Abstract

This dissertation addresses the critical need for science-based support to guide policymaking throughout the complex challenges of energy transition, focusing on decarbonization and electrification to meet the ambitious targets set by the European Climate Law. To achieve a 55% reduction in EU-27's carbon emissions by 2030 and carbon neutrality by 2050, integrated policies and strategic actions are necessary across multiple dimensions (energy, environmental, social, and economic dimensions) and spatial scales. This commitment requires robust scientific evidence to inform policymakers, support data-driven decision and enhance public trust in policymaking. The research emphasizes the importance of bridging the gap between science and policy, by promoting a shift from traditional, selective and curiosity-driven research to a more inclusive, policy-oriented approach, known as 'Science 2.0' or 'Science for Policy'. Metric-based methodologies, ensuring clarity and conciseness of scientific evidence, play a crucial role in synthetising key findings and translating complex results into key policy-relevant insights. To further enhance audience understanding, metric-based methods need to be empowered with effective data visualization and interactive interfaces. The study introduced three novel metric-based methodologies for assessing energy transition trends at different spatial scales (European, national and urban scale), revealing both benefits and worsening across diverse domains. To validate the developed methodologies and demonstrate their wide applicability, three real-case applications are discussed: metric-based scenario analysis to evaluate the impacts of increasing intermittent renewable generation in Europe, assessment of the 'energy trilemma' evolution in Italy through the composite index ISPRED, and monitoring of the urban energy transition in Turin, Amsterdam, Eindhoven, Utrecht, Rotterdam through the composite index UETI. Additionally, the research encompassed the development of three interactive web platforms to support informed policymaking and improve public trust and awareness by providing clear and timely insights on real-word issues: ET@IT designed for monitoring national energy transition in Italy, E3 devoted to evaluate large-scale renewable energy impacts and benefits at the European level, and SERT aimed at assessing the energy risk of energy supply corridors and perform risk scenario analyses. By developing these platforms, this study makes a significant and tangible contribution to empowering evidence-informed policymaking. It exemplifies a novel, more inclusive approach that enhances audience understanding, promotes data-driven decisions, and fosters transparent policies, ultimately increasing public acceptance and trust in policymakers.