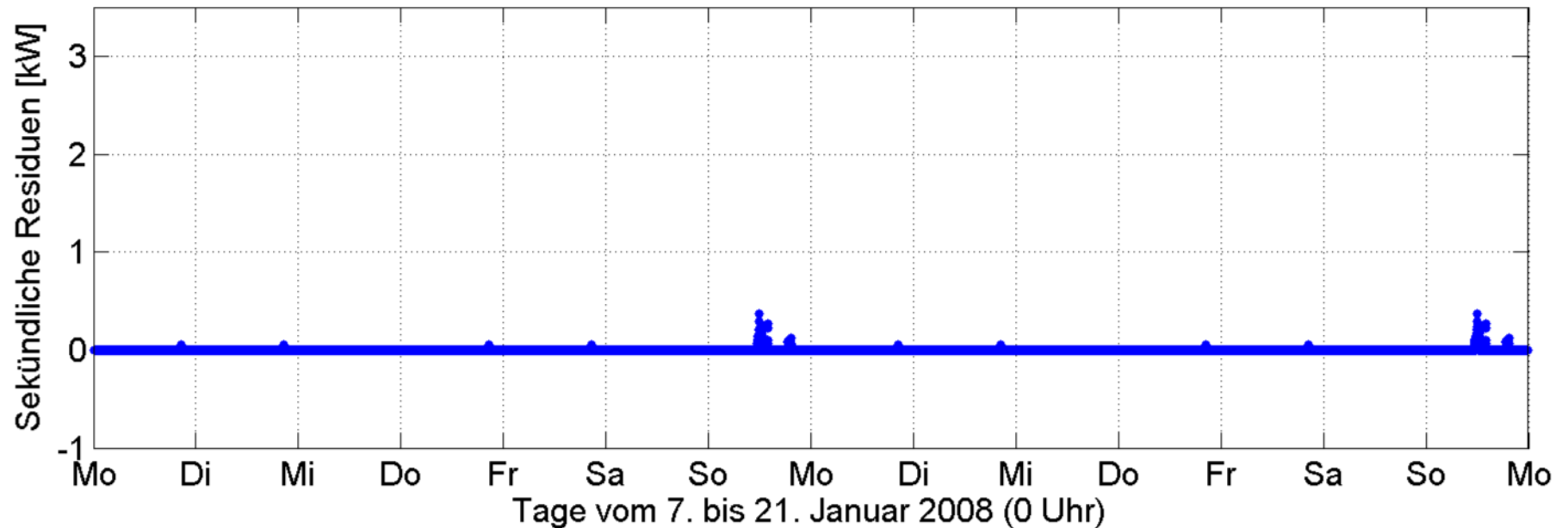


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# Challenges and chances

## Existing studies and methods offer promising outlook for WFE nexus

- Assessing trade-offs
- Predicting potential (unintended) effects
- Providing a co-optimization base for different stakeholders who often have conflicting interests
- Visualizing the impacts for informed decision making

## Limitations of current studies still exist

- Definition of the system boundary
- Data uncertainty and modelling (sensitivity analyses to the help?)
- Nexus mechanism (physical, chemical processes associated with resource flows as well as their supply chains, decision making mechanisms)
- System evaluation (evaluation of coupled nexus system, including assessment metrics and quantitative assessment approaches)

# Conclusions and the way forward

## Evaluation of the coupled nexus systems

- Urgent need to develop nexus-specific models to provide a better representation of nexus systems
  - Models need to go beyond partial description of feedback and interactions of nexus systems
- Nexus elements continue to expand
  - Given current data availability, such models are also required to have the ability to combine quantitative with qualitative data (insights locally into context, data requirements)
  - Integrated and flexible model for water-energy-food nexus, multiple stakeholders and decision makers should be engaged into modelling processes to incorporate valuable and timely information from different sectors
  - avoid ignorance of vital processes or interactions owing to the site-specific nature of nexus
    - **closer collaborations between sectors**

**Thank you. Do you have any questions?**

**Hudara gGmbH  
Rollbergstr. 26  
12053 Berlin  
Germany**

**T +49 (0)30 577 06310  
F +49 (0)30 577 063109  
E [hello@hudara.org](mailto:hello@hudara.org)  
W [www.hudara.org](http://www.hudara.org)**

**Managing Director: Dr. Lena Schmid  
Power of Attorney: Prof. Dr. Boris Heinz  
Charlottenburg District Court (HRB 130922 B) · VAT-ID: DE275099755  
Hudara gGmbH · IBAN: DE17 1001 0010 0917 3921 02 · BIC: PBNKDEFF**

