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INTERNATIONAL CONFERENCE

INCLUSIVE ENERGY TRANSITIONS IN SOUTHEAST ASIA AND BEYOND

Cross-Regional Learning from South Asia

10–12 February 2026 • Jakarta, Indonesia

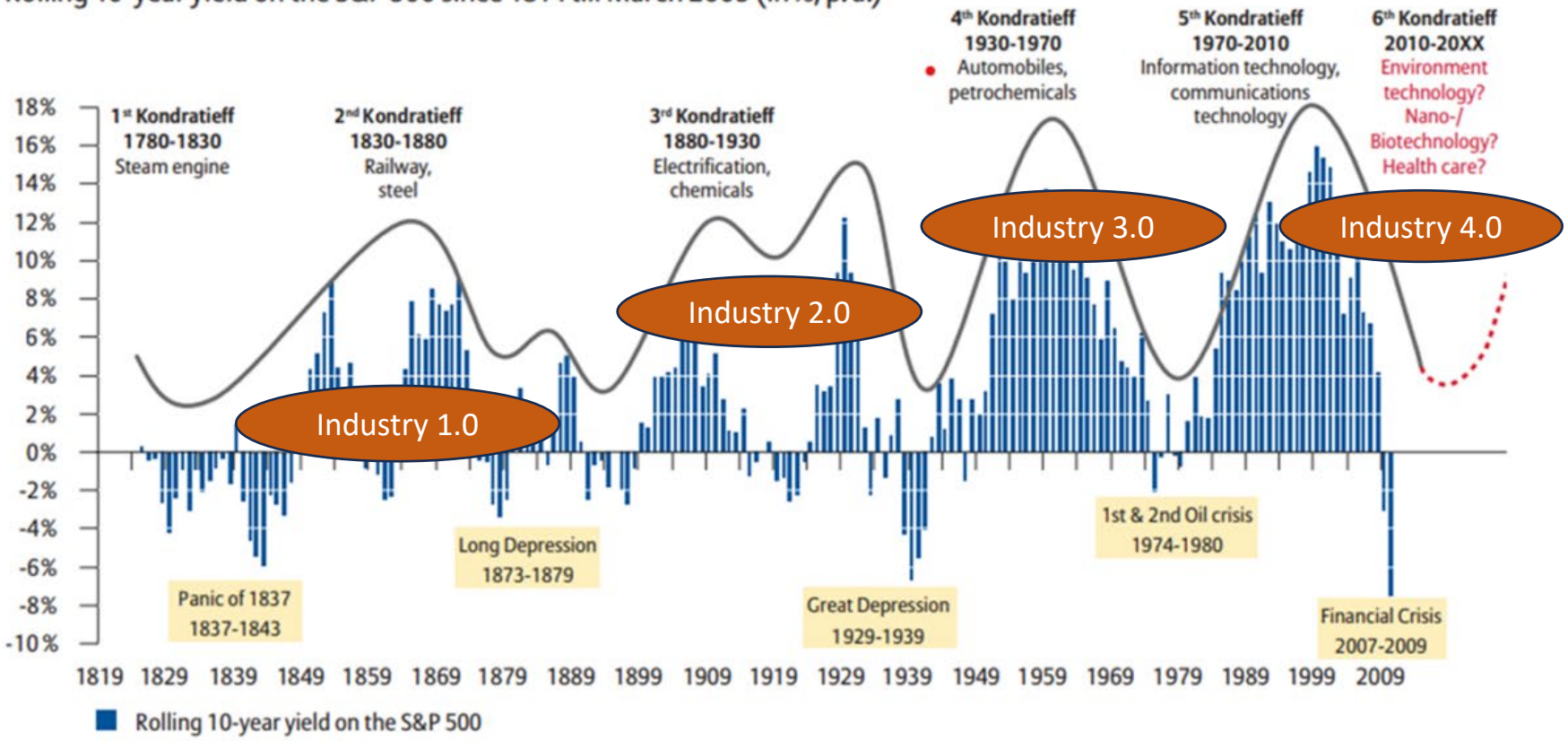
In collaboration with UNOPS, The University of Melbourne, NOSSAL INSTITUTE

Certified by IEEE SA STANDARDS ASSOCIATION, IEEE SSIT SOCIETY ON SOCIAL IMPLICATIONS OF TECHNOLOGY

A Techno-Economic History

Co-Evolution – Technology and Social Settings Co-Evolve

Figure 1: Kondratieff cycles – long waves of prosperity.
Rolling 10-year yield on the S&P 500 since 1814 till March 2009 (in %, p. a.)



Source: Datastream; Illustration: Allianz Global Investors Capital Market Analysis

Industrial Revolutions

Industry 1.0 (The Industrial Revolution): Starting in the 18th century, saw the rise of mechanization and the use of water and steam power to drive production, transforming manufacturing processes.

Industry 2.0 (The Technological Revolution): Beginning in the late 19th century, this period introduced electricity and mass production techniques, significantly increasing efficiency and output.

Industry 3.0 (The Digital Revolution): Starting in the mid-20th century, this era saw the widespread adoption of computers and automation, leading to the development of computer-aided design (CAD) and computer-aided manufacturing (CAM).

Industry 4.0 (The Fourth Industrial Revolution):This current stage, beginning in the early 21st century, is characterized by the integration of smart technologies like the Internet of Things (IoT), artificial intelligence (AI), and big data analytics, enabling real-time monitoring, data-driven decision-making, and enhanced automation.

Sociotechnical Lessons from Previous Grand Transition "Co-Evolution"

1. Transitions are Slow

Transitions take decades to unfold.

2. Addition, Not Substitution

New sources first add to the mix.

3. Infrastructure Rules

Networks and storage are key.

4. Deployment Cuts Costs

Learning-by-doing drives cost decline.

5. Co-Evolution with Society

Energy and society transform together.

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6. Incumbents Resist Change

Old industries fight to adapt.

7. Path Dependency

Early choices limit future options.

8. Social Acceptance & Equity

Fair benefits are key to success.

Technology, institutional and social settings *'co-evolve, mutually depending on, mutually cross-enhancing each other'*

(Arnulf Grubler)

Industry 4.0 – Some Descriptions/Definitions

Smart grids and automated decision-making

Industry 4.0 in the power sector underpins the development of smart grids, where digital control, automation, and advanced analytics enable real-time monitoring, decentralised generation, demand response, and system optimisation.

IEEE Power and Energy Society

Industry 4.0 & Inclusive Energy Transition

Linking technology, governance, and social outcomes in energy systems

Digital Energy Systems & Access

Smart Grids & Microgrids

- Expand electricity access
- Connectivity gaps, tenure issues
- Inclusive design to prevent exclusion

Automation & AI ✦ Affordability

Smart Meters & Automated Controls

- Improve efficiency, reduce waste
- Lower tariffs not guaranteed
- Regulatory oversight needed

Energy Efficiency & Rebound Effect

AI Optimization & Sensors

- Reduced costs, higher use
- Rebound effect risk
- Combine with social protections

Datafication & Governance

Energy Data & AI Insights

- Transparency & planning
- Who controls the data?
- Platform vs. Public oversight

Digital Twins & Planning

Virtual Energy Models

- Test scenarios, plan grid
- Designer bias in models
- Whose priorities?

Industry 4.0 ✦ Multi-Level Governance

Local, National, & Community Coordination

- Land, tariffs, participation
- Social dialogue required
- Equitable decision-making

This approach provides a vison of industry that aims beyond efficiency and productivity as the sole goals, and reinforces the role and the contribution of industry to society.
It places the wellbeing of the worker at the centre of the production process and uses new technologies to provide prosperity beyond jobs and growth while respecting the production limits of the planet.
It complements the existing "Industry 4.0" approach by specifically putting research and innovation at the service of the transition to a sustainable, human-centric and resilient European industry.

IEEE Inclusive Energy Transition Standards – P3564

- **The practice guidelines have a global scope of focus, nuanced, taking into consideration geographic, political, legal/governance, cultural, social, technology maturity, development, environmental, and ethical factors.**
- This recommended practice **provides a framework for implementing Gender Equity and Social Inclusion** (GESI) considerations including and measurable well-being outcomes into industry practices within power and energy projects and operations, primarily for the Low Carbon Energy Industry.
- The recommended practice scope:
  - (1) for how projects **supporting the Low Carbon Energy transition** can accommodate GESI considerations
  - (2) to address GESI considerations for **both the transition phase as well as the business-as-usual phase** after the transition phase has concluded
  - (3) on how to **monitor and to evaluate the effectiveness of GESI considerations** in industry practices.
- The requirements are complemented with indicators and metrics to evaluate progress and outcomes.
- This recommended practice encourages and helps engineers, scientists, technologists, and other professionals in the power industry to consider GESI factors in their practice and to create a clear record of the outcomes of those considerations in their projects.

P3564 Outcomes

- **Access and Quality of Access:** Generation and distribution side impacts; understand the context of social, economic and gender-based power relations; incorporate user knowledge and understanding of new technologies.
- **Affordability**: Social Inclusion, especially for low-income groups; Short-term cost increase planning and mitigation; network infrastructure cost planning, including off-grid
- **Enabling policy environment**: Holistic GESI policies that consider impacted communities; social license to operate; incorporate local and indigenous knowledge; social protection to mitigate impact of job losses.
- **Develop the GESI Inclusive Workforce and Livelihoods (Micro, Small and Medium Enterprises)**: Address gender disparity in employment and wages in the energy sector; establishing skills development programs to create livelihood (MSME) and green and decent employment.
- **Metrics**: Quantitative and qualitative metrics for reporting and evaluating GESI impacts of the energy transition, including uptake, affordability and workforce composition.

THANK YOU!

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