Narrative-Network Dynamics in Tipping Processes Towards Low-Carbon Energy Futures: The Case of Indonesia

Cynthia Ismail, J. David Tàbara, Takeshi Takama, and David Saurí

Abstract Deliberate actions by social networks and their transformative visions can generate the necessary conditions for the emergence of positive tipping points towards sustainability, such as those that create qualitative, structural changes in sustainable development goals. However, there is a need for more empirical research conducted in non-Western countries to assess these complex processes. In this research, we customised Integrated Sustainability Assessment (ISA) and combined it with participatory narrative analysis, social-ecological network analysis and Q-methodology to capture the transformation processes in social network structures with their guiding visions in two coal- and carbon-intensive regions (CCIRs) of Indonesia: Banten and Bali Province. Our research approach tracked transformation narratives and visions and their associated network dynamics and showed that they could be used as *anticipatory social tipping signals (ASTS)* in deliberate transformation-oriented tipping point processes. Our study revealed two guiding visions actors use to guide their transformative actions to change the energy system. Those transformations emphasise (i) governance coordination and (ii) socio-economic diversification. We argue that making explicit the presence of and promoting dialogue among different visions towards sustainability can promote new

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opportunities for mutual learning and transformative strategy building among diverse social networks.

Keywords Southeast Asia · Coal · Electricity · Networks · Visions · Transformation

1 Introduction

The shift from coal and carbon-intensive regions (CCIRs) is challenging, particularly in poorer but fossil-fuel-rich countries like Indonesia, where coal is abundant. As Indonesia's primary export is coal, reducing its dependence on this fossil fuel poses a challenge to the economy (S. E. Hosseini & Abdul Wahid, 2014; Sewandono & Munandar, 2021). However, addressing climate change necessitates swift and systemic changes globally, particularly in regions most intensive in the use of fossil fuels. For these adjustments to occur, it is necessary to understand the conditions and processes that may accelerate deliberated structural changes aligned with climate and sustainability goals. Without one-fit-all solutions, this requires implementing multiple interventions adapted and emerging from local contexts and endogenous capacities, leading to positive tipping points towards sustainability (Tàbara et al., 2018).

Recent literature has highlighted the role of deliberate agency in the social tipping processes. In this regard, social networks and their visions can be understood as key to building the preconditions for the emergence of tipping points because of their ability to mobilise collective actions, catalyse transformative change and promote adaptive capacities in response to change (Folke et al., 2005, 2010; Milkoreit et al., 2018; Winkelmann et al., 2022). Research has revealed that agents communicate and transmit their visions of the future within their networks to produce new joint activities or interventions for change (Markard et al., 2012; Olsson et al., 2014; Winkelmann et al., 2022). In particular, transformative visions explore alternate, desirable, and attainable futures to be shared across agents to trigger systemic changes (Pereno & Barbero, 2020; Tàbara et al., 2018). However, the ways social networks communicate their visions in complex social-ecological systems remain under-researched (S. A. H. Hosseini, 2009; Sayles et al., 2019).

Narrative analysis has emerged as a valuable tool in analysing complex social-ecological systems such as the energy sector (Moezzi et al., 2017). Through narratives, researchers can capture the complex dynamics of coupled social-ecological systems and explore the interactions between social networks and visions (Hahn et al., 2008). Hence, the transformation of dominant narratives can be seen as a prerequisite in any deliberate attempt to change social-ecological systems. This is particularly true when dominant narratives can no longer explain existing realities, or alternative narrative framings challenge prevalent narratives or present hitherto unexplored prospects (Moore et al., 2014).

Capturing the complex dynamics in switching energy systems towards renewables is particularly challenging in low-income countries. Additionally, tracking links between changes in energy narratives and actual structural practices on the ground has yet to be addressed in developing economies like those in Asia (Apfel et al., 2021). This is challenging for research because of the intricate and asynchronous interactions between narrative shifts and social changes. Also, narratives are developed in advance of actual policy measures or adjustments. In complex social-ecological systems such as energy systems, with high uncertainty and multiple outcomes that may be spurred by a single intervention (Papageorgiou et al., 2020; Shen et al., 2022), transformative narratives are often built upon practical and shared experiences from agents who communicate their aspirations and learnings through alternative visions (Hinkel et al., 2020). Pioneering agents generate transformative capacities through these visions via multiple learning networks and feedback loops (Ofoegbu & Ifejika Speranza, 2021). Therefore, the analysis of narratives provides evocative accounts that allow interpretation of the complex cultural processes that involve changes in collective systems of meaning (Geertz, 1973). Such studies can thus be enriched by examining the diverse agents' interactions in their unique cultural and political contexts and explaining transformation within the networks (Emirbayer & Goodwin, 1994).

Such combined analysis of agents' networks and narratives can be especially useful for understanding the possibilities of systemic shifts in the energy sector (e.g., Hermwille, 2016; Judson et al., 2020; Chailleux, 2020). Given the absence of empirical and integrated analysis in non-Western countries, our research investigates how social-ecological networks and agents' visions can serve as anticipatory social tipping signals, building the conditions for the transformation of systems. Our reference system comprises the agents influencing the Indonesian energy sector's policy-making, technological infrastructures, and market innovations. Against this backdrop, we employed a mixed-method empirical approach to examine the transformative visions of key agents and their interactions in two provinces of Indonesia: Banten and Bali.

We first adapted the Integrated Sustainability Assessment (ISA; Weaver et al., 2006) to identify how the agents envision and strategise the future with the needed capacities to transform the energy system. In addition, our methodology included a narrative analysis using the alternative pathways framework proposed by Lieu et al. (2020) and a more specific Q-methodology for exploring the content of their transformative visions (Charli-Joseph et al., 2018; Silaen et al., 2019; Nieuwenhuis et al., 2022; González-González et al., 2023). Social Network Analysis (SNA), with the region as the ecological boundary, was also employed to track agent structure dynamics (Devisscher et al., 2017; Froehlich et al., 2020). We hypothesised that the use of qualitative and quantitative SNA could constitute a useful tool to assess and anticipate possible social 'thresholds' of transformative change or tipping points and, in this manner, how agents' interactions may help to anticipate potential cascades of positive change or have telecoupling effects on other networks (Franzke et al., 2022; Froehlich et al., 2020). Although SNA is commonly used to map human nodes, it is limited to tracking social-ecological interactions. Given that we recognise the energy sector as part of social-ecological systems, we enriched the

qualitative SNA with the concepts of social-ecological networks and nodes (Janssen et al., 2006).

2 Banten and Bali as Coal- and Carbon-Intensive Regions

Indonesia is one of the largest emitters of greenhouse gases. Yet, the country is seemingly moving towards a high-intensity development pathway by relying on fossil fuels (e.g., coal, oil). Such a business-as-usual policy route is particularly visible in the two contrasting provinces of Banten and Bali. Due to their unique energy challenges and renewable energy potential, Banten and Bali provinces make good energy case studies to explore the narrative and agent-network preconditions for structural change (Fig. 1).

Banten Province is known as an economic hub. It is home to about 12.9 million people and thousands of medium and large industries (Rahayuningsih, 2017), such as coal-fired power plants, petrochemicals, and steel production plants. In contrast, Bali Province is recognised as the leading tourist island in Indonesia. As a top tourist destination, the highest energy demand comes from tourist activities (e.g., accommodation, food, transportation). Banten and Bali are connected through an electricity grid in which 50% of the electricity generated in Banten is distributed to the remainder of Java and Bali. Almost half Bali's electricity demand is supplied from Java through a sea cable. The electricity from Banten usually acts as *regional balance*[1] in western Java in addition to securing overall Java-Bali's electricity provision, especially during peak hours.

Indonesia's energy sector is organised by national and local governments and non-governmental, corporate and intergovernmental entities that encourage sustainable development initiatives. At the national level, the government sets national energy policies, regulates power plant operations, and promotes renewable energy sources. The Ministry of Energy and Mineral Resources (MEMR) oversees the country's exploration and extraction of natural resources and developing energy infrastructure. PLN (Perusahaan Listrik Negara)—the state-owned electricity company—is responsible for generating, transmitting, and distributing electricity to the country. As such, the company plays a significant role in implementing national energy policies, together with private generating companies.

At the provincial level, the roles of local government in regulating the energy sector can vary from province to province. However, some common responsibilities of local governments are promoting clean energy sources, ensuring the availability of reliable and affordable energy, and regulating the exploration and extraction of natural resources within their jurisdiction. The responsibilities of MEMR in each

[1] According to RUPTL by PLN (PLN, 2020), regional balance is a situation where the electricity demands of a region are met mostly by the generators in that region and do not depend much on power transfer from other regions through interconnecting transmission lines. Banten is one area that achieves regional balance in western Java in addition to securing the reliability of the JAMALI interconnection grid.

Fig. 1 Location of two regions under study

province are carried out by the local government body, Dinas Energi dan Sumber Daya Mineral (ESDM) or the Agency of Energy and Mineral Resources. For instance, affairs related to the energy sector in Banten are coordinated by the Energy and Mineral Resource Agency (ESDM-Banten) in collaboration with the district down to the local village government. The same pattern applies in Bali (i.e., ESDM-Bali).

3 Approach and Methods: Adapted Integrated Sustainability Assessment

The ISA procedure encompasses the following stages: Scoping, Visioning, Experimenting and Evaluating. As a first step, we adapted the general four-stage participatory integrated sustainability assessment (ISA; Weaver et al., 2006) approach to achieving the research objective. We applied network analysis and Q-methodology to examine agents' interactions and visions in the ISA phases (Fig. 2). The narrative analysis comprises the alternative pathways framework (Lieu et al., 2020) and a Q-methodology analysis to map out different narratives and explore their content differences. We also used the region as the ecological element, according to Cheruvelil et al. (2017), as a spatial unit that captures regional-scale heterogeneity in ecosystem properties and relationships; in this case, the energy system.

Regarding the research process and interactions with stakeholders informing this research, we first participated in ten webinars on the potential and ongoing Indonesia's energy transformations towards clean energy futures. Attending webinars helped to identify key agents constituting the social system the reference before conducting interviews. From May 2020 to September 2021, 20 pertinent national and local agents in the sector participated in semi-structured interviews[2] and acted as informants. We recorded and transcribed the interviews and the results from

[2]The list of interview questions can be downloaded from here https://www.su-re.co/post/semi-structured-interview-questions

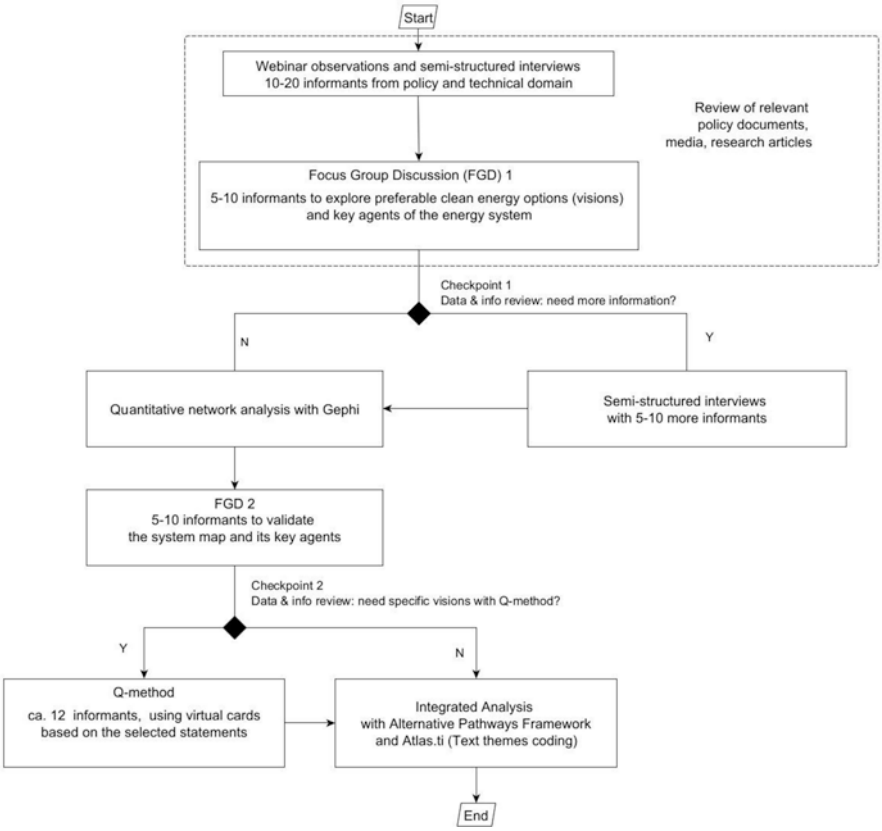

Fig. 2 Research strategy

webinars while keeping the informants' profiles anonymous. Desktop research examined relevant policy documents, media, and research articles. The desk-based review supported participants' data for subsequent phases to reduce bias. The interviewing procedure also followed the stages suggested by Weaver et al. (2006):

(i) *Scoping*: to understand the current situation and energy system and its related challenges in Banten and Bali
(ii) *Visioning*: to explore views of the future guiding the pertinent agents in transforming the current system,
(iii) *Capacity and Network Assessment*: Comprehend the agents' capacities and network dynamics in mobilising the energy sector toward clean energy futures.
(iv) *Strategy-building:* to identify what kind of potential tipping interventions for the emergence of positive social-ecological tipping points (SETPs) towards clean energy in these CCIRs are being mentioned by key agents.

The next step in the first phase was conducting the first focus group discussion (FGD) to validate the transformative visions and the key agents. A checkpoint was

suggested at the end of the first phase. Using a snowball approach, the first checkpoint assessed whether the obtained information and networks were sufficient to answer the research questions. The focus at this stage was to identify information on the transformative visions and to map out all key agents and their interactions in the energy system.

A second phase began with the implementation of additional semi-structured interviews to perform SNA within social-ecological networks or SEN. In this phase, 'Checkpoint 1' was used to ensure that valuable information on the agents' networks was not missing. At this stage, additional interviews were not conducted as the agents' interactions included diverse interactions from policymakers, private companies, and communities. Since the identified network was not considered sufficiently complex (<150,000 nodes), we conducted SNA with Gephi (Akhtar, 2014). Gephi is a free and open-source programme for visualising and studying massive network graphs such as social networks (Bastian et al., 2009). Before calculating the network characteristics with the degree of centrality, we listed the agents' capacities according to human-made resources and their regional operation. Subsequently, we deployed the concept of region according to Cheruvelil et al. (2017) to capture regional-scale heterogeneity in energy system dynamics as an ecological boundary. The region component also functions to locate agents' presence according to their authority (Avelino & Rotmans, 2009). Furthermore, we utilised two characteristics of the social networks of interest that Janssen et al. (2006) suggested can be regarded as tipping elements—they can undergo abrupt and irreversible changes in response to small perturbations—for tipping points: level of connectivity and level of centrality. The level of connectivity has two domains: the links' density and the networks' reachability: high density implies high reachability (Janssen et al., 2006). The level of centrality indicates nodes in the network with significantly higher-than-average links. We used Gephi 0.10.1 to examine the agents' networks (without a dynamic approach; Bastian et al., 2009).

'Checkpoint 2' involved assessing specific and shared transformative visions among the agents regarding sustainable futures in the Indonesian energy sector. If semi-structured interviews and FGDs are sufficient to capture the shared visions among the agents qualitatively, Q-methodology can be neglected. Otherwise, Q-methodology is the choice—a statistical method for analysing conflicting discourses around certain topics based on Z-score and eigenvalues. During the Q-methodology exercise, participants virtually sorted statements (see Table 1) on cards into columns ranging from −3 (high disagreement) to +3 (strong agreement): see Fig. 3. Before performing discourse analysis with Q-methodology, we selected several experts and pertinent agents to reduce redundancies and prioritise the relevant statements. Ken-Q—a software tool for conducting Q-methodology analysis online—was used to perform the analysis (Yang & Xu, 2021). A degree of agreement and disagreement for each statement was determined using the Z-score, which allows comparison of the scores of different statements across different visions. The unit of Z-scores is the standard deviation. For example, a statement with a z-score of −2.0 is two standard deviations below the distribution's mean. Finally, eigenvalues determine vision pluralism among agents: a higher eigenvalue indicates that a

Table 1 List of Q-statements[a]

Q statement No.	Description of Q statements
1.	Policy turbulence and technological barriers are the most challenging issues in energy transformation towards clean energy.
2,	Due to their intermittency, the great challenges in solar and wind uptake include storage technology and transmission and distribution infrastructure.
3.	Solar, wind, biogas and biomass are for decentralised and remote electricity systems.
4.	Solar energy can replace the old and inefficient fossil fuel power plants (i.e., oil and coal)
5.	The key agents at the regional level are national and local governments to implement energy transformation.
6.	The citizens can be the agents of change in the collective mode in deciding clean energy adoption (related to social acceptance and communal funding)
7.	The government should be more committed to implementing clean energy transformation with its enabling policy and regulations.
8.	The Government should consider fiscal incentives (e.g., subsidies and tax incentives) for accelerating renewable energy.
9.	Renewable investment from the business and industry sectors is crucial to transforming the coal and carbon-intensive regions combined before policy intervention.
10.	NGOs, village-owned companies and cooperatives are the key agents to ensure the implementation of renewable uptake at the local level.
11.	The role of the young generation is crucial for wide clean energy awareness.
12.	The tipping point towards clean energy also depends on fossil fuel availability.
13.	Clear visioning and targeting in energy transformation accelerate clean energy uptake. Hence, a more ambitious target is needed.
14.	Leadership is an important attribute owned by individual agents or collective agents.
15.	International pressure and support can accelerate Indonesia's energy Transformation towards clean energy.
16.	Overdevelopment in forest areas and the high cost and risk of exploration are the main concerns in geothermal development.
17.	Hydrogen is separate from the energy transformation towards clean energy in 10–20 years due to its high cost.
18.	The Law (Undang-Undang) is the preferable policy intervention to ensure the resilient energy transformation towards clean energy.
19.	The Government Regulation (*Peraturan Pemerintah*) is the minimum requirement to corroborate the position of the hub agent.
20.	Unfavourable and bureaucratic process for renewable operating permit hinders renewable uptake.
21.	Innovation in multiple sectors is crucial to change the regime system. However, policy innovation is essential to enable market growth.
22.	Energy affordability and access are preferable to the concern regarding climate change impacts.

Table 1 (continued)

Q statement No.	Description of Q statements
23.	Capacity building for financiers regarding clean energy uptake is important.
24.	If we only depend on the state budget, it is almost impossible to achieve clean energy. Thus, the private sector and banks are vital for energy transformation.
25.	Migration brings a paradigm shift regarding the importance of energy transformation towards renewable.
26.	Research and reliable data are required to increase the technology and social readiness for renewable energy implementation.
27.	Knowing the importance of clean energy is crucial in determining social acceptance of clean energy uptake.
28.	The pandemic forces the community to be prosumers in generating their energy (i.e., back to nature), for example, by using rooftop solar technology.
29.	The carbon market is one of the triggers for renewable investment.
30.	Engaging the indigenous (local) people with a good philosophy supports the preservation of nature, and they hold an important role in the social movement towards clean energy transformation at the local level.
31.	Under the scenario of energy transformation towards clean energy, coal should be used for downstream activities, e.g., the production of Dimethyl Ether for cooking.

[a]The statements were presented in Indonesian language during the Q-methodology exercise

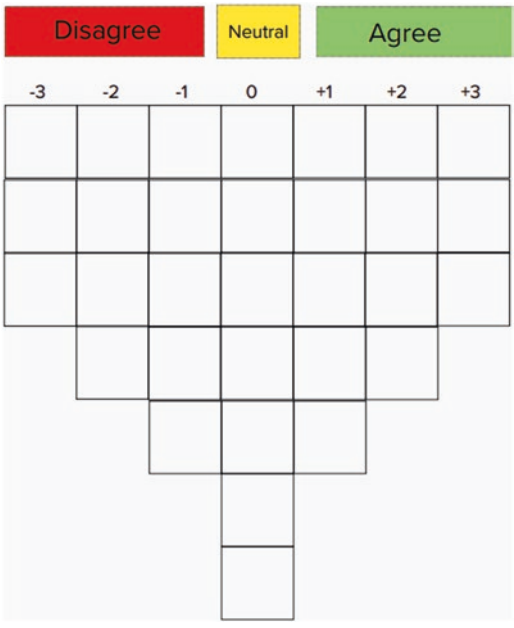

Fig. 3 Q-sort grid

Table 2 List of coding categories to identify transformative visions and the networked agents

Coding Category	Description
Types of human agents	International agencies, government, private companies, state-owned enterprises, civil society, non-governmental organisations (NGOs), financiers, universities/research institutions, policy advisors
Ecological nodes	The natural resources for electricity generation include fossil fuels, land, geothermal, solar, and water (Janssen et al., 2006) and region (Cheruvelil et al., 2017).
Transformative narratives or visions	Narratives that imply "where we want to go" and offer solutions to get there (Hinkel et al., 2020)
Tipping interventions	Farmer et al. (2019) and Otto et al. (2020) refer to deliberate actions that can cause multi-level qualitative changes from the respective agents in an energy transformation context involving social-economic and technological components.

perspective accounts for more data variance and offers a distinct view. A factor or perspective with eigenvalues <1 is usually ignored (McParland et al., 2011).

The Alternative Pathways Framework approach (APF; Lieu et al., 2020) was first used to position agents' general narratives of current and future energy systems collected from semi-structured interviews and FGDs. The Atlas.ti software was used to classify the collected insights to place narratives based on categories: types of human agents, ecological nodes, transformative visions, and tipping interventions (Table 2). Subsequently, the features of future narratives were specified with Q-methodology. APF looks at the mainstream and alternative narratives, where the latter can be characterised as on-stream, off-stream and transformative. The mainstream narrative depicts the dominant energy system, while the alternative narratives operate with different natures from the mainstream system. According to Lieu et al. (2020), the on-stream narrative occupies a niche within the mainstream but does not challenge the regime. Off-stream narratives represent niche clean energy technologies. Transformative narratives encompass radical technological innovations and fundamentally new ways of reorganising the socio-energy system. In Q-methodology, the features of transformative visions were explored beyond technological change. For example, key agents are initiating new political structures and modes of social-ecological interactions aligned with sustainability (a positive tipping point).

4 Results: Narratives-Network Dynamics of Current and Future Energy Systems in Indonesia

We summarise the different perspectives identified from agents' interactions and desktop research into mainstream and alternative narratives as follows:

4.1 Mainstream Narratives

The mainstream narrative emphasises the significance and continuation of oil and coal as the main primary energy sources. The background of this narrative is that before resource depletion made the nation a net importer in 2004, oil was considered the national energy backbone (Asia Pacific Energy Research Centre, 2016, p. 48; Iswahyudi, 2016). Indonesia then prioritised coal to meet rising energy needs, and Banten and Bali were no exception. For instance, the electricity demand of Banten Province is mainly supplied by coal-fired power plants (approximately 19 units owned by PLN and private companies). Moreover, the region ranks first in the country in installed coal-fired power plants (MEMR, 2020). Similarly, Bali has seven power generation plants that are fossil-fuel-based. The energy demand in Bali mainly comes from tourism and agricultural activities. Since the energy demand is higher than the supply capacity, Bali imports electricity from Java. Thus, coal is currently the dominant fuel for the Java-Bali system, as depicted in Fig. 4.

Regarding the agents, the policy system at the national level is actively governed by the Ministry of National Development Planning (Bappenas) and MEMR. In addition to private enterprises, PLN (a state-owned power company) implements and maintains the nation's electricity sector. Although private enterprises can only produce and sell electricity to PLN, PLN controls most electricity supply, transmission, and distribution. On the other hand, PERTAMINA oversees both upstream and downstream activities in the Indonesian oil and gas sector. These agents are commonly mentioned in the literature and interviews as crucial players in the sector to

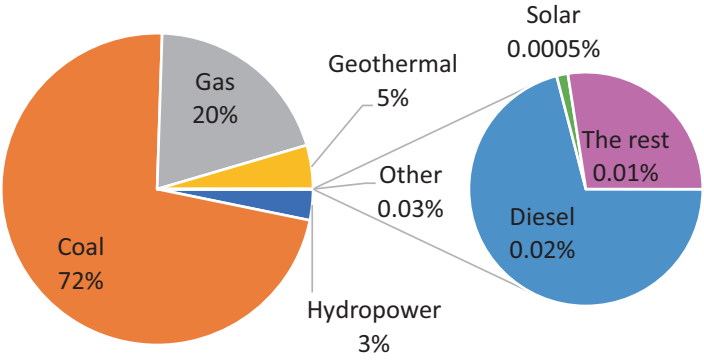

Fig. 4 Electricity Mixes of Java-Bali Interconnection in 2018 (BPS Indonesia, 2020)

trigger a systemic transformation towards sustainability (e.g., Maulidia et al., 2019; Setyowati, 2020; Shojaeddini et al., 2019).

Current energy policies allow lush fossil fuel growth that aims to provide 100% electrification. The national energy policy (Government Regulation No. 79/2014) emphasises energy conservation, oil reduction, renewable use, gas optimisation, and coal as security. This implies coal still occupies a fundamental position in the country's electricity system, including the regions of Banten and Bali, until 2030, as reported by Perusahaan Listrik Negara or PLN (2021).

4.2 Alternative Narratives

4.2.1 On-stream Narrative

The on-stream narrative argues for using natural gas as an alternative to coal to lessen oil dependency and address problems with air pollution. This narrative also describes several lower-carbon solutions, such as co-firing coal power plants with biomass, clean coal technologies/CCT (i.e., supercritical and subcritical boilers) and hybrid systems (i.e., clean energy coupled with diesel). The Indonesian government intends to build nuclear power plants in the future, but this is still subject to feasibility studies. Some power plants in Banten and Bali have already started using such suggested on-stream technologies. There are two coal power plants in Banten using CCT (about 2600 MW out of 8494 MW). With the central government and PLN (state-owned electricity company), Banten's local government plans to use up to 5% biomass in co-firing mode at the province's coal power plants. On the other hand, Bali only uses natural gas, supplemented by diesel power plants during peak hours. Also, the province imports additional electricity from Java Island (PLN, 2021).

4.2.2 Off-stream Narrative

The off-stream narratives emphasise the growth of clean energy. The off-stream narrative suggests hydropower, geothermal, solar, and wind have undiscovered potential in Indonesia. PLN amended its 2021–2030 electricity supply business plan (RUPTL) to include 51.6 per cent renewables by 2030. This shows PLN's commitment to diversifying the country's electrical system, including the Banten and Bali Provinces. At the provincial level, Bali and Banten's local governments perceive that solar energy has a promising potential to transform into clean energy in the electricity system. ESDM Banten and PLN also intend waste-to-energy, geothermal, bioenergy, and micro-hydro power. The Bali government noted that micro-hydro is practical but difficult because it often negatively affects tourism destinations. However, Banten private enterprises reported that "greener" approaches are poorly communicated, and some "green" initiatives are voluntary. In contrast, more inclusive interactions were observed among agents in Bali Province. The Bali

government actively collaborates with green companies, NGOs, universities, and research institutions for collective actions.

4.2.3 Transformative Visions

Transformative narratives or visions are not only about energy transitions. They also include other socio-economic, political and cultural aspects of the kinds of relationships that agents wish to have in their interactions with ecological systems. In the case of Indonesia, transformative narratives are related to critical issues like women's empowerment and access to education, the democratisation of governance arrangements, providing a voice to social movements (Temper et al., 2018) and, more broadly, the achievement of the UN Sustainable Development Goals (SDGs). Developing resilient local socio-energy systems can contribute to local and global climate mitigation and adaptation.

The study generated two *factors* or perspectives on who could be involved in developing the socio-political conditions for the emergence of positive tipping points in these regions based on z-scores from Ken-Q analysis (see Table 3). These two perspectives elucidated the variance between the participants' views (Fig. 5). They revealed two guiding visions towards clean energy futures: (i) transformations emphasising governance coordination and (ii) transformations focusing on economic diversification.

Vision 1: "Governance Coordination"
Vision 1 (V1) underlined that a systemic change in the country required the interventions of government and international agencies to enable clean energy (e.g., carbon tax) because of its authority and resources to do so. Most participants agree that the government and international agencies are the tipping agents. Given their

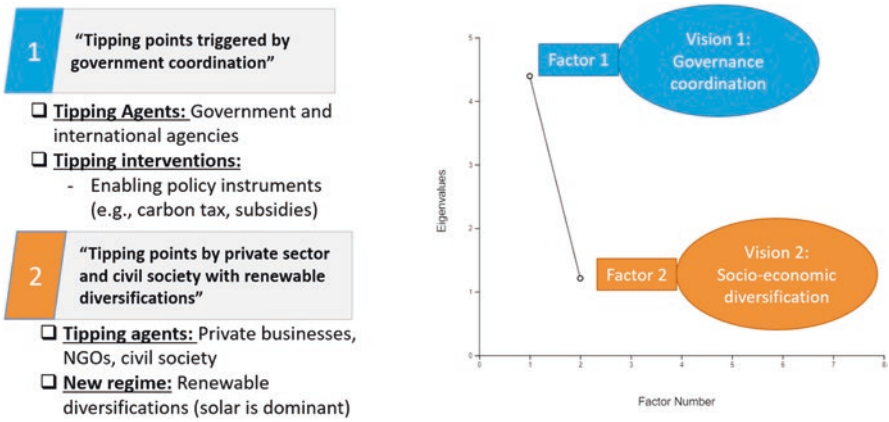

Fig. 5 Results of the Q-method on the perspectives on transformative narrative towards clean energy in Banten and Bali

authority and resources, these agents would build conditions for enacting deliberate systemic tipping points. Many participants, including private companies and NGOs, opined that the existing policies still promote mainstream narratives that hinder the development of technology for renewables. For instance, Banten private enterprises await government directives to replace business-as-usual. However, some private companies in Bali recognise the Bali government's objective of clean and green energy as a "green light" for clean energy investment.

Vision 2: "Socio-economic diversification"
Vision 2 (V2) favours tipping points triggered by agents other than government agencies. In this perspective, private firms, universities/research institutions, NGOs, and civil society must collaborate to spark local systemic change, rather than relying on the government. This group promotes non-governmental agents and more polycentric approaches to energy governance to build sufficient human resources and capacities to enable sustainable transformations. Private companies are often seen as the innovation sources that make new technologies more competitive. NGOs and universities or research institutions are important as the bridging agents between the government and society to endow them with adequate knowledge and sustainability awareness. This perspective promotes the diversification of renewable energy from solar, wind and bioenergy, particularly in decentralised and remote areas. It also envisions a more complex socio-economic structure and decision-making processes. For example, private firms install solar panels for community use and to facilitate economic diversification.

4.3 Narratives within Social-ecological Networks of the Indonesian Energy System

The network of relevant agents in the Banten and Bali Province's energy sector is derived from interviews and focus group discussions. From their perspectives, we positioned the agents according to which narratives they were promoting (See Figs. 6 and 7). Government agencies such as BAPPENAS, PLN, PERTAMINA and local governments advocate fossil fuels and renewable energy, placing them between the Mainstream and Alternative narratives.

By deploying degree centrality with Gephi, we identified the potential agents that could steer the current system toward sustainability, given their connectivity. The networks centre on MEMR and PLN (see Figs. 8 and 9). Using regions as the ecological element for agents' authority and the resource flow of energy, the results highlighted the key roles of PLN, local governments (ESDM Banten and ESDM Bali), and civil society.

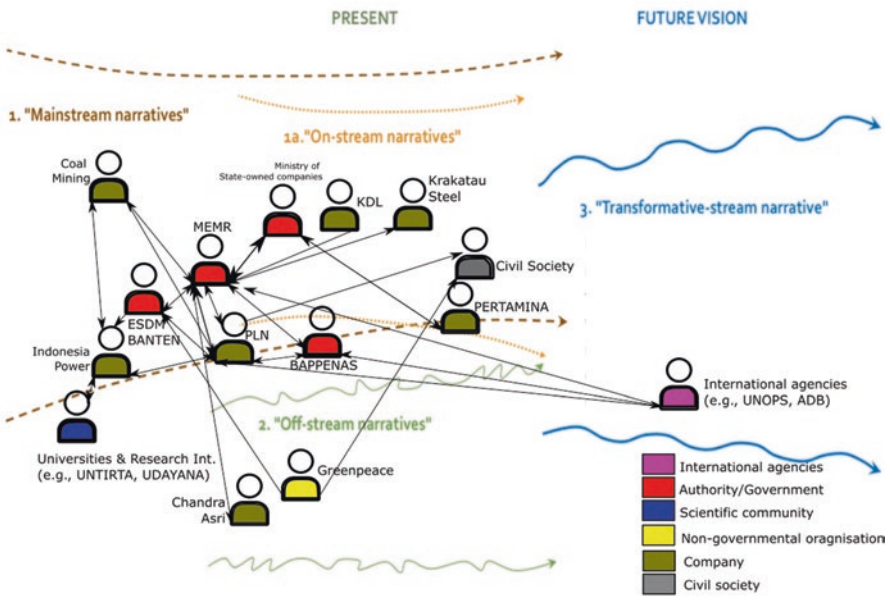

Fig. 6 Narrative position within agents' network in the energy sector in Banten based on APF

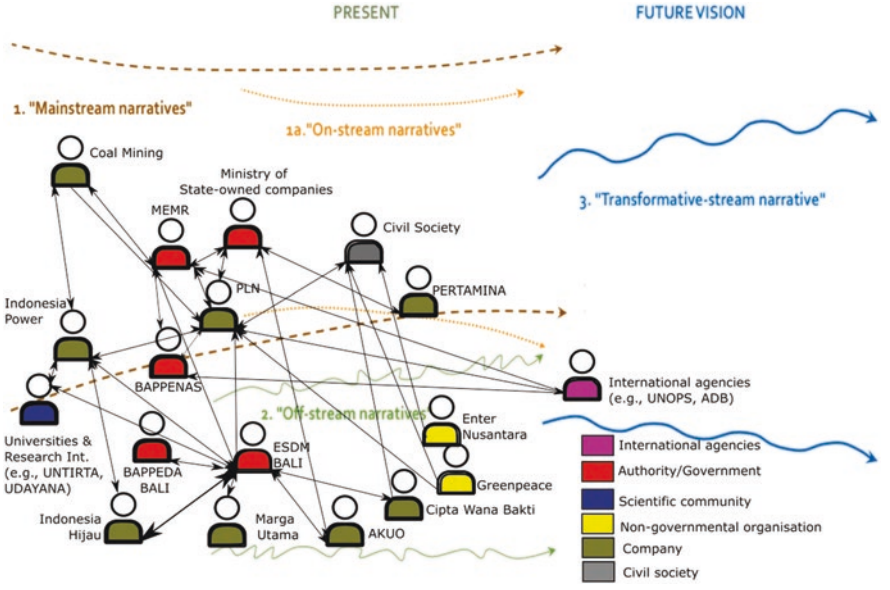

Fig. 7 Narrative position within agents' network in the energy sector in Bali based on APF

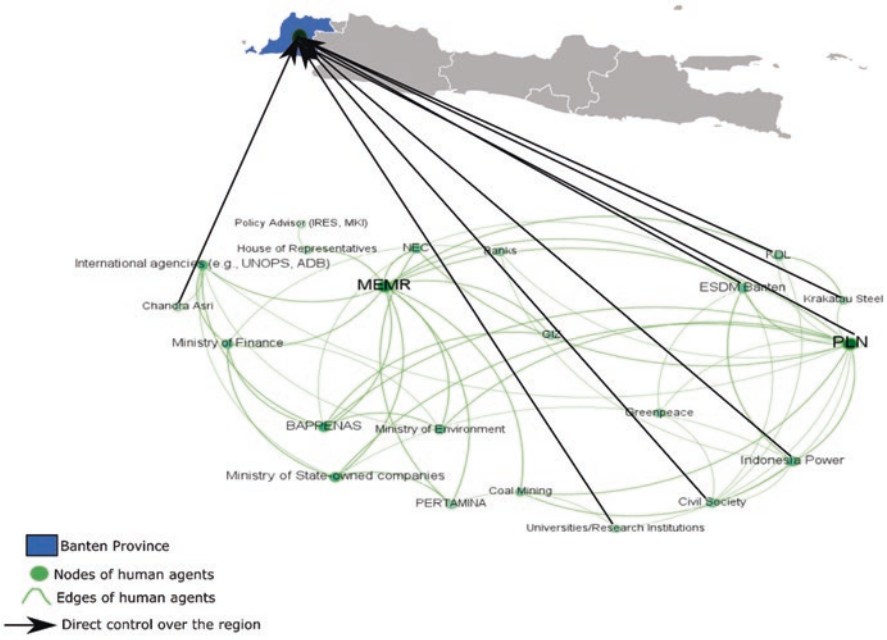

Fig. 8 The social-ecological networks for energy operationalisation in Banten

5 Discussion: Network Dynamics and the Diffusion of Transformative Visions

Our study looked at the role of narratives and network configuration in creating the cognitive policy and social conditions for tipping systems toward desirable, sustainable futures. We conducted discourse analyses with SNA (with an ecological element) to check to what extent agents' actions and visions could serve as components of anticipatory social tipping signals for positive tipping points. The Banten and Bali case studies indicated that narratives take time to become actions and create the conditions for transforming social-ecological structures, whilst some narratives may fail to influence reality. Social-ecological network analysis also revealed that some significant agents in the network were central to shifting narrative discourses and energy policies. These results offered two visions that, by making them explicit and allowing them to be discussed, could help mutual learning among different networks.

Most interviewees agreed that renewable diversification is feasible in Indonesia in the future, yet transformative visions about sustainable futures take time to ensure systemic changes. As noticed by other studies (such as Lenton et al., 2022; Pereno & Barbero, 2020; Tàbara et al., 2018), large systemic changes occur due to the interplay of actions at different scales. Understanding tipping dynamics at lower

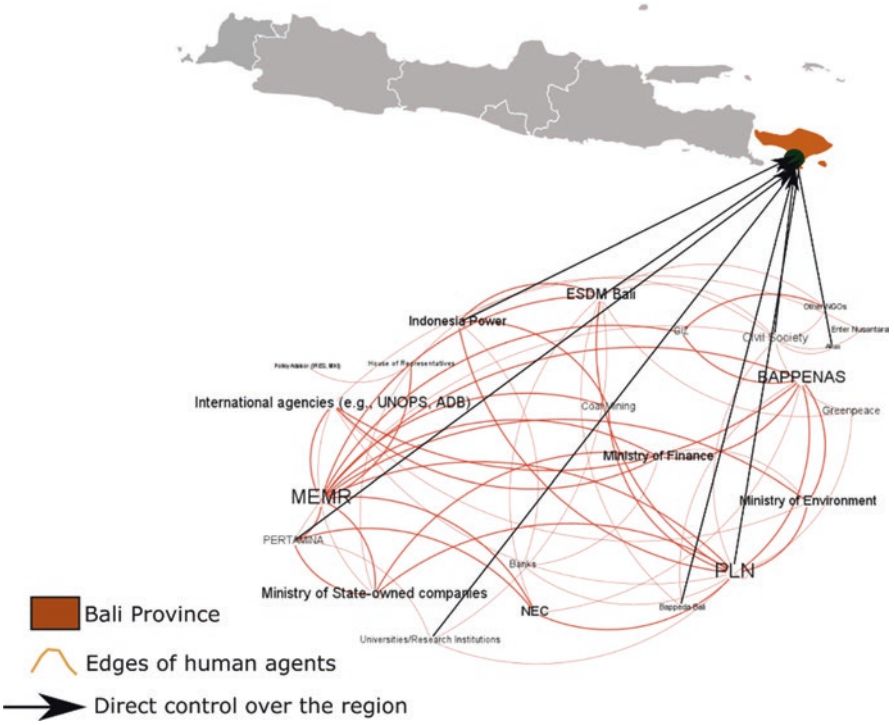

Fig. 9 The social-ecological networks for energy operationalisation in Bali

scales, such as communities, may serve as social anticipatory signals of tipping points, either positive or negative, that may occur in larger social-ecological configurations (Gangwal et al., 2020; Lenton et al., 2022; Tàbara et al., 2018). For instance, NGOs like the Indonesian Renewable Energy Society (IRES) and Greenpeace bridge government and communities according to their Vision 1 to influence the governments' narrative position towards off-stream technologies. Therefore, mapping how different agents learn and interact across scales is crucial to understanding positive tipping points' potential and complex dynamics.

Whilst transformative visions alone may not be sufficient to trigger and consolidate change, we argue that the different configurations of network structures play a crucial and differentiated role in enacting systemic change. Targeting specific nodes or subgroups in the networks that contribute simultaneously to narrative building and policymaking can be extremely effective in knowing where to target actionable tipping interventions. For example, most agents driven by Vision 1 aim to interact with the government in amending the government's narrative position from mainstream to off-stream technologies. Other international organisations are also increasingly playing a role in the socio-energy network configuration, as is the case of the assistance from the United Kingdom for constructing a dam and hydropower plant

in the Buleleng Regency, Bali (Investor Daily, 2019). Another example is that the proportion of clean energy in Banten's electricity rose to 5.9% according to Local Regulation of Banten No. 7/2022 when PLN moved towards clean energy deployment, given its access to human-made resources and direct control over the region (Banten Local Government, personal communication, 2021).

At the same time, other weak-tie agents in the social energy network, such as civil society organisations and small businesses, are also important, albeit performing different functions in the energy transformation processes. Some private companies with Vision 2 in both provinces are beginning to deploy clean energies despite the absence of local directives. For instance, one company in Banten disclosed that their green initiatives were voluntary and contributing to national GHG reduction pledges. Ultimately, SNA with ecological elements helped identify a centrality approach over a concrete region and its power dynamics to trigger or hinder change.

This study also demonstrates that the analysis of narrative-network dynamics can constitute an appropriate methodology to identify anticipatory social tipping points (ASTS) that create the previous conditions of systemic change, new opportunities for mutual learning and joint transformative strategy building among diverse social networks. The energy sector is projected to change rapidly and systemically if agents with different visions can collaborate (Pereira et al., 2015). Understanding these complex socio-economic and political processes is paramount in non-Western countries with vast amounts of fossil fuels like Indonesia. For instance, agents that aim to influence the government (Vision 1) could utilise best practices such as private sector installation of clean energy sources to influence the mainstream narrative of governmental agencies. A shift from the mainstream to the off-stream narrative can signal positive or negative tipping points before interventions, such as policies favouring renewable diversification (off-stream narrative) through carbon pricing or subsidies.

6 Conclusion

Using participatory discourse analyses and social-ecological network analysis, our study looked at the role of narratives and network configuration in creating the conditions for tipping systems toward desirable sustainable futures. Discourse and network analyses are used to check to what extent the actions and visions of agents in networks can serve as components of anticipatory social tipping signals for positive tipping points. The Banten and Bali case studies revealed that transformative visions of sustainability can inspire positive tipping points. Still, time and effort are required for narratives to become actions and change social-ecological structures. Furthermore, not all narratives successfully influence the conditions leading to transformative changes. Through network analysis, it was possible to discover some

key agents within the networks that could be identified as having a centrality position in changing narrative discourses and energy policies. These results also offered two kinds of visions that, if combined or reconciled, may help mutual learning among different networks.

Most interviewees agreed that renewable diversification is feasible in Indonesia, but transformative visions of sustainability do not ensure instant systemic changes. Precedent studies showed that large systemic changes result from the interplay of actions at different scales. Tipping dynamics at lower scales, such as in communities, can indicate potential tipping points in larger social-ecological systems, either positive or negative. For example, local actions like Indonesia's micro-hydro and geothermal energy can lead to rapid and systemic changes in the national energy sector if combined with other small-scale actions. Therefore, it is important to map the role of multiple learning networks and feedback loops by all relevant agents at different scales to understand the possible emergence of positive tipping points. Whilst transformative visions alone may not be sufficient to trigger and consolidate change, we argue that the different configurations of network structures affect in various and, in some cases, complementary ways the building of conditions for systemic change. Targeting specific nodes or subgroups in the networks that contribute to narrative building and policy-making simultaneously can be an effective approach to knowing where to target actionable tipping interventions. In this case study, social network analysis with ecological elements helped identify a centrality approach over a concrete region and the power dynamics to trigger- or hinder-change.

With discourse-network analysis, the case studies showed that PLN and MEMR were powerful national agents, yet their discursive positions were still halfway between mainstream and off-stream narratives. These findings imply the importance of empirically tracking social network dynamics and the benefits of a mixed-method approach with modified ISA to assess their relationships by constructing alternative, transformation-oriented narratives. The results also underlined the need to consider the views of weak-ties agents such as civil society organisations and private companies operating at lower scales, given their direct and key participation in achieving broader social and sustainable development goals at the regional levels. Therefore, this study suggests that narrative-network dynamics may serve as *anticipatory social tipping signals* (ASTS) in socio-energy systems to learn from each other and develop transformative strategies.

Nevertheless, this research also acknowledges two important limitations: first, the social networks were observed at a certain time, so their long-term effects on broader structural dynamics cannot be fully assessed. Second, this study only focused on one ecological element, the energy flows and resources of the selected regions. Empirical research may need to explore other biophysical components and interaction features to obtain a more comprehensive view of social-ecological agents and tipping dynamics.

Appendix

Table 3 Q statements and their z-scores

Statement No.	Statement	Z-score	
		Factor 1	Factor 2
1	Policy turbulence and technological barriers are the most challenging issues in energy transformation towards clean energy.	1.56	−1.16
2	Due to their intermittency, the great challenges in solar and wind uptake include storage technology and transmission and distribution infrastructure.	0.69	1.2
3	Solar, wind, biogas and biomass are for decentralised and remote electricity systems.	−1.11	1.62
4	Solar energy can replace the old and inefficient fossil fuel power plants (i.e., oil and coal)	0.47	0.2
5	The key agents at the regional level are national and local governments to implement energy transformation.	0.09	1.47
6	The citizens can be the agents of change in the collective mode in deciding clean energy adoption (related to social acceptance and communal funding)	0.9	0.86
7	The government should be more committed to implementing clean energy transformation with its enabling policy and regulations.	2.15	−1.38
8	The Government should consider fiscal incentives (e.g., subsidies and tax incentives) for accelerating renewable energy.	1.7	0.38
9	Renewable investment from the business and industry sectors is crucial to transforming the coal and carbon-intensive regions combined before policy intervention.	−0.19	0.59
10	NGOs, village-owned companies and cooperatives are the key agents to ensure the implementation of renewable uptake at the local level.	−0.36	1.53
11	The role of the young generation is crucial for wide clean energy awareness.	0.79	0.74
12	The tipping point towards clean energy also depends on fossil fuel availability.	−1.5	−1.68
13	Clear visioning and targeting in energy transformation accelerate clean energy uptake. Hence, a more ambitious target is needed.	1.01	−1.96
14	Leadership is an important attribute owned by individual agents or collective agents.	0.53	0.55
15	International pressure and support can accelerate Indonesia's energy Transformation towards clean energy.	0.83	−0.4
16	Overdevelopment in forest areas and the high cost and risk of exploration are the main concerns in geothermal development.	−0.88	−0.22

(continued)

Table 3 (continued)

Statement No.	Statement	Z-score	
		Factor 1	Factor 2
17	Hydrogen is separate from the energy transformation towards clean energy in 10–20 years due to its high cost.	−0.87	0.73
18	The Law (Undang-Undang) is the preferable policy intervention to ensure the resilient energy transformation towards clean energy.	−0.01	−0.87
19	The Government Regulation (*Peraturan Pemerintah*) is the minimum requirement to corroborate the position of the hub agent.	−0.32	−0.31
20	Unfavourable and bureaucratic process for renewable operating permit hinders renewable uptake.	0.02	−1.04
21	Innovation in multiple sectors is crucial to change the regime system. However, policy innovation is essential to enable market growth.	−0.24	−0.34
22	Energy affordability and access are preferable to the concern regarding climate change impacts.	−1.03	0.16
23	Capacity building for financiers regarding clean energy uptake is important.	0.44	0.28
24	If we only depend on the state budget, it is almost impossible to achieve clean energy. Thus, the private sector and banks are vital for energy transformation.	0.31	1.14
25	Migration brings a paradigm shift regarding the importance of energy transformation towards renewable.	−1.31	0
26	Research and reliable data are required to increase the technology and social readiness for renewable energy implementation.	0.79	1.17
27	Knowing the importance of clean energy is crucial in determining social acceptance of clean energy uptake.	−0.17	−0.28
28	The pandemic forces the community to be prosumers in generating their energy (i.e., back to nature), for example, by using rooftop solar technology.	−1.99	−0.65
29	The carbon market is one of the triggers for renewable investment.	−0.26	−1.6
30	Engaging the indigenous (local) people with a good philosophy supports the preservation of nature, and they hold an important role in the social movement towards clean energy transformation at the local level.	−0.36	0.15
31	Under the scenario of energy transformation towards clean energy, coal should be used for downstream activities, e.g., the production of Dimethyl Ether for cooking.	−1.64	−0.87

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