# Regional Energy Transition (RET): how to improve the connection of praxis and theory?



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Abstract. A regional energy transition (RET) implies a drastic transformation of the energy system and, hence, a lot of challenges. A RET calls for an integrative local approach. In this essay we describe and compare the current practice and the state of knowledge on this topic. We find that theory has not yet developed sufficiently to address the practical challenges. Part of the problem is that what has been developed has too little connection with local practice. We conclude that the development of theoretical knowledge must be better attuned to the needs of the practitioners.

Keywords: Energy system transformation, Regional planning, Climate change mitigation

## Introduction (1)

Deep greenhouse gas reductions will require a drastic transformation of the energy system (see e.g. EEA, 2017 and IEA, 2017). In this essay we will focus on the regional approach for such an energy transformation. We will refer to this as Regional Energy Transition (=RET). One could substitute RET for "Smart Cities" or "Sustainable Urban Planning" and you will get a similar analysis, because all three are associated with multiple interests/values of stakeholders, institutional complexity and scientific uncertainty.

This essay first sketches the challenges involved in a RET (§2). Then it describes the current state of knowledge and tools that could support a RET (§3). In §4 we draw conclusions by comparing knowledge development with the challenges of a RET. This essay is based on preliminary research results of the ESTRAC research project *Transforming Regions*[1].

## Challenges of RET (2)

A regional energy transition (=RET) is a process to achieve a certain outcome (=deep emission reductions). A region is defined as a coherent geographical area, varying from a district to an area with several municipalities or cities. A regional energy system is also internationally interconnected in most parts of Europe. Figure 1 makes tangible that a RET involves different geographical levels.

In the Netherlands, a pilot on RET was organised: regional energy strategies (RES). The pilot was carried out in five regions in the Netherlands and was finalized with two evaluations (Schuurs and Schwencke, 2017; Bosman et al, 2017). These evaluations helped us to frame the challenges of a RET in a concrete way. The challenges were divided according to three topics: stakeholder involvement, organisation of a RET, and the possible transformation of the energy system.

## Involve stakeholders

A lot of parties or persons are affected by a RET: residents, local companies, local authorities (provinces, municipalities, water authorities), utility companies (energy, energy infrastructure and water), real estate owners, project developers and so on. In the implementation of a RET, stakeholders are mutually dependent on each other, not only within the region, but also outside. Decisions on the national level determine to a large part which local system changes are possible: e.g. legislation on energy infrastructure or on pricing (taxes). Local decisions influence the realisation of national transformations. Some local decisions require the cooperation with other local levels: for instance, if citizens in one neighbourhood want district heating, this may require other nearby neighbourhoods to also adopt district heating in order to be feasible. The interdependency of stakeholders also has a financial side: common or collective business cases could lead to the lowest social costs for all. And last but not least, the issue of timing: decisions of stakeholders mostly do not happen simultaneously because activities of individuals will not be synchronous. A regional approach could be used to organise the interaction with all stakeholders in a satisfactory way; a way that leads to collective support and to the least (collective) costs solutions.

Another key issue for a RET is leadership: one needs 'something/someone' to organise this collective effort. In most regions there is no single stakeholder that would be exclusively in charge of the RET activity. And mostly no stakeholder can decide about investments of other stakeholders. This means that an initiator is needed. Often, stakeholders are looking at a local authority to act as such, but there are alternatives. Examples could be energy network operators wishing to extend their assets or housing corporations needing to renovate their buildings. This 'choice' of the initiator can be highly coincidental and this contingency can and will have an impact on the dynamics of stakeholder involvement as a whole. In a general sense, every stakeholder can (justly) question the legitimacy of the initiator as the responsible actor for a RET.

In summary the main challenges are:

- Large diversity of relevant stakeholders and interdependency of decisions.
- Leadership- who can be a trusted and convincing initiator?

## Organizing a RET

The organisation of a RET is connected to the plans of stakeholders in the region. Most stakeholders have their own plans at a strategic, tactical and operational level. A strategic plan articulates the long-term ambition, for example: 'Region X wants to lead the way in the energy transition in the coming 15 years'. The stakeholders have to find a way to align their own strategic plans with the common and shared strategic plan for the RET. The strategic plans of national or multinational companies will surpass the boundaries of the region. These companies will have to fit the


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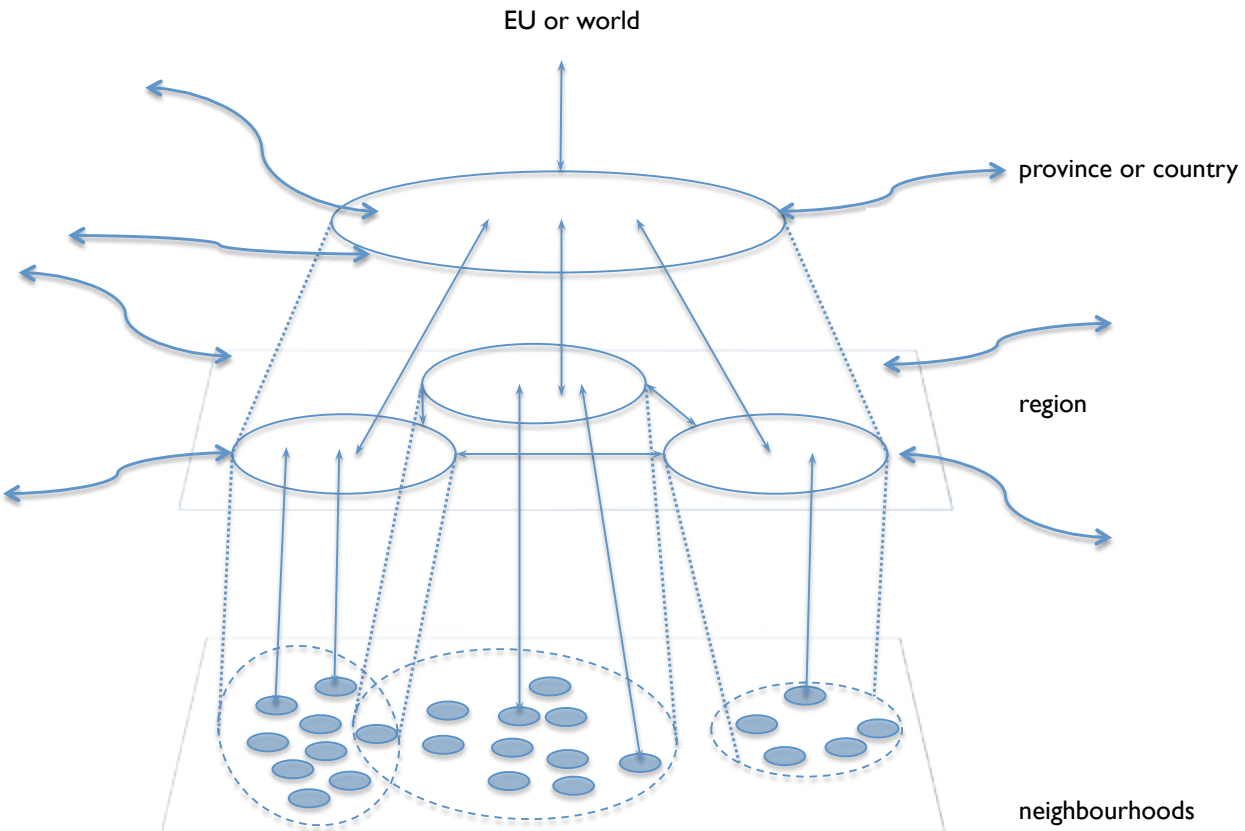
strategy for the region internally with their own management and strategic department.
Next, the tactical and operational plans of all relevant stakeholders have to be adapted to that strategic plan. Examples of tactical plans are: a plan for a sustainable heat supply or a plan on stimulating electric transport. Examples of operational plans are: (i) a housing association that will isolate its building stock in one street by providing double glazing or (ii) a network operator that will change the gas infrastructure to an electric grid in a specific location. The collaboration inside a RET could lead to common tactical plans (e.g. on 'heat', on 'mobility'). No matter what will happen, these adaptations will lead to iterations within the organisation of each stakeholder and the outcomes of those iterations could very well lead to new discussions on the strategic or tactical level. It could also cause problems at the operational level. This interaction and iteration at and with the different levels can go on for some time. Figure 2 gives an idea of the connection between types of plans.
What makes things even more complicated, is the fact that each plan comes with its own decision cycle and timing. The time horizon of the plans varies per level (strategic is longer term, operational is short term) and per stakeholder: long term for a local authority can be 15-50 years, for a housing association 25-30 years and for a company even less than 10 years.
In summary the main challenges are:

- Achieve a common process for decision-making and implementation;
- Analyse and understand the interconnectedness of all stakeholders and their activities, at all relevant scales;
- Find ways to match timing and content of all types of plans of all relevant stakeholders in the region.

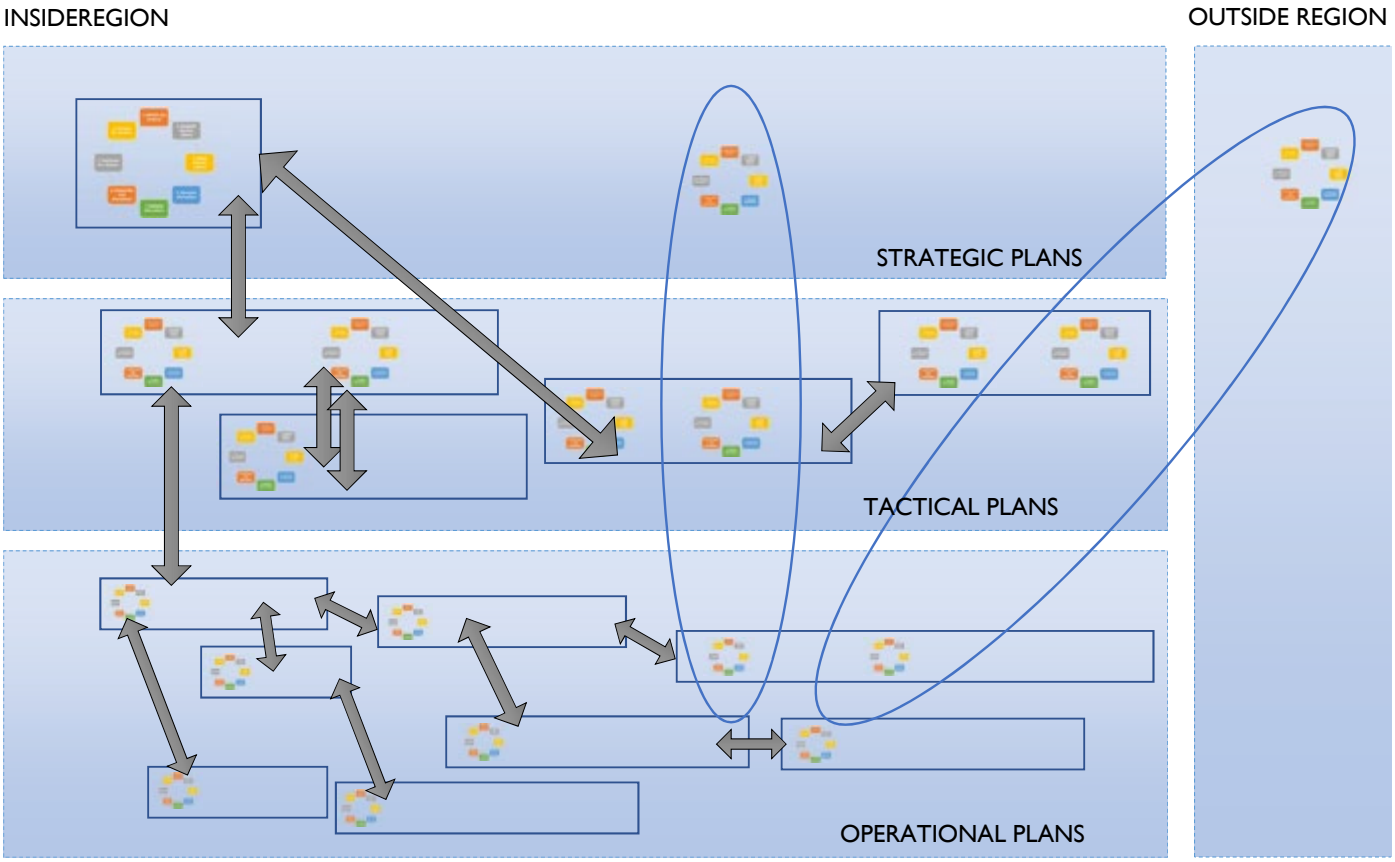
**Transforming the energy system**

A RET assumes a drastic transformation of the energy system: at the supply side, at the demand side, as well as in the intermediate part (storage, transformation and distribution). The adjustments at the supply side need to match changes in energy demand and the other way around. The following sections provide a short overview of the trends and possibilities in the demand, the supply and the intermediate part:

01 |




01 | Interconnectedness of activities in a region with activities at other levels




02 | Inclusion of the decision framework into planning at the different levels of regional development

- **Buildings.** New buildings meet stringent energy performance standards, which significantly reduce heat demand. This low heat demand makes electrification of the heating systems possible by using electric heat pumps. For existing buildings the picture is different: electrification only seems possible in combination with large-scale renovations. In cases with higher remaining heat demand, partial electrification (= hybrid heat pumps combined with a gas-fired boiler) can be an alternative. Other alternatives are gas-fired systems or district heating.
- **Transport.** There is a trend towards electrification of transport and zero emission vehicles. The design of the e-charging infrastructure is still under development. There are a lot of open questions with regards to type and scale. Hydrogen powered fuel cell electric vehicles increasingly seem to present a viable alternative in case of energy-intensive transport applications (for instance heavy duty trucks and regional buses). And probably some applications will continue to rely on the use of liquid fuels, for instance aviation and international shipping.
- **Supply side**. All energy carriers (in the current system: electricity, natural gas, gasoline, kerosene etc.) are expected to become climate-neutral. Electricity may be generated from renewable sources like solar and wind power or from the conversion of climate-neutral fuels. The gaseous and fluid alternatives can either be bio-based or synthetic fuels based on hydrogen and a climate-neutral carbon source. District heating systems can be fed with climate neutral heat (like residual heat from industry or geothermal heat).
- **Storage and distribution.** Demand and supply of energy (electricity in particular) most often do not occur at the same location or at the same moment. Therefore, some form of national grid is required for the transportation and storage of energy carriers. Such grids are very capital intensive. This results in high costs at the beginning and benefits that are only realized (much) later. Another important aspect is to ensure that demand can always be met. The current energy system can easily fulfil this criterion: storage costs for fossil fuels are

low and large-scale thermal power plants for electricity can easily be operated to achieve a good fit between supply and demand. The new energy system will depend more on intermittent electricity sources and seasonal biomass. This means that buffers must be made to handle daily fluctuations as well as seasonal fluctuations. Large-scale storage of electricity and heat, but also of gases is necessary but such systems are still technologically and economically premature.

Looking at these trends and possibilities, the following main challenges can be observed:
- Uncertainty with regards to solutions. There are a lot of options to achieve a RET. It is not yet clear what options fit best in what situation. The interdependencies between decisions of various stakeholders also increase the uncertainty.
- Uncertainty with regards to data. There is a lot of different data on the different solutions. Sometimes exaggerated by proponents or opponents of single options. On the other hand, the development state of new options is changing. This means that the corresponding techno-economic data cannot be very accurate. The interdependency of solutions adds to this uncertainty.
- Prisoners' dilemma. The collective part of the solutions (like grids and district heating) could help to bring down the social costs of the energy system. Investments for the collective parts are big and risky and the income comes (much) later and is not certain.

**Available knowledge and tools (3)**

A scientific literature survey[2] has been carried out in the ESTRAC project. Scientific research gives a very clear conclusion on complex societal issues. Tackling these complex societal can only be done by adaptive management or "learning by doing": an iterative process of analysing, documenting, envisioning, experimenting, evaluating, and adjusting policies and procedures (see e.g. Woestenburg et al, 2017). An important requirement is to have a holistic or systemic view and not a linear or partial view on the problem (APSC, 2007). Based on the challenges addressed in §2, we can conclude that a RET is such a complex societal issue. So the first conclusion is that a RET needs a systems approach (including system integration) and adaptive management.
Below we will summarise the lessons from the survey for the following subjects: (i) stakeholder involvement and (ii) tools, models and methods. In the ESTRAC survey we also found that the article of Bibri & Krogstie (2017) is a very helpful summary of scientific results for most of the subjects relevant for a RET.

**Stakeholder involvement**

The scientific literature on the involvement of stakeholders in complex processes is very clear: real collaboration with all relevant stakeholders is essential to achieve lasting results (and current practice generally falls short in this respect). In the case of a RET 'all relevant stakeholders' means: everyone who has an interest in the area. These are all residents in the area, all companies based in the area, all employers of those companies, all real estate owners in the area, all local authorities, all owners of the infrastructure in the area and all suppliers of energy to the area.
The other main lesson is the magic word "trust" (or rather: an observed lack of trust between relevant parties). Real cooperation is the only way to build trust, and trust is what is needed for all parties to act together, and acting together is a prerequisite for the adaptive approach that is needed to deal with this complex planning situation.
Scientific literature also gives some guidance for the effectiveness of these interactive processes:
- **Clarity and transparency.** To build the necessary trust, the analytical part needs to be clear to and transparent for all stakeholders, and they must be able to understand the inputs and the outputs (and their possible relations). The chosen energy solutions should be relevant and realistic to the stakeholders throughout all phases of development: from a vision to the final construction plan.
- **Incorporate the knowledge of all.** Using, and building on, the knowledge and experience of all stakeholders involved is not only effective in gathering local data but it also helps to increase the feeling of joint ownership and the credibility of the whole project.
- **Systematic learning.** It is very effective and efficient to organise cooperation in such a way that those involved are learning together. When stakeholders are learning together, they get a shared understanding of the issues at stake and they (as a group) become more able to adapt to the unexpected events to be faced.

**Tools, models and methods**

A wide range of tools, models and methods are available to support a RET. In the ESTRAC program, factsheets have been made of about 40 of those tools. Below we will discuss these tools in two categories: (1) organisational models and (2) techno-economical tools.

***Organisation models***

The organisation of a RET resembles decision-making in spatial planning. Analytical models for such decision-making are mostly characterised by a decision cycle that is derived from the general PDCA (Plan-Do-Check-Act) cycle: the idea is that decision-making is a cyclic process and this cycle consists of separate serial activities.
These cyclic models are meant to be able to carry out a meaningful conversation about the organization; they are not meant to be an exact description of the succession of processes. One can, for instance, focus on the step of *problem identification* and what is needed to organise that step in the right way and what exist-

ing (analytical) support tools are available and relevant. It might be useful for a RET initiator to use a specific cyclic model for the organisation of the RET. Up until now we did not find any scientific report on the practical use of specific cyclic models in real life cases[3]. We did find a lot of other scientific lessons. Bibri & Krogstie (2017), among others, point out that it is essential (for success) to have a common and shared problem definition, to achieve real large-scale cooperation and to monitor the organisational process. One could use so-called co-creation methods, where different parties practically work together to explore and find solutions that are broadly supported. Such methods help to engage stakeholders in transition processes. It is also essential for the initiator to monitor the status of the common support at all times. This means that next to the material progress, also the attitude of the stakeholders should be monitored continuously.

***Techno-economical models*** Pfenninger et al (2014) and Hall & Buckley (2016) describe and review a broad set of models that could be useful for energy system transformation, from energy system models to bottom-up (cost) engineering. Together these models enable the analysis of the energy supply and demand in a region; make it possible to develop scenarios; determine a preferred mix of technologies, given certain constraints; simulate behaviour of energy producers and consumers in response to prices and other signals, etc. These tools could support a RET in getting all relevant information at the table in each step of the decision cycle.

Each tool has its own scope and goal. The scope and goal determine the level of data. For a national roadmap one can use simpler models with average data, for a regional energy plan one needs to determine the actual costs, effect and capacity of concrete actions. No matter what is done, it is essential that the tools are "transparent" in the sense that each stakeholder understands at least conceptually why, what and how it is implemented and that the outcome is broadly trusted and accepted.

The analysis and assessment of all available techno-economical models in ESTRAC is still going on. The good news is that for all phases of the decision cycle, one or more tools are available and applicable for a RET. The bad news is that hardly any of these tools are ready-for-use and most of them have to be tailored to a specific region; some of these tools are very data-intensive; and some need data that are not available yet.

**Conclusions (4)** We start with a couple of observations:

- **Experience is recent and growing**. Nearly all integrated local approaches started their development after 2010. Currently some cities, regional authorities, and regional stakeholders are trying to use some form of an integrated approach. The experience is still building up. Scientific research on the new approaches has only just started.
- **There are relevant lessons from sustainable urban planning**. Integrated approaches have their roots in sustainable urban planning (SUP). Several articles on SUP contain a review of an overall approach in practice. Next to Bibri and Krogstie (2017), a complete volume of the journal *Current Opinions in Environmental Sustainability*[4] can be seen as a state-of-the-art on SUP. Both sources give a lot of general and specific lessons learned: on the opportunities in cities, on governance ('urban living labs'), on innovative processes, on involving citizens and residents, on the role of stakeholders, on ICT and combining smartness with sustainability.
- **There is a need for tested decision-making approaches**. Looking at the challenges of RET (see §2), we observe a large need of verified decision-making approaches. The scientific testing of such approaches is still absent. This should be a challenge to all (social) scientists active in sustainable development (or other complex societal problems).
- **Guidance for practical application is needed**. A RET practitioner would tell you that there is too much "out there", and he does not know how to choose the tools and the approaches and how to assess the results. They ask for some kind of guidance or guidebooks (Bosman et al, 2017).

Comparing the challenges of the current RET practices with the current state of knowledge, we can only conclude that knowledge and tools do not match the needs of the practitioners. Practice and theory need to be connected in a better way. The theory has not yet developed sufficiently, and what is being developed has too little connection with practice. The current state-of-the-art of knowledge and tools can at most be called promising, but certainly not fit for practice, as Bibri and Krogstie rightly conclude: "*The findings show that existing smart city approaches […] are associated with many issues and challenges—when it comes to their development and implementation as to the incorporation of and contribution to the fundamental goals of sustainable development, respectively. […] Therefore, there are several critical questions to address or problems to investigate concerning definitional, conceptual, theoretical, analytical, evaluative, empirical, and practical aspects.*" (2017, p. 208). We strongly recommend to carry out scientific research more closely with practice and practitioners, and to intensify this research especially in two directions: (i) decision-making at local level and (ii) testing integrated tools for RET.

## NOTES

[1] This research is, however, still in progress, see acknowledgements.

[2] Articles and reports on the following subjects: (sustainable) urban planning; smart cities; sustainable development; achieving climate change goals in cities and regions; and regional economic development.

[3] In the scientific literature we could not find one review of a practical integrated approach for sustainable (urban or regional) planning neither could we find detailed evaluations of such an integrated approach in real life.

[4] *Current Opinions in Environmental Sustainability*, Vol. 22, October 2016. This is a special issue on the subject of "System dynamics and sustainability" and according to the editors especially focused on urban transitions to sustainability and resilience.

## ACKNOLEDGMENTS

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