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Laboratório Nacional de Energia e Geologia, I. P.

Wiring the Future of Sustainable Cities

20.09.25, Teresa Ponce de Leão

Wrocław University
of Science and Technology

crp Conference of Rectors and Presidents
of European Universities of Technology

Empowering Cities for a Net Zero Future:

Unlocking resilient, smart, sustainable urban energy systems

International Energy Agency

Cities account for more than 50% of the global population, 80% of global GDP, two-thirds of global energy consumption and more than 70% of annual global carbon emissions

These factors are expected to grow significantly in the coming decades: it is anticipated that by 2050 more than 70% of the world's population will live in cities, resulting in massive growth in demand for urban energy infrastructure.

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The remarkable rise of “greenhushing”

Businesses once trumpeted their climate goals. Now they are quietly plugging away

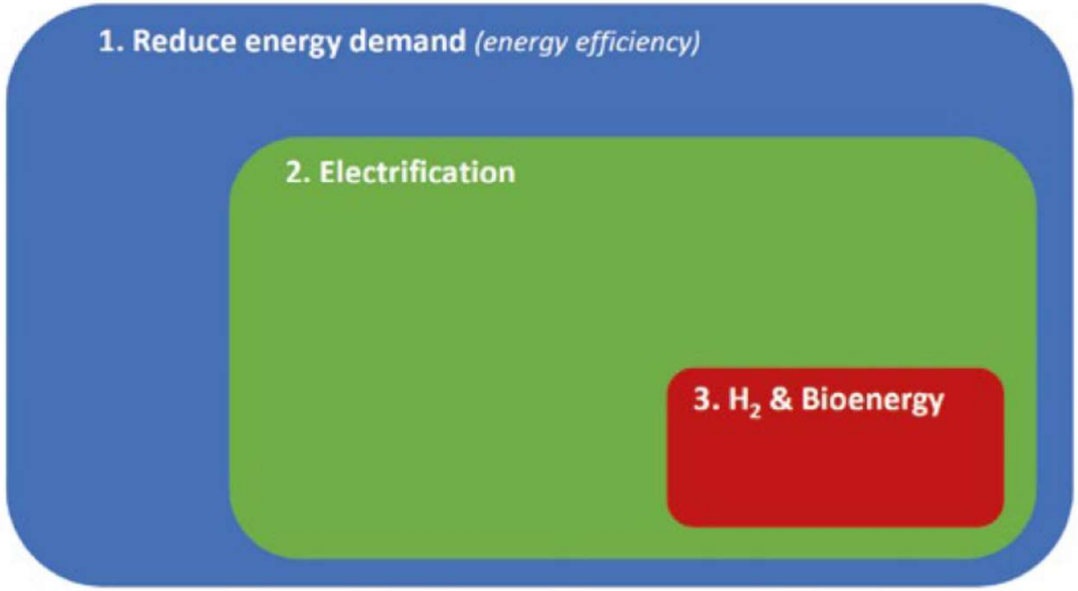
Global needs on energy to Net ZERO

The EGD

Digitalization

The EU strategy on energy system integration (July 2020)

3 Approaches:



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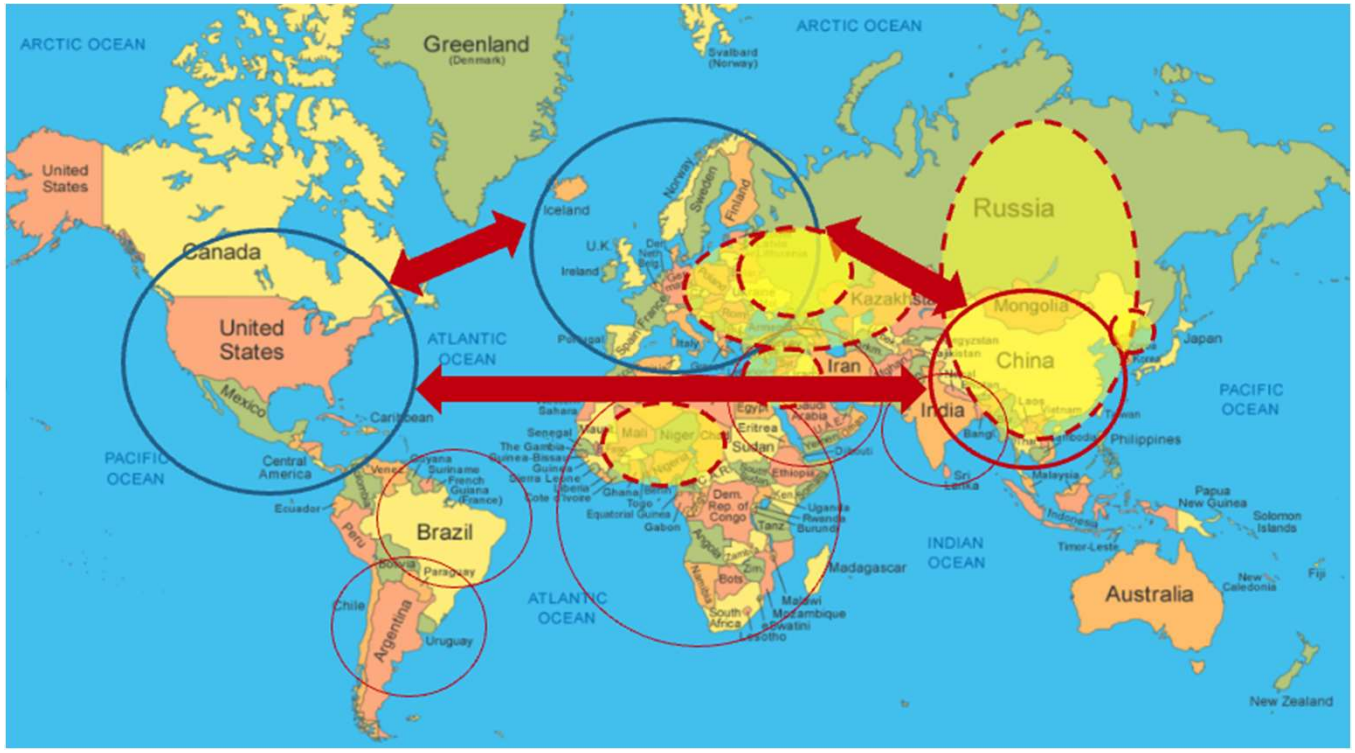
The World Order has irreversibly changed

For Reference

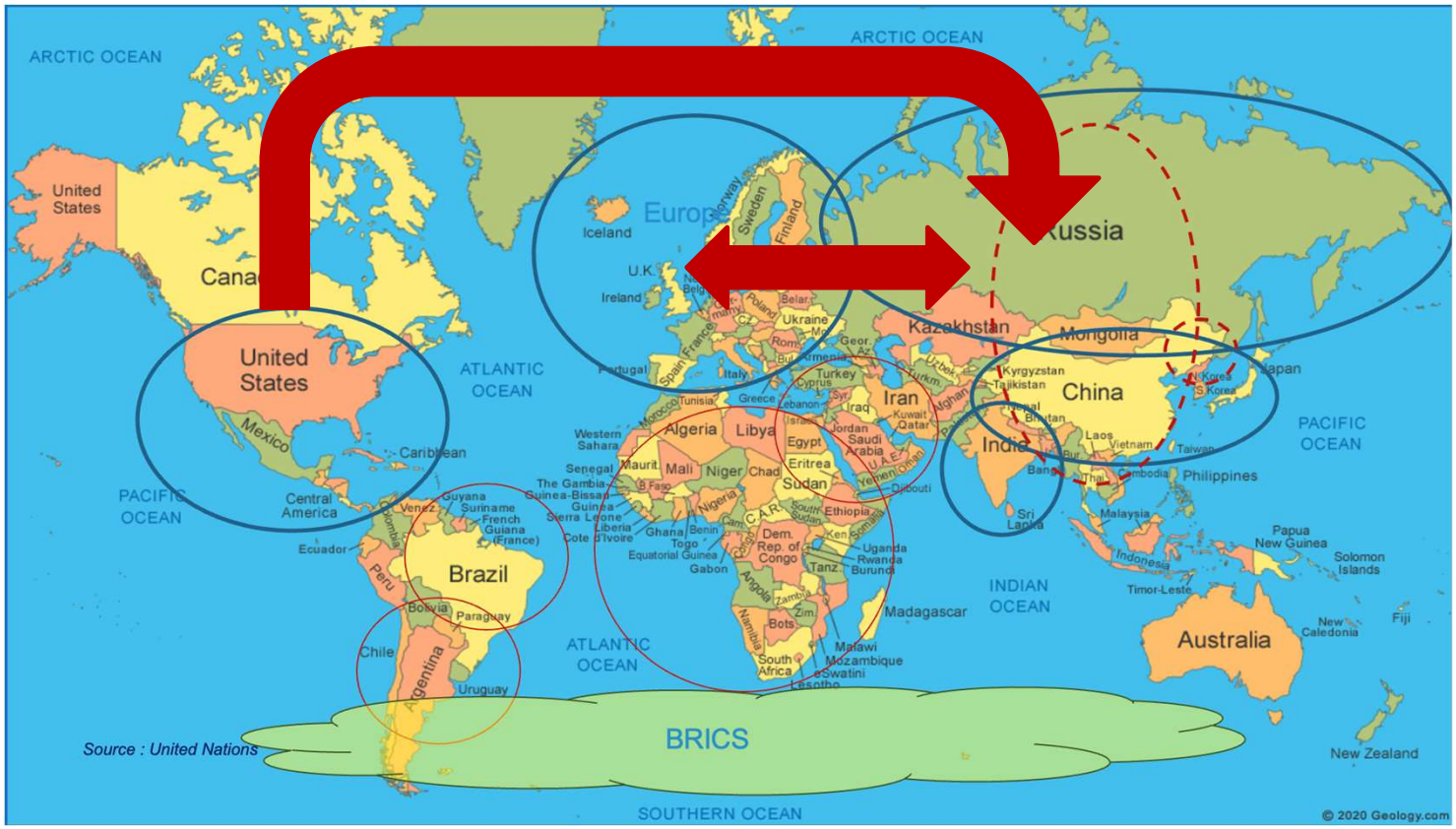


From a US dominated...
to a fragmented World Order

Unipolar	→	**Multipolar**
Multilateral	→	**Ad Hoc Alliances**
Rule based	→	**Power Politics**
Free markets	→	**Protectionism**
Competition	→	**Confrontation**

A new World (Dis)Order emerges : Defense and Security

For Reference



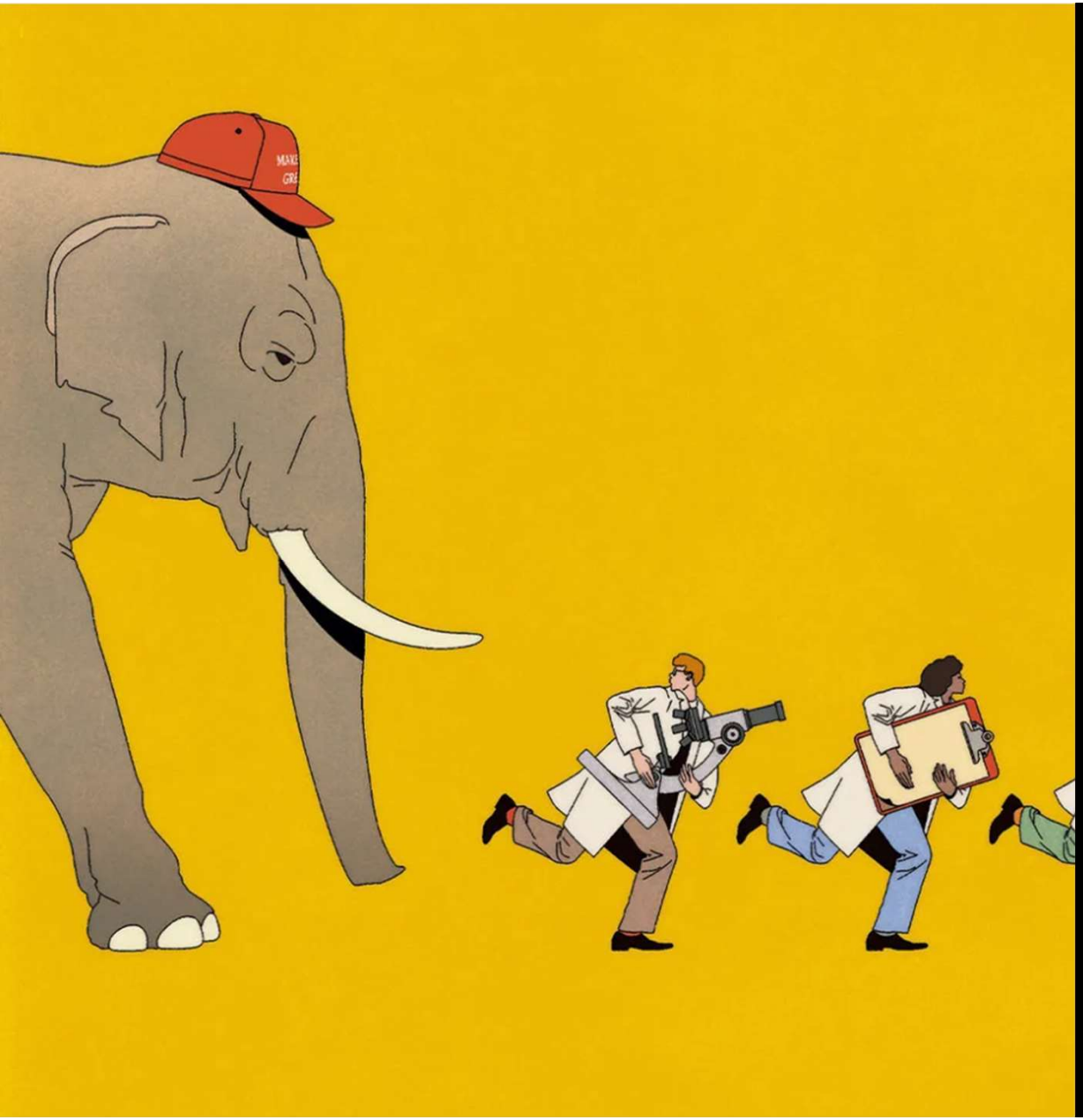
28 February 2025

80 year of Trans-Atlantic Alliance "Trashed"

An unanticipated new challenge to EU

Populism

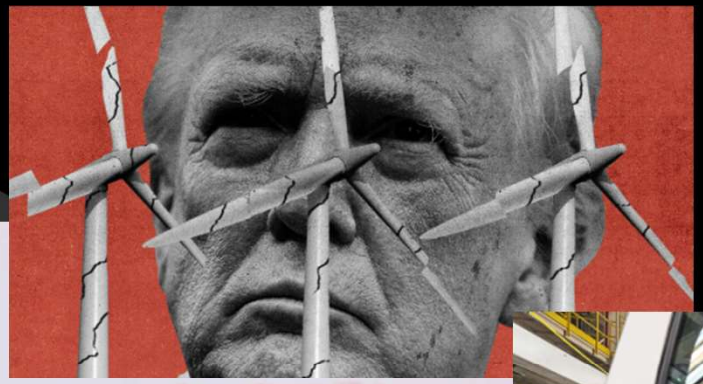
And a boost to Russia …

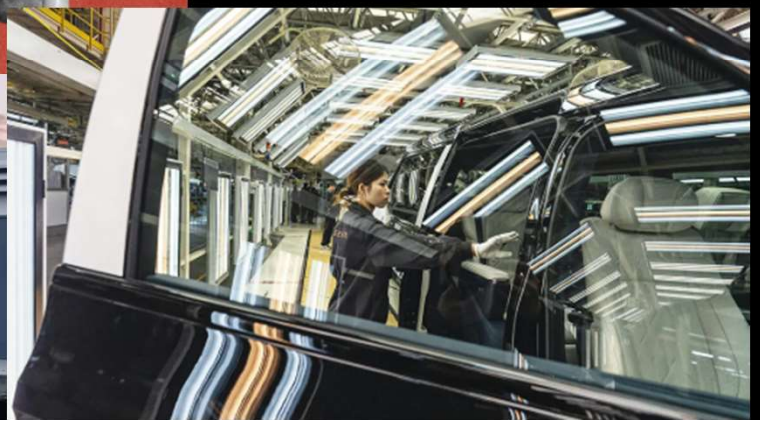


Science diplomacy refers to the use of **scientific collaboration** as a tool to build bridges between nations, promote peace, and address shared global challenges through evidence-based cooperation.

Setting the Stage

Electricity is the invisible foundation of modern life
Climate neutrality requires transforming not only technology, but fairness





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CHINA vs USA

Similarities

- Indispensable for climate, trade & technology
- Seek global influence and shape rule-making
- Create EU dependencies in strategic sectors

Differences

- China: state-driven economy, CRM dominance, human rights concerns
- USA: market-driven but protectionist (IRA, tariffs), ally in security & values
- China offers scale and cost; USA offers innovation and security umbrella

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- Ch ts concerns
- US curity & values
- China offers scale and cost; USA offers innovation and security umbrella

How can the EU position itself as an independent “third pole” in a world shaped by US–China rivalry?

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Electric Systems as Strategic Enablers

From utility → backbone of resilience & sustainability
Decentralized energy grids
Smart buildings
Electrified mobility
Energy storage

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Why Fairness Matters

= trust, participation, legitimacy

Unfair markets: volatility, exclusion, weak adoption

Fair markets: enable engagement, attract investment, accelerate transition

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Bridge to the Future

Fairness is the foundation — but innovation wires the future
Electricity systems = enablers of climate-neutral

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FACTS

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Regulatory and Policy Shifts

EU Electricity Market Reform (REMA)
Net Zero Industry Act & Clean Industrial Deal
Role of regulators: fairness + inclusion + innovation
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The cheapest electricity gets sold first. Usually this is electricity from renewable energy.

If supply is not sufficient, other, more expensive power plants can sell their electricity (coal and gas).

However, the electricity is not sold at the individual price offered by each power plant. The price will settle at the price offered by the last and most expensive power plant.

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PRICE PEDIA

INFOGRAPHIC: 2024 REFORM OF THE ELECTRICITY MARKET

THE NECESSITY

Electricity price determined by the least efficient marginal offer

Effects of higher gas prices

THE EU DECISION-MAKING PROCESS

CONTRACTS INTRODUCED BY THE REFORM

- Power Purchase Agreements (PPAs)
- Futures contracts
- Two-way contract for difference
- Dual contracting

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EU Electricity Market Reform

Problem	Reform Goals	Key Tools
High exposure to gas price volatility	Make bills less dependent on fossil fuels	Contracts for Difference (CfDs), hedging instruments
Mismatch: renewables are cheap but bills remain high	Ensure consumers benefit from low-cost renewables	Power Purchase Agreements (PPAs), long-term contracts
Insufficient investment signals for clean energy	Boost renewable, storage & demand response investments	Capacity mechanisms, flexibility markets
Weak consumer protection during crisis	Stronger consumer rights & stable prices	Default fixed-price contracts, supplier obligations

Structural Models Alone May not Protect Consumers

- Often **focus on efficiency** and **wholesale outcomes**.
- **Retail markets**, **tariff design**, and **equity outcomes** are either ignored or treated exogenously.

- **Noah Dormady's* work** shows this can lead to **counter-intuitive results**: e.g., wholesale prices fall but consumer bills rise due to poor retail design or misaligned incentives.

**University of Illinois and Southern California*

EUI FLORENCE SCHOOL OF REGULATION

The FSR Energy & Climate addresses the challenges facing the energy transition through applied research, innovative training, and policy dialogue. It brings together the worlds of academia and practice to develop economically and socially sound energy regulation and policy in Europe and worldwide.

@https://sustainable-energy-week.ec.europa.eu/florence-school-regulation-fsr_en?utm_source=chatgpt.com

A combination of market design elements and regulation is required.

Structural models should be **expanded** to incorporate:

- Retail tariff structures
- Demand response, smart tariffs and Community Choice
- Investment dynamics
- Risk allocation - hedging and CfDs and forward markets (PPA)
- Consumer segmentation and behavior
- Capacity remuneration mechanisms

Electricity Market Reform: Problem → Goals → Tools

Problem:
Gas-driven price volatility
Weak consumer protection

Reform Goals:
Stable, fair, affordable prices
Investment in clean energy

Key Tools:
CfDs, PPAs, capacity markets, flexibility & consumer rights

Good governance is essential

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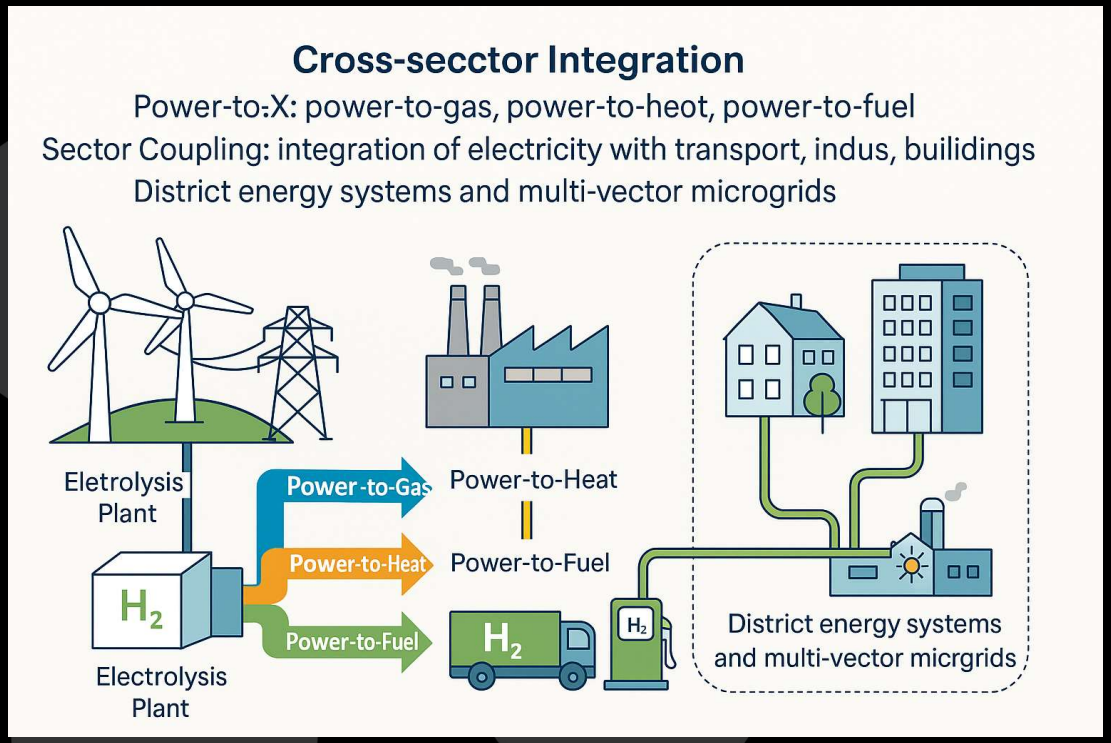
BUT… We Cannot Just Electrify Everything

- **Sectoral diversity**: heavy industry, aviation, shipping need high-density fuels
- **Infrastructure limits**: grid, storage and flexibility challenges
- **Resource intensity**: batteries & grids demand CRM
- **System resilience**: renewable gases & fuels ensure reliability
- **Fairness**: risk of inequality (clean electricity is costly or limited)

Cross-sector Integration



- Power-to-X: power-to-gas, power-to-heat, power-to-fuel
- Sector Coupling: integration of electricity with transport, industry, and buildings
- District energy systems and multi-vector microgrids

Example: Smart Energy System in Denmark – GreenLab Skive

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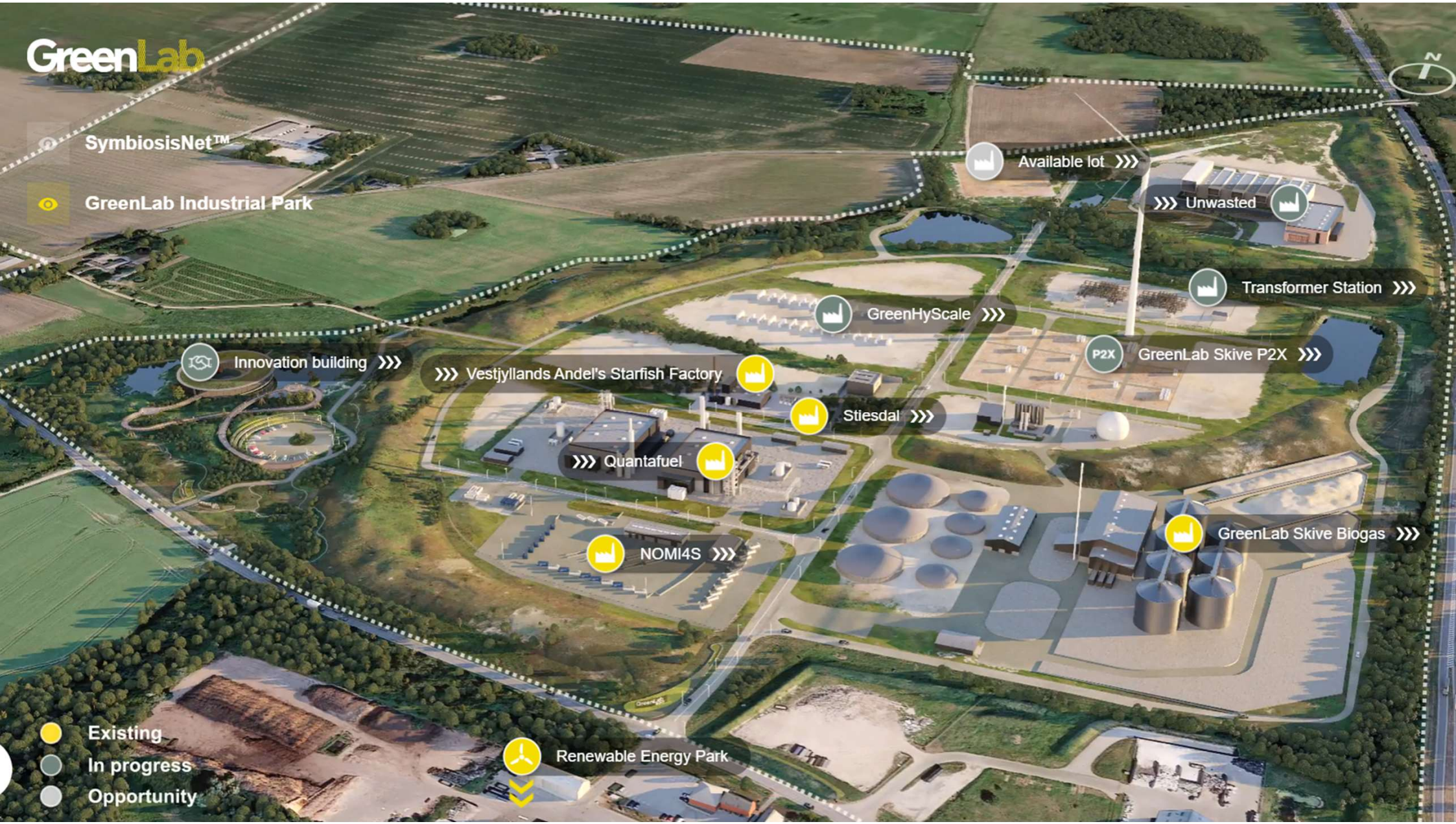
GreenLab
SymbiosisNet™
GreenLab Industrial Park
Available lot
Unwasted
Transformer Station
GreenHyScale
P2X
GreenLab Skive P2X
Innovation building
Vestjyllands Andel's Starfish Factory
Stiesdal
Quantafuel
NOMI4S
GreenLab Skive Biogas
Existing
In progress
Opportunity
Renewable Energy Park

Role of Digitalisation

- Digitalisation enables smart, sustainable energy systems
- Smart building controls: cut 350 Mt CO_2 by 2050
- Digital tools improve urban planning, efficiency, and business models
- Transport digitalisation addresses >40% of transport emissions

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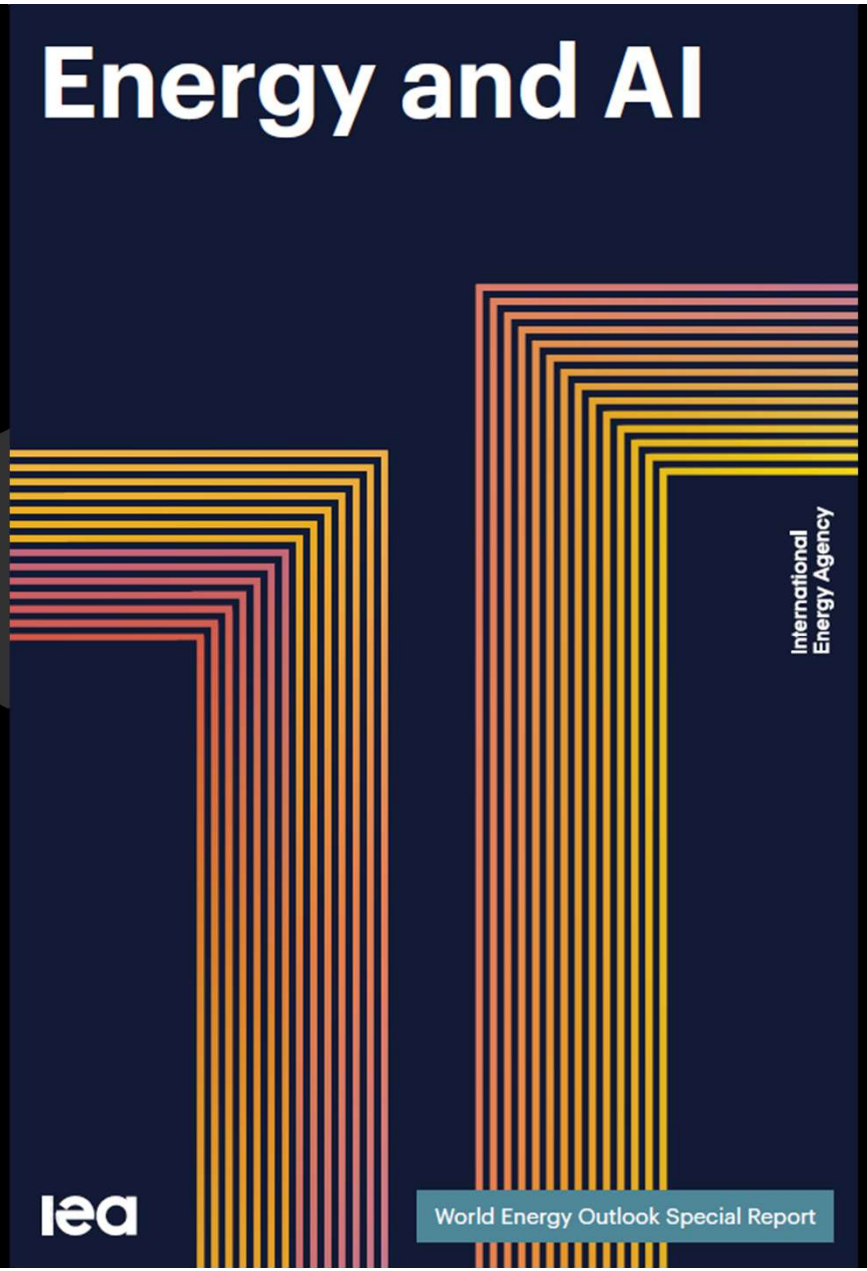
Role of Digitalisation

- Smart, data-driven cities optimize infrastructure and empower fairness:
- IoT, smart meters, AI demand response cut curtailment >25%
- System efficiency can increase ~30% and consumer costs fall up to 30% by 2030
- Digital tools align city planning with energy system needs

Digitalisation supports integrated urban planning practices

Digitalisation can support cities in:	Examples
Enhancing urban planning	• Access to new, granular data • Real-time data for decision making • Models and simulations to identify impacts of interventions
Implementing integrated solutions	• Identifying sources of waste heat and cooling that could be utilised • More effective utilisation of existing space and assets
Deploying clean energy	• Identifying potential and best locations for rooftop solar • Improve the business case for local renewables
Fostering public participation	• Enabling public and private participation in city innovation • Create new platforms for citizen engagement and consultation • Engage citizens in clean energy transitions
Supporting inclusivity	• Improve access to services • Open up new channels of communication • Create new employment opportunities
Supporting nature-based solutions	• Map existing natural resources • Help quantify impacts of nature-based solutions implementation • Help manage and expand natural resources
Strengthening resilience	• Enhance monitoring capabilities • Enable faster response • Help identify effective preventative measures • Enhance communication with citizens during emergencies
Enabling a circular economy	• Provide opportunities to track products, components and materials to enable reduction, reuse, refurbishment and recycling • Stimulate behaviour change • Identify opportunities to reduce and reuse waste
Enabling new business models	• Reduce risks • Improve investor confidence • Create opportunities for start-ups



- **Digital and Systemic Integration**
  - Role of AI in forecasting and optimization
  - Digital twins for scenario analysis and control
  - Cybersecurity in integrated infrastructure

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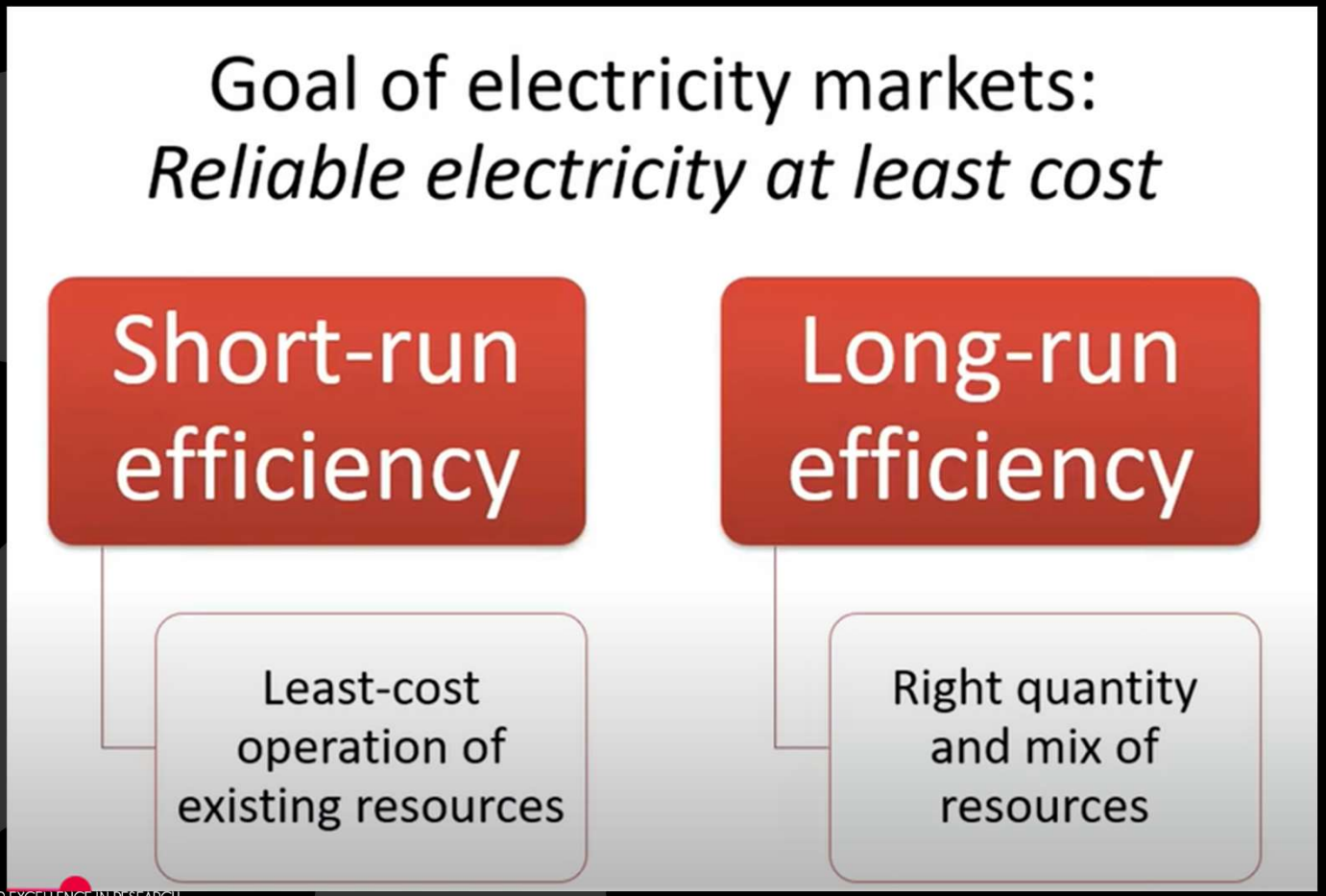
Plan Long-term, act short term



Cities, utilities, tech, and citizens as partners

Business models: community energy, P2P trading

Fairness embedded in governance

Science-based decision-making

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Pathways forward

- Establish equitable market regulations
- Allocate resources to durable infrastructure
- Encourage cooperative management
- Expand innovation by implementing pilot programs
- Combine with RE gases & sustainable fuels (sector coupling)
- Expand EE & demand Flexibility
- Ensure fairness

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Economic ensions

- Integrated e ty services
- New busine ergy communitie
- Investment systems

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Finance & economics | Free exchange

Europe's energy market was not built for this crisis

It must be reformed without jettisoning what makes it work in normal times

Save Share Give

Sep 8th 2022 | 5 min read

MOST PEOPLE hate fluctuating prices. When they fall too far, they are seen to be threatening firms. When they rise too high, they are seen to be unjustly enriching them. But economists look at price movements and see the revelation of crucial information. The recent frenzy about interventions in European electricity markets is an especially brutal example of this age-old dynamic.

In recent weeks, forward prices for daytime electricity for the fourth quarter of the year briefly spiked above €1,200 ($1,200) per megawatt hour in Germany and above a surreal €2,500 in France. The usual price is around €50. The reason for this is simple: scarcity. The loss of generating capacity to maintenance (in France), closure (in Germany) and drought (across the continent) brought more and more gas plants into action, and their fuel has become extremely expensive since Russia wielded its energy weapon.

Smart Grids & Investment Needs

- Urban electrification requires major smart grid upgrades:
- Global power demand could rise 2.5× by 2050
- 80 million km of new/modernized lines needed by 2040
- Grid investment must more than double to ~USD 750B/year by 2030
- 75% of this for digitalized distribution networks

Resilience & Community Inclusion

- IEA shows how digitalization supports resilience and equity:
- Microgrids, PV + storage, EV-to-grid keep cities running during heatwaves and blackouts
- Urban design (green corridors, tree planting) reduces cooling loads
- Community energy projects (7,700+ in Europe) empower citizens
- Digital inclusion ensures no household is left behind

Key Takeaway

- Structural … nd demand-side fairness.
- Policymake… ions.
- A balanced … rotection.

Effective elec… . By integrating consumer-foc… olicymakers can ensure that c… t also affordable and equitable…

Decision makers must deliver:

- Consumer protection
- Resilient private markets
- Long-term investment certainty
- Future-proof grids

All while balancing EU integration with national flexibility.

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Accelerate

Support most impacted countries and communities (LMIC)

Promote inclusive and equitative finance

Act based on long-term thinking

Integrate climate and biodiversity

Guarranty transparency

Decide on science based solutions

E.T.

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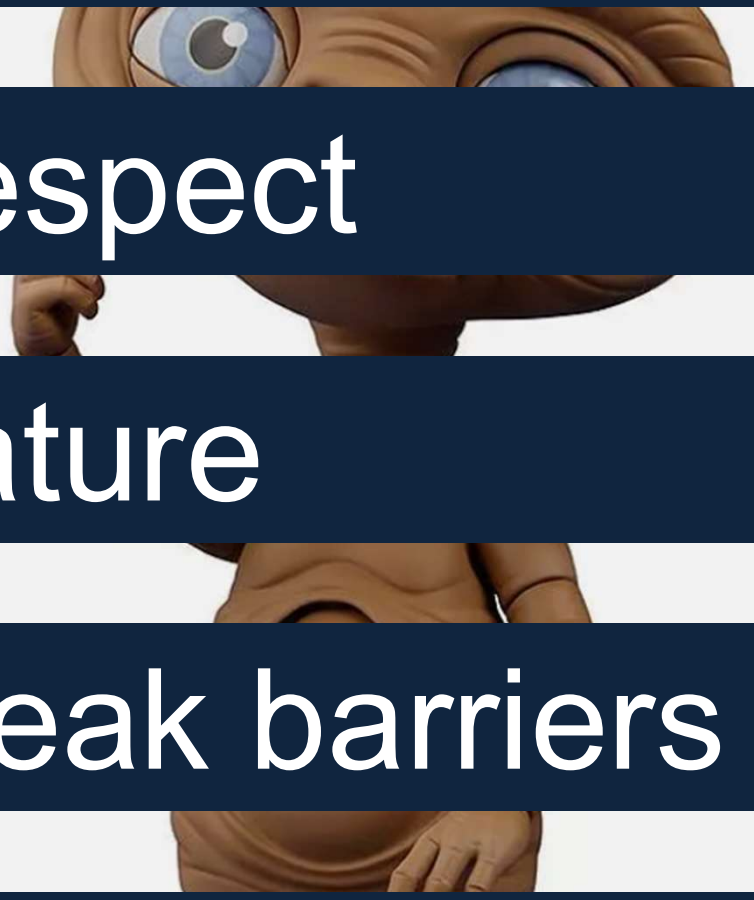
Belief



Respect

Nature

Break barriers

Responsibility

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