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Preparing the ground: Regulatory challenges in siting small-scale wind turbines in urban areas

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ABSTRACT

Countries worldwide have set national targets for energy production from renewable sources. Yet, while many governments are committed to more renewable energy, obtaining permission to site installations is becoming increasingly difficult. With large tracts of land for renewables becoming intensely contested, countries seeking to meet their renewables targets are directing attention also towards tapping the potential in the urban environment through smaller-scale facilities. These entail other challenges, and countries are seeking ways to overcome them.

The focus of this paper is on one, still evolving, type of renewable energy technology: small-scale wind turbines (SSWT). The paper presents a review of current but limited international academic knowledge on the land-regulation aspects of siting SSWT in countries that already have experience with such installations, including the USA, UK and New Zealand. The paper also reports on a comparative analysis of the land-related regulations and practices in two selected Mediterranean jurisdictions – Spain (Catalonia) and Israel. The approach of this study is exploratory, relying on analysis of legal and policy documents complemented by field work through in-depth interviews with key-stakeholders in both jurisdictions. The overall aim of this study is to examine different approaches of planning systems to new technologies.

The findings show that despite their shared objective factors, the two jurisdictions have adopted almost opposite approach to regulating SSWTs. The findings, therefore, suggest that the incorporation of an unknown technology within the city requires a change of mindset both among the officials and among the city residents. A more effective regulatory framework might therefore entails a combination of strategic thinking, an experimental approach and the capacity to learn from cross-national comparative experiences.

1. Introduction

Countries worldwide have set national targets of energy production from renewable sources, primarily involving hydropower, solar, wind, bioenergy and geothermal power. In January 2014, the EU countries agreed on the target of 27% share of renewable energy consumption by 2030 as part of their policy framework for climate and energy. The much-acclaimed December 2015 Paris Agreement hosted by the United Nations has set new global targets for emission reduction, thus entailing further national commitments for renewable energies.

Yet, while many governments are committed to more renewable energy, the voices against siting of facilities are becoming louder, and with rising impact. Obtaining permission to site installations is becoming more difficult. To date, objections to renewables have been directed to large-scale installations of solar, wind or biomass facilities. These contestations are usually intertwined with the land and building regulation system of each country and are spatial in essence [1–3].

With large tracts of land for renewables becoming more intensely contested, countries seeking to meet their renewables targets will likely direct increasing attention towards tapping the potential in their built environment by means of smaller-scale facilities. According to studies, decentralized and small scale facilities may therefore have the potential to bypass the lock-in situation and to substitute to some extent for large-scale renewables [37]. The focus of this paper is on one specific type of renewable energy technology: small-scale wind turbines (SSWT), up to 10 kW (see definition in Section 3.1). Such applications are not yet widely installed in built areas but are continuously maturing from a technical perspective, While technological innovations draw much financial investments and academic research (see for example [4] in this journal), the regulatory contexts for the actual siting of these technologies has received much less consideration. Speaking generally,

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[18] warn that a "non-transparent regulatory framework with respect to planning and building laws" could be a deterrent to the uptake of SSWTs (p.347). [21] make an important point, noting that regulators should beware that the cost of obtaining planning approval for SSWT installations should not be disproportionately high, considering their small production scale.

There are, therefore, two objectives to this paper. First, to present a thorough review of current international academic knowledge on land-regulation aspects of siting SSWT; Second, to report on the findings about the land-related regulations and practices in two selected jurisdictions – Spain (Catalonia) and Israel. The overall aim is to review and analyze similarities and differences in land policy and planning approaches to new, potential, technologies in the built environment and how such approaches might constrain or promote future technological uptake.

1.1. The challenge of designing appropriate land-related regulations

By "land-related regulations" we seek to encompass the various laws, regulations and practices concerning land or buildings. Such regulations can be divided into two major categories: Those related to land-use planning and control of development, and those relating to land ownership or other types of property rights or tenure. Other aspects of regulation, including capacity for grid connection or independence, financial incentives, or taxation, may of course indirectly influence decisions about siting, but they are outside this paper's scope.

Land-use regulation (also called spatial or territorial regulation) is part of public law and thus depends on public institutions and administration. Land-use decisions often entail long and costly procedures, and some reach a "no go" impasse. Wind turbines are a totally new item within the traditional urban-planning horizon. They are more susceptible to opposition based on real or perceived nuisances than well-entrenched land uses with equivalent or higher generation of noise or visibility. There are many regulatory questions that decision makers in each country would have to consider, once this technology would become economically viable. The overarching question facing the land-regulation institutions, is whether the siting of SSWT should be permitted, considering their negative externalities, and if so, should they receive some priority in order to streamline the permitting process. This question will require a more detailed discussion, for example, on whether or not such installations should be exempt from building permits, as for example, are micro-cellular antennas in some countries? Under what procedures should their environmental impacts be assessed? Should neighbors or NGOs be granted the same objection or hearing rights as regular land use decisions, or should these rights be reduced (or maybe increased?) with the rationale that renewables are an essential public objective?

The following review concerns some of these questions. The rest of the paper is divided into five sections. The next section introduces the research method. Section 3 presents a brief introduction to the literature on the "non-technical" aspects of SSWT, depicting the economic challenge of SSWTs and the various barriers to faster uptake. It continues with a review of the rather limited literature on our direct topic - the land-related regulatory aspects. The legal-empirical research about two case-studies is presented in Section 4. The discussion Section (5) weaves together the literature review and the case-studies, and points to preliminary lessons that researchers and decision makers may embrace.

2. Research methods

The motivation for this study is anchored in the assumption that the multifaceted transition facing current energy regimes requires diverse tools and cross-national policy and regulatory learning. There is no "one size fits all" solution for appropriate land-based regulation. The comparative regulatory approach provides an integrative viewpoint on local contexts, including laws, regulations, policies, land-use planning and implementation. The analysis of each jurisdiction is carried out against the backdrop of its social and institutional contexts of energy policy. Comparison across countries provides scale - absent if one remains within the "silo" of a single jurisdiction or location. A comparative approach may also contribute to local public debates on the topic.

Given the exploratory nature of this study, we focused on only two countries. In selecting our two case studies for the comparative research we looked for jurisdictions with enough in common to enable analysis of the differences in laws and policies.[1] In order to identify and gauge the detailed, sometimes subtle differences in land regulation, a comparative researcher in this field should have prior familiarity with the broader legal and institutional context of the planning and land systems in the selected country. With this in mind, we selected Spain's Autonomous Community of Catalonia and the State of Israel. These jurisdictions share important background factors, yet display divergent implementation capabilities of renewable energy projects. We did not have prior knowledge about the specific regulations that pertain to renewable energy. By adopting an exploratory approach to the comparative analysis, (for relevant examples of comparative studies in planning see [54,55]), it became possible to gain an in-depth factual and critical perspective on each jurisdiction's approach to the land regularly aspects of SSWTs. These two case studies already opened a previously unknown span of approaches and practices related to the siting of SSWTs.

Our study is, therefore, based on a combination of methods: a review of current knowledge about the legal frameworks concerning land-based regulation of renewables; legal and field research in two national case-studies; and comparative analysis of the findings. We reviewed the relevant literature published in peer-reviewed journal in English, Spanish, Catalan and Hebrew, as well as policy and governmental official documents. The study also reviewed the specialized legal literature in each of the local languages.

The empirical data was gathered through document analysis and semi-structured interviews. Selection of interviewees was based on prior consultations with academics and practitioners in the field, and followed by a "snowballing" approach. The set of fifteen interviewees in total included government officials and planners on the municipal and national levels, renewable energy professionals, and academic in both Catalonia and Israel.

3. Literature review

Back in 2004, a short article in *Nature* raised the question whether city dwellers are ready for wind power [6,7]. More than a decade later, the answer is that there have been technological improvements, but there are still many barriers. This section presents a brief review of SSWT in general. Sections 3.3.1 and 3.3.2 focus on the crux of the literature review - existing knowledge about land-related laws and regulations pertaining specifically to SSWT.

3.1. The mainstreaming of SSWT technology

[8] estimated that in 2012, approximately 900,000 small wind turbines (of less than 100 kW) with an estimated capacity of 850 MW were already in use globally. According to the World Wind Energy Association, China accounts for 41% of the global installed capacity, the USA for 30% and UK for 15% [9]. However, the share of renewables is still tiny. For comparison, another small-scale technology - rooftop photovoltaic systems – currently produces a much larger share of

[1] The Autonomous Community of Catalonia is legally independent, to a large extent, regarding matters of land use planning. Where relevant, we shall refer to Spanish national laws and policies as well.

renewables; in the US alone it is estimated to provide 664 GW of installed capacity [10].

For the purpose of land-related regulations, as well as for international comparative statistics, it is useful to have a legally anchored definition of SSWT. However, none is yet available. Each country may decide whether to adopt a binding definition, and what it should be. In addition to their type and shape, the turbines may be classified according to various other parameters, such as their height, power rating, surface cover of blades, or rotor diameter. In one example (adopted in Israel), turbines are divided into four major categories: micro (below 4 m height and between 0.5 and 5 kW); small size (below 18 m, 5–10 kW); medium size (up to 40 m height and generation capacity below 50 kW); and large (above 50 m. and usually of a few megawatt).[2] Other countries may have adopted other definitions[3] or none.[4] SSWT can be building-mounted, integrated into the design of the building or free-standing [11]. Such facilities can either be used for self-consumption or connected to the grid [12]. As one can expect, each category and physical context may require different land-planning procedures and permissions, and different clearances in terms of property ownership or other rights.

There is already a modest body of research on the "non-technological aspects" of renewables that does address some of the socio-environmental potential of small-scale energy facilities, especially in terms of contribution toward national renewable energy targets, security of supply, and climate change adaptation [13–15]. According to [16] and [17] there are still many non-technical knowledge gaps regarding the capacity to install small scale wind turbines within the built environment. These authors argue that while the potential installation of SSWT in cities should align well with current urban trends (e.g. "smart cities"), they might also face technical, economic, environmental, and social challenges. We depict some of these in greater details below.

3.2. Economic and structural challenges

Indeed, there are still some technological challenges before SSWT will become a common sight in our cities.. Primarily, the technology still requires improvement in its ability to cope with the highly turbulent built environment [7]. According to [18], variable conditions in the urban setting including wind speeds and average heights of the surrounding buildings significantly impact both the operation and economic potential of SSWT, especially for private households. But technological advances can be quite rapid [19]. For instance, new methodologies are being developed to assess wind resources in urban contexts (e.g. in this journal [20]. Other technological improvements may address the need to reduce health and safety concerns such as noise, vibration or fatigue loads [i.e. 73,74].

One of the most relevant issues facing the proliferation of SSWT is economic feasibility, especially due to the challenge of economy of scale [15,21,22]. This is why national incentive schemes (such as Feed-in-Tariffs) are considered crucial for the adoption of grid-connected SSWT [9,23,24]. Studies have shown that even when renewable energy is environmentally valued by households, they will not be willing to cover the high capital costs of micro-generation energy technologies, such as SSWT [25]. Other socio-environmental barriers to the adoption of SSWT relate to social acceptance and perceptions of risk [26,27], as well as neighbors' objections surrounding visual disturbance, noise etc. [28]. Finally, various barriers to SSWT rest within the wider institutional setting of the renewable energy sector and the electricity sector at large (cf. with [29]). That sector is notorious in many countries for its centralized structure and path-dependent decision modes [30,31]. The various players in the energy sector are still debating the structure of a distributed/decentralized electricity system and the appropriate forms of transition [32,33]. In fact, decentralization of renewable energy technologies and their integration within the urban setting is a new research arena, and related implications are only now starting to surface (e.g. [14]). The general idea is that instead of almost total reliance on centralized mega-infrastructures, there will be increasing distribution to small technologies at the urban, neighborhoods or household scales, for both self-production and self-consumption [34]. Such technologies are coupled with an additional transition toward smart grids [26]. Currently, however, the lack of efficient storage mechanism is a major impediment [35], but storage technology is developing quickly [36].

3.3. Land-based regulation of renewable energy

As noted, current literature on our direct topic is rather scarce. Although researchers have recognized the strong link between the geographic distribution of costs and benefits of renewable energy (e.g. [38]), and the landscape impacts of renewable-energy facilities [39], research has generally neglected the role of land-based regulatory frameworks in siting renewables. Studies such as [40,41] on planning regulation of wind turbines in France, are quite exceptional in their level of detailing. Comparative studies are particularly rare. We found two important exceptions, but they both focus on the siting of large scale wind projects rather than small ones. One study by [42] provides a comprehensive legal and policy analysis of the relevant environmental and planning laws in Denmark, Norway, the USA and New Zealand. Another study focused on questions of siting and permitting of large scale wind turbines in the Nordic countries [43].

There are very few publications that analyze land-based regulations about renewables in general, and especially about SSWTs. [44], for example, provides an initial cross-national discussion of siting renewable energy in the context of urban planning. Another interesting study from Scotland, analyzes developmental stages and strategies used to minimize a potential implementation impasse for siting SSWT in an urban brownfield [3]. Based on the existing academic literature alone, it is therefore hard to assess to what extent legislation, planning regulations or the courts around the world have been tuned to regulating SSWT projects. Likely, in many countries, technologies of micro-generation for renewable energy (especially at the household level) have not yet received the full attention of the land-regulation bodies. In the sections below we present the meager published comparative research specifically on SSWT, and then focus on existing literature about individual countries.

3.3.1. Comparative analysis of land-based regulation of SSWT

There is very little systematic comparative research specifically on our topic. The dearth of systematic comparative research on our topic reflects the general scarcity of systematic comparative research on most subjects relating to planning regulations. [5,48]. One exception is a comparative report was published by The European Commission [45], but it is probably outdated because we are dealing with fast-innovative technology. The report analyzes the administrative procedures in the contexts of the UK, the Netherlands and France. Notably, the authors argue that in practice, legislation supporting renewables in many EU countries have historically favored large-scale projects over small scale. The report gives the impression that although the three countries covered did prepare distinct regulatory bases for SSWT siting, these were characterized by vague guidelines, lengthy processes and low rates of local-level planning approvals [45]. A more recent comparative research, [21] covers *Germany*, the *United-Kingdom* and *Sweden* and reports that they have successfully streamlined their planning permis-

[2] This example is based on the categorization in a statutory National Plan decided by the Israel Planning Authority. International accepted technical standards (ISO) might not necessarily be in congruence with planning definitions.

[3] For instance, the Energy Act of the UK defines microgeneration as the generation of electricity of up to 50kW.

[4] Spain is among the countries which have not yet adopted any legislative classification based on size/generation capacity.

sion processes by exempting small scale wind projects from environmental impact assessments (EIA). These observations will echo in our empirical case studies.

Country-specific literature on our topic is somewhat richer – but it covers only a few jurisdictions. These contributions are detailed below.

3.3.2. Land-based regulation of SSWT in individual countries

Although the literature provides only sporadic information about land based regulations in several countries, it does demonstrate clearly that there is a broad range of approaches, and no apparent convergence. In *the UK, for example,* local authorities play an important role, and are even authorized to require installation of micro-renewables in newly-built developments. Such installations may be exempt from planning permission so long as they comply with a list of strict conditions: types of buildings, types of land, turbine number and heights, distance from the property lines, and more [45].[5]

By contrast, in *New Zealand* any application for SSWTs received extra scrutiny. It must be accompanied by an EIA and should also consider a wide range of impacts, including cultural, socio-economic, natural habitats and noise. These main legislation is the Resource Management Act (RMA 1991) and since 2011, there is also a National Policy Statement for Renewable Electricity Generation. Additionally, before an application can be considered, the initiator must submit a statement of non-objection from potentially affected persons such as neighbors. The complementary Building Code might also impose additional standards [46].

Despite these regulations, New Zealand legislation sets an objective of promoting renewables by placing an obligation to include renewable generation, especially small and distributed, within regional/district plans and policy statements [46]. Such plans are empowered to make the permitting process for SSWT much easier by exempting SSWT from building permits, so long as stringent standards are met regarding noise and structural stability, vibration limits, height and distance to the property boundary [47]. A plan may also adopt another approach by defining SSWT as a controlled activity. The permitting authority may then set restrictions only if the permit request raises issues including on a pre-specified list, to be determined by the national authority. Additionally, regional statutory plans are not authorized to restrict SSWT, unless these are located in specific areas protected by the Resource Management Act (RMA) such as coastal marine areas, beds of a water body, flood areas or zones with plans to conserve the soil [46]. In all cases, however, obtaining consent does involve financial costs and can also be a timely process. We did not find any research about the implementation of these rules.

Moving on to The *United States,* we find more published research than for the other countries. Still, compared with other land-based regulatory topics addressed by US academics, the number and span of publications about SSWTs is rather small. The USA does not have a federal land-use planning law, so the 50 states are authorized to legislate their own rules. Property law also varies to some extent across states [50,51]. Thus, across the vast USA, laws and practices differ greatly from state to state and across localities [52]. We did not find any publication that analyzes the land-based laws and regulations for all or even most of the states.

[49] is one of the few American scholars who address SSWT land regulation issues directly. She stresses that “rooftop and small-scale freestanding wind turbines are gaining momentum in the renewable energy sector” (p.354). The researcher's examples show how local governments sometimes adopt regulatory restrictions, such as setback and height limitations, intending these to be a way to lower opposition. Wind Ordinance also set visual and flickering requirements, restrict the colors of the blades, or prohibit wind facilities from displaying advertisements [49]. For example, the Town of Ithaca (New York) limits SSWT in height, distance from the property line, and the number of masts on the ground per lot, but does not limit the number of building-mounted facilities, thus enabling micro-generation.

Additional land-use regulations intended to support SSWTs include streamlined permitting processes, such as undertaken by New York State for SSWT (below 25 kW). In some States, application fees are waived [49]. [49] also reports on local experimental financial incentives offered by some local governments, such as local tax abatements, rebates, grants, and low-interest loan programs. Finally, in order to promote some uniformity among the states and local governments, another author recommends the creation of a *model local ordinance* for SSWTs [53]. Showing concern for the likelihood of disputes, he emphasizes the need for “getting the applicant to reach out to his or her neighbors to talk about the project before formal submission”.

In sum, the literature reveals an emerging consensus that to facilitate the siting of SSWT, there is a need for careful thinking about the appropriate regulatory track. Yet, it is rare to find studies that evaluate the practical experiences with real-life t regulatory frameworks. We now turn to the first-hand findings from our two jurisdictions – Catalonia and Israel.

4. Background data of the two case-studies

Table 1 presents selected background indicators about physical, economic and administrative aspects. Catalonia and Israel have rather similar geographic sizes and percentages of built-up land. Both are among the more densely populated in the OECD. Both are located in the Mediterranean area and are considered “hot spots” for various negative effects of climate change (i.e. [56]).

Regarding their economic and administrative capacities, the two jurisdictions are, in many ways, “middle of the road” among OECD members, with a shared Mediterranean culture, Spain and Israel display similar score on the socio-economic and governance indicators. Both have a very similar GDP per capita which is well among the advanced economies, yet they not among the richest. The two jurisdictions are also ranked similarly on the “government transparency” indicator: their governments are not among the most transparent, but are also not among the lowest in the OECD. The lessons drawn from this study about the capacity to carry out good land-based regulation may therefore be relevant to a wide range of countries.

Table 2 presents relevant energy parameters. Here the two jurisdictions diverge considerably: Israel has only a 2% share of renewables in its electricity production, while Catalonia has achieved approximately 20%. Some of this glaring gap reflects two geographic facts: First, with no major rivers, Israel has no hydroelectric energy at all. Second, Catalonia has more wind resources than Israel, and wind does indeed constitute a much larger share of its renewables. Yet, Israel's absolute low rate of renewables to date, mainly reflects policy lethargy in both the solar and wind sectors [57]. At the same time, renewables policy in Israel has received a big boost in recent years, also expressed in land-based regulations.

Both jurisdictions today are challenged by their Paris Climate Change Conference commitments to GHG emission reduction, and both have adopted renewables-share targets for 2030 - 27% for Catalonia and 17% for Israel - which are much higher than their current achievements. To reach these targets, both jurisdictions would have to upscale their policies for all types of renewables.

The following sections present in a nutshell the Spanish and Israeli institutional contexts and renewable energy policy. We can then zoom into planning and land-based regulation and policies with consideration of SSWT in built areas in each case.

[5] The details here refer to “building-mounted” turbines and not stand-alone turbines, although these can also be exempted from building permit, see [69].

Table 1
Israel-Catalonia comparison of background indicators.

	Population (2016)	Surface area (km^2)	Built-up area (km^2)	Density (inhabitants / km^2)	Density in major city (inhabitants / km^2)	GDP per capita (€) (2014)	Government transparency (rank on global index)
CATALONIA	7,516,254[a]	32,108	2146 (6.68%)	233.8	Barcelona: 15,991	26,624[b]	(Spain) 36 (of 168)
ISRAEL	8,502,900[c]	22,072[d]	1300 (5.88%)	364.7	Tel Aviv: 10,673	28,059	32 (of 168)

[a] Source: Institut d'Estadistica de Catalynya website (unless indicated otherwise).
[b] Source: Instituto Nacional de Estadistica at: http://www.ine.es/jaxi/menu.do?type=pcaxis & path=%2Ft35%2Fp010 & file=inebase & L=1 [accessed:17.4.2017].
[c] Source: Israel's Central Bureau of Statistics website (unless indicated otherwise).
[d] Excluding West Bank and Gaza, including East Jerusalem and the Golan Heights.

Table 2
Israel-Catalonia comparison of parameters regarding renewable energy (RE).

GW h/MW (2015)	Renewable energy commitments	Electricity production (Total)	RE (% of electricity production)	Wind energy production (% of RE)	Solar (thermo+PV) production (% of RE)	Hydroelectric energy production (% of RE)
CATALONIA[a]	27% in 2030	45,355.2	8367.8 (18.4%)	2695.7 (32.2%)	502.9 (6%)	4769.3 (56.9%)
ISRAEL[b]	17% in 2030	57,119.2[c]	1142 (2%)	22 (2%)	1120 (98%)	NONE

[a] Source: Institut d'Estadistica de Catalynya website at: http://icaen.gencat.cat/web/.content/03_planificacio_energetica/documents/balancos_energetics/arxius/Balanc_Energia_Electrica_2010-2015_16-04-29.pdf [accessed:17.4.2017]
[b] Ministry of Environmental Protection report from 2014, available at: http://www.sviva.gov.il/infoservices/reservoirinfo/doclib2/publications/p0701-p0800/p0796.pdf. [accessed:17.4.2017]
[c] Israel's Electricity company annual report at: https://www.iec.co.il/environment/Documents/tzav_eishi_annual_report_2013.pdf (Hebrew) [accessed:17.4.2017]

4.1. The Catalan case study

4.1.1. Background

Spain's electricity generation mix is composed of: nuclear (20.9%), wind (19.1%), natural gas (17.2%), coal (16.3%), hydro (14.3%), oil (5.2%), solar (5%), biofuels and waste (2%). This represents much more electricity than local demand, thus making Spain a large exporter of electricity to Portugal, France and Morocco [58]. Spain signed the Kyoto Protocol in 2002 and the Catalonia government committed to limit emissions to a 15% increase during 2008–2012 compared with the 1990 levels. In line with European Union targets, the Spanish government has also set a 20% renewable energy target by 2020. Since the 1980s, and especially during 2004–2014, there was a sharp decline in the use of fossil fuels for electricity production while renewable energy generation rose rapidly. This achievement was made possible by a generous feed-in-tariff (on top of the market price) and an almost unlimited quota. This national policy led to a boom of large wind farms and solar field installation, placing Spain among the five largest wind-energy producing countries in the world.

However, in 2012 the Spanish government canceled the feed-in-tariffs for all new facilities (Royal Decree 1/2012), and then extended this to existing generators as well (Royal Legislative Decree 9/2013) [59,60]. National policies might also affect small scale installations, as we shall see in the next section.

To understand Catalonia's spatial policies, one should take note of Spain's division of legal powers. The post-Franco Constitution (1978) assigns land-use planning powers to the autonomous communities and to regional governments. Infrastructure crossing more than one autonomous community remains under the responsibility of the national government. The Autonomous Communities have legal powers to authorize power generation plants of less than 50 MW. This covers most renewable energy facilities and their distribution networks, as well as broader energy efficiency policies [58]. As a result, policy, planning and regulation with respect to siting of wind turbines may vary across regions. Municipalities too have extensive powers, especially regarding land-use planning and building [61].

Catalonia has its own energy plan for 2006–2015 which sets a target of 3500 MW renewables by 2015. Although this target has not been achieved, almost 40% of renewable energy production in Catalonia is already based on wind (see Table 2). This significant share, however, was not achieved without encountering territorial disputes, starting as far back as the late 1990s [62,63].

4.1.2. SSWT land-based regulation in urban areas

Spain's national renewable energy policy reflects the realization that siting facilities in open land will not be enough to meet the country's declared targets and the 2011 National Renewable Action Plan sets a target for mini-wind installations of 370 MW by 2020, later reduced to 300 MW (Annual production of 50 MW from 2015). The Spanish Secretary of Economy and Finance published the "Guide on Small Wind Energy Technology", which states in its opening sentence " *... It is evident that the sector of small wind energy was not developed in Spain as oppose to large-scale wind energy and that the fundamental reason for this is the absence of a specific regulatory framework, including financial aspects."*

The regulatory framework for the connection of small scale facilities (less than 100 kW) to the grid was set in 2011 [Royal Decree 1699/2011]. However, some of our interviewees have argued that the 2015 recent Royal Decree (900/2015)[6] might place the economic viability of SSWT in jeopardy by imposing a tax on the energy produced, and even on the use of batteries or storage systems. The Decree also cancels the feed-in-tariff incentives for any unused electricity transferred to the grid.

Notably, Barcelona - a densely inhabited city - has expressed its opposition to the draft version of the 2015 Decree by noting that demand should *"be complemented by boosting self-consumption through several technologies, not just co-generation but also the use of solar panels and micro wind turbines which can make as much sense, if not more, to a city like Barcelona. The Royal Decree would lead to a total lack of any incentives for distributed generation"* [64]. In the opinion of two of our interviewees, "the Decree was a mere political decision to support the big electricity companies". They added that Barcelona is seeking ways to bypass the decree's potential implications.

[6] Real Decreto 900/2015, de 9 de octubre, por el que se regulan las condiciones administrativas, técnicas y económicas de las modalidades de suministro de energía eléctrica con autoconsumo y de producción con autoconsumo.

Barcelona has already earned a reputation for its innovation in urban solar energy. The city's 2002 Solar Thermal Ordinance established a target of 96,300 square-meters of rooftop thermal solar collectors to be installed in the city. The approval of building design should be done simultaneous with the approval of the building permit [65]. Barcelona's pioneered regulation is backed by the Spanish Technical Building Code, which refers to solar energy contributions, but not to other renewable options. Other modes of renewables - biogas, solar PV and mini-hydraulic installations – also contribute modestly toward the City's renewable energy targets [66].

But Barcelona has a long way to go before small-scale wind turbines capture a place of any significance in its energy regime. By 2016 there were only t installations on the ground – both experimental: one where the municipality has mounted six micro turbines on street lamps, and a small private project where a SSWT was installed for charging electric vehicles in an industrial park. Both are off the grid. Our interviewees within the municipality could not recall any recent request for SSWT permits.

Why has the adoption of SSWT in Barcelona been so slow compared with its solar micro-generation facilities? A possible simple answer could the city's lower wind resources compared with rural areas, as well as its high solar potential. Indeed, some of our interviewees did make this point (Interview with urban planner, *Barcelona Regional*, February 2016). However, this assumption counters the municipality's declared policy to promote SSWTs as well as evidence of wind potential to a feasible degree [67], as well as evidence that the urban wind potential is reasonable [67]. What, then, is the reason for the gap between declaration and practice?

All our interviewees acknowledge that the city had not yet taken major initiatives to formulate policies or regulations regarding SSWTs, except for an initiative to prepare a Wind Map for Barcelona. The rules about the regulatory requirements for setting up SSWTs are as yet rudimentary and unclear. The interviewees agreed that at least a building permit would be required and that the Barcelona's Municipal Urban Landscape Byelaw authorizes the city to place limits on any installations on buildings and in public spaces (communication with Energy Department representative, Barcelona Municipality, June 2016). In the absence of any special rules, most other land-use matters would probably be left to the discretion of the planning and building authorities. Thus, entrepreneurs would be in the dark about questions such as: Will an environmental impact statement be required? What design considerations might be expected regarding installations of various sizes and different building heights and share? Questions regarding neighbors' rights to information, participation and objection will also arise. This regulatory fog, however, is unlikely to persist for long. Once the technologies for SSWTs are enhanced and nuisance and cost are reduced, Barcelonians will likely start to propose such facilities. The city decision makers will have to develop clear policies about urban SSWTs.

4.2. The Israeli case study

Israel's regulations for wind turbines are quite different from Catalonia's and the comparison thus promises a few important insights.

4.2.1. Background

Until recently, Israel was considered to have no significant fossil fuel potential [30]. The concern with energy security was therefore the guiding principle underlying the county's energy policy: the country's geopolitical constraints isolate its grid system from all neighboring countries [68]. Although since 2010, several large beds of natural gas have been discovered in Israel's economic waters, these discoveries have not resolved the key issues of clean, secured electricity sources [30,69].

One would have expected that such challenges would have galvanized renewable-energy policymaking even earlier than in more placid countries. Israel's renewable energy policy started relatively late, and still lags behind. In 2016, the share of renewable energy of the total energy production does not exceed 2% (Table 2). The 2020 target of 10%, and the 2030 target of 17% (Governmental Decision no.542, September 2015) are far-away beacons and would require much concerted policy effort.

In one area of renewables, however, Israel was a global pioneer. Already in the 1960s, the Planning and Building Law directed all new residential buildings to install thermal solar panels for domestic water heating [70]. Today, this statutory obligation is viewed both as an economic measure to lower electricity bills for households and as an environmental instrument. It has achieved a 40% share of solar heating for domestic water consumption.

In 2008 the Israeli Government approved the first policies to encourage solar energy by means of attractive feed-in tariffs for individual households or business [72]. In subsequent decisions, the Ministry of Energy adopted the “smart meters” strategy to facilitate small photovoltaic installations (Interview with representatives of the Planning Administration, May 2016).

Solar PV farms are currently promoted in the Southern arid and less populated region of the country. Due to the country's small size and extremely high population density (already the highest among the OECD countries), remaining open land in other areas is scarce and designation of large and land-consuming PV sites is becoming extremely contested. Other types of renewable energy technologies, some even carry the promise of economic profit – such as wind turbines - are therefore receiving more interest than in the past.

4.2.2. Land-based regulations of wind turbines in Israel

The first few working large wind turbines received land-use approval in the beginning of the 1990s. These decisions were made directly by the National Planning Board – the country's highest land-use regulation body. The legal instrument was the preexisting National Outline Plan for Electric Installations (NOP 10). The first sites proposed were in the Galilee, in areas relatively endowed with wind, but also happen to be among the major bird-migration routes in the world. The requirements to evaluate and monitor potential impact of proposed wind turbines on birds will become crucial in the following years [70]. In 2011 the Ministry of Energy, Water and National Infrastructure has set a quota of 800 MW for grid connected wind farms (later reduced to 740 MW). As of 2016, projects in total capacity of approximately 200 MW are under consideration. Quota is therefore not an obstacle to future utilization of wind resources.

The debates surrounding the approval of the first sites led the National Planning Board to prepare a dedicated National Plan for Wind Turbines (NOP 10/D/12), approved in 2014 after extensive inter-ministerial discussions. The intention was to create a clear set of rules which could help the authorities to balance the desire for renewables with environmental goals while at the same time streamlining the approval process. Although NOP 10/D/12 in still that of a national plan, it sets up procedures that diverge significantly from the original NOP 10. Under the new plan, approval of detailed plans would be decentralized to the district or local levels.

The NOP for Wind Turbines defines two tracks of approval, based on the size of the wind turbines: a fast track to facilitate approval of micro, small, and medium-scale facilities, and a more stringent and demanding track for large turbines (see definitions in Section 3.1). The focus here is on what is intended to be the “fast track” for the smaller facilities.

The fast track applies to an area with a pre-approved Local Detailed Plan. If there are no additional constraints, only a building-permit would be required, and the local planning commission would be empowered to issue it without requiring the approval of the District Commission. However, a closer reading of the regulations reveals that in reality the “fast track” might present significant challenges for SSWT. Three aspects of the regulations contribute to this effect: the list of exceptions, the broad degree of discretion, and the participatory procedures.

Some of the limitations on siting are clear and promise some certainty for initiators of SSWT, such as the exclusion of heritage or historic sites and buildings. Less understandable is the total prohibition of siting, for example, in agricultural areas designated as “greenhouses”. Restrictions on height of the turbines and the requirement of a site with at least 5000 m^2 within a built-up area (for small wind turbines), are considered by entrepreneurs impossible to overcome (Interview with Israel's Wind Association representative, January 2016).

Even more problematic might be the high degree of discretion allowed to the planning bodies in the ostensibly fast track. They are required to consider a whole range of issues without set standards including the amount of open spaces left and the value of the local landscape and ecosystem. Planning bodies must also consider noise, visual, and architectural impact. In Israel's high density pattern, each of these issues is likely to be contested by neighbors or environmental NGOs. The new National Plan makes EIAs and birds risk assessments mandatory only for the larger installations. Nevertheless, any planning body is authorized to request supporting evaluation documents of environmental impacts. In fact, the direct-permit track is so mostly in name. It is quite different from the regular permitting procedure, where planning bodies do not have any significant discretion and must issue a permit if it accords with the detailed plan.

The new NOP Wind Turbines dramatically broaden the participatory (hearing) rights of the broad public compared with the first large wind farms approved before its inception. According to the original National Plan for Electric Installations, only formal bodies and NGOs had the right to be consulted. This is because national outline plans are usually exempted from such procedures, on the assumption that they are entrusted with a subject of national interest. By decentralizing approval powers to the district or local levels, the NOP for Wind Turbines takes on the full hearing obligations applicable to any district or local plans [71].

The expansion of hearing rights pertaining to the “fast track” is dramatic, in comparison with not only to other NOPs, but to any other direct-permit processes. In Israel, building permits normally do not entail the obligation to hear the parties because permits are expected to comply with the detailed plan, and the latter would have already undergone a hearing. NOP Wind Energy is the first plan – national or otherwise – to divert from this general rule by making permits discretionary. Therefore, full hearing rights are introduced at the permit stage as well. Under Israel's planning law and the courts’ broad interpretation of legal standing, this expansion means that every person who submits an objection may have grounds to appeals to the planning tribunals, and later to petition the Administrative Courts. Opponents might make their way all the way up to the Supreme Court. Expansion of the right to be heard is, of course, desirable in its own right. However, this can hardly be considered a “fast track” streamlining the approval of SSWTs.

Our interviewees said that since the approval of the plan, no requests for SSWT permit are known to be approved or “in the pipeline”. A prospective entrepreneur interviewed noted that the “fast track” is so replete with requirements and uncertainties, that it is not advantageous over the regulator track where preparation of a detailed plan would be required.

Could the stalemate in new facilities be simply the result of a generally low wind potential? The national authorities have not prepared wind-survey information with enough detail to assess specific locations at the urban scale. Unlike Barcelona, no Israeli city has undertaken this task. According to an expert in the field of wind energy, some dense urban configurations possibly create favorable wind conditions, but no pre-measured data is available (Interview with Israel's Wind Association, January 2016). This point is especially pertinent to Israel's large number of residential and office towers rising across the country.

So, the Israeli case harbors a paradox: Policymakers have devoted much effort to formulating a very sophisticated set of regulations ostensibly intended to encourage wind energy facilities. Yet, the regulations are replete with conditions and discretionary junctions that they might in fact deter initiatives.

5. Comparative analysis and conclusions

The stories of the land-based regulations of SSWTs in our two jurisdictions are very different. Neither jurisdiction has much experience with SSWTs, yet their approaches to preparing appropriate land-based regulations are almost diametrically opposed. Catalonia's land-related regulatory approach to SSWTs is very rudimentary. There is no direct national involvement in planning regulations by Spain, so the topic is left to the discretion of the Autonomous Regions and their local governments. The major city we studied – Barcelona –has not articulated any specific land-based regulations or policies either to encourage or to discourage SSWTs. Beyond the requirement for a building permit, there is currently extensive room for ad hoc discretion by the urban planning bodies. This means high uncertainty for anyone wishing to propose an installation. This situation is surprising considering the city's general statement (quoted above) that it regards SSWTs as an important element in meeting its future renewable-energy targets, as well as its effort to map wind resources in the city. One may assume that once more requests for SSWTs are submitted, Barcelona and other cities are likely to develop more detailed laws, plans and policies.

As we saw,, Israel's approach is very different. Despite the lack of prior SSWT initiatives or even knowledge about potential wind resources, the national authorities devoted much time to designing detailed national planning regulations tailed especially for SSWTs. The legal tools harnessed were ostensibly an optimal mix: A binding National Outline Plan prepared by the highest-level planning body which is composed of all relevant government ministries, complemented by metered decentralization of powers to the local and district levels. The declared purpose was to provide greater certainty for both developers and environmentalists and to create a “fast track” for smaller installations. However, in their attempt to reconcile the need for renewables with many other concerns, the authorities in fact created a track replete with regulatory barriers which deter potential entrepreneurs rather than encourage them. To date, the conflicts wrapped up within the planning procedures are still dormant. But once more requests for permits for SSWTs come before the local planning bodies, conflicts are likely to wake up, along with protesting neighbors, concerned NGOs and lengthy hearing and appeal procedures. Under current regulatory procedures, not much of a visible addition may be expected to the share of wind energy.

If neither the “low key” nor the “high key” approaches in our study bode well for SSWTs in urban areas, what is their future? We encountered both pessimistic and optimistic views and scenarios. In our interviews, some urban planners and renewable energy experts expressed pessimism about the compatibility of SSWTs with urban limitations. They argued that in sun-rich countries, PV technology is likely to remain more suitable. These experts acknowledged that technological improvements are making wind turbines more affordable, but also noted that the costs of PVs are decreasing too. Other stakeholders have nevertheless expressed optimism about the future of SSWTs in urban areas because technological improvements are making storage possible as well as reduction of noise and glare nuisances. Most agree that to meet their renewables targets, countries and cities must promote all types of renewables. Siting renewables in open areas is no longer necessarily easier than locating them within the urban fabric.

To sum, the two case studies highlight the difficulties in “getting it right” in the land-based regulatory arena: The Catalan case is one of current inaction and future incrementalism. Allowing room for incremental rule-making has its merits, but the loss of time and precedent might prove to be detrimental to the future acceptance of SSWTs. The Israeli approach is an example of over-action. The full-grown regulations arrived much before the cart, without any opportunity for incremental learning by gauging demand or the types of reactions to proposals to install SSWTs. It is likely that the National Plan for Wind Turbines will have to be revisited. Meantime, progress with tapping wind energy has been delayed.

The incorporation of an unknown technology within the city scape requires a change of mindset both among the officials and among the city residents. The currently popular concept of "smart city" should be extended to encompass smart land-based regulations. The paradox is that while renewable energy technologies are designed to be "footloose", the land-related laws and regulations are not easily amenable to transfer across legal-administrative boundaries. Yet in real life, such regulations and practices are important for governments' capacity to "ground" renewables and thus, to meet their national targets for renewable energy share.

In this study, we selected two jurisdictions where we were acquainted with the general context of planning regulation, but did not have any prior knowledge about the specific laws and policies that apply to SSWTs. As noted, we selected these countries because they have several relevant objective background factors in common. Yet, we discovered that regarding SSWTs, their land-regulations and policies are very different. Research projects on other topics of land-based regulation has also been unable to provide convincing "reasons" for many of the differences they discovered between countries – even between countries that seemingly have many other shared attributes [4].

For those who seek "best practice" ways of regulating SSWTs or other renewables, our findings are somewhat pessimistic. They indicate that under the current state of research on land use regulations and their capacity to meet the targets for renewables, it is hard to discover ready-made "optimal packages". Without further extensive research, systematic exchange of knowledge, and assessment of transferability, it is unlikely that convergence of practices will occur.

Meantime, our conclusions offer two approaches that may aid decision makers in their quest for a locally appropriate approach to land-based regulations for SSWTs: At the policy level, the integration of small wind turbines in the built environment can be facilitated by a combination of strategic thinking and an experimental approach. The strategic approach should scope the role of small-scale technologies for renewable energy in urban areas and propose broad flexible policy guidelines. At the same time, to correct for the disparity between the fluidity of technological niches and the legally heavy-handed land regulations, an experimental approach would be suitable.

At the research level, there is room to extend the comparative research approach to more national and local jurisdictions. Comparative research can reduce current insularity in land-based regulations and enable better cross-national learning. Even at the scale of two jurisdictions, this paper' findings have exposed a range of issues and options which are when one has only the single-country perspective. We are convinced that as more findings from comparative research are added, both decision makers and developers will find it easier to anticipate some of the challenges and to ameliorate potential problems.

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