Fields of Gold

Employing Actor-Network Theory to Investigate the Construction and Spread of Large-Scale Solar PV Technology in Apulia, Italy

Fabio Buonsanti

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Centre for Development and the Environment

University of Oslo

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List of Acronyms, Units and Figures

Acronyms and Abbreviations

AC: Alternating Current Electricity
AU: Regional 'Start-of-Works' Authorisation
ANT: Actor-Network Theory
CO_2: Carbon Dioxide
DC: Direct Current Electricity
DIA: Municipal 'Start-of-Works' Authorisation
DNA: National Antimafia Commission
EU: European Union
FiT: Feed-in Tariffs
GHG: Greenhouse Gas
ISTAT: Italian National Institute of Statistics
PEAR: Regional Environmental Energy Plan
PV: Photovoltaic
REP: Region of Apulia
SEL: Left Ecology Freedom Party
SRL: Limited Liability Company
STS: Science and Technology Studies
UNFCCC: United Nations Framework Convention on Climate Change
VIA: Environmental Impact Evaluation

Units of Measurement and Currency

POWER:	1 MW_p = 1,000 KW_p
	1 GW_p = 1,000,000 KW_p
	1 TW_p = 1,000,000,000 KW_p
GENERATION:	1 MWh = 1,000 KWh
	1 GWh = 1,000,000 KWh
	1 TWh = 1,000,000,000 KWh
AREA:	1 ha = 10,000 m^2
CURRENCY:	1 € = 1.3099 US$[1]

[1] 06.12.2012 (Source: http://coinmill.com/EUR_USD.html).

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Abstract

This research seeks to explore and address the dynamic organisational aspects and the mechanisms of construction, maintenance and diffusion of a socio-technical innovation network revolving around the spread of large-scale photovoltaic technology in Apulia, Italy.

Actor-Network Theory (ANT) is used in this case study to facilitate the understanding of how the development of large renewable-energy projects results from the chronological history of contingent stages of translation, in which complex mutual relationships and alliances between innovation and society materialise through interconnected chains of diverse events, strategies, interests and arguments, owned by diverse actors that merge together in support or in rejection of technology.

In order to obtain a perspective on the dynamic mobilisation-implementation process undertaken by the Apulian PV project over space and time, this research serves to analyse and discuss agency, power and convergence of interests of a wide and multifaceted range of organisational phenomena which constitute the socio-technical actor-networks underlying the innovation system object of study.

Besides acknowledging the importance of the social in studies of technology, the present network analysis demonstrates that when actors' interests in innovation are not perfectly aligned due to occurrence of resistance, a system faces a loss in convergence, which in turn results in a more or less emphasised slowdown of technology implementation, that is often the only trait visible from the outside.

Acknowledgements

Writing up this thesis has been a long, arduous, yet highly gratifying journey. A number of people helped me in different ways throughout this demanding process and I would thus like to share here my immense gratitude with them.

First of all, I wish to express the warmest thanks to my skilful, expert and professional supervisor Tanja Winther, for her role in my academic growth, for always showing great attention and engagement in my project, and for motivating me all along the way. Thank you Tanja for encouraging and believing in me even when I thought I would drop it all due to a series of surgeries (wrist ligaments break and displaced-multiple fracture of my right ulna, radius and elbow), which kept me in bed for more than a semester.

Special thanks go also to all of those people I spent time with in Apulia, for sharing their knowledge, information and experiences with me, and for explaining their subjective views over a very complex socio-technical system.

I feel very indebted to Norway, to the University of Oslo (UiO) and to the Centre for Development and the Environment (SUM) for the academic honour granted onto me. Being a student at SUM proved to be a challenging opportunity that I personally regard as metamorphosing at many levels. Here, the high standard of academic excellence decisively improved my capabilities of thinking differently and challenging established truths. I learned how to create value and results through teamwork and how important it is to work both independently and together in multi- or inter-disciplinary teams, where collaboration and goal-directed exchange of ideas, solutions and innovation resources may prove fundamental to solving the huge challenges that energy and sustainability pose to our world. I want to sincerely acknowledge SUM also for two other reasons. First, because it introduced me to people with which I have enjoyed two unforgettable years, filled with a constant exchange of knowledge inputs. Second, because one of the essays I presented in partial fulfilment of the master programme ended up being published on *Consilience*,

a peer-reviewed, scientific journal of sustainable development, based at the Columbia University (New York, NY, USA). Later, the credibility gained with that very same article earned me the privilege of an invitation for a speech at the international *Arctic Frontiers Conference 2012: Energies of the High North* (Tromsø, 20-27 Jan 2012) and at the following PhD workshop *Young Scientist Forum 2012* (Svolvær, 27 Jan – 3 Feb 2012), an interview by *The Arctic Institute – Centre for Circumpolar Security Studies* (Washington, DC, USA), one by *RIA Novosti* (Moscow, Russia), and the participation to the Norwegian PhD Research School in Renewable Energy *NorRen 2012* (Asker, 6-10 Aug 2012). I will never forget such memorable experiences.

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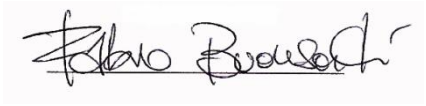
Fabio Buonsanti, 10 January 2013
fabiobu@student.sum.uio.no



1. Introduction

The complex and still not well-understood interactions between the webs of variables that move the mechanisms of the Earth's climate make the issue of anthropogenic climate change[2] very difficult to address. On the one hand, scientists are called upon to frame and communicate reliable models and future scenarios based on the uncertain behaviour of factors that are necessarily selected and studied in isolation from their complex original contexts and timescales (Borroughs 2007). On the other hand, policy makers are urged to come to difficult national and international binding agreements, so as to fund, in the most rapid, precise and cost-effective ways, not only measures capable of removing barriers to the implementation of concrete initiatives of adaptation in the most vulnerable areas of the world, but also mitigation actions (Adger *et al.* 2009).

Amongst them, switching to new and more efficient technologies is seen as a mitigation measure able to immediately help limit the inexorable increase in global average temperature (Seifried and Witzel 2010). Yet, because carbon dioxide is the gas whose natural atmospheric concentration has been altered the most from pre-industrial levels, and because about 74% of global CO_2 emissions currently originate from the energy sector (Bournay 2008), it appears meaningless to argue about climate change without explicitly referring to energy patterns as a core issue. As a consequence, faithful to the debate around mitigation which broadly attests the need for "a human intervention to reduce the sources or enhance the sinks of greenhouse gases" (UNFCCC 2012), how to shift from supply by finite fossil fuels to alternative energy sources becomes one of the most central and challenging questions within the global sustainable development agenda.

[2] The scientific community mostly agrees on attributing to anthropogenic causes, in particular to the impact of those human activities connected with the burning of fossil fuels, massive deforestation practices and polluting industrial and agricultural operations, the exceeding of the atmospheric capacity to assimilate GHG, which is considered to have led to disruption of the fragile natural 'radiative' balance of the planet, thus to manifestation of 'global warming'.

Within said international context, EU Directives under Kyoto commitments have prompted the Italian Government to recently promote its internal renewable-energy market. Coupled with this, photovoltaic (PV) power has been established as a major contributor of renewables to the future national energy mix, becoming the recipient of very favourable governmental subsidies.

Triggered by both financial incentives and decreasing prices for solar modules, the internal national development of solar photovoltaic technology was fast and prominent, whilst differing from county to county. Official statistics show that today, outside any expected fluctuation, Apulia is the only administrative region of Italy in which the photovoltaic sector is being almost entirely developed in a large-scale[3] fashion. Here, as will be shown, a complex interplay of various actors' interests in support (or in rejection) of large and ground-mounted photovoltaic projects, has contributed to the spread of PV innovation over lands that one of my informants metaphorically defined as 'Fields of Gold'. The allusion concerned the massive series of mitigating actions that occurred in a very short period of time in Apulia, which reflected the unique traits of a large, local and pervasive industrial business with no parallel in the rest of Italy. As a landowner confided (R31):

> I would daily irrigate solar panels, rather than tomatoes, olives and salads... Look at me, I am a happy man now, I can dedicate more time to my nephews and go to the beach every day. The sun works for me. When it sets, I go down, check my production meter, convert its numbers in Euro, and joyfully wait for our shiny star to rise again the next day.

1.1 Objectives and Research Questions

With this thesis I seek to show the value of using Actor-Network Theory (ANT) to examine the processes of construction, maintenance and diffusion of a socio-technical innovation network around the adoption of large-scale PV

[3] In this study, 'large-scale' PV plants are defined as ground-mounted systems with a nominal power equal or higher than 200 kW_p. Although by custom architecturally integrated plants with a capacity exceeding 1 MW_p are also frequently considered within the same category, these systems will not be taken into account throughout the text because out of object of this dissertation.

technology. I wish to demonstrate that the Apulian PV innovation did not impose itself as it is commonly assumed by those who consider the abundance of flat and sunny areas as factors that naturally call for the allocation of capital, work, etc. in the PV sector. Instead, it resulted from exclusive, diverse and interconnected chains of arguments and events contained in the identical perpetuation over time of a series of contingent actions. These actions, locally linked with large-scale photovoltaic initiatives (merged and named here as 'the PV project'), and united by the common intention of improving the development of Apulia through access to new jobs and profits, are also indirectly helping Italy to meet its share of renewable-energy commitments within the Communitarian and international political arenas.

ANT delivers a theoretical and methodological lens to analyse and demonstrate the existence and relevance of mutual relationships between PV innovation and society in Apulia. More specifically, Apulia is a relevant case because the actions taken by multiple actors (people, organisations and other hybrid entities) appear to employ diverse sets of strategies and exhibit different interests in the very same PV project. In doing so, they truly affect the system and its constituents as a whole. Yet, in turn, as the features and rules set within the boundaries of that socio-technical whole (the PV network) also necessarily affect the ways constituents behave, their actions cannot be said to be moved by any idealistic idea of free and open choice, but are also mediated.

With the aim of creating a robust, visual model for comprehending the strength of the PV network, the 'Local/Global' framework (Law and Callon 1992) from the broad realm of ANT appeared to be particularly useful for this case study. As we shall see, it was adapted to this research in conjunction with the concept of 'convergence score' (my terminology, used to define my perception of the local and global actors' degree of agreement within the PV network). Taken together, such tools are employed with the hope of enabling me to obtain a final model for grasping the trajectory of the mobilisation-

implementation process undertaken by the Apulian PV project over time. This will serve to track the life of the project, which in turn is intended to put interested readers in a better position to guess on future scenarios and act accordingly.

This study assumes relevance to the field of Technology and Innovation Studies for three reasons. First, to the best of my knowledge ANT has never previously been applied to a case study based on large-scale photovoltaic spread. As such, this research may primarily show how the theoretical and methodological framework used here can fit this sector, just like it does with a number of other disciplines. Second, this dissertation may demonstrate the usefulness of ANT (like other theories from STS) in contributing to the debate around the existence of a close relationship between technology and society. Finally, I hope this study manages to add something to the current limited understanding of how to track and help ensure the success and implementation of complex, large-scale innovation projects in the renewable energy sector.

Following the aims expressed above, the main research question of the study is:

Considered as a complex, socio-technical and heterogeneous actor-network system, what are the driving forces and the organisational forms of the massive push for deployment of large-scale solar PV technology in Apulia, Italy?

In an attempt to answer my main research question, I will seek to:

- Recognise the most important complex patterns responsible for the spread of large-scale PV technology (innovation) in Apulia.
- Grasp meanings, agency, power and control in the actions performed by fluid actors that emerge out of organisational contexts of interaction between a ‘global’ and a ‘local’ network.

- Show that technology development is intrinsically a process of contingent ‘translation’, that is, a process in which hybrid actors advance positions, negotiate roles, set rules and finally induce their intermediaries to act in their own support.
- Examine and assess the dynamic degree of ‘mobilisation’ (actions taken according to the rules set in translation) and ‘convergence’ of interests (level of agreement) over time and space of the wide range of organisational phenomena which constitute the socio-technical local and global actor-networks underlying the innovation project object of this study.
- Produce a visual representation of the life-trajectory of the PV project as a means to represent its dynamic degree of solidity and indispensability over time.

1.2 Structure of the Thesis

The remaining part of this thesis is structured as it follows.

In chapter two, the presentation of selected case study’s background information is organised in three sections, each of which is meant to provide some of the keys for the analysis and the discussion of the findings. First, I present a geographical introduction to Apulia, followed by an overview of some of its relevant environmental, cultural, political and socio-economic aspects. The second section concerns the use of graphs and statistics to acknowledge the historical/numerical development of the photovoltaic sector in Italy and in Apulia. Lastly, I describe the chronological evolution of the national legal framework for the photovoltaic sector.

In chapter three, I present the theoretical approach employed throughout the research. I initially provide a discussion of some of the engaged philosophical assumptions and then further this by offering ANT as an analytical and methodological tool for the study of the ‘translation’ processes of construction, maintenance and diffusion of a ‘socio-technical’ innovation.

Next, ANT is identified through the vocabulary developed by its theorists, with particular attention to the concepts of agency, power, control, dynamicity, and convergence. Together, these will be added to the 'Local/Global' vision of ANT, and proposed/adapted to the Apulian context as the predominant theoretical perspective. In this chapter, several insights are therefore described with the intention of contributing to the creation of a composite analytical and methodological approach that shall both reflect and justify the choice of diverse perspectives within the broad realm of ANT for the analysis of this case study.

The fourth chapter presents the methods engaged in the process of data collection. It also includes ethical reflections on my role as a researcher and on the ways used to gather relevant and reliable information.

In chapter five, I describe, analyse and discuss Apulia's PV four-stage itinerary of 'translation'. This is presented through quotations of selected heterogeneous actors involved in the process, in an attempt to illustrate how various forms of agency emerge and, by doing so, highlight different arguments, negotiations and strategy efforts not only aimed at performing participation, network stability, 'black boxing' and spread of large-scale PV innovation, but also resistance and support for different forms of innovation.

In chapter six, I focus on the organisational forms of the large-scale Apulian PV actor-network in the period investigated (2001-2012). Here the alliances and negotiations found among the heterogeneous players that sustained innovation are explored in terms of power and dynamic convergence, resulting in a visual trajectory on a 'Global/Local' mobilisation graph.

In chapter seven, I present the concluding remarks of the study.

2. Winning the Italian PV Energy Race: Facts and Statistics about Apulia

This chapter provides the contextual background of the case study. The context presented here proved essential for mapping the field and gathering data. Presented as follows, it is intended to put the reader in a better position for understanding the analysis of the findings discussed in chapters five and six. The first part of this section presents a geographical introduction to Apulia, followed by an overview of some of its relevant environmental, cultural, political and socio-economic aspects. The second part concerns the development of PV technology in Italy in general, and Apulia in particular. This segment also includes some notable graphs and statistics that helped me refine the main research question and its sub-questions. The third section describes the evolution of the national legal framework for the photovoltaic sector.

2.1 Orography and Climate

Located in the south of the Italian peninsula, Apulia represents its easternmost and least mountainous region. Its total area covers 19,358 km^2. In the north it is mainly occupied by a large plain (the *Tavoliere delle Puglie*) and by two mild mountainous sub-regions (the *Gargano* promontory and the eastern appendix of the Campanian Apennines). A semi-arid karst plateau (the *Murge*) dominates the centre, whereas another vast plain (*Salento*) occupies the south of the region. Apulia is bounded northwards by Molise, westwards by Campania and Basilicata (other regions of Italy), eastwards by the Adriatic Sea, and southwards by the Ionian Sea, which are waters shared with Albania and Greece, respectively.

Apulia's climate is typically Mediterranean, with hot and dry summers that often exceed daily temperatures of 40°C, and mild winters, where scarce precipitations are concentrated. Due to such an arid climate and to the karst

geological nature of the region, only underground watercourses are considered to be abundant, with the few rivers on the surface being mostly short, seasonal and torrential. These features make Apulia's surface one of the driest areas of Italy (Macchia *et al.* 2000).

2.2 Heterogeneity

According to the Italian national institute of statistics (ISTAT), amongst the 4,091,457 inhabitants of the region (2011a), only 95,709, equal to 2.34 % of the total regional population, are foreign-born immigrants, mainly from Albania, Romania, Morocco and China (2011b). Despite such ethno-demographical uniformity, heterogeneity appears as a keyword for describing Apulia. Below I focus on some of its relevant environmental, cultural, political, and socio-economical heterogeneous aspects.

From the environmental point of view, Apulia's diversity of unique ecosystems, landscapes, flora and fauna stands out in the Mediterranean panorama. For example, the area accounts for two national parks, three protected marine areas, seventeen state reserves, eleven regional parks, seven regional reserves, the proposal for sixteen new areas subject to ecological protection, and seventy-one other 'Sites of Community Importance' (Regione Puglia 2012a).

Culturally speaking, Apulia is usually identified as a historical land of conquest, but also as a natural bridge to the east, or as an access harbour to the European continent. Today's Apulia hosts internationally relevant archaeological and historical traces that go back to prehistory, the Stone Age, the ancient Greeks and the Roman Empire. In addition, it includes two UNESCO world heritage sites and fine examples of Venetian-Byzantine, Romanesque, Gothic and Baroque art and architecture. This heterogeneous mixture of heritages is mainly a consequence of the interaction and alternation of different dominations over the centuries, each of which was a carrier of peculiar traditions, and responsible for the spread of the six officially

recognised Apulian dialects (Bertoni 1916). Nowadays, these very different dialects are still widely preferred to the standard Italian, especially in informal contexts.

Biodiversity and multifaceted historical trajectories are thus heterogeneous features of Apulia. Shifting of political choices, too, is another trait that helps define the area. Although the last three national presidential polls (2001, 2006 and 2008) labelled Apulians as tenacious right-wing oriented voters, locally, the region is being governed by an extreme left-wing coalition since 2005. Nichi Vendola of the Communist Refoundation Party was elected president for the first time in April 2005 and re-elected president of Apulia for a second-consecutive term in March 2010, this time as leader of his own socialist party: '*Sinistra Ecologia Libertà*' (SEL), namely 'Left Ecology Freedom'.

In comparison with the Italian average and in particular with regions of the centre and the north of the country, Apulia ranks very low in both the per-capita gross domestic product index (Confcommercio 2011) and in all unemployment rankings (Regione Puglia 2012b). The extent to which we can consider these indexes as well-being indicators in a developed country like Italy is a discussion that does not concern this study. However, it is my view that alone such tables can neither tell the full story of a region's contribution to its national economy, nor provide a complete picture of the overall living standards of its population (see also Allen and Thomas 2000, Bjørkdahl and Nielsen 2012). In order to have a broader and more precise idea of what Apulia's economy looks like, it is important to consider at once, together with the indexes mentioned above, at least two diverse crucial aspects. First of all, there is a spread equivalent to 54% between declared income (the only one considered in the official statistics) and real income. This makes Apulia's regional economy the one that, nationally speaking, relies most on a black market (Eurispes 2012). It follows that all of its official per-capita GDP or employment data are incorrect because they are widely underestimated. The black market plays also an important role in creating the right conditions for

the local mafia, '*Sacra Corona Unita*' ('United Sacred Crown'), to survive, recruit, invest capital, draw nourishment, develop itself further, and even to be considered as "an alternative sovereign institution to the State" amongst some of the local inhabitants interviewed in this study (R26, R27, R29, R32).

The role played by Apulia's services sector in the local economy, with particular reference to the tourism business, is prominent in terms of employment (Regione Puglia 2012c). Despite that, today's main drivers of the regional economy are characterised by a few, large-scale and highly specialised industries: steel-making, petrochemicals, and renewable energy.

It is in this context of general heterogeneity and plurality that the solar photovoltaic business has found fertile ground for its remarkable expansion. Describing the development of this growth is the object of the next two segments.

2.3 Solar Photovoltaic Technology

Solar photovoltaic technology (PV) makes it possible to generate electrical power by converting solar radiation into direct current (DC) electricity. This process is possible due to employment of semiconductor materials, such as silicon, in solar cells. Their property of triggering the photovoltaic effect[4] when hit by solar radiation is therefore put to use and exploited (Seifried and Witzel 2010). Silicon is a widespread element in nature and, integrated in a solar cell, it is able to supply DC electricity (GSE 2012a). Within a solar module more cells are connected together so as to form a structure capable of producing a quantity of energy serviceable for common uses. Depending on the amount of energy desired to be generated, just like with cells, more modules can also be connected together, establishing power stations that can

[4] The photovoltaic effect refers to the generation of direct electric current in a material upon exposure to light. In such a process electrons are moved between different bands within the material, giving rise to creation of voltage between two electrodes.

even be designed so as to exceed an overall nominal power[5] of several thousand kW_p.

To directly use the electricity generated, a PV system necessitates two other devices: an inverter, which is a device that switches the DC produced into alternating current (AC) ready for consumption, and a voltage transformer, which is positioned right before the power generated flows into the grid (Figure 1).

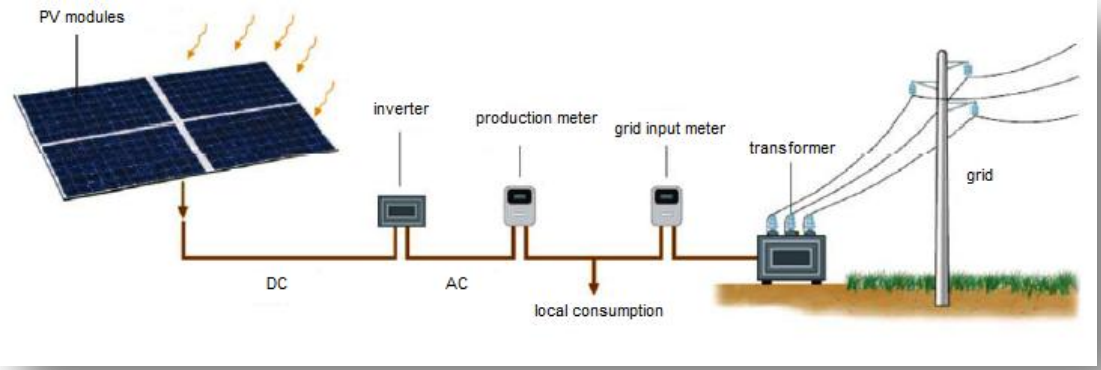


Figure 1: Operation of a solar photovoltaic system (Source: adopted and translated from GSE 2012a:4).

According to GSE (2012a), in Italy an optimally set PV park (oriented towards south and with an inclination of 30-35 degrees) generates on average, in relation to every kW_p installed, from 1,000 kWh in the north of the country, to 1,500 kWh in the south. It has also been calculated that every kW_p of PV technology deployed on surfaces like walls or roofs requires an area ranging from 8 to 10 m^2. In order to maximise the generation[6] in PV parks that are scattered on flat surfaces like agricultural lands and that present modules arrayed in several lines, it is vital to avoid units getting covered by their own shadows during operating hours, even partially or temporarily. For that to happen, nearly twice as big an area is needed (on average 1.7 ha/MW_p). For example, with today's best cost-effective PV technology, if we are to design

[5] The nominal or installed power of a PV station corresponds to the sum of the peak power (unit: W_p) of each of its constituent modules, measured under standard laboratory illumination conditions (radiation: 1,000 W/m^2; temperature: 25ºC).

[6] The electric current generated by a solar PV plant is the one measured at the output of its inverter, after it has just been transformed in AC, and before it becomes available to direct use or to the grid (unit: Wh) (Figure 1).

an ideal 1 MW_p plant, one would need a surface of around 17-20,000 m^2 (17-20 m^2 for every kW_p installed, depending on the solar modules chosen). This reveals one of the shortcomings peculiar to this technological innovation[7]: its low efficiency in comparison to nuclear, fossil, or some of the other renewable energy sources.

Solar PV technology has a range of benefits, however. It converts sunlight into electricity without using fossil fuels, moving parts, and polluters; it is reliable, resistant, and quickly becoming more and more economically affordable; in addition, it does not need any particular maintenance throughout its long life (20-25 years), and it is almost fully recyclable. Yet, as most of solar radiation hitting the modules is missed and therefore rendered unconvertible, solar PV is still widely considered to be a space-consuming technology.

2.4 From 'Land of Sun' to 'Land of Solar': Describing How the PV Sector Growth Affected Italy and Apulia

2.4.1 Italy

According to the latest official statistics, Italy's 2011 total energy consumption equalled 346.4 TWh (GSE 2012b). About 76% of that was originated from traditional fossil-fuel based sources, imports from foreign countries, and hydraulics (pumping energy). The remaining 24% of the country's total energy mix was satisfied by a fast-growing renewable sector that was distributed as it follows: hydro (13.3 %), solar PV (3.2 %), modern and traditional biomass (3.1 %), wind (2.8 %), and geothermal (1.6 %).

Total solar PV contribution to the national energy mix, as seen in these terms, may look marginal, almost negligible. However, this does not reflect the full potential of solar PV. The number of different policies enforced and the statistics within the last few years suggest that Italy's extraordinary development of its PV sector may possibly embody the launch of an even

[7] Although PV technology is relatively old (the photovoltaic effect was discovered in 1839 by a French physicist, Antoine-Céar Becquerel), it is only in the last few years that it started being adopted in its large-scale to maximise the generation of electricity. For this reason, it can be considered as a technological innovation (Sovacool 2006).

bigger expansion, which promises to play a key role in the immediate future of the Italian energy supply.

By the end of the year 2011, 330,196 PV plants were operative in Italy. Together they accounted for an installed power of 12,773 MW_p and for an overall generation of electricity equal to 10.796 TWh (GSE 2012a:8-9). Italy's PV positive trend is especially evident in the course of the year 2011, when 174,219 new stations became operative (+112% compared to 2010). As a whole, they added to the total national nominal power 9,304 MW_p, almost tripling (+268%) the installed power that was already in place by the end of 2010 (Figure 2).

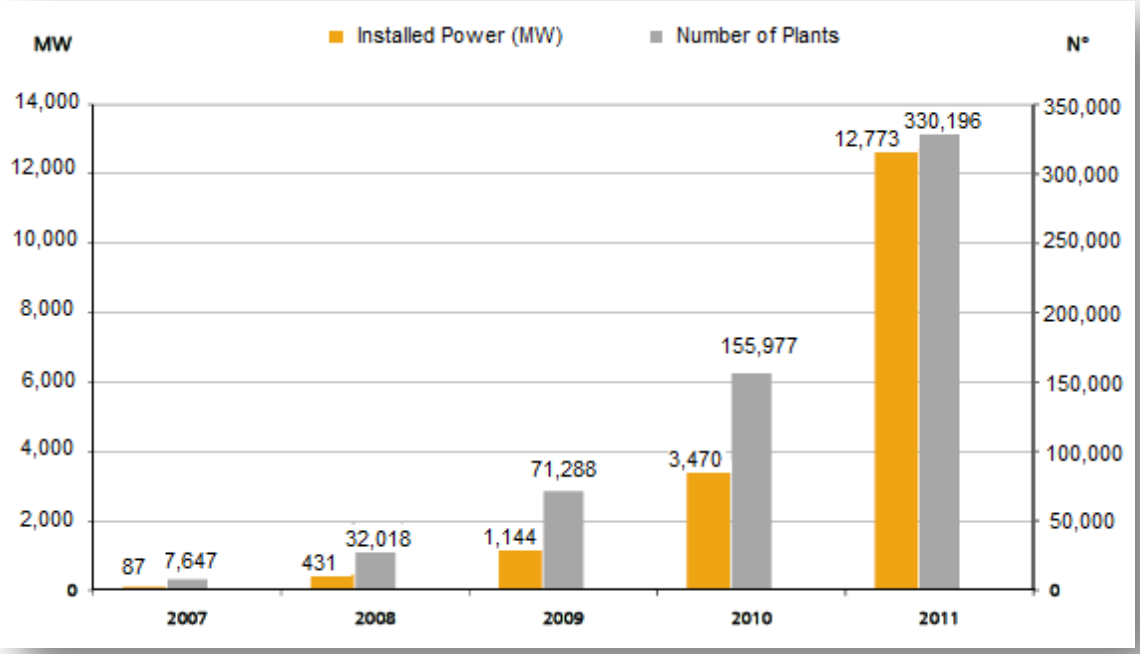
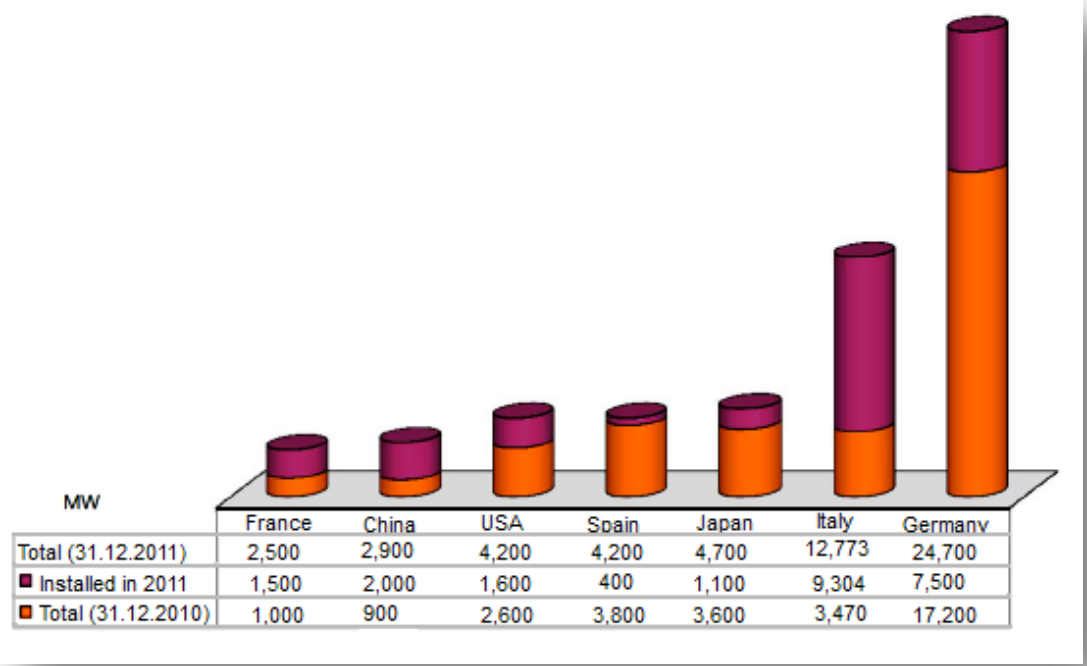


Figure 2: Evolution of the installed PV power and of its related number of plants in Italy (Source: adopted and translated from GSE 2012a:9).

Statistics indicate that since 2007 the number of plants experienced a vertiginous expansion, more than doubling year by year. Yet, historical data also point out that the installed power has not grown proportionally to it. This is because in four years the average power of each plant has even more dramatically increased: from 10.4 kW_p in 2007, to 53.4 kW_p in 2011, attesting

the final cumulated average power of each unit to 38.7 kW_p (GSE 2012a:9). Such a quick deployment of photovoltaic technology decreed Italy at the same time the world's leading PV installer in 2011, and the world's second country, after Germany, for largest total installed PV-power (Figure 3).



MW	France	China	USA	Spain	Japan	Italy	Germany
Total (31.12.2011)	2,500	2,900	4,200	4,200	4,700	12,773	24,700
Installed in 2011	1,500	2,000	1,600	400	1,100	9,304	7,500
Total (31.12.2010)	1,000	900	2,600	3,800	3,600	3,470	17,200

Figure 3: Installed PV power of countries that rely the most on solar photovoltaic technology (Source: adopted and translated from EPIA 2012, cited in GSE 2012a:38).

To understand the extent and the rapidity of Italy's remarkable PV development, it is also interesting to look at data concerning the generation of electricity from PV in the last five years. On the basis of these, it emerges that at the end of 2011 Italy had increased by 280 times its 2007 production (+466% only in 2011, in relation to 2010) and, by doing so, had managed to create the right conditions for a prosperous market to flourish around the solar PV technology (Figure 4 below).

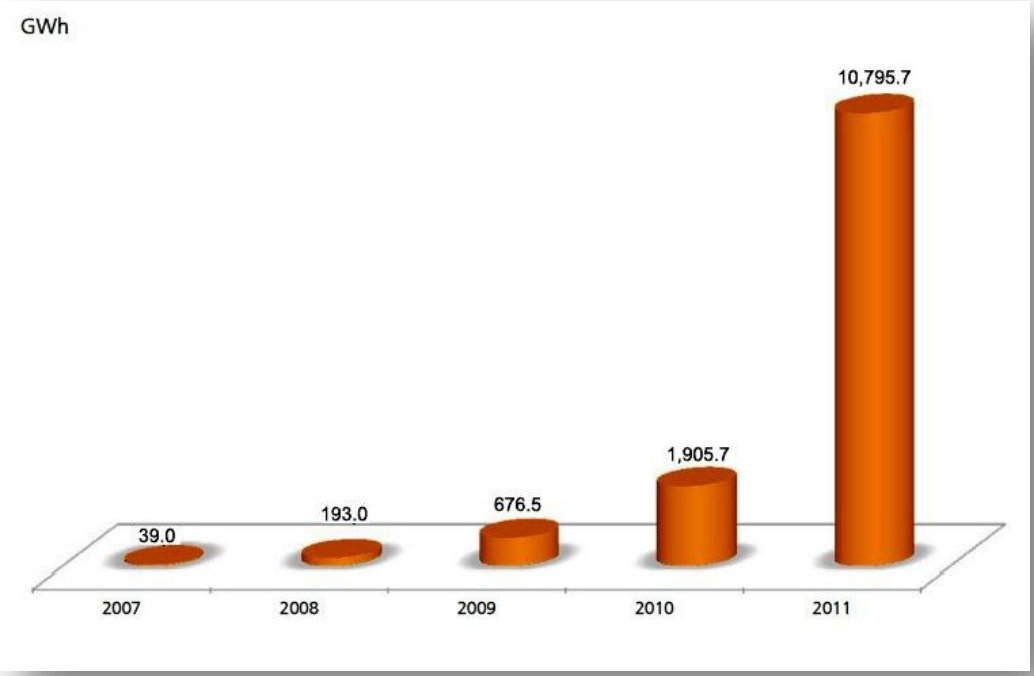


Figure 4: Evolution of electricity generation from solar PV in Italy (Source: adopted and translated from GSE 2012a:28).

Solar photovoltaic technology has rapidly become a solid, widespread and, according to the media, well-accepted reality in Italy. There is already at least one PV power plant in 95% of the 8,094 Italian municipalities (Appendix 1) and the continuing growth of PV is not likely to be obstructed in the nearest future.

There seems to be little doubt that solar PV is a technology very likely to assume an increasingly stronger role in the future Italian energy mix.

2.4.2 Apulia

To understand the driving forces of the photovoltaic sector in Italy it is essential to focus on the contribution given at each administrative region level to the expansion of this industry.

Official tables issued by GSE (2012a) highlight that the distribution of installed power and number of plants in Italy is extremely heterogeneous (Figure 5 below). Nearly the whole of the central and northern regions of the

country (central-left side of the table) present a high number of plants (grey column) and a relatively low installed power (orange column). If we divide the overall nominal power installed in each of these regions by their own number of stations, we realise that the average size of their plants is lower or roughly in line with the Italian average (38.7 kW_p).

The more we move south (right side of the table) the more the number of plants tends to decrease. Inversely, the regional installed power meets a tendency to increase. In contrast with the regions located in the north, southern regions' PV-plants are in fact on average characterised by a slightly higher average nominal power than the national one.

Yet, there is one single region of Italy that, with its average installed power of 95.4 kW_p, stands out of all plausible fluctuations that a researcher would reasonably expect to come across in a case like this. That is Apulia.

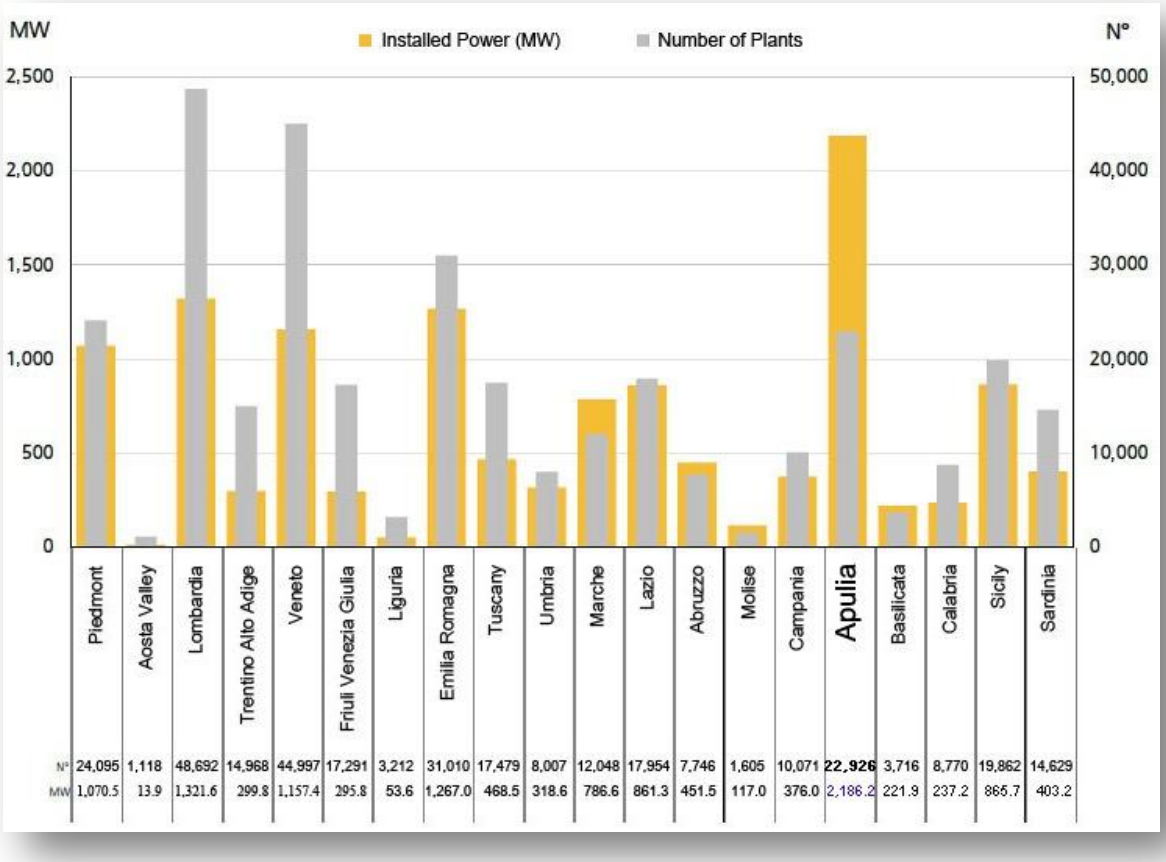


Figure 5: Regional distribution of the installed solar PV power (orange column), number of plants (grey column), and average nominal power (Source: adopted and translated from GSE 2012a:12).

Apulia is not only the region of Italy with the highest average installed PV-power. Whichever official PV-related national table we decide to consult, we encounter its name as a top contributor. One may think that, as a fairly large region, it is easier for Apulia to reach such records. In order to clarify and counter this misconception, let us relate our absolute numbers (GSE 2012a) to the local area and to the inhabitants, and compare the results with the national average.

The findings are notable. With 112.9 kW_p/km^2 installed, Apulia holds the Italian record for concentration of PV technology in one region, almost tripling the national average (42.4 kW_p/km^2). Apulia also leads the national ranking for per-capita installed power with a score of 535.9 W_p/inhabitant, against the national average that marks only 211 W_p/inhabitant.

In 2011, Apulia alone generated 19.4 % (2,095.7 GWh) of the entire national PV production, and deployed on its land 17.1 % (2,186.2 MW_p) of the total installed power (28.8 % if we consider only the solar plants installed in open fields and not on rooftops, walls, or greenhouses).

Once again in great contrast with the national average (49.4 %), 83% of Apulia's total nominal PV power is scattered on the ground, in large PV parks. They occupy a record area of 33,751,101 m^2, predominantly concentrated in the southern districts of Lecce, Brindisi, and Taranto (a flat sub-region called Salento, see Figure 6 below). Here the development of large-scale PV technology assumes the traits of a huge, industrial business that meets no equals in Italy.

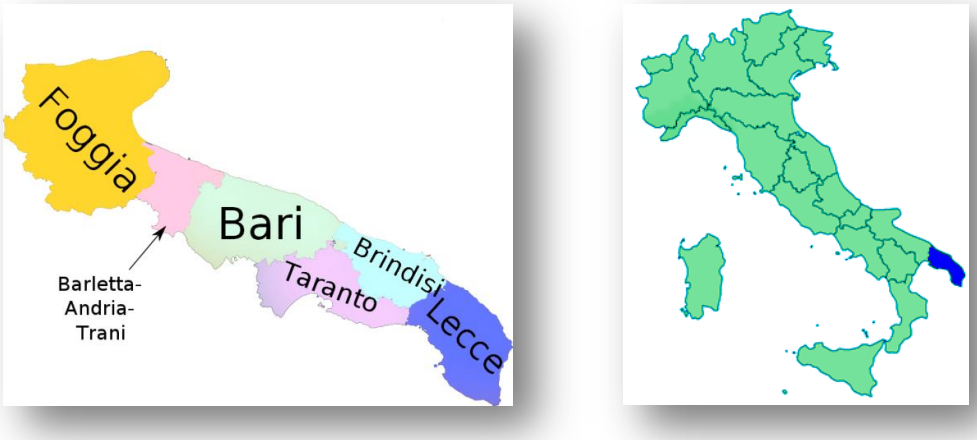


Figure 6: On the left: the six districts of Apulia region. On the right: Salento is a sub-region of Italy located in the southernmost area of the region (Source: produced by the author).

2.5 Evolution of the Legal Framework for the PV Sector

Apulia is not one of those regions of Italy that benefits from particular forms of autonomy under a special law ('*statuto speciale*'). As such, in order to comprehend how its photovoltaic sector is being administered, it is important to look back in time at general regulations on renewable energy contained within the Italian and Communitarian legislation that have been directly or indirectly affecting it from the year 2005, when the first guidelines appeared, to the present.

In the following chronological journey across various energy policies, a particular focus will be reserved for legislation that has effected and continues to effect the object of this case-study: large-scale PV plants ($\geq$ 200 kW_p) (for the complete list of relevant laws see the table in Appendix 4).

Conto Energia I (2005-2007)

The creation of a Community framework for promoting the production of electricity from renewable energy sources in the internal electricity market resulted in the Directive 2001/77/EC of the European Parliament and of the Council of 27 September 2001 (D 2001/77/EC). According to this act, new diverse environmental policies were to be implemented in all countries of the European Community.

In Italy, the Directive was acknowledged by the Italian Parliament through the passage of the Legislative Decree No. 387 of 29 December 2003 (LD 387/2003), of the Ministerial Decree 28 July 2005 (MD 28/07/2005), and of the Resolution No. 188 of 14 September 2005 (R 188/2005), signed by the Authority for Electricity and Gas. Inspired by the successful 'Feed-in Tariffs' (FiT) implemented in Germany, through such acts the Italian Government gave birth to the *First Conto Energia*.

Unlike the past, when the promotion of renewable energy was propelled through the assignments of grants in which the private sector could limit the amount of capital it needed to invest, the revolutionary FiT principles that governed the *First Conto Energia* allowed investors to access the economic incentives only through the production of energy from renewable sources. As in a mechanism for funding operating expenses, the amount of private investment needed to achieve the production was therefore left outside of the incentive system.

The owner of a PV plant now received sums on an on-going basis (typically once per month) for the first twenty years of plant life, in accordance to the electricity generated. A prerequisite to obtaining the tariffs was the grid connection of the system and a nominal size of the same greater than 1 kW_p.

The Ministerial Decree 6 February 2006 (MD 06/02/2006) updated the *First Conto Energia* with the establishment of the first clear distinction between 'domestic PV systems' (with an installed power not exceeding 20 kW_p and registered in a natural person's name, in a joint ownership of a residential building, or in a Public Administration), and 'PV plants' (registered in the name of a corporate body with legal status).

PV plants under the *First Conto Energia* could benefit from a twenty-year incentive, free of VAT for the entire duration, calculated on the whole PV production and not only on their self-consumption. From the date of entry into operation, these kinds of plants were awarded a tariff of:

- **0.445 €/kWh** for plants between 1 and 20 kW_p that chose to operate the 'net metering': a balance between the annual electricity fed into the grid and the electricity absorbed from it within the same year;
- **0.46 €/kWh** for plants between 1 and 50 kW_p that chose to feed into the grid their entire production ('energy sale');
- **0.49 €/kWh** for plants between 50 kW_p and 1 MW_p.

In addition, the owners of those plants that decided to feed into the grid their entire production were also instantly awarded a compensation for the electricity sold to the distributor. The price, this time, was subject to VAT and set in advance by the Authority for Electricity and Gas for the complete period. Namely, the price was:

- **0.095 €/kWh** for plants whose annual production accounted for less than 500 MWh;
- **0.08 €/kWh** for plants whose annual production varied between 500 MWh and 1 GWh;
- **0.07 €/kWh** for plants whose annual production exceeded 1 GWh.

Conto Energia II (2007-2010)

As already experienced in Germany, the *First Conto Energia* in Italy proved itself to be an economic and cultural success, also in terms of employment. The entire 'incentive + saving/selling' mechanism guaranteed on average a payback time of six to ten years, and a safe revenue over twenty years.

When the first Italian FiT mechanism reached its cost budget, it was followed by the Ministerial Decree 19 February 2007 (MD 19/02/2007), which resulted in the approval of the *Second Conto Energia*. The major news introduced by *Conto Energia II* included: higher incentives for small-scale PV systems (1-3 kW_p and 3-20 kW_p) and for initiatives taken by Public Administrations, awards for energy efficiency and extension of maximum capacity size (from 20 to 200 kW_p) for PV systems operating under 'net metering', separation of PV plants into three categories, divided according to their architectural

integration ('integrated', 'partially integrated', and 'non-integrated'), fastening of most of the bureaucratic procedures relative to application and authorization of new PV stations, lowering of VAT to 10%, and full deduction of expenses concerning the realisation of PV plants.

Under the *Second Conto Energia*, large-scale PV plants (PV systems with a nominal power higher than 200 kW_p) were eligible for a twenty-year incentive equal to:

- **0.365 €/kWh** for 'non-integrated' systems (with a 5% increase in base tariff in case of self-consumption of at least 70% of the energy produced);
- **0.384 €/kWh** for 'partially integrated' systems;
- **0.442 €/kWh** for 'integrated' systems.

The changes adopted by the *Second Conto Energia* kept maintained the certainty and attraction of the FiT offered by Italy (always to be summed to the revenues coming from the selling of electricity to the grid or to the savings due to self-consumption). The open Italian plan of developing a quick and widespread implementation of photovoltaic technology throughout the country, together with the grant of the highest PV-incentives in the world, helped grab the attention of investors worldwide.

National Action Plan (PAN, 2010)

In line with the EU's '20-20-20 targets'[8], the Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 (D 2009/28/EC) was part of a series of energy and climate change legislation that offered a legislative framework for Community targets oriented to greenhouse gas emission savings. It stimulated energy efficiency, energy consumption from

[8] In March 2007 the EU leaders committed Europe to converting itself into a model energy-efficient, low carbon society. In order to start this process, a series of challenging climate and energy targets were set to be met by 2020. The so-called '20-20-20 targets' concern: *"A reduction in EU greenhouse gas emissions of at least 20% below 1990 levels"* (the EU leaders also offered to increase the EU's emissions reduction to 30%, on condition that other major emitting countries in the developed and developing worlds commit to do their fair share under a global climate agreement. United Nations negotiations on such a topic are still on-going), *"20% of EU energy consumption to come from renewable resources"*, and *"A 20% reduction in primary energy use compared with projected levels, to be achieved by improving energy efficiency"* (European Commission 2010).

renewable sources, the improvement of energy supply, and the economic development of a vibrant sector in which Europe set (and is still setting) an example to the rest of the world.

The Directive defined binding targets for each Member State of the European Community. Such objectives were calculated according to the share of each country's energy from renewable sources in its gross final consumption for 2020. It also compelled each Member State to establish a 'national action plan' so as to reach its own target by setting the intermediate and final share of energy from renewable sources to be consumed within 2020 in three key-sectors: transport, production of electricity, and heating/cooling.

Italy's overall target set by the European Directive (17%) was acknowledged by the Ministry of Economic Development with the preparation of the Italian 'National Action Plan' (PAN[9]), a legislative tool containing two hundred and seventeen pages, filled with institutional, financial and legal measures, guidelines and strategies necessary for achieving the binding goal of 17% of energy from renewable sources in its 2020 gross final consumption. The overall target of 17% resulted from the average of three key-sector share objectives: 26% in production of electricity, 17% in heating/cooling, and 7% in transport.

The stipulation of PAN raised once again a dilemma born with the issue of the *First Conto Energia* and never solved by the Italian Parliament: how to share the burden of reaching a national target amongst the twenty different administrative regions of Italy?

Conto Energia III (2010-2011)

On August 24, 2010 the Ministerial Decree 6 August 2010 (MD 06/08/2010) was issued in the Official Gazette. It introduced the long announced *Third Conto Energia* and the new incentive rates for the production of electricity from photovoltaic systems in operation from January 1, 2011.

[9] The document was transmitted to the European Commission on July 28, 2010.

Amongst the new regulations introduced by the Decree, a significant innovation was the new categorisation reserved to PV systems. Abandoning the old division ('integrated', 'partially integrated' and 'non-integrated'), they were now to be classified as: 'ordinary PV systems' (with two sub-categories: 'installed on buildings' and 'other type of PV plants'), 'integrated PV plants with innovative features', 'concentrated PV plants', and 'PV systems with technological innovation'.

With the goal of installing (and incentive) an overall capacity of 8 GW_p by 2020, *Conto Energia III* introduced for the first time single caps, namely limited subsidised capacities for each category of PV plant:

- 'Ordinary PV systems': 3 GW_p;
- 'Integrated PV plants with innovative features': 300 MW_p;
- 'Concentrated PV plants': 200 MW_p;
- 'PV systems with technological innovation': -- (this cap was never set).

From the date on which the cumulative cap of each category was reached, the tariffs were set to be eligible to operative systems for only the next 14 months (24 months for the Public Administration).

The need to implement for the first time a regressive FiT over time officially decreed the cumulated success of *Conto Energia* in Italy. It also implicitly declared the need to catch up with the marked reduction in the cost of solar modules around the world.

Under the *Third Conto Energia*, in the period *January 1, 2011 – April 30, 2011*, large-scale PV plants (Category: 'ordinary PV plants'. Subcategory: 'other type of PV plants'. Class: PV systems with a nominal power higher than 200 kW_p), were eligible for a twenty-year incentive equal to:

- **0.314 €/kWh** for PV plants with a nominal power comprised between 200 kW_p and 1 GW_p;

- **0.313 €/kWh** for PV plants with a nominal power comprised between 1 GW_p and 5 GW_p;
- **0.297 €/kWh** for PV plants with a nominal power exceeding 5 GW_p.

For the same type of PV plants, the first regressive tariffs came into effect in the period *May 1, 2011 – August 31, 2011*. They were equal to:

- **0.303 €/kWh** for PV plants with a nominal power comprised between 200 kW_p and 1 GW_p;
- **0.289 €/kWh** for PV plants with a nominal power comprised between 1 GW_p and 5 GW_p;
- **0.275 €/kWh** for PV plants with a nominal power exceeding 5 GW_p.

A third regressive FiT period was also set for the period *September 1, 2011 – December 31, 2011*[10]:

- **0.266 €/kWh** for PV plants with a nominal power comprised between 200 kW_p and 1 GW_p;
- **0.264 €/kWh** for PV plants with a nominal power comprised between 1 GW_p and 5 GW_p;
- **0.251 €/kWh** for PV plants with a nominal power exceeding 5 GW_p.

Other minor innovations were introduced by *Conto Energia III*. In order to increase efficiency, the process of application became 100% computerised. Certain premiums were introduced for specific types, location and applications of PV plants (i.e. ground-mounted installations located in industrial or commercial areas, rubbish dumps or contaminated areas were entitled to a 5% increase in base tariff).

Renewables Decree (2011)

The endorsement of the PAN (2010) and the unexpectedly fast development of PV in Italy reflected a radical change in Italy's national energy policy. The Parliament, through the passage of the so-called 'Renewables Decree', namely

[10] Because of reached limits of cumulative nominal power, this third period was never implemented.

the Legislative Decree No. 28 of 3 March 2011 (LD 28/2011), not only finally adapted its energy strategies to the European Directive 2009/28/EC, but it also prepared the field for the ratification of a new, much more prudent *Conto Energia*.

Conto Energia IV (2011-2012)

The huge success of the *Third Conto Energia* resulted in a rapid flourishing of PV installations that far exceeded anybody's expectations. However, after the Italian Government comprehended that PV plants in Italy had developed exponentially and that the estimated cost of the *Third Conto Energia* (funded by rate increases being passed to consumers), would quickly become unsustainable, the Ministry of Economic Development was asked to operate an immediate revision of the incentive system.

Strongly debated, the so-called *Fourth Conto Energia* was approved with the Ministerial Decree 5 May 2011 (MD 05/05/2011) and entered into force on 13 May 2011, replacing the FiT system introduced by Conto Energia *III* only nine months prior.

With the announcement of the *Fourth Conto Energia*, helped also by the public vote against nuclear power development in a national referendum, Italy reaffirmed its commitment to the development of photovoltaic technology. Yet, elements such as the existence of a PAN, the approximation of the age of grid parity[11], and the need to guide the manner in which PV is deployed, accompanied by the necessities connected to the economic crisis, produced a significant change into the energy priorities that were reflected into the new FiT provided. With a market showing increased maturity and sophistication came the aim to better integrate PV into the Italian landscapes, a key that was central to the last *Conto Energia*. As a consequence, the deployment of large PV plants was highly discouraged through cuts in FiT as high as 20 to 30% by

[11] Grid parity is the point after which all incentives will be phased out. In Italy a full grid parity is expected to occur by 2016-2017.

the end of 2011, and even more in the months ahead, according to the size of each park (MWE 2011, WFW 2012).

For the first time specific restrictions appeared on agricultural land use for PV deployment. To be entitled to obtain incentives, any new ground-mounted installation was not to exceed 1 MW_p, occupy more than 10% of the crop-producing land area, and be at least 2 km away from the closest PV station belonging to the same owner. Such constraints were approved not only to prevent destruction of productive land and risks of speculation, but also to specifically avoid negative visual impacts that large-scale renewable projects may provoke in beautiful rural areas.

The categorisation of PV systems remained more or less unchanged ('ordinary PV plants', 'PV plants using concentration technology', and 'PV plants integrated in buildings and using innovative technologies'). So did the Feed-in Tariffs.

Like its most recent precursor, *Conto Energia IV* offered a differentiated and regressive FiT system, subject to size and category of each PV plant. Within each group, tariffs were designed to decrease as a function of the size of the PV plant and the start date of operations (on a monthly basis until the end of 2011, half-yearly in 2012. See Appendix 5 for more details).

Italy's *Fourth Conto Energia* reflected a new, more sustainable approach to the national development of PV technology. For the first time it was recognised the fact that the country is absent many of the vacant land regions that countries like the United States or Australia have, or the open deserts of China and North Africa, where perhaps the deployment of bigger PV plants may imply a better possibility to exploit solar energy. Instead, Italy owns a rich and heterogeneous landscape, occupied by productive lands, orchards, natural reserves, dense urban areas, and historical sites that *Conto Energia IV* intended to protect by awarding efficiency and integration upon industrialism and speculation. Yet, despite the enactment of this new and more protective

energy law, for the experts Italy still remained "one of the most-lucrative markets in the world for PV developers" (Banin 2011:2).

Liberalisation Decree (2012)

New laws, regulations, plans and proposals on future mechanisms to be adopted for a more sustainable development of the photovoltaic sector in Italy appeared very often in the course of the year 2012.

The Law No. 27 of 24 March 2012 (L 27/2012) added new sets of limitations to the existing ones legislated by the '*Conto Energia IV*' and the 'LD 28/2011'. In such a context, the admission to the 2011 and 2012 Feed-in Tariffs of large-scale PV plants commissioned between 1 September 2011 and 31 December 2012 became guaranteed under the following provisions:

- These systems had registered with the '*Gestore Servizi Energetici*' (GSE);
- They had obtained a suitably high priority ranking to permit them to fall within one of the incentive caps available for the semester in which application was handed in;
- They had presented file documentation to the GSE attesting the completion of their works.

Large PV plants that were not able to obtain a priority ranking falling within a pertinent incentive cap of their related semester were given the possibility to apply for the 2013 FiT.

Besides the limitations set by the '*Conto Energia IV*' and the 'LD 28/2011' in terms of capacity, land accessibility and contiguity of ground-mounted large PV plants scattered over agricultural areas, the new Law 27/2012 (converted from the Art. No. 65 of the so-called 'Liberalisation Decree') provided for these systems only two slots for grid connection and access to FiT: 24 May 2012 and 21 September 2012.

Burden Sharing (2012)

Nearly nine years after the Legislative Decree No. 387 (LD 387/2003) that compelled the Italian government to approve a 'Burden Sharing' law, seven years after the enactment of the *First Conto Energia*, two years after the publication of the Italian PAN, and more than 1,100 days of delay from the legal terms established by Law No. 13/2009 (L 13/2009): this is the unenviable timeframe record signed by the ratification of the 'Burden Sharing' law. As we shall see later in the text, the delayed achievement of this agreement amongst the State, the twenty administrative regions of Italy and the special-status districts, caused a legislative vacuum that opened up room for different local interpretations.

The Ministerial Decree 15 March 2012 (MD 15/03/2012), commonly called 'Burden Sharing', entered into force on 3 April 2012 with the aim of defining the exact contribution of each region to the achievement of the minimum national binding target. Such target, calculated on 17% of the energy from renewable sources in Italy's 2020 gross final consumption[12], had already been expressed in the Directive 2009/28/EC and in the PAN.

Each administrative region was supplied with the ideal renewable-share trajectory that reflected their expected gross final consumption scenarios in the years 2012, 2014, 2016, 2018 and 2020. In order to guide and supervise all the regional administrations, the Ministry of Economic Development, from the end of 2013, will operate an annual verification of the progress reached.

The Decree, apart from indicating each region's intermediate and final goals (resulting from the average of three key-sector share targets: production of electricity, heating/cooling, and transport), also provided the Government with the tools necessary to intervene in case of default. Starting from 2016, when the transitional goals will become compulsory, the Ministry of Economic

[12] The target to be shared amongst the Italian Regions has been reduced to 14.3 %. The Italian Government relies on the perspective of increasing the use of biofuels and the imports of renewable energy from other countries to reach, together with the efforts of its Regions, the final binding goal of 17% by 2020.

Development will also be able to provide a commissioner for those regional administrations that fail to achieve the targets.

From the entry into force of the Decree, the regions were given three months to approve a sort of 'Regional Action Plan', containing, just like the PAN, several intermediate and final targets for each of the three key-sectors. The local administrations were left free to choose policies for lowering their final gross consumption, establish limits for the development of every single renewable energy source, and suspend for no more than eight months the on-going processes of authorisation for new renewable power plants, when accompanied by valid safety reasons reported by the grid-managing companies.

Conto Energia V (2012-Currently in force)

Ministerial Decree 5 July 2012 (MD 05/07/2012) of the Ministry of Economic Development, in collaboration with the Ministry of the Environment and of the Protection of the Territory and the Sea, concerning the new FiT system for the production of electricity by PV plants, entered into force on 11 July 2012, the day after its publication on the Official Gazette. Yet, the new incentive system applied only from 27 August 2012, precisely forty-five days after the official announcement by the Authority for Energy and Gas of the achievement of the yearly-cost threshold (€ 6 billion) of the FiT mechanism provided in the *Conto Energia IV* (see Resolution No. 292/12 of 12 July 2012) (R 292/2012).

The *Fifth Conto Energia*, currently in force, introduced further severe conditions to the access of large-scale PV plants to the even more restricted FiT granted by GSE. The present incentive system keeps a differentiated and regressive mechanism. Its tariffs for utility scale PV facilities are designed to decrease as a function of the category, size and start-date of operations. The new FiT scheme cores its budget on five limited bi-annual expense caps, distributed on the basis of a complex priority ranking system.

Figure 7 below provides a visual trend of the decreasing 20-year tariffs granted to large-scale PV plants under the *Fourth* and *Fifth Conto Energia* (for the complete list refer to Appendix 5).

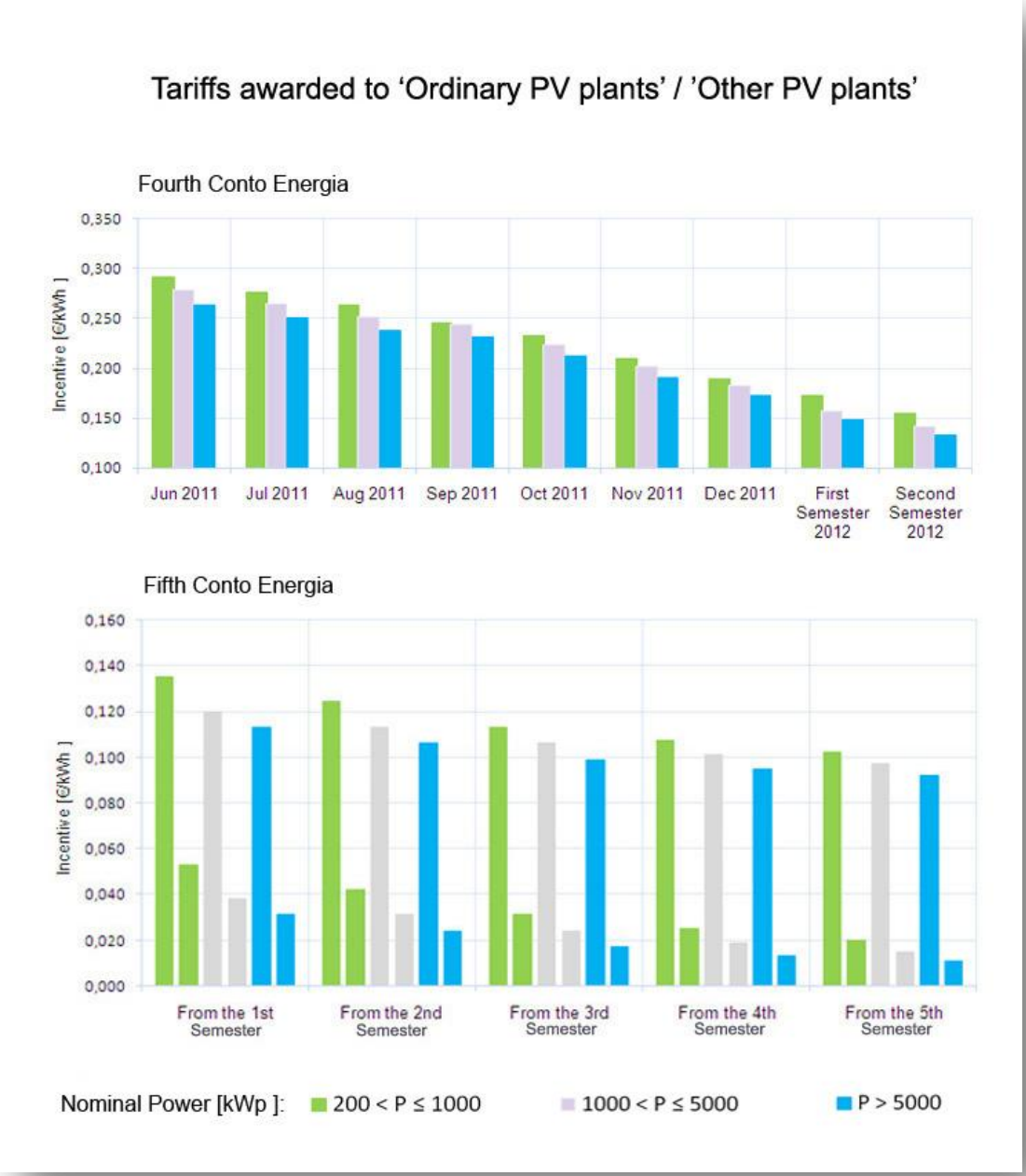


Figure 7: The graph on top shows the differentiated and regressive 20-year Feed-in Tariffs system granted to the 'ordinary PV plants' that started their operations in Italy from June 2011, under the regime of the *Fourth Conto Energia*. The lower graph refers exclusively to the *Fifth Conto Energia* and demonstrates the decreased tariffs granted to the same class of PV plants as above. Here, two columns correspond to each colour. The high one concerns the tariff assigned to producers that decide to feed their entire production in the grid. The low one refers to producers that choose to spend their generation for self-consumption (Source: produced by the author).

Under *Conto Energia V* all large-scale PV plants have to apply to the GSE for admission in one of the three special registers, so as to be entitled to a ranking position. In order to protect projects that were already developed under the *Third* or *Fourth Conto Energia*, a higher cap was reserved to the First Register, whose main priority criterion became the starting date of operations. The next two regressive registers, still unassigned, will award, amongst other features, higher energy-efficiency class certificates, PV modules produced in the European Union, and plants with a lower nominal power.

2.6 Italy's and Apulia's Different 'PV-Phenomenon'

The statistical data and the historical evolution of the national legal framework presented above in this chapter testify a certain 'PV-phenomenon' peculiar to Italy in its general form (absolute numbers, i.e. see Figure 2, 3 and 4), and distinctive of Apulia in its large-scale facet. Whereas the rapid and massive deployment of PV power in Italy may easily be explained (as already happened in Germany; see Galvin 2009) with the adoption at a national level of a series of generous, yet regressive energy policies that made it extremely convenient to invest into the photovoltaic sector until the achievement of the age of 'grid parity', the exclusive Apulian 'large-scale PV phenomenon' clearly requires different and more complex explanations.

Apulia's singular case is a source of interest. As I shall elaborate later in the text, it is not possible to fully understand and explain it by listing favourable factors such as the abundance of sunlight, national incentives, flat rural areas, and possible availability of work and capital to be allocated into the PV sector. Besides that, Apulia's average annual exposition to solar radiation[13], fuel of the photovoltaic effect, is high, but notoriously lower than that of some other regions of Italy (i.e. Sicily, Calabria, or Sardinia. See Appendix 2). Yet, in these regions, despite the presence in some cases of more positive geographical, climatic, and occasionally socio-economic conditions, it has not

[13] Solar radiation is the integral value of radiation from the sun that hits a unit area in a specified period of time, usually a year (unit: kWh/m^2 per year).

even closely been experienced a similar deployment of large-scale PV plants. The very hot and dry climate, too, especially in summer, in name shall play against any rational big investment in Apulia's photovoltaic sector. Solar panels, in fact (from a merely technical point of view) optimally operate in colder climates, where they see their efficiency considerably increased in absence of clouds and dust (Buonsanti 2011). The unclear economic conditions in Apulia are also a contextual circumstance that makes it interesting to investigate more in depth the ways local actors attract the substantial capital needed for triggering the investments allocated into their atypical regional photovoltaic sector.

For these reasons my research interest was first moved onto this "intrinsic case study" (Stake 1994:237, emphasis in the original). It was neither exclusively turned by the possibility of contributing to the application of a theory (ANT) in a field of study (large-scale photovoltaic energy) that at the present is, to my knowledge, still under-researched, nor by the chance to represent with this study a precedent for future similar researches. In all its uniqueness, this case itself was primarily chosen for understanding a local phenomenon that, together with involving 'visible' political, economic and technical structures, clearly appeared to involve 'invisible' social systems, and that, as such, was to be considered as inherently complex. The phenomenon explored in this thesis concerns the investigation of the socio-technical organisational processes that underlie Apulia's massive push for deployment of large-scale PV parks.

3. Theoretical Approach

In this chapter I present the theoretical approach employed throughout the study. The first part provides some background information concerning the research approach, followed by a discussion of the philosophical assumptions that I have engaged. I will then go on to present Actor-Network Theory (ANT) as a valuable analytical and methodological tool for studying processes of construction, maintenance and diffusion of a socio-technical innovation (Harrisson and Laberge 2002, Papadopoulos 2007). Next, ANT will be identified through the vocabulary developed by its theorists in the early 1980s, and proposed/adapted to the Apulian context as the predominant theoretical perspective, in its global-local vision (Law and Callon 1992). Since both material and social factors appeared to play a role within a network of power, this research puts to the test the visual peculiarities of Local/Global[14] ANT and merges them with the broader ANT concepts of agency, power, control, dynamicity (Callon and Latour 1981, Latour 1986, Callon and Law 1995) and, we shall see, with the notion of 'convergence score' (which I use to define my perception of the local and global actors' degree of agreement within the PV network). Taken together, these insights are employed with the intention of contributing to the creation of a composite analytical and methodological approach that shall both reflect and justify the choice of diverse perspectives within the broad realm of ANT for the analysis of this case study.

3.1 Research Approach

Based on insights from the fields of renewable energy, science and technology studies (STS), philosophy of technology, political science and contemporary history, this intrinsic, case-oriented and interdisciplinary thesis draws upon a pluralistic approach and a holistic research strategy (Stake 1994, Creswell 1998, Hirsch 2010). It is a case study that sees me dealing with a variety of disciplines, actors and material: from the understanding and the historical

[14] More details below in the text.

analysis of complex legal structures, to the interpretation of political and civil society points of view; from the examination of tables, numbers and statistics, to the investigation of purely technical issues.

This research has been moved and inspired by different frameworks, practices and disciplines. It reflects both my interdisciplinary training in mechanical engineering and in modern and contemporary history, and my firm conviction that classical research approaches to the investigation of technology are to be challenged for the reason that they appear too loose, dualistic, deterministic, human-centred and spatially-fixed. These in fact generally focus only on the binomial relationship between "men and the machines" (Sovacool 2006:4; see also Verbeek 2006), at the expenses of larger socio-cultural and/or geographical, historical, political, legal and economic contexts.

This case study challenges traditional approaches to the study of technology through the employment of Actor-Network Theory as the framework for data collection and discussion of the findings. The application of such a strategy is justified by the object of study, which I consider to be an inherently complex system of networks, where ensembles of hybrid, socio-technical relationships, meanings and invisible patterns strive for attention. The importance of these networks has been widely underestimated by a number of previous studies revolving around different classical approaches to the very same Apulian PV phenomenon (i.e. Deleonardis 2008, Canelles 2010, Friolo 2010). By means of ANT, the purpose of this case study is therefore to map the composite and often invisible connections, power relations, negotiations and interests that lay behind the systematic push for development of large-scale PV technology registered in Apulia, Italy.

3.2 Philosophical Assumptions

Although all scientific research seeks credible and defensible knowledge, the "*ways* of knowing" (Moses and Knutsen 2007:1, emphasis added) are by definition multiple. According to Guba and Lincoln (1994, see also Lincoln

and Guba 2003), these are representable as a series of points on an imaginary finite line, whose two ends are occupied by the Positivist and the Constructivist paradigms, connected by the Postpositivist paradigm and by Critical Theory[15].

What lies at the bottom of the distinction between the two extreme approaches is the recognition, from a social constructivist point of view, of the fundamental role played by the observer and by the society in 'constructing' the patterns revealed by the findings of scientific projects. Constructivists confute the positivist view according to which the good researcher experiences the world in a direct, dualistic and objective way, unfolding or decoding truths concerning a 'given' world that is independent from the observer. Differently, constructivists recognise that human beings are all dissimilar and that, as such, they may experience the same things in different *ways*. It follows that biological features such as age, gender, or ethnicity; social factors such as era, culture, or language; and not least importantly, contingent psychological drivers, prevent scientists (human beings themselves) from collecting broad, impartial and unbiased sets of data. Such a condition stops them from fully comprehending and explaining the real nature or the rationale of the actions performed by their objects of study (Lincoln and Guba 2003, Moses and Knutsen 2007). Yet, the existence of multiple observers with multiple perceptions does not denote the presence of an infinite relativism filled with infinite truths. Constructivists are not idealists and they recognise the existence of a reality, too; it is just that according to their basic beliefs there exist a number of different *ways* for getting knowledge about it, as any real thing is at the same time credited with being both physical and social. Such *ways* of knowing are complex by nature and that is the main reason why social scientists hesitate more when it comes to claiming absolute truths about reality. Instead, they prefer to concentrate their efforts on the actions and

[15] Following Heron and Reason (1997), there is a fifth inquiry paradigm, too. It is called 'participatory' and, if integrated into the distinction presented above, it would push further right the end of its imaginary line, becoming the new right extreme of it.

interactions of human systems, through the study of concepts such as power, agency, interest and meaning, as these are believed to be of key importance to a more accurate understanding of those different *ways* employed to construct our social/physical world (Tsoukas 2000, Papadopoulos 2007).

This study is anchored in 'soft' social constructivist assumptions, therefore oriented towards the middle-right side of the imaginary line described above. On account of that, I reject in my work the adoption of any strict relativism[16] by partially adhering to Critical Theory and to a specific *ontology* which, as I elaborate below, eventually turned out to be inspired by the Performative view from the 'socio-technical' interpretation of innovation (Latour 1986, 2005, Harrisson and Laberge 2002; more details below in the text), and by Historical Realism (Guba and Lincoln 1994, Lincoln and Guba 2003).

As I entered the field without any rigid framework in mind, no specific preconceived ideas were adopted in the first place. Such a choice was also endorsed by the early employment of Actor-Network Theory, whose ontological stance (described in the next two sections) considers reality as something that exists because it is constructed and sustained by the interplay (mediation, negotiation and association) of actors/agents affiliated to the very same networks, and interlinked by the aim of pursuing their relative agendas or interests (Papadopoulos 2007). As a consequence, the emerging 'out there' of real phenomena requires the adoption of a 'performative' ontological view, as this allows actors "to define the world in their own terms" (Latour 1999:20), that is to state that the world exists because socio-technical processes of hybrid associations get continuously 'performed' (Latour 1986, 1987, 2005, Cordella and Shaikh 2006).

The influence of historical realism is also important in this study. This school recognises the existence of a virtual reality that, apparently immutable in the

[16] "A relativist ontology asserts that there exist multiple socially constructed realities ungoverned by laws, causal or otherwise. 'Truth' is defined as the best informed (amount and quality of information) and most sophisticated (power with which the information is understood and used) construction on which there is consensus (although there may be several constructions extant that simultaneously meet that criterion)" (Guba and Lincoln 1985:84).

present, is the effect of the combination of "historically situated structures" (Hirsch 2010:31), or sets of values that shaped and re-shaped the 'real world' in the past, to create temporarily stable platforms in the present. Historical realism makes use of a perspective that may well adapt to ANT's, where several actors and agents, human and non-human, mobilise and/or are mobilised to continuously construct and re-construct networks of associations that might look apparently unchanging in the present. In the course of this work's analysis of the findings, recognising the context in which the project was deployed corresponded to acknowledging as relevant the history of some of its platforms (above all, those described in chapter two), which contributed to achieving a better comprehension of those behavioural changes occurred over time within the organisational structures of the networks object of study.

As in Hirsch (2010), in order to attain valid knowledge about the reality under investigation, a Transactional and Subjectivist *epistemology* was employed. I was fully aware of the risks connected to the value-mediation of the findings produced by the inevitable interaction of all those subjective ethics that came in contact during the processes of data collection and analysis of the findings (inquirer's-, inquired subjects'-, and possibly all situated others'- values). Therefore, I tried to minimise the risks of producing partial or prejudiced findings by attempting at a severe and continuous critical process of reflexivity and triangulation of data throughout the whole duration of the study (Lincoln and Guba 2003, Hirsch 2010). Such methods, described more in detail in chapter four, are in line with the social constructivist tradition and not only imposed a reflection on myself as a researcher, but also as a respondent.

3.3 Actor-Network Theory as Analytical Tool to Study the Construction of a 'Socio-Technical' Innovation

From a social constructivist point of view, Innovation Studies aim at highlighting how new, more or less temporary, converging/diverging power relations, meanings, directions and interests surrounding technologies are

generated, performed, improved, and protected (Bijker *et al.* 1987, Harrisson and Laberge 2002). In this research, mass-adoption of large-scale PV technology ($\geq$ 200 kW_p) in the Apulian territory is considered as innovation implementation. This process is representable as a social arena in which multiple negotiations, mediations, designation and/or variation of positions and hierarchies, and institution and/or re-distribution of responsibilities, are considered to be taking place alongside the adoption of PV technology, that is, in a 'socio-technical' context. As Law and Bijker (1992:290) straightforwardly assert:

> Purely social relations are found only in the imaginations of sociologists, among baboons, or possibly, just possibly, on nudist beaches; and purely technical relations are found only in the wilder reaches of science fiction.

My conviction in the indissoluble connection between the social and the technological results in the adoption of the 'socio-technical' view of Innovation, according to which not only the social and the technical, but also the textual and the conceptual, get merged and transformed together within the same networks of heterogeneous materials (Harrisson and Laberge 2002, Papadopoulos 2007).

As stated by traditional, 'thermodynamic' views, large-scale solar PV energy systems may simply be conceptualised as in Figure 8 below. Rich access to primary energy in the form of sunlight, together with a certain abundance of flat areas (input), in the presence of available and enhanced photovoltaic technology, are the essential prerequisites for the attraction of work and capital, necessary for the implementation of large-scale PV projects. Through the operation of such a technology human beings are able to convert 'useless', primary energy into 'useable' electricity (output), that in turn contributes to feeding the national grid. Energy consumption, in its various forms, ends the system by transforming that originally 'useable' form of energy back into 'useless' energy (in the form of GHG emissions, diffuse heat, etc.).

The conversion of such a model in simplified mathematical terms for the production of electricity from large-scale PV projects within the Apulian territorial boundaries, would look as it follows:

Output = f(Input, PV)

Where *Output* stands for 'useable', ready for consumption, electricity; the Output parameter is a function of the *Input* (sum of Apulia's solar exposure and its abundance of spare, flat areas), and of the *PV* (installed large-scale PV power within the boundaries of Apulia).

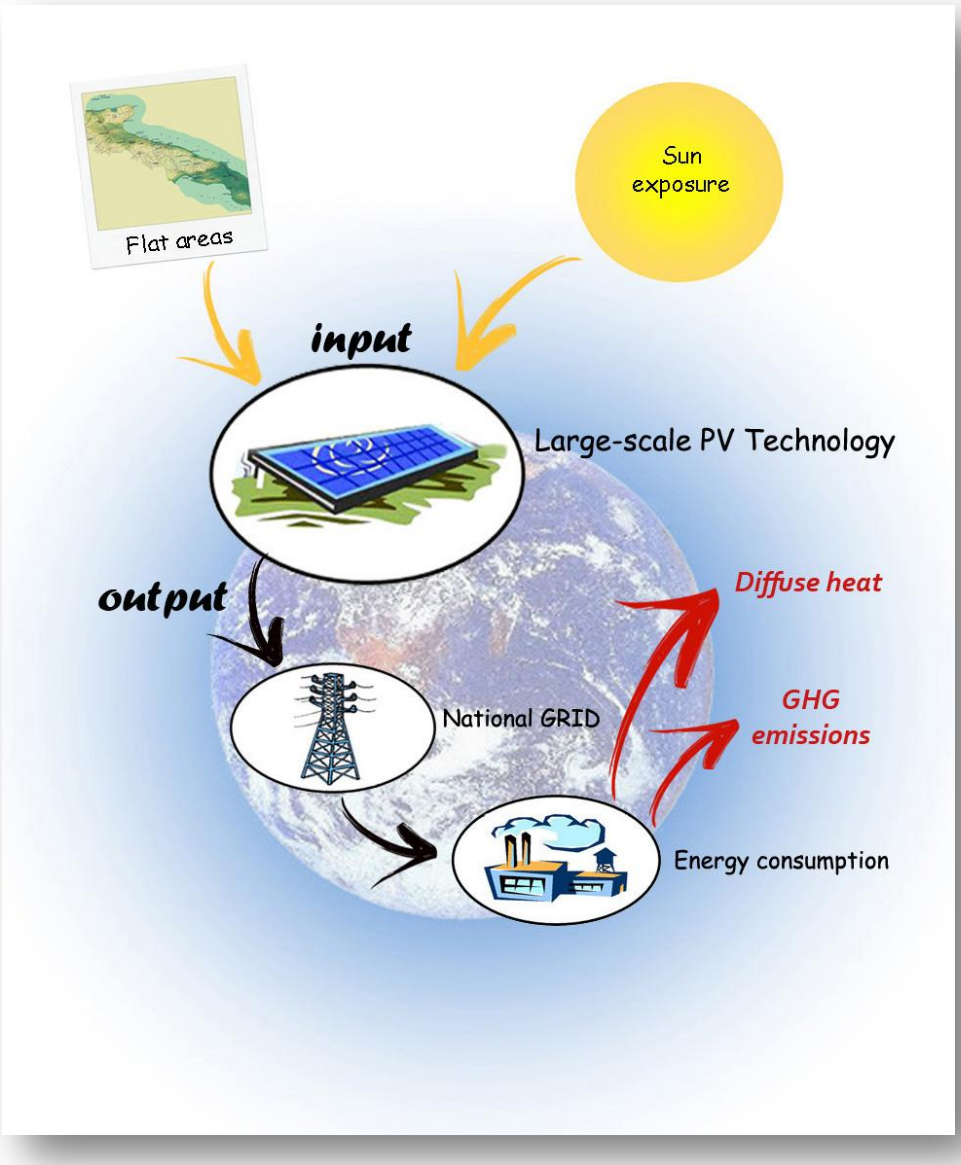


Figure 8: This graph shows the traditional, 'thermodynamic' view of a large-scale, solar PV energy system (Source: produced by the author).

Is the abundance of sunlight and flat, spare areas, added to the overall regional installed PV power, able to explain alone, as it is in a traditional, 'thermodynamic' model, the production of electricity from the deployment of Apulian large PV parks? From a critical, social constructivist point of view, the answer is negative. Principally, this is because if we accept that primary energy is 'intentionally' converted into a 'useable' form of energy through the employment of large-scale PV technology, then we indirectly admit the involvement of the social, hence the intangible complexity of that passage. Secondly, the 'thermodynamic' view appears as simplistic, too. There are regions of Italy that experience similar or higher levels of *Input* than Apulia. Assuming the potential of deploying the same nominal power as nationally constant, the sole *Input* parameter would never be able to explain the unique adoption of large-scale PV technology that has been registered in Apulia. Therefore, there must be something else.

> Every major technical change reverberates at countless levels: economic, political, religious, and cultural. If we continue to see the social and technical domains as being separate, then we are denying an integral part of our existence (Feenberg 1999:i).

It is at this stage that a 'socio-technical' approach to innovation/technology might help. In line with such an approach, Apulia's large-scale solar PV energy system may well be conceptualised as in Figure 9 below. As shown by the traditional model, a rich access to primary energy in the form of sunlight and an abundance of flat areas (input) are indispensable prerequisites for the implementation of large-scale PV projects and for their consequent production of electricity (output), available later for consumption. Yet, the energy system as intended in this socio-technical study contains a great deal more than just that. In line with the ANT-school, one may assume part of that energy system as a complex actor-network, in which an invisible 'black-box' silently underlies the significant Apulian push for deployment of large-scale PV technology. According to the 'socio-technical/ANT' model, the conversion in simplified mathematical terms of the production of electricity from large-scale PV projects within the Apulian territorial boundaries, would look as it follows:

Output = f(Input + PV)

Where *Output* remains unchanged as in the 'thermodynamic' model, whereas *Input + PV* stands for the hybrid, 'black-boxed' network, in which the overall installed PV power, flat areas, sun exposure, or factors like work and capital, embody just the visible features of a far more complex (and largely invisible) socio-technical system, whose examination is the object of this thesis.

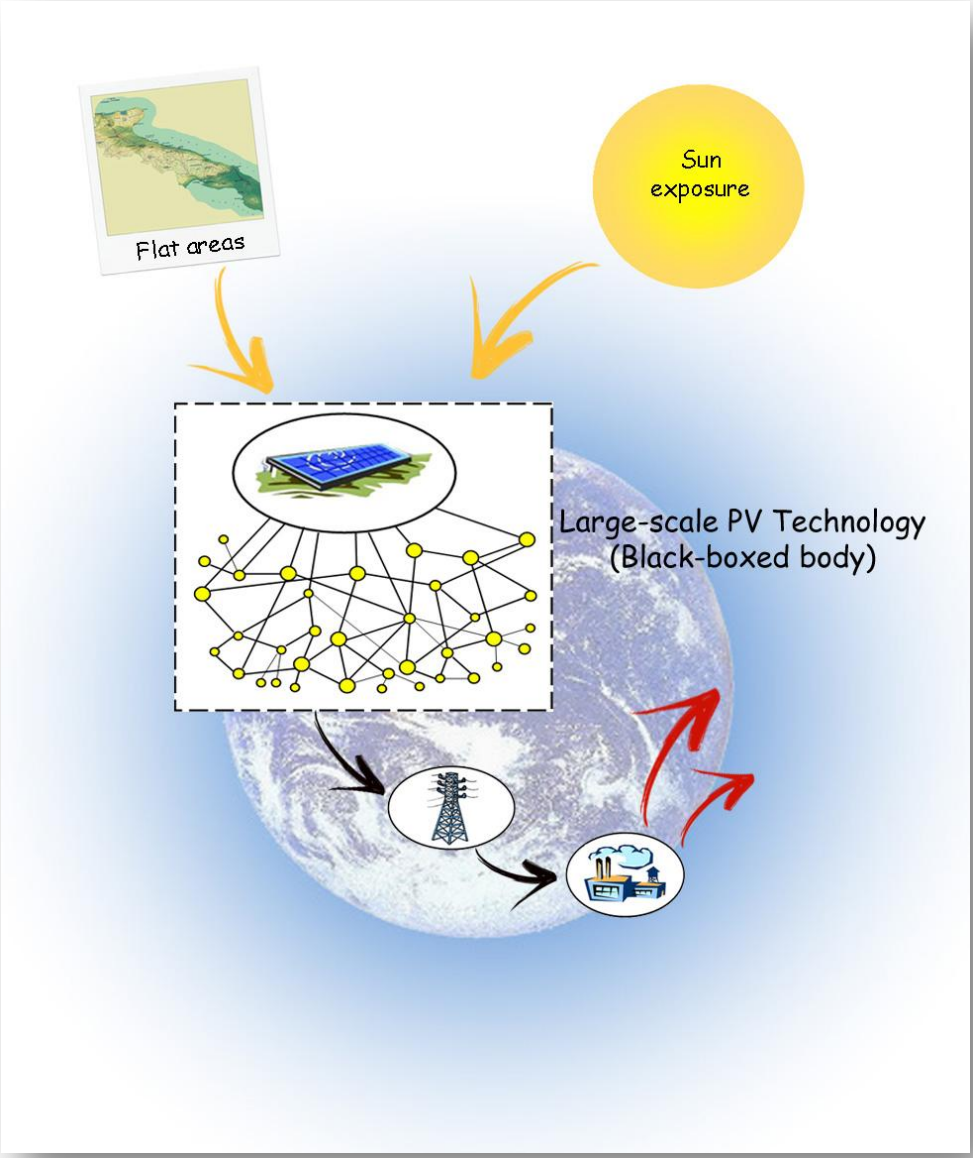


Figure 9: This graph shows the 'socio-technical/ANT' view of a large-scale, solar PV energy system (Source: produced by the author).

As we shall see, the Apulian large-scale PV energy system reaches far and touches upon material and non-material actors, bounded or unbounded by the Apulian territorial borders, and directly or indirectly affecting/affected by the black-boxed network represented in Figure 9. This in turn is considered as a single entity by traditional approaches to technology, and as a gate to a complex socio-technical world by ANT scholars.

Through the lens of Actor-Network Theory this dissertation will attempt at a qualitative investigation of the complex organisational aspects contained within that socio-technical world. Namely, it will be about acknowledging the existence of unique and unrepeatable chains of events, through which organised systems of actors have been capable of constructing and performing long-term structures for locally supporting the large-scale PV innovation.

3.4 Core Concepts from the Vocabulary of Actor-Network Theory

Actor-Network Theory (ANT) was founded in the early 1980s by two French social scientists, Bruno Latour and Michel Callon. Due to their collaboration with another sociologist, John Law, ANT can as well be defined as the expression of a strong British influence (Latour and Woolgar 1979, Callon and Latour 1981, Callon 1986a, Latour 1987, Callon and Latour 1992, Law 1992, Law and Callon 1992).

As a Science and Technology Studies' wing, ANT shares with it the aim at conducting critical and empirical research into the practice of science and the non-recognition of any kind of dualism (Hess 1997, Harrisson and Laberge 2002). For instance, ANT does not distinguish between science (knowledge) and technology (artefact). Equally, it challenges distinctions of traditional epistemological opposing categories such as: human-non-human, nature-society, truth-falsehood, object-subject, inside-outside, natural-cultural, material-semiotic, micro-macro, and so forth (Ritzer 2004, Papadopoulos 2007).

As all of these single bodies, whether people, institutions, symbols, texts, or technologies, attain meaning only in relation to other bodies, the significance applied to each of the categories mentioned above is to be considered nothing more, nothing less, than the outcome of heterogeneous relations and joint interactivities of diverse materials. To use Law's words, "if differences exist, it is because they are generated in the relations that produce them. Not because they exist, as it were, in the order of things" (2001:3).

As per ANT, scientific knowledge may take on several forms. Its emergence 'out there' is a socio-technical product, rather than the result of privileged scientific practices. Hence, knowledge occurs due to sets of different practices performed by networks of heterogeneous, socio-technical (f)actors which are bound together by alliances and compromises that are incessantly executed and carried out to achieve particular interests or expectations (Law and Callon 1992, Latour 2005).

In the following sections, the core concepts of Actor-Network Theory are in the first place identified and presented through the use of the same specific vocabulary developed by ANT theorists, and finally contextualised to the object of this case study.

3.4.1 The Actor and the Network in ANT

Actors are the starting point of any innovation study (Harrisson and Laberge 2002). An actor is defined by Callon as "any entity able to associate texts, humans, non-humans and money" (1991:140). It can literally be any agent, collective or individual, material or non-material, which is capable of associating or dissociating with other agents; that is, any agent granted to be either the source of an action/agency or the recipient of its effects, falling within the boundaries of a heterogeneous network of interrelated bodies (Law 1992, Latour 1999, Toennesen *et al.* 2006, Papadopoulos 2007).

The actors of a network embody compromises at different levels. Their nature is necessarily indeterminate, that is to say, their essence cannot be *a priori*

defined, as it is derived by the networks in which they associate (Ritzer 2004). This implies for ANT practitioners the need to study agents without imposing *a priori* meanings, guesses or anticipations on them.

Yet, in order to comprehend how diverse actors and meanings succeed in emerging from the complex interconnections at stake, it is more convenient to reason in terms of "networks of relations" (Williams-Jones and Graham 2003:273, see also Thompson 2003), or more precisely, actor-networks.

Actor-networks are by definition heterogeneous, shifting systems of alliances, incessantly built and performed by the agents out of which they are composed. Apart from being complex, these networks are also intrinsically local, contingent, and unstable over time. Their strength and solidity depends on the level of engagement and on the number of associations achieved by the actors involved, according to which they may enlarge, shrink, or in some cases even totally collapse and/or be replaced by other networks (Law and Callon 1992, Williams-Jones and Graham 2003, Ritzer 2004). Actor-networks are innately dynamic systems. As a matter of fact, when innovation moves in time and space it may produce changes that are proportional to the changes occurring in the agenda of its constituents. In other words, by varying in number and quality, the mutating associations of an actor-network's constituents are responsible for provoking the technological dynamics that are visible from the outside (Czarniawska and Hernes 2005).

The notion of heterogeneous, socio-technical, actor-network applies to all, micro and macro, and can be used to define the entirety. Human beings, institutions, computers, trees, books, stones, bacteria, etc. are all the result, or the effect, of heterogeneous networks. Therefore, for ANT "there are no causes, only effects. There are no essences, only heterogeneous networks" (Cressman 2009:5). It may seem an oxymoron, but just like anything else, all of the actors taking part into a network can be defined as heterogeneous networks, too, therefore 'actor-networks' themselves. As Cressman asserts, it

is just "a matter of perspective" (2009:3). Consequently, as per ANT, in any actor-network the whole is always paradoxically intended as infinitely smaller than the parts (Callon 1987, Law 1992, Feenberg 1999).

3.4.2 Agnosticism, Generalised Symmetry and Free Association

The issue concerning the analysis of the production of scientific knowledge is addressed by ANT through the application of three radical principles.

The first principle is known as 'Agnosticism'. By advocating it, ANT imposes *a priori* analytical impartiality to the researcher, in an attempt to produce unprivileged interpretations of the data collected on the actor-networks under investigation (Ritzer 2004). In simple terms, such a principle categorically forces the researcher to start his/her study with no preconceived ideas about the field.

The second radical principle is called 'Generalised Symmetry' and it is derived from the empirical observation of labs, research centres and fieldworks, where people, texts, symbols, and technologies play an equally essential part in the construction of actor-networks (Cressman 2009). Its adoption coincides with the creation of a common vocabulary and ontology for the 'symmetrical' approach of humans and non-humans:

> To insist on symmetry is to assert that *everything* deserves explanation and, more particularly, that *everything* that you seek to explain or describe should be approached in the same way (Law 1994:9-10, emphasis in the original).

In other terms, this principle which is central to ANT, far from being interpreted in its extreme form, implies for researchers a commitment to employ the very same analytical and descriptive framework when dealing with people, texts, symbols, or technologies (Callon and Latour 1981, 1992, Latour 1996, see also Ritzer 2004, Galvin 2009). In doing so, scientists and technologists become 'heterogeneous engineers', that is, interdisciplinary experts not only able to do science inside their laboratories, but also professionals capable of dealing with diverse materials and with a range of

social, economic and political perspectives outside their research centres (Law 1987, Toennesen et al. 2006, Díaz Andrade and Urquhart 2010).

The early adoption in this study of an approach inspired by the principle of Generalised Symmetry made it difficult to ignore, alongside with all people and human-based institutions involved, actors such as the solar exposure, the abundance of flat areas, the legal framework, the solar modules, the incentive rates, infrastructure, capital, black market, etc.

It is worth mentioning that, by advocating this principle, ANT does not erase the differences between humans and non-humans. On the contrary, ANT recognises agency but not intentionality to non-humans, as the latter remains a peculiar characteristic of human beings (Latour 2005).

'Free Association' is the third fundamental cornerstone of ANT. This principle stands for the *a priori* revoking of any division between natural and social phenomena. Such distinctions are to be intended only as effects of networked activity, never as its causes (Ritzer 2004).

3.4.3 Black-boxes and Punctualisation

According to ANT, black-boxes can be defined as technical, intrinsically "leaky" (Callon and Latour 1981:286) objects that, due to a variety of durable and consolidated associations amongst their own mix of social and technical agents, appear in normal operational environments as evident and incontrovertible to their observers. It follows that i.e. toasters or mobile phones are technical artefacts/black-boxes that can be considered just as complex as personal computers, solar panels or even space shuttles. All of them, in fact, exist because of their own 'obvious' actor-networks; networks which are so strong that transform objects in 'taken for granted' technologies (Callon 1987, Ritzer 2004, Latour 2005, Cressman 2009).

Punctualisation underlies an analogous notion and refers to the way in which very complex (and precarious) actor-networks get simplified, that is, shaped

through the connection of different black-boxed networks in one larger actor-network. By means of punctualisation, along with the perspective of the observer, a whole network may thus be transformed "into a single point or node in another network" (Callon 1991:153).

3.4.4 Translation, Spokespersons and Obligatory Passage Points

In order to explain what takes place inside a black-box during the process of socio-technical innovation, ANT refers to 'Translation'. According to Callon, translation is the process by which "the identity of actors, the possibility of interaction and the margins of manoeuvre are negotiated and delimited" (1986a:203). It is actually through the actors' negotiations occurring within this process that explicit wills are clashed over, agreements are met, identities are attributed, power relations are recognised, and scenarios are delineated. Translators, or 'spokespersons', play a key role in this. These network builders effectively speak and act in the name of the heterogeneous entities that constitute them. With their 'words', they vitally represent and define a large body of constituents through the expression of their sets of wishes, opinions, interests, expectations, and mechanisms of operation. Yet, spokespersons and their constituents are mutually dependent. On the one hand, translators are indispensable, 'obligatory passage points' for their constituents because, without them, no participation in the network would be possible (their wills would not be negotiated and represented, as they would be located outside the options demarcated for the network). On the other hand, the entire network's stability is dependent on the 'health' of each spokesperson, that is to say, on the satisfaction of their small constituents, whose interests and expectations require an incessant translation to avoid resistance (Callon 1986a, 1986b, Williams-Jones and Graham 2003, Toennesen *et al.* 2006, Ruming 2008). Translation, as presented by Toennesen *et al.* (2006:7), may thus be reassumed and defined as "the means by which actors come to exercise some authority over the elements of which a network is composed".

In this study, the Apulian large-scale PV implementation is seen as a black-boxed process of network translation in which the ability of some conflicting actors to activate other actors and intermediaries secured outcomes closer to the purposes and expectations of their own network's constituents.

3.5 Employing ANT in this Case Study

Since 1980s the concept of Actor-Network Theory has often been considered as much a theory as a method (Ritzer 2004, Toennesen *et al.* 2006). Gad and Jensen has recently pushed the discussion forward by defining it as a "postplural attitude" (2010:70). Whether ANT is principally devoted to the improvement of an ontological vocabulary or to the application of a method is beyond the purpose of this study, as I will substantially limit its employment to what Toennesen *et al.* defines the 'simulating' strategy of translation[17]:

> Simulation refers to the act of representing certain key characteristics of a physical or conceptual system – typically at a smaller scale or within controlled constraints. Thus, studies that embrace ANT primarily as a method and for the sake of its terminology seem to exemplify these aspects of simulation (2006:11-12).

Analytically, by adapting ANT's principles and terminology to this research, I aim to reveal the organisational aspects (and with them, the origin of power) of the actor-networks that underlie the Apulian adoption of large-scale PV technology. As in Harrisson and Laberge (2002) or in Díaz Andrade and Urquhart (2010), in order to comprehend what drives such a network or brings it into being, ANT is employed with the aim to "unpack" (Williams-Jones and Graham 2003:273) the 'PV black-box' and reveal its meanings, its acts of persuasion, map out its heterogeneous connections, and explore its precariousness through processes that may not be visible or entirely explicit from the outside.

Along the way, particular focus will be allocated to the ways in which the Apulian PV actor-network strengthens internally by gaining consistency

[17] Whether ANT is used as 'terminology' or as 'ontology', Toennesen *et al.* identifies four possible translation strategies: "Simulating ANT", "Emulating ANT", "Reasoning ANT", and "Crafting ANT" (2006: 11-22).

(stabilisation), rejecting resistance and preventing proclivity (durability); to the ability of certain actors to interest, recruit, activate and organise, namely, to convert and convince others that the network built around them is worth defending, performing, or expanding (translation); and to their capability of becoming indispensable, obligatory passage points (Callon 1986a, Law and Callon 1992, Ritzer 2004, Latour 2005).

A four-phase translation approach will be employed by deconstructing those processes that, according to Callon (1986a, 1986b, see also Harrisson and Laberge 2002, Toennesen *et al.* 2006), when successfully and constantly carried out, result in network stability:

1. *Problematisation* (problems are presented on the constituents' way).
2. *Interessement* (what they would like to be/become to tackle them).
3. *Enrolment* (how a spokesperson may help them be/become that).
4. *Mobilisation* (constituents grant obedience to the spokesperson and accept the role that is proposed to them).

Due to the possible establishment of new sets of divergent associations or to the emerging of more convincing and competing spokespersons, some of the entities constituting an actor-network may decide to change network, resulting in a mutation, an impairment or even a collapse of the network which they used to support. It is in such cases that a fifth phase occurs:

5. *Betrayal* (constituents abandon their network to grant obedience to a competing or more convincing one).

3.5.1 Agency, Power and Control

Agency is traditionally seen as the capacity of collective or individual (human) actors to act upon situations (Hirsch 2010). Yet, studying a 'situation' through the lens of ANT makes things slightly more complex. Given the *a priori* adoption of a "symmetric fashion" (Díaz Andrade and Urquhart 2010:355),

the ANT researcher is forced to deal with the equal and intrinsic capability of acting owned by both humans and non-humans.

The agency of human actors is a well-recognised feature, although it may become an issue when, for example, mental illness or an extremely different power relation prevents them from performing it. Differently, conferring agency to non-human actors (objects, technologies, texts, unanimated things, etc.) may probably sound controversial to most. Despite that, it is really difficult to deny the role played by such actors in shaping our every day's behaviour (Williams-Jones and Graham 2003). For instance, as pointed by Callon and Law (1995), the human opinion of a telephone usually shifts from being a conventional, value-neutral and passive technology, to becoming a distinctive, value-laden and active one, when it rings. Although one may decide to ignore the call, the telephone would still ignite a decision-making process and eventually a reaction in the mind of a person. In light of this, can we still label the telephone (or i.e. a solar PV panel) as a passive, meaningless technology?

Due to its unique ontology, ANT offers a complex analysis of the concept of agency. Since all phenomena are viewed as the effects of heterogeneous networks, 'enrolment', or else the ability of certain agents to recruit divergent or undecided others, is the fundamental process by which actors constitute networks of other actors in their own will/agency (Ruming 2008, see also Allen 2004). 'Translation' is instead used to describe the ways in which such agency gets recognised and negotiated within a network. It follows that human or non-human agency is never effectively exercised by one single actor, as this is by definition the expression of other actors, too. Hence, actors define one another in networks of heterogeneous connections, through the intermediaries they manage to activate and by all the other agents that they succeed in enrolling and translating for by means of agency (Callon 1991, Ruming 2008). ANT offers a way to illuminate and describe these webs of exchanges. By treating them with the very same tools, it manages to reveal both practices of

adaptation, co-operation and accommodation, as well as forms of conflict within the same networks (Harrisson and Laberge 2002).

Rather than being measured in terms of natural size, strength, hierarchy, possession or coercion, ANT sees power as the "construction of consent" (2002:497), a condition that must be considered as the invisible effect and not the cause of "persuasion" (Ritzer 2004:2). Power is therefore assessed according to the successful strategies adopted by each actor in the act of enrolling and translating for many others, that is, according to the extent, hybridity and durability of each actor's network (Latour 1986, Law 1986).

Power and connectivity are the two sides of the same coin. Power allows some actors to speak on behalf of other actors due to the dynamic interconnections, translated into consent, which take place between them in a specified time (Callon and Latour 1981). As per Cressman (2009:4):

> There is literally nothing else, for ANT, except associations. (…) Power (or lack thereof) and connectivity are intertwined then, to speak of one is to speak of the other. We should not ask if this network is more powerful than another; rather, we should ask if this association is stronger than another one. Any actor-network, then, is the effect, or result, of the connections that constitute it.

For all the reasons described above, control in a network (as in a democracy compared to a dictatorship), even if attempted by its initiator, is inevitably limited. This is essentially due to the circulating nature of power which, spread amongst the actors, is exercised only if these agree with it or choose not to oppose it. Given this view of power and control, networks become definable as inherently dynamic, precarious, and more or less convergent associations of entities and interests.

3.5.2 Local/Global Actor-Network Framework

Following Law and Callon's (1992, see also Papadopoulos 2007) view of space in innovation, I employ here a 'Global/Local' actor-network framework as predominant theoretical approach. Throughout the text, when referring to 'global network', it is intended the set of heterogeneous, independent and

controlled relationships that covers the external sphere of the Apulian large-scale PV development (i.e. the national incentive schemes and laws, etc.). In contrast, the 'local network' concerns the socio-technical associations occurring within the internal sphere of the Apulian large-scale PV development, that is to say, the actor-network that strictly includes merely local or locally-acting agents (i.e. regional political support, regional solar exposure, land owners, local community, etc.). Although the rules set in translation supervise all sort of interactions between the two possible spheres/spaces, in order to delineate the type of relationship that takes place between agents belonging to the two networks (and with that, define anything passing between them), ANT uses the notion of 'intermediary'. The complexity of the intermediary itself is irrelevant to the researcher, as long as it remains constant as it circulates within networks of heterogeneous relationships (Ruming 2008). Callon (1991) distinguishes four primary categories of intermediaries: literary inscriptions (books, newspaper articles, etc.), technical artefacts (machines and other non-human artefacts), human beings (with a focus on their skills and knowledge), and money (intended as a means of exchange).

Having said that, the life-trajectory reflecting the overall Apulian push for large-scale PV innovation is expected to change over time. This is because any technological course is by definition a function of three dynamic and interconnected factors (Law and Callon 1992, Papadopoulos 2007):

1. The ability of a project to involve the support of a global network that provides disparate kinds of resources in prospect of a final return and that, at the same time, 'imposes' on others its agency/view of the project and of the roles to be attributed to other actors;
2. The ability of a project to shape a 'local network' entirely dedicated to the implementation of the project itself, thus to the ultimate production of "a material, economic, cultural or symbolic return to actors lodged in the global network" (Law and Callon 1992:46);

3. The ability of a project to last long by operating as a perfect synchroniser between the two networks.

The combination over time of these three interconnected factors will result in a dynamic trajectory that, if drawn on the two-dimensional Cartesian graph proposed by Law and Callon (1992, see Figure 10 below), may visually help finding patterns for comprehending the current state of the project, future scenarios, and i.e. how the temporary stability of certain dynamics occurred in the past are more important than others in the local establishment of a certain kind of innovation.

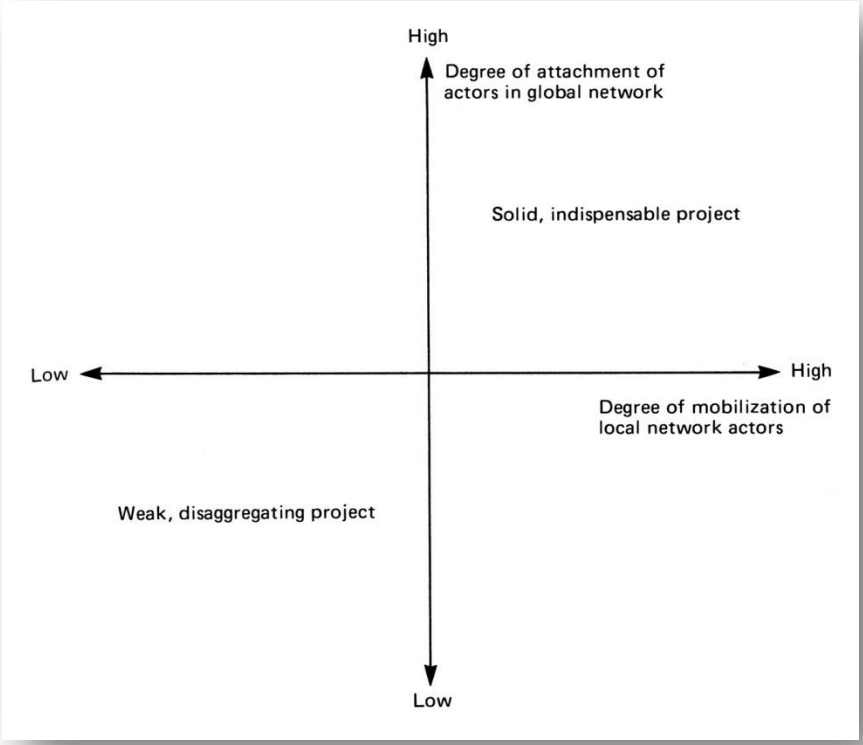


Figure 10: The X-axis embodies the degree of local actors' mobilisation. The Y-axis stands for the degree of involvement of global actors. The historical trajectory describes the solidity over time of the technological innovation represented in the graph (Source: Law and Callon 1992:49).

3.6 Reflections on the Theoretical Framework Adopted

In conclusion, as suggested by Sovacool (2006) and Cressman (2009), to study innovation through the lens of ANT, is to study the agency and the associations between hybrid actors, enrolled within a network of power. If we

assume the size and the strength of this network as its causes and not as its effects, that is to say, if we miss explaining how it is constantly performed and made durable before the power gets distributed and bound to societal perceptions and behaviours, we fail to explain the clockwork of a tiny piece of the socio-technical world we live in.

Summarising and contextualising, by employing the Global/Local framework of ANT into the study of the anomalous spread of large-scale PV technology occurred in Apulia, I seek to recognise the most important complex patterns responsible for such a spread of innovation. In order to get there, meanings, agency, power and control in the actions performed by fluid actors that emerge out of organisational contexts of interaction between a 'global' and a 'local' network will be grasped. Particular attention will be reserved to the process of 'translation', in which hybrid actors are supposed to advance positions, negotiate roles, set rules and finally induce intermediaries to act in their support (and in that of technology development, too). Understanding the dynamics of Apulian PV translation will hopefully help my examination and assessment of the degree of 'mobilisation' (actions taken according to the rules set in translation) and 'convergence' of interests (level of agreement) over time and space of the wide range of organisational phenomena which are expected to constitute the socio-technical local and global actor-networks underlying the innovation project object of this study. In the end, the analysis and discussion of the data produced will result in a visual representation of the life-trajectory of the large-scale PV project. This will immediately help detecting the dynamic degree of solidity and indispensability of the project over time, its current situation and future scenarios, and possibly its need for external intervention.

4. Methods

Inspired by the research guidelines described in Booth *et al.* (2003) and by the overall structure and approach employed in Hirsch (2010) and Iskandarova (2011), in this chapter I will present the methods engaged in the course of data collection, including some ethical reflections on my role as a researcher and on the ways used to gather relevant information.

4.1 Choice of Methods

I have primarily chosen to collect data with qualitative methods (in particular through semi-structured, mainly one-on-one interviews, field notes, and careful observation of public events), but I have also frequently referred to secondary data like document analysis and statistics as an essential part of my study.

As suggested by Amussen and Creswell (1995, cited in Creswell 1998:120), the principle of "maximum variation" should always be employed with a selection of the most diverse cases and actors within the borders of a given area. By employing this principle in Apulia, I have sought to represent a wide and composite web of perspectives and, at the same time, reduce the risk of misinterpretation that may affect case-study researchers who choose to position themselves close to the social constructivist paradigm (Guba and Lincoln 1994, Stake 1994, Lincoln and Guba 2003, Moses and Knutsen 2007).

Shaping a methodological approach and adhering to methods out of a broad collection of theoretical perspectives may be done in a variety of ways. Following the decision to use Global/Local Actor-Network Theory as the predominant framework, I decided to start from its recommendations, adapting them to my case study. With the intention of avoiding hasty, anticipated interpretations about the field, I attempted an early adoption of the main principles of ANT.

By means of practice, these 'suggest' opening fieldwork from the spaces in which usually science and technology come into being: labs, organisations, governmental and funding agencies, meeting rooms, etc. Once there, they 'propose' to follow the agents around as they go about their day-to-day efforts of assembling heterogeneous associations, until identifiable actor-networks are recognised (Hughes 1983, Latour 1987, Law and Callon 1992, Toennesen *et al.* 2006, Cressman 2009). The next step is to primarily give attention to the actors involved in the spread of technology that seem to be able to "modify it, deflect it, betray it, add to it, or appropriate it" (Papadopoulos 2007:9) and, by doing that, track how their actions get to create and appropriate innovation. Subsequently, the local/global vision of ANT proposes to focus on how all the other actors ascribe and construct meanings of innovation in their intentions to achieve particular goals and expectations (*ibid.*). Finally, Law and Callon (1992) suggest to convert our data in a local/global mobilisation graph (see Figure 10), whose trajectory over time may highlight answers to the case study's research questions, as well as show patterns that may perhaps indicate, together with the inherently precariousness of technology, i.e. how the temporary stability of certain dynamics are more important than others in the local establishment of technological innovation.

The first part of the fieldwork consisted of observing seminars and public debates, and of consulting new and old newspaper articles, statistics, documentaries, official reports, laws, and other secondary sources in order to map a historical overview of the players influencing the photovoltaic system under investigation. This served to obtain a first basis of information on their arguments in favour or against the deployment of large PV technology. Then it followed a phase in which my door-openers or "gatekeepers" (Creswell 1998:117) provided me with the necessary keys to select, access and follow in time and space some of the network builders. Through their eyes I sought to introduce myself into fragments of the Apulian large-scale PV 'black-box', with the purpose of exploring the incessant construction of its complex actor-network. As per Latour (1987:4):

> The impossible task of opening the black box is made feasible (if not easy) by moving in time and space until one finds the controversial topic on which scientists and engineers are busy at work. This is the first decision we have to make: our entry into science and technology will be through the back door of science in the making, not through the grandiose entrance of ready made science.

Approaching the field

The fieldwork in Italy was mainly conducted in the period comprised between June and September 2011, though I had started collecting information some months ahead. Due to recovery from a wrist fracture partially treated in Italy, I also had the chance to return to Apulia in March-April 2012, where I was updated about some of the on-going situations concerning my case study. Just a small part of the information used in this thesis derives from that last field visit; most of the data comes from material collected in the course of the year 2011.

When I first entered the Apulian field in June 2011 I had not decided yet where to focus my attention. I knew that I wanted to explore how the extraordinary diffusion of large PV parks happened to occur in Apulia rather than describe its present consequences or its future scenarios for the environment and/or for the local communities. I also wanted to seek explanations in terms of actor-network building, that is, in terms of durable interplay of heterogeneous agents, in a 'black-boxed' context in which the natural and the social are interlocked. Yet, because players who are usually considered to hold power in a traditional, human-based system may not always correspond to the most powerful ones under an ANT framework (where for example non-humans may count as much as humans, or more), on the one hand, it made difficult, at that stage, to be precise on the number, agenda and class of the informants that I was looking for; on the other hand, it helped minimise any anticipation or pre-conceived ideas about the field.

Focusing on and learning more about what triggered the Apulian PV network to take its shape not only seemed to me a central aspect of my study, it also opened an opportunity for working with something that could be of larger use,

such as an effective research-approach to the organisational field of renewable energy.

I noted relevant players, sites and key aspects of the network as I went along with my research. Locating a broad area of interest was not a particularly demanding task though. For every report or statistics consulted in the first half of 2011, and for each relevant article concerning either a case of conflict or one of facilitation of new large PV plants deployment, I used to pinpoint its relative location on a map of Apulia. Very soon it became clear that the hot spot, the one I would give most of my attention to, was not the entire region, but essentially Salento. This is the southernmost part of the county, the so-called 'heel of the boot', namely, the area that embraces the whole administrative district of Lecce and large parts of the districts of Brindisi and Taranto (see Figure 6). In this area of Apulia the concentration of large photovoltaic parks is highest, so it was here that I decided to direct most of my interviews and research efforts. However, because official statistics are always issued including the entire area of Apulia, and because I also undertook several trips outside Salento (in particular to Bari, the capital city of Apulia region, where most of the institutional actors that I interviewed are permanently located and were reached in their own offices), the focus of this case study remained on Apulia as a region delimited by precise boundaries, rather than Salento.

4.2 Data Collection

Choice of respondents

My primary criterion for choice of sample was inspired by the "opportunity to learn" (Stake 1994:244). The selection of respondents was continuously adjusted according to a snowball strategy. In snowball sampling a minor group of relevant contacts is first engaged and is then used to recruit new contacts of interest (Bryman 2008). It is often claimed that this kind of sampling strategy, widely adopted by qualitative researchers, leads to bias because of the

impossibility of reflecting a representative sample of the arena object of study. In my research, I have tried to counter the threat of bias by encouraging all of my connections to suggest relevant actors with as many different perspectives and locations as possible.

When I started the fieldwork my main contacts were essentially two. First of all one of the 315 members of the Senate of the Italian Republic, who helped me gain access to Apulia's political high spheres; then a high manager of Enel Group, a big company that, amongst other things, is devoted to developing and operating renewable sources in Italy. This last contact not only proved itself to be fundamental in providing access to its large net of information and contacts within Apulia, but also acted as a reference in the interpretation of the national legal framework and clarification of technical aspects that concern the Italian renewable energy sector.

As the interviews continued, I inevitably extended my contacts, and with them the complexity of the actor-network that I was studying, until I was able to recognise the other actors that I needed to reach so as to complete my research. In total I carried out 32 interviews: 29 one-on-one interviews, 2 pair interviews, and 1 group interview. Nine interviews were undertaken with state and local government institutions, three with municipal officials, four from academic institutions or experts connected to the photovoltaic field, four from private sector, two from the media, three with representatives from non-governmental organizations, and seven with civil society representatives (peasants, landowners and community members). Apart from the official interviews, I also carried out numerous (and not less important) informal conversations, sometimes with the same respondents, some others with people that I casually happened to meet before or after an official interview.

At large, my sample of informants was a mix of men and women, but with pair and group interviews I only engaged men, whereas just eight of the twenty-nine official, individual interviews were directed to women. Four of

these were state or local government institution representatives, two were community members, one was an exponent from the private sector, and one a journalist. As I come from an area adjacent to Apulia, it did not surprise me to meet a gender disparity within the official interviews. This is not only because Italy seems still to be a country inclined to allocate a majority of men in positions commonly considered to be 'of power and responsibility' (where my interviews were mainly directed), but also because adult women, in particular community members, tended to provide information only if approached through informal conversations (not listed). Without following any preliminary choice, my respondents turned out to be all adults, aged between 32 and 61 years old.

Access to informants and trust

My two initial contacts remained essential gate-openers throughout the entire period of fieldwork. Without their help, I would not have been able to reach all major Apulia's policy makers, experts and private sector representatives. Being 'sponsored by *Qualcuno*' ('Someone') is in fact a widespread practice in Apulia, without which it is very unlikely to reach, within a reasonable period of time and amount of stress, important and trustful information or persons that hold 'power positions' (visible in terms of actions). I experienced such a feeling every time I tried to approach potential informants in formal positions without any 'sponsor'. In contrast, actors from civil society, universities and non-governmental organisations that had not been introduced personally by somebody else proved instead to be informants much easier to engage on my own. This is because in Apulia such actors are not considered to hold as much 'power' as, for example, a politician or a high manager. I always contacted this latter category of actors well in advance by letter or via email, and their replies were generally fast and positive. Later they would usually admit a certain fascination induced by the fact that a young local from a distant, leading academic institution like the University of Oslo, to which I always referred as a researcher and as a master's degree student, would pay attention to their local issues, a situation that in a way made me feel again like

‘sponsored by *Qualcuno*’ or, more precisely in this case, indirectly ‘sponsored by *Qualcosa*’ (‘Something’).

All of the informants were explained about my plan of using their information for my thesis, perhaps for a publication. I also informed them about my desire to explore how actors perceive other actors, so as to find myself in a privileged position to investigating those power relations that may or may not result in the developments undertaken by the regional photovoltaic sector. In addition, they were informed of my intention to speak with several different actors, in order to reach the widest possible assortment of perspectives.

I believe they felt free and safe when expressing their views both as Apulians and as representatives of their own institute or category. This is certainly due to my sponsors’ fame and credibility, which is one of the biggest advantages of using a snowball sampling. The way I safeguarded my respondents by ensuring them confidentiality and, when specifically requested, anonymity throughout the whole process of data collection and in the production of the final work, played also an important role in terms of trust. Furthermore, I believe that a series of other elements helped the establishment of trust. For example, I have used interviews in a scientific publication, in my bachelor’s thesis, in other master’s papers, and in my past as journalist. The experience gained as interviewer highly facilitated my fieldwork. The use of a flexible dressing code, properly adapted to each interview context, and the meticulous preparation for every meeting proved just as important. Last but not least, my fluency in all six Apulian dialects, completely different languages from the official Italian, helped some categories of actors (in particular peasants, landowners and other civil society players) to feel at ease during the interviews. However, despite an undeniable sense of mutual reliance, I noticed that during the interviews some specific categories of actors tended to intentionally oversimplify or just omit some of the elements concerning the PV network that most of the other groups of actors that I had previously interviewed labelled as very important.

Interviewing

In order to facilitate the analysis of the material gathered, I tried to maintain as much as I could the same broad questionnaire structure for each of the categories of actors identified and engaged, yet adapting some of the topics discussed to every respondent's group association, background and context. For example, whereas the first question was usually an open and general one concerning the meaning of photovoltaic as a concept, the next gradually tended to turn into more and more specific and network-related ones. From the regional social, economic and environmental impacts, the strategies used to make a new, large technology acceptable, and the description of any moment of tension amongst the actors, I would go on and ask about the personal advantages or shortcomings induced by the massive development of large-scale photovoltaic technology, the access to confidential information, and the perception of the role played by the other actors.

As my fieldwork proceeded, I continuously rephrased, added or deleted some of the questions from the initial semi-standard questionnaire, which in the end turned out to look very different. By way of practice, I always let my informants choose the location for their interview, which usually happened to correspond with their own office or, in a few cases, a café. Every meeting assumed a peculiar feature though, which required me to remain constantly acute and elastic while listening. Some respondents were very short and formal, almost disappointing at first sight; some much longer and talkative than I expected; at times their answers seemed full, at times poor of 'useful' contents; others instead almost assumed the character of a conversation between friends. I am fully aware that in these latter cases the advantage of having grasped more in depth material is balanced by the fact that I may have altered the information generated, as this could have potentially been the product of the interaction and relation between my thoughts and those of my informants (Fontana and Frey 2000). In any case, though, most of respondents' answers turned out to make full sense only later, during the analysis of the transcriptions.

The reason why I conducted only one group interview is due to an uncomfortable situation that was created by the fact that some of the individuals who participated in that informal meeting I had organized would later confide me to have felt too unsafe in giving me their sensitive information, no matter how similar their positions were. Some others, instead, acted as dominants for the entire interview and did not let the rest of the individuals express liberally. In order to turn around the problems that I encountered, I ended up arranging separate additional meetings for each of the components of that group interview. Such an unpleasant and time-consuming event catalysed my decision to drop the group interviews from the list of methods fitting with my case study.

Observation of public events

What proved very useful were the many debates, press conferences and other public events that I had the fortune to observe. These were generally organised either by academic institutions, municipalities, and policy makers, or by local NGOs. It was by observing such public meetings that I initially had the chance of dividing, following and somehow interlinking different actors, but also of understanding and mapping out their arguments in favour or against the large-scale photovoltaic development. Observational data, compared to interview settings, provided me with the chance of following from a distance live and spontaneous interplays of representatives from different categories of actors. In doing so, they helped me to confirm or reject my knowledge about the field, avoiding risks of influencing my informants.

Recording

Most of the interviews performed were recorded. The same was done with some of the informal conversations. Due to complexity of the actor-network object of my case study and the length of fieldwork, I found it fundamental to keep digital record of the content discussed in each meeting, which I always made sure to have transcribed on paper within twelve hours from the interview. The adoption of such a method helped my work in different ways.

First of all, it allowed me to compare diverse answers to the same type of question in the analysis process of the material gathered, thus to get a quick interpretation of the facts. While talking, the use of a recorder also facilitated my concentration on different contextual aspects like the meeting environment or the informant's reaction to sensitive questions. Lastly, it permitted me to return to my original sources at any time.

I always asked my informants before an interview whether they preferred to be recorded or not, and referred anonymously or with their full name and position. When the actors interviewed approved the use of a recorder, which is in 31 out of 32 circumstances, I would go on informing them about the possibility of turning it off at any point during the interview, a condition that unfailingly happened to occur in 29 out of those 31 cases, and always when the topic of discussion revolved around mafia issues. As they were free to choose, I do not think my recorder changed the content of the information obtained in any case, but it certainly made my respondents very self-conscious when giving sensitive information.

Field notes

Hand-written field notes were not exclusively taken when I was asked to turn my recorder off. Time, location, basic information about the actor group, relation to previous interviews, preliminary findings and anything other than my respondent's voice that I considered to be relevant was also noted down, in a forty-page section dedicated to all sort of considerations. On purpose, I kept this section without any precise order, which made it look apparently meaningless because mixed and always handwritten in one go, but in the end it turned out to be a very important support, especially in the course of the deconstruction of the interviews performed.

Transcription and translation

All thirty-one interviews recorded, in addition to small parts of some informal conversations, were fully transcribed in a direct style and double-checked

later. That is, they were transcribed integrally and, when needed, true to Apulian dialect. In those cases I decided not to stick to the official Italian or English standards in order not to lose the peculiar richness that distinguishes Apulia's local vocabulary. With that, I accepted to adopt a very time-consuming but safe from mistakes process of transcription, which revealed itself necessary in terms of analysis and real meaning of my interviewees' words.

4.3 The Analytical Work

I have constantly reflected on my study. Data collection and analytical work were treated as one stage only, in which any information gathered followed the attempt to gain a preliminary organisation and analysis of it, which in turn determined whether to collect more data, or to move on. The employment of such a method became a crucial reason for having two periods of data collection (June-September 2011 and March-April 2012).

Due to the unique ontological nature of local/global ANT and to its still vague boundaries, I would say that my study was inspired by the use of different ANT perspectives, rather than a pure analytical framework. I started my fieldwork with a broad topic in mind (large-scale photovoltaic development in Apulia) and with very loose research questions. I let data come up first and, only when I was sure of the processes that interested me the most, I realised where to precisely focus my attention on and how to narrow down my initial research questions. I could therefore let the details of the theoretical perspectives chosen come into play to shape a pertinent categorisation of the material collected.

Allowing Apulia's PV projects to 'speak' and uncovering through a 'soft' constructivist approach the complex interaction of similar and opposing interests within the same heterogeneous environment that determine large PV technology to flourish or to fail, became the target of my research. Throughout, a particular focus was reserved for the often invisible orders of

power created by particularly influential network-builders ('spokespersons'). The ability of such agents to persuade and enrol with their values more actors than others, namely, to convince that the development and carrying out of large-scale PV projects was, in turn, positive or negative to their own constituents, captured most of my attentions. In addition, emphasis was also given to the analysis over time of the ways in which various human and non-human actors use and speak about solar technology, and to the diverse arguments employed in favour or against its implementation. Such a focus, applied to space and time, crucially helped the understanding and the tracing of those heterogeneous, socio-technical associations of human and non-human actors that constructed a complex, durable, 'black-boxed' system of exchange, where large-scale PV technology acts as an important medium of different sorts of relationships and interests.

Coding and text analysis

The analytical work usually consists of an organisational phase, where the material is reduced and categorised, and of the analysis itself (Booth *et al.* 2003). In my study, I widely used codes as a resource for simplifying the comprehension of the most important information received, for producing tables and therefore highlighting those common patterns considered to require further research. I applied codes early in the process to all different actors identified, to their support or rejection towards PV development, to their arguments, power relations, benefits gained and losses. Coding was a fundamental tool for getting an overview of the material collected and created the necessary basis for the adoption of my analytical perspectives. As specified above, the inspection was developed during fieldwork and began with literature review on Actor-Network Theory, where I found network analysis (Law and Callon 1992, see also Papadopoulos 2007) to fit with my material. Yet, it was quickly clear that I needed more policy- and power-oriented inputs in support of the global/local interpretation of ANT, which is why I also focused on the general ANT concepts of agency, power and

convergence of interests, as an important step towards the completion of the analytical stage.

Triangulation and quality of my study

As a qualitative researcher, I constantly tried to collect, but also to construct the information that my respondents provided me with (Elliott 2005). Since I acknowledged most of my material in the aftermath of events, in order to avoid the risk of dealing with possible mistakes in their recall from my informants, I used data triangulation throughout the whole fieldwork and after so as to be more confident with my conclusions. This process of cross-verification not only included the use of different sources, spaces, methods and categories of actors, but also implied the return on some of the same interviewees at different time intervals between 2011 and 2012, especially when contradictions occurred. This practice led to a continuous search for further data aimed at cross-examination of results, to a meticulous documentation of my steps and, perhaps as a consequence, to a higher reliability of my study.

4.4 My Role as a Researcher

Strategic contacts, my home academic institution, familiarity with the field, flexibility, preparation, proper dressing code, guarantee of confidentiality and knowledge of the Apulian dialects were features that gave me the necessary credibility in front of the majority of my respondents. Generally, the informants that accepted to be interviewed seemed very keen on contributing to my research and this is proved by the fact that some of them kept a regular contact with me because they were eager to receive news on the findings and on the submission of my research. Yet, it is important to point out that not all of the actors that I had contacted in advance responded to my invitations, as some of those that ensured their availability and already set a fixed and detailed time and location for the interview, turned out to vanish without warning. It happened twice that I had to come back home after nearly four-

hundred kilometres of road, just because my informants did not feel it necessary to notify me of their ‘unexpected’ circumstances and supervening unavailability. It is not a case that these were actors that I had approached ‘without sponsor’. Both of them never ever replied to my following invitations. Sometimes it is very frustrating to realize how difficult fieldwork can be without holding the right keys.

Although I repute complete neutrality as impossible, throughout my preparation for fieldwork, data collection, analysis and writing up, I never felt affected by preconceived ideas and views about the object of my study. The choice of topic, locations and actors was in fact exclusively moved by the curiosity of comprehending the driving forces of what I eventually came up to label as an inherently complex system of robust and heterogeneous association of actors that triggered and continuously sustained Apulia’s massive push for implementation and development of large-scale photovoltaic technology (see paragraph 2.4). Of course, I was also aware of the feasibility of my research in advance, especially in terms of availability of primary contacts and door-openers, logistical support, language issues and knowledge of the field. It is for these genuine reasons and for all my self-reflective efforts that I consider to have avoided risks of bias in the data that I have produced, and to have acted as an overall fair qualitative researcher all along my study (Lincoln and Guba 2003).

4.5 Ethical Considerations

Following Fontana and Frey’s criteria of responsibility (2000), I have always sought to set my informants first, my research next and finally me.

Prior to any interview, I made sure that all of my respondents were well informed of the purpose of my research, and of its rationale and timeframe. An explicit consensus for recording and for referring to their full name and position in my study was always requested. Yet, I reserved to myself the right to bring the issue of anonymity up again later, in the writing-up stage, so as to

choose to what extent covering peoples' identities, regardless of any previous consensus.

Eventually, I decided to omit the names and the origin of my informants and, when possible, of their organisations or institutions, too. Such a choice was not only made unavoidable by the direction undertaken by my research and by the sensitive topics touched in it, but also by the high number of informants that chose to be referred anonymously. These were generally afraid that I would involuntarily report their own interests, views or considerations around and, with that, threaten their safety and that of their relatives; but also to lose their own self-respect ('*dignità*'), or their job.

Protecting my informants from uncomfortable situations was a primary but not unique reason for adopting a politically neutral and anonymous approach in the end. I, my contacts and my family, just like my respondents, have also a role in the Apulian society, and this was an additional reason that imposed me to be careful and self-reflective while carrying on my project, from the selection of topic and informants to the evaluation of my interviewees' agenda and final writing up (Lincoln and Guba 2003).

4.6 Interview Code and Actor Groups

In this final section I introduce the relevant human-based actor groups of the Apulian large-scale photovoltaic network which have been either interviewed or accessed through secondary data.

The information gathered has been coded according to the system shown in the table in Appendix 3, which guarantees full anonymity to the interviewees. Each of the informants has been conferred an 'R' (which stands for 'Respondent'), and a serial number that relates to its own actor group, rather than its chronological order. The codes arisen find correspondence mainly in the text of chapters five and six of this study. The system provided in Appendix 3 also takes into account the interview group and the sex of each

informant, the date (month and year only), place and category of the interview, and lastly whether or not an interview has been recorded. Non-human groups of actors considered in this thesis (i.e. solar modules, financial incentives, relevant laws, climate, etc.) deliberately do not appear in the following list:

The Ministry of Economic Development (MSE) is responsible, amongst other things, for framing and managing the guidelines of national energy policy, including the incentives to the development of renewable sources (a task that was formerly assigned to the Ministry of the Environment). MSE also coordinates all activities within the energy and mining sector of Italy.

The National Antimafia Commission (DNA) consists of a national Antimafia director and of twenty public prosecutor's assistants spread all around Italy, so as to facilitate identification and coordination of new areas of investigation. Amongst its sectors of interest, DNA pays particular attention to what it is ironically defined as 'eco-mafia', namely that branch of organised crime devoted to money-laundering huge amounts of capital into the green (thus 'eco-' and beyond suspicion) sector of renewable energy.

The National Operator for Renewable Energy (GSE) is a company owned by MSE. Its mission consists in adopting environmental sustainability through promotion and development of renewable energy sources in Italy. Its wide net of activities includes: support and verification of electricity generation in almost all of the Italian power plants fuelled by renewable sources, recognition of economic incentives to producers in accordance with the applicable legislation issued by MSE, purchase of electricity generated from renewable-energy plants and resale in the market, support and training to public institutes, business operators and citizens by providing services and technical advice for the implementation of energy policies, reliable statistics on the energy sector in Italy, and information activities aimed at spreading the renewable-energy industry and the awareness of sustainable energy.

The Region of Apulia (REP) is, from 2010 on, responsible for approving the final authorisation (AU) for the implementation of large-scale photovoltaic projects in rural areas of Apulia. The technical authority of REP appointed for approving or denying these applications is the Regional Authority for Energy and Grids (ERSAP, '*Ufficio Energia e Reti Energetiche*'). Its final decision is the formal result of an agreement reached amongst all competent public administrations, institutions and agencies that convene together in an official meeting ('*conferenza di servizi*') to express advices and views on each specific case. Amongst the organisations that take part into these official consultations there are also representatives from different public arenas (i.e. the Regional Agency for the Protection of the Environment (ARPA), **Municipalities (MUN)**, and the administrative **Districts (PROV)** in which the construction of PV plants are planned).

Private Sector (COMP) companies are businesses responsible at various levels of generating, transmitting, and distributing energy (or energy-related services) from large-scale PV modules.

Academics and Experts (EXP*)* from Apulia's two main academic institutions (University of Salento and University of Bari) were interviewed.

Mass Media (MM) were not only an important source in the approach-stage of the field. Articles and documentaries from national and local media were in fact consulted and analysed before, during, and after fieldwork. Journalists from different local media were reached at different times during my study.

NGOs (NGO) were also consulted to understand whose voice and interest these local or national organisations represented in the network that revolved around the development of large solar PV technology in Apulia.

Civil Society (CS) actors were engaged through reference to a number of citizens, landowners, farmers and other people who either represented themselves, or were representatives of associations formed in support or in

rejection of the local PV development. Interviews with these people and observation of public hearings and **Conferences (CON)** in several communities of Apulia were some of the methods used to comprehend their points of view.

4.7 Additional Observations

Primarily due to space limitations, there is a number of information, data and facts connected with the development of PV power in Apulia that I have decided not to present here. The hope is to make use of such material later on, in the course of my career.

The text/visual analysis and discussion of the findings of this study will be presented over the next two chapters. In chapter five, after a brief introduction, I will describe Apulia's PV four-stage itinerary of ANT translation (Callon 1986a, 1986b). This will be presented through the arguments, negotiations and strategy efforts of the selected heterogeneous actors involved in the process. In the course of the text, I will use several quotations from my informants, in an attempt to let various forms of agency emerge and, by doing so, help highlighting the initial common aim (for different reasons) at performing participation, network stability, 'black boxing' and therefore spread of large-scale PV innovation. Yet, competing arguments, resistance and betrayal will eventually come to the fore, too. Just like an earthquake, they will test the stability, cohesion and durability of the Apulian PV actor-network, and will call for the fastening of its remaining constituents for survival.

In chapter six, the focus will be exclusively oriented towards the visual discussion of the peculiar organisational forms assumed by the large-scale Apulian PV actor-network in the period investigated. Here, alliances and negotiations amongst the heterogeneous players that sustained innovation will be explored in terms of power and convergence of interests, at last resulting in a dynamic visual trajectory on a 'Global/Local' mobilisation graph.

5. Describing the Process of Translation: Analysis of the Findings

Different social groups may attribute different meanings to the same technological innovation (Iskandarova 2011). To explore the Apulian large-scale PV development as a 'black box', it is therefore essential to understand what 'photovoltaic technology' means to some of the various constituents of the Apulian society. For instance, is it just "a set of grid-connected physical objects: solar modules, inverters, meters, and transformers" (R32), that is, something merely intended in its broad operational sense (R12, R18, R30, R34), or is it a symbolic term that immediately reminds us of ideas as diverse as the "production of knowledge into scientific labs" (R13) and "university departments" (R14), or the prospect of a "more sustainable and prosper future" (R5)? Is it an incredible economic opportunity (R3, R20, R22, R26) or just "pure speculation" (R1)? Is it Apulia's "most practicable alternative energy source" (R16) or only "a psychological pressure" (R6)?

Taking into account the dissimilar meanings and priorities attributed to the PV innovation by national and local public bodies, academic institutions and experts, banks and other funding bodies, NGOs, mass media, landowners, constructors, distributors, private businesses, farmers, final users, and all the other groups expected to have a direct or indirect interest in the spread of large-scale PV technology within Apulia's boundaries, was not enough for the analysis of this study. The application of ANT's central principles to the case, made it impossible to ignore or simply consider only as a context, alongside all the people and human-based organisations mentioned above, actors such as the climate and solar exposure, the extent of flat areas and infrastructures, the EU legal framework, the solar modules, the evolution of the national incentive rates, the regional regulations, the capital, the local mafia, the black market, the power grid, and the concepts of 'green future' and 'teamwork'.

Just like in Harrisson and Laberge (2002), innovation in this case study is mainly achieved and performed through the construction of consent rather than through oppression and intimidation. This means that the spread of large-scale PV technology in Apulia largely relied (and it still relies) on arguments that employed persuasive methods. Yet, the set of data collected throughout fieldwork also highlighted sporadic cases in which some actors more than others proved to have a tendency to use coercive methods to ensure the establishment and the continuous performance of PV innovation. In the following sections, a four-stage itinerary of actor-network translation (Callon 1986a, 1986b. See Figure 11 below) will be described in its making, that is to say, in its continuous aim at performing participation, network stability, PV 'black-boxing' and, lastly, spread of large-scale PV technology. This itinerary will include a selection of the identified different, and sometimes contradictory, arguments, negotiations, strategy efforts and hybrid actors involved. As suggested by ANT theorists, the description of the process of translation will start from the voice, over space and time, of its own network initiator: in this case, Region of Apulia (referred as 'REP' throughout the text).

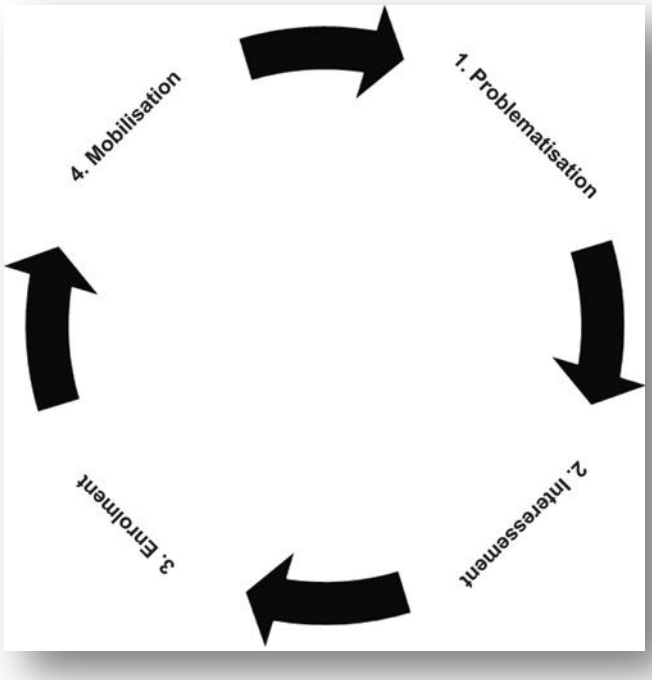


Figure 11: If successfully carried out in all of its stages, the never-ending process of translation brings to never-ending network stability (Source: adopted from Díaz Andrade and Urquhart 2010:360, cited in Callon 1986a).

5.1 Problematisation

'Problematisation' is the first stage of translation. For the initiator of an actor-network, it consists of framing a problem and suggesting its solutions, with the ultimate goal of grabbing the attention and the consent of as many interested actors as possible (Callon 1986a, Harrisson and Laberge 2002).

The effort of creating a heterogeneous actor-network around PV technology, thus of inducing a process of translation around such innovation, was primarily initiated during the speeches for the 2005 elections of the Apulian government. More precisely, it started when Nichi Vendola, who would soon be elected President of Apulia, was busy with his "impossible left-wing campaign" (R7) for the upcoming regional polls. Vendola approached the Apulian community (intended in its hybrid sense) with a series of "exciting" (R31) public meetings in which, amongst his major arguments, he stated the importance of implementing the sustainable proposals contained in his programme. In particular, his dominant idea was to provide for the spread of photovoltaic technology so as to contribute to improving the living standards of the locals. The candidate president spoke to crowds with reference to the economic and environmental benefits, to the international visibility (with obvious indirect returns in terms of employment and tourism), and to the general prosperity that a regional policy conspicuously oriented towards the development of renewable energy sources would bring to the whole area and to its inhabitants (R2, R21, R26, R31).

Against all odds and against the renowned right-oriented local political trend in the national polls (already shown by Apulian voters in 2001, and later also in 2006 and 2008), Vendola won the 2005 regional elections as leader of an extreme left-wing coalition, representing the Communist Refoundation Party. Likewise, he was re-elected President of Apulia for a second-consecutive term in March 2010, this time as leader of his own socialist party: 'Left Ecology Freedom' (SEL). As Vendola reminded himself during a public speech given in the course of his political campaign for the 2010 regional elections:

> The south is hot, there is sun here! The reason why people from the north of the world deal more than us with business, trade and money is only because when they leave their own offices and look at the sky they become sad. In Apulia, we are a bit different. For example, let us take this Christmas time. Walking Bari's seafront is a pleasure: every day we can admire a spectacular sky and feel the warmth of the sun as if it were spring. Yes, because the south is hot, there is sun here! It is by walking our region in 2005 that we thought: 'Instead of importing the energy from the north (which comes from ashes and fossil fuels, which brings poisons into the lungs of our children, which pollutes and besieges our health), why do not we produce our own energy with the things that God provided us with? God gave us sun and wind and with them we may build a new economy focused on the development of renewable energy'. Ladies and gentlemen, today we are proud to announce that Apulia is officially leading the Italian ranking for production of energy from renewable sources!
>
> (Source: extracted from Nichi Vendola's public speech. Bari, December 2009)

Detecting the problematisation stage in this case study means moving back in time, in search of the first series of acts of persuasion 'in the making' concerning the development of PV energy in Apulia. In this respect, the sustainable arguments employed in Nichi Vendola's 2005 electoral speeches and programme can be considered the first actions conceived and taken with the specific purpose of convincing a large negotiation arena constituted by hybrid actors, bounded or unbounded by the Apulian territorial borders, about the benefits of actualising a prominent renewable PV programme. Apulian citizens of all classes and professions, together with their organisations, were involved in this negotiation arena as much as the climate, the regional orography, the environment, the national legal framework and many other material and non-material actors.

In 2005 Vendola, initiator of the PV network, asked for attention, justification and consent to the Apulian community through the formulation of a problem that was intended to touch upon several of its constituents, if not upon all of them:

> *«How can we provide a sustainable kick to our regional economy? Can we modernise and lift it up in a short time by relying only on our own resources and, simultaneously, guarantee the respect of our health and of our unique diversity of ecosystems, landscapes and cultural heritages?».*

The initiator completed the problematisation stage by responding himself to the problem that he had risen before. The suggestion of a solution tells:

> *«Vote for me and for my party! In your representation, we will introduce innovation in Apulia and make it become the world's 'Eldorado' of solar photovoltaic technology. We will produce and sell green energy, create new jobs, attract investments from every corner of the globe, take advantage of the generous incentives provided by the Italian government, spread well-being and, at the same time, preserve our health, our cultural roots and our beautiful and diverse environment».*

Nichi Vendola, by acknowledging a problem and proposing its solution, created the conditions for a common, heterogeneous platform to materialise around consensus rather than imposition. Bound by different arguments and benefits promised by the realisation of the PV project on a massive scale, it became natural for those actors that considered their association with the initiator as advantageous to support him, actively participate in his initiatives, and form complex webs of alliances with fellow supporters.

With 1,165,536 votes in favour, the 2005 regional elections pronounced Vendola as new Governor of the Region of Apulia (Repubblica 2005). In the light of ANT though, that was also the moment in which he became the 'spokesperson' of a much higher number of hybrid actors, anchored by various interests to the very same energy strategy. A journalist (R21) declared:

> The avant-garde emphasis on PV development was one of the most creative, convincing and determinant moves of his 2005 electoral programme. For a reason or another, it made crowds dream and hope for a better future, independently from the political orientation of the singles. Vendola's energy programme represented the novelty for Apulia and for Apulians. Without any doubt, it proved to be a main driver for his election to the Office of the President.

5.2 Interessement

'Interessement' in translation highlights the reasons that push sets of actors to revolve around a spokesperson. By definition, these are kept together by the fact that the interests and the expectations defined by the initiator of a network are in line with theirs (Callon 1986a, Harrisson and Laberge 2002, Díaz Andrade and Urquhart 2010).

The new government of Apulia (REP), in order to actuate its PV strategy, worked hard throughout the first months of administration to provide the region with three distinctive legal tools. According to REP intentions, these acts were meant to trigger its strategies for a double aim: on the one hand, the achievement of a fast local renewable-energy sector development; on the other hand, these acts would help capture the interests and expectations of as many actors as possible, so as to align, enlarge and strengthen the number of mutual connections and, by doing so, empower the overall PV network. The description of these three regional legislative tools will follow as an essential part of the 'interessement stage' of the Apulian PV project.

PEAR (2007)

It took nearly two years for REP to write, negotiate and approve the first Regional Environmental Energy Plan ever ratified in Italy ('*Piano Energetico Ambientale Regionale*', referred to here as 'PEAR') (RES 2007/827/REP). This document, an expression of the agreement around the "hot spots" (R2) of the immediate future regional energy policy, was reached by REP, local public bodies, private businesses, research institutes and NGOs. Its four hundred and seventy-one pages strongly recalled the need for energy sources differentiation and presented a particular emphasis on the importance of implementing renewables, thus revealing its unhidden inspiration to the Kyoto commitments (R2). PEAR contained a set of indications which dealt with a ten-year planning on as diverse regional energy issues as nuclear, hydrogen and fossil fuels, CO_2 emissions, and renewable sources (in particular biomass, wind and solar PV power). Due to its propensity for future green-energy scheduling and to its exclusivity in the Italian panorama, the successful negotiation of PEAR was considered by the entire regional public opinion as a great collective achievement for Apulia (R8, R17, R22, R24, R28).

'RL 1/08' and 'RL 31/08' (2008)

The endorsement of PEAR was an act that facilitated REP's popularity in the local and national energy arena, but the two laws that would completely

revolutionise Apulia's photovoltaic network and provide its entire sector with a propelling impulse were yet to be approved. In this respect, the passing of Regional Laws No. 1 of 19 February 2008 ('RL 1/08') and No. 31 of 21 October 2008 ('RL 31/08') must be considered as the most central measures undertaken by REP.

'RL 1/08' (with reference to its Art. 27) and 'RL 31/08' introduced significant administrative and bureaucratic simplifications for the implementation of renewable energy projects in Apulia. By means of these laws, photovoltaic plants with a nominal power of up to 1 MW_p could now be authorised through a simplified, municipal, 'start-of-works' declaration (DIA, '*Dichiarazione di Inizio Attività*'), instead of a long, selective, expensive, and regional '*Autorizzazione Unica*' (AU). DIA is an easy process that simply consists of communicating the beginning of works to the municipal authority. It is a silence procedure, that is, the authorisation is formally given to the applicant even in case of silence from the authority for a period of time longer than thirty days from the application.

The change for the Apulian PV sector was relevant. Before the introduction of these laws, a DIA procedure was granted only to PV projects with a nominal power lower than 20 kW_p, as established by Legislative Decree No. 387 of the 29 December 2003 (see chapter 2). By changing the limit from 20 to 1,000 kW_p (+ 5,000 %), Apulia became "the only place in the world" (R1) in which large-scale, ground-mounted PV plants up to 1 MW_p, could be implemented with a simple and fast municipal DIA.

Amongst the other things, 'RL 31/08' also raised the limit for mega-PV projects, namely, those plants designed with a nominal power higher than 1 MW_p. For them, there was no longer need to obtain also an Environmental Impact Evaluation ('*Valutazione di Impatto Ambientale*', VIA), which is a scientific preliminary report that was kept as a fundamental prerequisite only for the projects exceeding an output of 10 MW_p.

A legislative vacuum

Apulia's PEAR, 'RL 1/08' and 'RL 31/08' were regional acts ratified in a context dominated by a general legislative vacuum. As observable in the analysis of the national legal framework described in the last section of chapter two, these acts were approved in a time of absolute absence of any sort of binding national and/or regional target for the limitation of energy efficiency, generation and consumption from renewable sources. The only laws already in force concerned stimulating incentive measures given on the production from renewable sources (*Conto Energia I* and *II*). As the photovoltaic option was still not a widely-used technology in Italy, no limitations to generation or size of the plants had been set yet. Similarly, no VIA was ordained by the national law ('*Testo Unico per l'Ambiente*') for the implementation of large-scale or mega-PV projects. The same goes for the general, domestic renewable aims: a 'National Action Plan' (PAN), resulting from the acknowledgement of Communitarian directives, entered into force just in 2010, whereas the following 'Burden Sharing' law, which applied to regions, was enforced only in 2012.

The national legal vacuum that surrounded Apulia during the period of enforcement of PEAR (from June 2007), 'RL 1/08' (February 2008 – March 2010) and 'RL 31/08' (October 2008 – March 2010), forced REP to make its own rules at home. As these laws ended up working as three arbiters that set the conditions for participating in the network and defined the positions of its members, they implicitly became the indispensable, 'obligatory passage points' of the Apulian PV actor-network (Callon 1986a, Díaz Andrade and Urquhart 2010). A community member (R28) confided:

> [The three laws], in a period of deep economic crisis, opened new promising doors for all categories of Apulian society... Perhaps from this situation some groups took more advantage than others, mostly depending on their far-sightedness, accessibility to flat and well-positioned lands, availability of capital and involvement in the right networks... but definitely all of us, either in terms of safe and long-term profits or in terms of job security, had the chance to eat from the same attractive pie and grasp something out of it.

In line with the then-current national policy (exclusively oriented to stimulation of renewable production), the Apulian period of 'legislative freedom' was initially used by Vendola's government for negotiating and ratifying laws in favour of a 'free' development of the photovoltaic sector, that is to say, irrespective of the ways in which such a technology would locally be deployed (small- or large-scale, roof-by-roof or ground-mounted, etc.). In this opening period, the logic of the gain suggested to all PV investors of Apulia an equation between nominal size and profits. As a consequence, all of them turned an interest in developing ground-mounted PV technology. By doing so, they could be assured exceptional administrative and bureaucratic conditions confined to the borders of Apulia and, at the same time, a free access to the generous Feed-in Tariffs provided by the national government in all regions of Italy, regardless of the sometimes different legal frameworks locally in place[18]. In this respect, the administrator of a local public body and citizen of Apulia (R4) recalled:

> Back in 2008-2009, right after the enforcement of those Regional Laws ['RL 01/08' and 'RL 31/08'], there has been a long moment in which the expansion of the market around large-scale PV and the potential returns connected thereto had become so important, but so important that it was just un-thinkable for all of us administrators not to push forward in the same direction and not to accept that 'golden' technology as our new every-day neighbour!

Since the interests and goals of the spokesperson perfectly coincided with those of its constituents, a mechanism of interessement led by REP around the pursuit of profits and job security could be successfully performed for the first time, resulting in creation of widespread support around the PV innovation, hence in optimal conditions for establishment of network stability. The road to completion of translation could therefore go on through the next crucial stage.

[18] Calabria and Tuscany had also developed special regional laws for filling the same national legal vacuum. Yet, in these regions of Italy the development of photovoltaic technology did not take the large-scale feature of Apulia.

5.3 Enrolment

In an effort to shape a solid, resistant and well-organised actor-network, the stage of ‘enrolment’ consists for the initiator of an innovation network of distributing and transmitting active roles to its heterogeneous constituents, and of coordinating them to ensure that these get performed in an effective way (Callon 1986a, Díaz Andrade and Urquhart 2010).

The Apulian PV-network, yet to be enrolled, was primarily composed of a ‘messy’ mixture of human, non-human and conceptual actors that were united by two major elements: a common interest in the implementation of PV technology and a sort of ‘contract’ that authorised REP to speak for them. Accordingly, a number of national and local public bodies, academic institutions and experts, banks and other funding organisations, NGOs, mass media, landowners, constructors, distributors, private businesses, farmers and final users got to share the same socio-technical arena with actors such as the climate and solar exposure, the extent of flat areas, solar modules, the EU directives, the evolution of national incentive rates, the regional regulations, capital, local mafia, black market, power grid, and the concepts of ‘green future’ and ‘teamwork’. REP’s duty was to provide organisation and stability within the fleeting boundaries of such a hybrid and confused arena. It is in this context that the distribution of roles and responsibilities that took place alongside PV technology in Apulia should be considered.

In order to “prepare the field” (R15) for the spread of PV innovation and, at the same time, in an attempt to create the necessary teamwork conditions for an easier coordination that would ultimately provide jobs and profits within the components of the network, REP identified (but did not assign as it left constituents free to choose) three different key roles, as represented in the three-circle Venn diagram proposed in Figure 12 below:

1. Anticipated start of the bureaucratic and technical processes of application for installation of new PV power stations (request of connection to the power grid, application for Feed-in-Tariffs, etc.).
2. Selection of appropriate building lands and employees.
3. Extensive attribution of green and positive meanings to the PV technology.

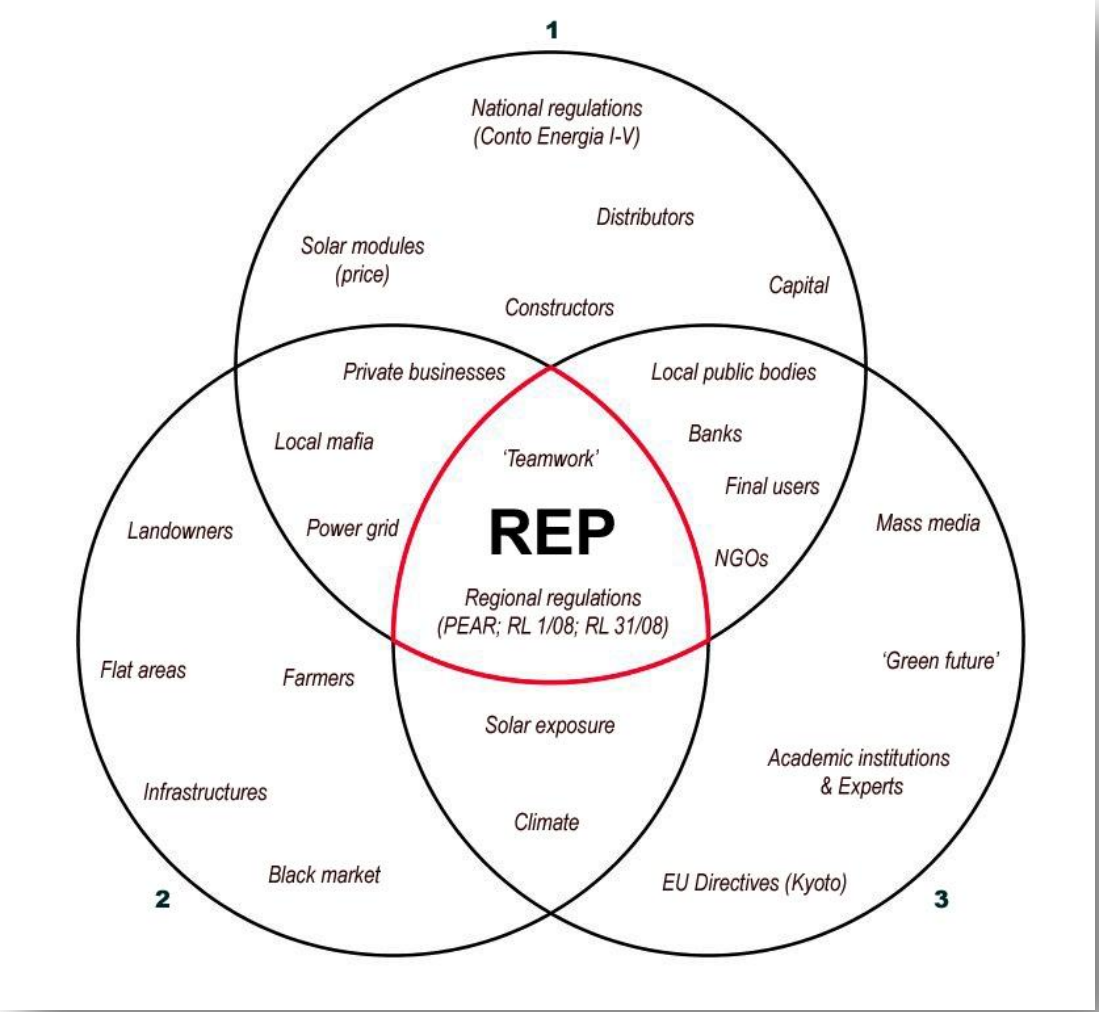


Figure 12: Three-circle Venn diagram representing the *Enrolment* stage of translation of the Apulian PV actor-network. Three role-areas were identified and assigned by the initiator Region of Apulia (REP) to its constituent agents. REP, due to consensual recognition of a central, spokesperson position, kept supervision and coordination over all of them (Source: produced by the author).

As REP limited itself to enlist and recruit for roles that were spontaneously taken and played by its constituents according to their characteristics, enrolment in this case study can be said to have taken the extreme initial form of pervasive devotion and natural "commitment" (Harrisson and Laberge

2002:503). The almost total absence of negotiations around REP's call for support, the following manifestation of obedience around its regulations, its proposal of abandonment of old habits and embrace of a new ethic in exchange for a promise of jobs, easy profits and a better future, are all elements that demonstrate the level of attachment and belief in the capability of the PV-innovation project of translating desires and expectations of a multitude of heterogeneous actors.

As noted by Harrisson and Laberge (2002), the stage of enrolment of technology is a significant aspect for at least two reasons. Firstly, because it is not the result of random combination of factors, but it is preconceived on purpose to take place in a certain phase of an unrepeatable chain of events. In so doing, technology expresses its entire agency and establishes, by means of a spokesperson (REP), the elements of the innovation process (the three role-areas mentioned above) that must be secured through the continuous performance of actions played by a number of consenting actors. Secondly, enrolment is significant because throughout it, technology "speaks for itself" (2002:506) and finally shows its own identity through the acts of a spokesperson that first idealises what could be accomplished (interessement), and then distributes roles amongst its constituents to get there, but always in the name of technology (dispenser of indirect agency).

Consistent with Figure 12 above, at this stage of translation, contact, dynamic exchange of agency, association and overlaps between human and non-human actors started to become obvious features of the new-born network. This state was reflected in most of my respondents which, in turn, granted agency either to PV, or to themselves, or to both of them. For instance, whereas an exponent of REP (R33) declared:

> When we decided to implement PV in Apulia it was not only about dealing with a promising technology in terms of potential for technical improvements and savings of GHG emissions; it was, first and foremost, our biggest hope for a better future… PV is a means for projecting areas like Apulia into the future. Our early adoption puts us

> (and our next generations, too) in the condition of reaching that future before any other region of Italy, and enjoy its fruits.

A local journalist (R22) consciously advocated mutual agency:

> There is a love-hate relationship between us [local journalists] and the photovoltaic technology. I think we both gave and received a lot from it… On the one hand, the more we write about PV, the more it seems to spread. On the other hand, personally speaking, the more I write about PV, the more I sell… PV's 'boom' made me and my magazine very popular.

According to Díaz Andrade and Urquhart, the continuous switch of agency between heterogeneous actors belonging to the same actor-network, referred as the "indeterminacy of the actant" (2010:363), is a typical feature of ANT analyses. Because of it, agency can be attributed to both 'enrolling' agents and, given their allowance, to 'enrolled' actors, too. These last ones, although formally incapable of directly taking initiative (i.e. technology), are able to indirectly influence other actors.

After having effectively performed the stage of enrolment, the Apulian PV network was now finally ready to move on. Only one last stage remained to be achieved with success before the entire network could be a candidate for 'black-boxing'.

5.4 Mobilisation

'Mobilisation' is the last stage of translation. At this point, the allied agents employ intermediaries so as to act according to the orders transferred by their initiator. If 'black-boxing' of innovation does not occur in this phase, that is to say, if technology does not become irreversible, it is very likely that "the network begins to fall apart" (Harrisson and Laberge 2002:503).

Mobilisation in this study is described, as far as possible, through my informants' direct voice and true to the division in role-areas identified by REP during the stage of enrolment (represented above in Figure 12).

Role-area #1

Role-area number one, concerning the push for an anticipated start of the bureaucratic and technical processes of application for installation of new PV stations, included several actors. All of them were either activated by money, here intended as a means of exchange, or somehow promoting it. The national and regional legal frameworks (*Conto Energia I-V*, PEAR, 'RL 1/08' and 'RL 31/08', respectively), local public bodies, capital, private businesses, constructors, distributors, final users, banks, NGOs, mafia, the power grid, the price of solar modules, and finally the idea of 'teamwork' spread by REP were all part of this role-area.

Minutely described in previous sections of this dissertation, the national and regional legal frameworks played a key role in creating the conditions for the other actors of the first role-group to perform the tasks proposed by their initiator REP. On the one hand, the Italian Government adopted a series of decreasing, "but not too fast" (R9), Feed-in Tariffs. These were expressly set as "the highest in the world and without any constrain" (R1), so as to help Italy meet as soon as possible its share of the '20-20-20 targets' ratified in Kyoto by EU (R25, R35). On the other hand, the Region of Apulia, through two consecutive Regional Laws, made it possible for photovoltaic plants with a nominal power of up to 1 MW_p to be authorised with a simple 'start-of-works' declaration (the so-called DIA), as if they were small-scale plants installed on a rooftop. In addition, with another Regional Law, REP simplified also the procedures for authorisation of PV plants up to 10 MW_p. As confirmed by R1:

> Basically, the combination of the legal frameworks produced by the National and the Apulian Governments were the ingredients that facilitated the initiatives taken for the proposal of PV plants in Apulia, in particular in their large-scale form... More permissive mechanisms of DIA and VIA determined a worldwide spread of the conceptual equation between large-scale Apulian PV and enormous profits.

Such a desirable context made it easier for the other actors of the same role-group to perform their tasks.

Most of my informants highlighted the surprising fact that to every new PV project application corresponded the establishment of a new corporate body, which unfailingly happened to take the legal form of a 'limited liability company' ('*Società a Responsabilità Limitata*', SRL). According to the Italian legislation, in order to officially form an SRL, it is necessary to pay only a share capital equal to € 10,000. In case of debts or default, that sum is the only capital which can be compulsively taken out of the company's assets. By means of SRL, groups formed by local and national agents, sometimes co-financed by famous NGOs too, provided support to enormous investments that, as we shall see, involved millions of Euro (R21, R23, R24, R25, R26).

Large banks from all over the world, especially from China (R19, R21), rapidly "sniffed the deal" (R18) and, thanks to their access to fresh capital, arrived in the countryside of Apulia to support large PV projects, initiated by SRL and concocted through processes of project financing. An investigative journalist (R21) reported the complex, standard financing route of such projects as it follows:

> The bank usually finances 80% of the costs of a project, whereas the remaining 20% is paid by the SRL through an investment fund. In turn, investment funds gather capital from ordinary savers backed to management companies that are based in Luxembourg, Switzerland, Cyprus, or in some other inaccessible tax havens.

As a PV plan obtained its registration number, ordered by GSE in a chronological ministerial list of pending projects, it automatically became a safe candidate for authorisation, "acquiring a value that often reached millions of Euro" (R22). As a way of practice, such pending projects were either immediately sold by SRL to big holdings which, in doing so, avoided the complex and nebulous bureaucratic process happening at the local level (see also role-area #2 below), or used, again by SRL, to negotiate and establish new businesses with other actors for the material implementation of PV parks and for the consequent long-term enjoyment of their relative profit shares (R21).

Yet, banks, capital, laws and local businesses were not the only actors taking part into role-area n.1. Local public bodies performed an important task, too. Most of the municipalities in which PV projects were designed to be implemented, stipulated "compensatory-economic-infrastructural agreements" (R1) with the companies that applied for them, in exchange for fast and positive DIA authorisations. A municipal official (R12) declared:

> Those who had an interest in large-scale PV projects to be implemented here [Apulia] provided municipalities with new kindergartens, streets, sport facilities and other kind of services and infrastructures. In some cases, local public bodies were directly paid a share of the profits, despite the fact that this was not required by law... Can you imagine what could all this mean for little municipalities with a devastated budget?

The prospect of a flow of tens or even hundreds of thousands of Euro per year, or the provision of services that otherwise would never have been given to citizens, confirmed that permissive Apulian municipalities were just as involved as the agents mentioned above in the actor-network that pushed for large-scale PV development.

"The hunt for profits touched upon every component of the Apulian society, in particular upon those who could invest capital" (R23). In this regard, R1 said:

> I heard about some people with a large availability of capital that, rather than trying to earn a few percentage points into the stock market, invested it into the Apulian large-scale photovoltaic sector. Here, the guaranteed return reached peaks of 18% per annum. Not even the best Wall Street operator could guarantee such an average and free-of-risks big return for twenty consecutive years!

In this context and in a perspective of decreasing FiT, in order to maximise profits, it is not a case that "almost the totality of large investors in late 2008, in 2009 and in the initial part of the year 2010, forwarded to the Apulian authorities 'copy/paste' applications for different 999 kW_p PV parks" (R20).

Large-scale stations up to 1 MW_p were prioritised by investors simply because they could be authorised with a municipal DIA and because, at the same time, they guaranteed substantial economic returns. The legal mechanism in force also provided a window for a "semi-legal" (R1), but not less widely-utilised,

possibility for splitting mega-PV plants in many 999 kW_p parks adjacent with one another, formally registered to different corporate bodies, but mostly related to the same firms or subjects. In this way, the red tape could be avoided, PV plants exceeding 1 MW_p could be subject to several, easy DIA authorisations, their payback minimised, and profits immensely maximised (R3, R10, R11, R16).

R15 calculated that, with the average FiT provided in the course of 2009/2010, and with the price paid for the electricity produced and expected to have flown into the national grid, the corporate bodies that had installed a 1 MW_p ground-mounted PV plant in Apulia, managed to earn an overall "net-of-expenses sum of € 9,470,000 in twenty years". Such enormous sums attracted another actor, too. "In Apulia everybody knows that wherever there is business, there is mafia, too" (R22). The respected journalist who confided this to me would subsequently add:

> Two years ago I wrote a long inquiry article on the relationship between '*Sacra Corona Unita*' [the local mafia] and the Apulian renewable energy arena... I have tried it on my own skin what it means to deal with these powerful, arrogant and unscrupulous people... I have received several forms of threats and intimidating phone calls from them and I would better stop here or else I will put you in the very same situation of mine... Whoever works as an investigative journalist in Salento knows from the beginning what to expect when dealing with such topics.

Since role-area n.1 was all about authorising legal bodies to implement PV plants and not about awarding to them contracts for the same purpose, the mechanisms of capital tracking and control provided by the Italian Law could not be actuated by REP, at least not at this stage (R1, R3, R9). Although no one could still demonstrate it, the fact that the National Antimafia Commission (DNA) had been working for a long time in this sector of Apulia, made the risk of dealing with a green and legitimate business soaked with dirty mafia capital considerably high (R3, R4, R9, R11, R14, R21, R22, R24, R26, R27, R30).

The companies that invested in Apulian PV could rely on a safe and free-of-risks double source of income, proportional to the nominal power of their installed PV plants. On the one hand, there were the national Feed-in Tariffs. Formally paid by ministerial GSE, these were in reality directly taken from the energy bills of the final users, which contained fees specifically designed for covering the promotion of renewable energy sources. As such, assuming the improbability of the sun to stop shining and of the Italian citizens to stop paying their energy bills, FiT could fairly be considered by PV investors as an extremely safe source of income, to be enjoyed over twenty years from the connection of their power plants to the national grid. FiT's slow decrease over time did not concern the investors, as it was balanced by a much faster and prominent decrease of the price for solar modules (R13, R15) which, we shall see, decisively helped maintain the attractiveness of the PV sector through the years to come (R28). On the other hand, 'ENEL Distribuzione', the company that owns the entire power grid, was forced by law to buy the whole production of electricity from renewable sources at a price generally set in advance by the relevant *Conto Energia*. This condition gave another safe and somewhat precisely calculable-in-advance form of revenue to PV investors. As one of ENEL managers (R20) declared:

> We ['ENEL Distribuzione'] are like a highway. Our highway is the national power grid, in which cars/users enter, exit and passively pay for their transit. PV plants, instead, are more similar to highway builders, as they actively feed our grid with the electricity that they produce. In any case, both cars and builders are our clients. If they are authorised by national and local administrative bodies to enter our highway, then they have the right of connection, and we the duty of dealing with them.

The sudden creation of a number of large-scale photovoltaic power plants not only resulted in the occupation of wide agricultural lands and the implementation of solar modules. It also consisted of an enormous deployment effort of "cabins, kilometres of cables, bigger power stations, and other devices to improve the capacity of a grid that initially was not designed to absorb such a quantity of electricity" (R13). The investors, sure of the vast profit perspectives, did not bother taking care of all the expenses that the

adaptation of the existent, obsolete energy infrastructures required to the new situation. In this respect, R20 affirmed without exaggerating:

> Whereas before in Apulia we built a new power station every fifteen or twenty years, today we would need to build twenty different power stations in one single day to satisfy all the requests of connection that on average we receive... At the present, the overall nominal power of the operating and pending Apulian PV projects can alone satisfy the entire Italian electricity demand at its peak... I think this is a distortion of sustainable development!

One of the managers of the same company (R18) added:

> Obviously, the adaptation to the new trend brought to a revolution in terms of work organisation. In particular with human resources, we had to employ a number of new people and rely on the help of other territorial departments, like those of Basilicata and Calabria, especially for testing PV plants right before the deadlines imposed by *Conto Energia* laws, that is, when every investor pushed hard for being connected.

In this section I have described role-area number one as an arena built around money and aimed at the push for an anticipated start of the bureaucratic and technical processes of application for installation of new PV stations. Yet, in the eyes of the initiator, its mobilisation would have been useless without the concomitant and synchronised mobilisation of the other two areas.

Role-area #2

Inspired by the gates disclosed by regional regulations, role-area number two, whose activation concerned the search for appropriate building lands and employees, included several actors: private businesses, landowners and farmers, the black market, the power grid, the availability of flat, building areas, the infrastructures, the climate and solar exposure, the local mafia, and the idea of 'teamwork'.

Any subject who aimed at accessing the Apulian PV network had to take into consideration at least four important factors before choosing suitable lands:

- Flatness and width of the fields and of their surroundings.
- Presence of fine infrastructures (wide road network and power grid).
- Legal possibility of building on their surface.

- Securing of their use for the PV cause.

As already described in chapter two, the prior presence of infrastructures such as a wide road network and an extensive power grid (consequence of the high population density), along with the abundance of large, flat areas, and of disposed bio-climatic conditions (scarce precipitations and high solar exposure), were some of the co-responsible pre-conditions that induced a massive PV attention towards Salento. After having localised and labelled this sub-region of Apulia as the most suitable one for the implementation of large-scale PV technology, it remained to select and secure its best flat, building lands. This important role was performed by a series of local subcontractors and private businesses (referred here as 'freelancers'), whose position was literally "created" (R25) by the actors that neighboured them. These freelancers were agents in the privileged position of knowing very well local people and their issues and, at the same time, PV companies. One of them (R17) confided:

> The truth is that our agricultural sector is one of the weakest nowadays. There are more and more fields that remain uncultivated, unsold, unwanted. We provided their owners with incredible opportunities to get rid of them.

In such a context, the work of the intermediaries consisted in finding suitable flat, building lands, contacting their owners, convincing them to sell or rent them out for twenty years, and finally propose the deals to the companies that had an interest in investing in the Apulian PV sector (see role-area #1). A farmer who decided to rent his land (R30) affirmed:

> On average the profit of my wheat field consisted in around € 600/ha per annum and it implied also my hard manual labour. When I was proposed to rent out the surface of the very same field to a company that wanted to install PV modules in exchange for a revenue of € 5,000/ha per annum, I did not think twice. I signed, I had to sign that contract.

On the same frequency, a landowner who sold his field (R32) declared:

> € 29,000/ha! I had bought it for € 13,000/ha and they paid it more than twice as much, such an affair... My neighbours also sold their properties. Full of tears, one of them

> had to sell the land that he had inherited from his father's life sacrifices... But what can we do? The main problem here is that we can no longer make a living out of agriculture. People accumulate debts over debts, until banks refuse to lend us money. It is actually a fortune the fact that there are still some people who are interested in our fields.

Apulia's assorted PV network was also filled with rich landowners who decided to start a smaller, but still large-scaled ($\geq$ 200 kW_p) PV business on their own, or in association with some friends. One of them (R31) told me:

> I would daily irrigate solar panels, rather than tomatoes, olives and salads... Look at me, I am a happy man now, I can dedicate more time to my nephews and go to the beach every day. The sun works for me. When it sets, I go down, check my production meter, convert its numbers in Euro, and joyfully wait for our shiny star to rise again the next day.

The liquidity, generosity and purchasing power of companies that came all the way to Apulia for their interest in building lands to be destined to PV, soon became a well-known feature amongst landowners. In this regard, a curious incident happened to me whilst I was visiting an Apulian natural park with some guests of mine from Lithuania. Our guide, having noticed me busy translating for them, asked me about my origin and job. Right after I told him about my interest for the Apulian PV sector, he proposed me that I buy his land which, according to him, was "absolutely fitting for large-scale PV scattering". I smiled before I presented myself as '*solo un ricercatore*' ('just a researcher'). The guide apologised for having exchanged me for one of those freelancers that come to Salento to buy lands for PV and went on with his tour.

The mediation role played by some of these freelancers did not limit itself to procuring and securing suitable lands for PV deployment. Some of these "mysterious agents" (R21), took the form of the so-called '*caporali*', and worked also to provide investors with manpower for physical installation of photovoltaic parks. Whether their activities are carried out legally or not, it is a topic that does not concern this dissertation, however, it is important to point out that the National Antimafia Commission (DNA) is currently investigating possible mafia infiltrations in their role of mediation between SRL and the

local territory, but also for labour exploitation and recruitment of illegal immigrants (R3, R21, R22).

Role-area #3

Role-area number three, concerning the attribution of green and positive meanings to the spread of PV technology, was again mediated by REP's will of 'teamwork' and by its regional regulations. It incorporated several actors: local public bodies, banks, mass media, final users, NGOs, constructors, academic institutions and experts, the climate and solar exposure, the EU Directives, and the idea of 'Green future'.

The mobilisation of this role-area revolved around spread of encouraging information about the PV technology. It was entirely activated through the use of intermediaries such as public events, meetings, debates, press conferences, and also literary inscriptions like advertisement, the next day's newspaper articles and other textual expressions.

The public events that I observed (R33, R34, R35, R36) were all organised either by officials from the municipalities in which the events took place, in association with local academic institutions, or by NGOs. In any case, they also counted on a varied selection of people representing other actors, amongst which REP's policy makers and district representatives were always present.

By observing public meetings from a distance, I had the initial chance of dividing, following and somehow interlinking the agenda of different actors, therefore of understanding and mapping out their arguments in favour or against the development of large-scale photovoltaic innovation. Yet, it was only after I had interviewed, one by one, all of the actors that I reputed as important within the Apulian PV network that I could fully comprehend the importance of those public events and their collocation in a bigger scheme. As a professor from a local leading university (R13) confided:

> Representatives from the Region of Apulia [REP] and from different banks contacted me twice, two years ago and this year. They asked me to help them organise big

> public events with a regional echo... As an expert, my role would consist of giving a positive speech on PV and of ensuring the participation of students from my research institution, professors, and other colleagues of mine... I accepted in both cases.

Equally, the representative of an NGO (R24) admitted:

> Spreading green words and informing the population about the positive opportunities created by the photovoltaic technology was a complementary strategy used to meet the interests of as many Apulian citizens as possible... As we were really convinced of the benefits that PV development in a hot and sunny area like ours would bring to all of us, we always asked lawyers and professors to join our meetings, so as to explain to the crowds, in a way as accessible as possible, the complex legal aspects and the economic advantages provided by the acceptance of a common path towards Kyoto's commitments, even in the absence of a 'Burden Sharing' Law.

The green and positive messages transpired from these public events were usually emphasised also in the next day's local newspapers, able with their capillary circulation to reach thousands of people living in Apulia. A journalist (R22) revealed:

> Although the Region of Apulia had its own portal and its own Press Office, we were asked by both public bodies and by our readers to decrypt the technical information that was going on around PV and make it available to all.

5.5 Completion of Translation

In a centralised context coordinated by REP and regulated by highly simplified regional laws, the allied agents simultaneously employed three different intermediaries in three diverse but synchronised and often overlapping role-areas, so as to act according to the orders transferred by their initiator. *Money* was used in the first group as means of exchange to fasten the start of bureaucratic and technical processes of application/authorisation for installation of new PV power stations. *Freelancers* were employed in the second group to select and secure relevant building lands and employees. *Information* was instead utilised in the third and last group to empower the photovoltaic innovation with green and positive meanings.

Mobilisation was successfully finalised with very little use of coercion (perhaps only where mafia was involved). Order and organisation were

transferred from the centre (REP) to the periphery and, with them, the four-stage process of translation could finally be completed. Consensus amongst the actors was evident. Each of them appeared to be in a perfect position to gain something out of their faithful participation in the network. For instance, banks could grant loans more easily than before because the safety of the FiT incentive-system guaranteed no risk of insolvency (R19); existing businesses and unemployed citizens of Apulia could find hope for remedy to their unstable job and financial situation by exploring the opportunities that the establishment of a legal market around PV had just created, as opposed to the risks of the black market (R16, R20, R22); rich actors had also found an un-risky and high profitable way of investing their capital (R1); at the same time, the Italian Government could enjoy vast energy production from renewable sources, which worked already in the direction tracked by the commitments signed in Kyoto (R1); universities could plan an increase in number of students to be enrolled in their socio-technical faculties, especially engineering and economy, which would grant them a higher flow in terms of admission fees and a better image too, as they would now link their institutes more tightly to the real developments of the local area (R13, R16). The Region of Apulia, spokesperson, coordinator and advocator of 'teamwork' around the three role-groups supporting the PV network, could as well plan to benefit from multiple advantages. First of all, it could already push on the generation and consumption from regional renewable sources, so as to find itself in a privileged position later, when the Italian Government would finally approve the 'Burden Sharing' law (2012). Amongst other benefits, REP would enjoy: considerable incomes in the form of IRAP ('*Imposta Regionale sulle Attività Produttive*'), a tax that affects all productive activities within the regional boundaries, possible improvement of regional living conditions due to adoption of carefully-planned political choices, international visibility, and finally also the propagandistic utilisation of a high PV score as a successful metaphor of 'Left Ecology Freedom' (SEL), the leading green regional party.

By translating the desires of all its constituents, on the one hand the Apulian large-scale PV actor-network had become stable, unquestionable and irreversible. Pronounced with ANT vocabulary, it was now converted into a 'black-boxed' or 'punctualised' body. However, as all of its actors were caught in the same socio-technical arena of obliging links, on the other hand, widespread consensus necessarily limited their "room to manoeuvre" (Harrisson and Laberge 2002:503). It was a consequence that from this time on, no deviations would be allowed. Belonging to the PV network would mean performing the same roles over and over again, and pushing in one direction only: the implementation of large-scale PV innovation to be scattered over the Apulian *Fields of Gold*.

5.6 Resistance, Betrayal and Reshaping

The Apulian PV network worked perfectly well from the first translation, which occurred during the year 2008, to the beginning of 2010. For all that time, as if it were one single, aligned actor, it incessantly and naturally performed, with the same familiar commitment advocated by its initiator REP, the four-stage translation described above, resulting in a massive development of the Apulian large-scale photovoltaic sector. Yet, due to inherent dynamicity and precariousness of the associations of hybrid entities of which any actor-network is by definition made of, resistance in the form of unsolved tensions and competing arguments eventually came to the fore.

As time passed, large-scale PV technology increasingly became synonymous with disillusionment and frustration amongst some of the constituents of the network. These began to organise themselves into associations to protest against the impossibility of stopping the "absurd number of new plans for large-scale photovoltaic development" (R11). Amongst them, there were some influential local mass media and NGOs, most of the final users, and many local public bodies (districts like Brindisi and municipalities like Melpignano and Cutrofiano). For all these actors, the network had partially or entirely

failed to provide the resources (jobs and profits) that PV, through the voice of the spokesperson REP, had promised it would. Discontented agents soon began to establish new sets of divergent associations that led REP to accept a compromise: abandoning the PV project in its 'large-scale' form, in exchange for a grant of obedience within a new, competing network revolving exclusively around the 'small-scale' variant of the same PV innovation (< 200 kW_p). At this stage, it is important to point out two things. First of all, that resistance did not feel it like a betrayal for the other actors in the network, as its new proposal orbited around the same technology, just in a different average size. Secondly, that the agents who attempted at this first form of resistance were, curiously and generally-speaking, either those who did not take part into the initial project (large-scale), or those who had accepted to commit themselves to it more because of a hope, a wish, or an aspiration at a better future, rather than a real conviction or an imminent, tangible set of benefits to be gained in the short time (see quotes above in the text).

From ordinary citizens and NGOs to district officers, many expressed serious concerns about the developing trajectory undertaken by the local large-scale PV technology: "Nothing, there is nothing left for us. No jobs, no money, no lands. It is the plunder of our fields for nothing" (R26); "It is an emergency that exceeds that of Naples waste, because here things will last at least twenty or thirty years" (R4); "PV will bury us at life under its panels and its gloomy affairs" (R25). These phrases included some of the typical arguments employed by a still weak resistance, but already spread all around the region. I heard them several times, in different communities of Apulia. It is worth mentioning that in general, large-scale PV technology (and not REP) was blamed as a whole either for its land-use management (vast areas of fertile lands subtracted to agriculture, loss of productivity, desertification, aesthetic issues; see also Robles *et al.* 2011), for benefiting only rich players, for creating merely temporary and underpaid jobs, or also for providing favourable conditions to the infiltration of speculators, mafia, and other illegal businesses. In the intentions of what is here defined 'resistance', detaching

REP from the large-scale project would not only cause its collapse, it would primarily bring a switch to a new and more sustainable actor-network around the support of the same kind of innovation (PV), but in a small-scale form.

The initially weak resistance strengthened internally and gained consistency over time due to enforcement of four legal acts, shortly analysed below.

'ICC 119/10' (2010)

The Italian Constitutional Court's decision No. 119 of 26 March 2010 ('ICC 119/10') declared illegitimate Regional Law 'RL 31/08' (2008), one of the legislative acts that, perhaps more than any other agent, had prepared the breeding ground for large-scale PV spread in Apulia (see section 5.2).

The decision was taken mainly because the administrative and bureaucratic simplifications contained in this law had unilaterally allowed photovoltaic plants with a nominal power of up to 1 MW_p to be authorised through a shortened, municipal 'start-of-works' declaration (DIA), instead of a selective and lengthy regional '*Autorizzazione Unica*' (AU). In doing so, this law had contradicted the guidelines of Legislative Decree No. 387 of 29 December 2003 (LD 387/2003) which, according to the Court, required an AU even for smaller projects ($\geq$ 20 kW_p).

'ICC 119/10', with immediate effect, implied for all new Apulian ground-mounted PV projects with an installed power above 20 kW_p and authorised by 'RL 31/08' to go through a regional AU procedure. Yet, the decision of the Constitutional Court also took account of the expenses sustained by those subjects who had already started a process of authorisation before the Court's verdict (under the framework regulated by Art. 27 of 'RL 1/08'). To ensure their financial safeguard, 'ICC 119/10' could not retroactively affect all of those PV projects that had not been implemented yet but that had already been fully permitted by a DIA process.

The Court's decision provoked a massive change within the PV network of Apulia. REP, its initiator, took the important political decision of dropping support from its creation, to join and espouse the arguments of the resistance and fight what it believed was a "phenomenon run out of control" (R5). Consequently, unexpected 'betrayal' of the spokesperson eventually manifested. R2, right after the Court's decision, peremptorily commented REP's change of perspective in this way:

> It is time to support our families with a policy oriented towards the incentive of small-scale photovoltaic technology only... It is time to take distance from the past and contrast the diffusion of PV energy gigantism, which found in Apulia its treasure map, and which presented clear incompatible environmental features with our territory.

Deprived of REP's supervision and coordination, and without also the support of a number of other actors, a transfigured Apulian large-scale PV network, in order to survive and not to face failure, was now for the first time called to a reshape and to a showdown. In turn, as per ANT, it would now need to tighten up, possibly nominate a new spokesperson/obligatory passage point, perhaps recruit new influent agents, avoid or limit slowdown of innovation, win the resistance, show cohesion, and go on its way.

The Regional Guidelines (2011)

Whilst the dominant network remained momentarily motionless, as a first move, resistance employed REP to enact, from 1 January 2011, new Regional Guidelines capable of "re-balancing development, environment and agriculture" (R6). These Guidelines, in full respect of the national norms (no risk for its legitimacy this time), provided a series of off-limit areas (national parks, archaeological sites, and other protected areas), upon which scattering any form of renewable energy technology was prohibited. For the rest of the region, effectively no authorisation would be requested for the installation of PV plants smaller than 20 kW_p (rooftop plants); a DIA became essential prerequisite for the authorisation of PV plants with a nominal power comprised between 20 and 200 kW_p; whilst mechanisms of financial control

and severe VIA/AU procedures were asked for all PV projects designed with a nominal power above 200 kW_p.

'Burden Sharing' and new PEAR (2012)

The long-awaited 'Burden Sharing' law finally entered into force on 3 April 2012 with the aim of defining the exact contribution of each region to the achievement of the minimum national binding target of 17% of energy from renewable sources in Italy's 2020 gross final consumption, as expressed into the EU Directive 2009/28/EC, and reflected into the PAN (see chapter two).

Apulia was finally supplied with the ideal renewable-share trajectory that resulted from the average of three key-sector share targets: production of electricity, heating/cooling, and transport. Starting from a 3% level, this law defined its expected gross final consumption scenarios in the years 2012 (6.7 %), 2014 (8.3 %), 2016 (10%), 2018 (11.9 %), and 2020 (13.7%).

The entry into force of the 'Burden Sharing' also resulted in the approval of a new PEAR (RL 25/12), which adapted the old, "outmoded" (R1) one to the new Regional Guidelines and the set of binding targets established with "improper delay" (R2) by the Italian Government.

Reshaping

Facing legal barricades erected by REP, but also the disillusioned citizens and some of the most influential districts, municipalities, local mass media and NGOs, the large-scale network stood at a crossroads: fight to defeat resistance or declare failure of the ground-mounted pattern undertaken by the project? The PV network chose to battle, but that decision implied moving the fight into a different arena: the courtrooms. A REP delegate (R1) confirmed:

> Nowadays we are situated in a limbo in which contrasting laws, ideas, advices and policy strategies have become far more restrictive than before. However, there are still several hundred pending large-scale projects that must be examined with the old regional regulations… By law, we are obliged to either authorise or deny them within 180 days from their application. Yet, as we are literally inundated by such requests, on average, we conclude each process of authorisation/denial in no less than two years

> and a half. This delay exposes us [REP] to legal claims of every sort... We do not know how all this is going to end up.

It is in the courts that the actors which are still affiliated to the large-scale PV network are currently fighting for recognition of their rights. In case of victory, a new season for the Apulian large-scale PV technology is very likely going to take place.

5.7 Current Situation

In this chapter, we have learned about the importance of the social in developing a PV innovation project.

At the moment, in spite of the fact that resistance seems to show more dynamism and growing strength over time, the metamorphosis which the initial PV network had to go through due to occurrence of internal betrayal appears to have weakened but not yet to have removed its leadership within the Apulian boundaries. The latest official available statistics still show that, with a total installed PV power of 2,186.2 MW_p (83% of which is scattered over a record agricultural land of 33,751,101 m^2) and a generation of electricity of 2,095.7 GWh, little Apulia scores higher than entire countries which expressly rely on PV technology (GSE 2012a). These numbers suggest also that the large-scale network is successfully resisting external attacks, but they do not state for how long, as well as possible future circumstances.

Aid may be brought by an additional discussion of some of the dynamic elements already treated in this chapter. In particular, the capacity of the project to act upon unforeseen situations and adopt strategies to guarantee a certain level of internal agreement, that is, its ability to activate a number of interconnections high enough to ensure network strength, solidity and indispensability. Assisted by several visual representations, such factors will be further discussed in terms of space and time over the next chapter. This will serve to track the life of the project and to consequently put interested readers in a better position to guess on future scenarios, so as to act accordingly.

6. Examining Translation over Space/Time: Discussion of the Findings

The application of Callon's four-stage translation to the Apulian PV project alludes to a present stability of the network in its large-scale form. Differently from most of the research in which ANT has so far been employed as a main theoretical/methodological framework, technological failure due to network instability did not occur in this case study. More precisely, as networks are inherently dynamic and alive systems of associations, it would be safer to say that it did not occur yet. However, from a purely ANT perspective, it is even more surprising the fact that the Apulian PV network resisted strong and tight despite betrayal of several of its agents, amongst which there was also REP: at the same time initiator, spokesperson and one of the obligatory passage points of the primary system.

The discussion over the dynamic grade of consent and connectivity in the PV network can be further illuminated with the visual and textual aid provided by its local/global inspection. In the following sections, such examination is intended to explain in detail how some of the Apulian actors' interessement and mobilisation changed over time and led the project to take the trajectory that it did, surviving betrayal of an important number of its constituents.

6.1 Evolution of the Local/Global PV Network

According to Law and Callon, "the shape and fate of technological projects is a function of three interrelated factors" (1992:46): a global network, a local network (with its intermediaries), and their ability to impose themselves as obligatory passage points.

'Global network' entails the set of heterogeneous, independent and controlled relationships that, in the attempt of generating a return, covers the external sphere of an innovation project. Its reference in the Apulian large-scale PV development reflects the activity performed by just three actors: EU

Directives, national regulations, and the price of solar modules. These, by providing the project with a series of political, legal and financial settings and resources, shaped a space (global/local) and a time (from 2001 on) "within which a local network might be built that would in turn generate a range of intermediaries" (1992:42) capable of pushing the photovoltaic innovation further and further up, and ultimately pass its fruits (in the form of 'Kyoto credits' due to generation of electricity from renewable sources) back to the actors in the global network, in return for their support.

In this way, a 'local network' could find fertile soil for forming and operating in a confined space (Apulia) and in a time (eventually from 2005 on), around the spread of photovoltaic innovation and its promise of bringing profits and jobs. The local network included players that featured merely local hybrid agents or external ones acting locally, within the same internal space. REP, local public bodies (districts and municipalities), academic institutions and experts, banks and other funding bodies, NGOs, mass media, landowners, constructors, distributors, private businesses, farmers, final users, the climate and the solar exposure, the extent of flat areas and infrastructures, the regional regulations, the capital, the local mafia, the black market, the power grid, and the concepts of 'green future' and 'teamwork', were all part of this big and complex internal sphere.

Although the opening rules set in translation by the initiator REP supervised all sort of interactions between the three role-areas described in chapter five, in order to delineate the relationships that took place between agents belonging to the two local/global spheres or networks (and with that, define anything passing between them), three 'intermediaries' were employed in a 'meso-level' sphere: money, freelancers, and information. Figure 13 below represents the ordering of the Apulian PV network in its mature, stable, unquestionable and irreversible phase (2008-2010), namely, the phase which fully echoed the instructions designed by the spokesperson and obligatory passage point REP for the network, observably before betrayal occurred.

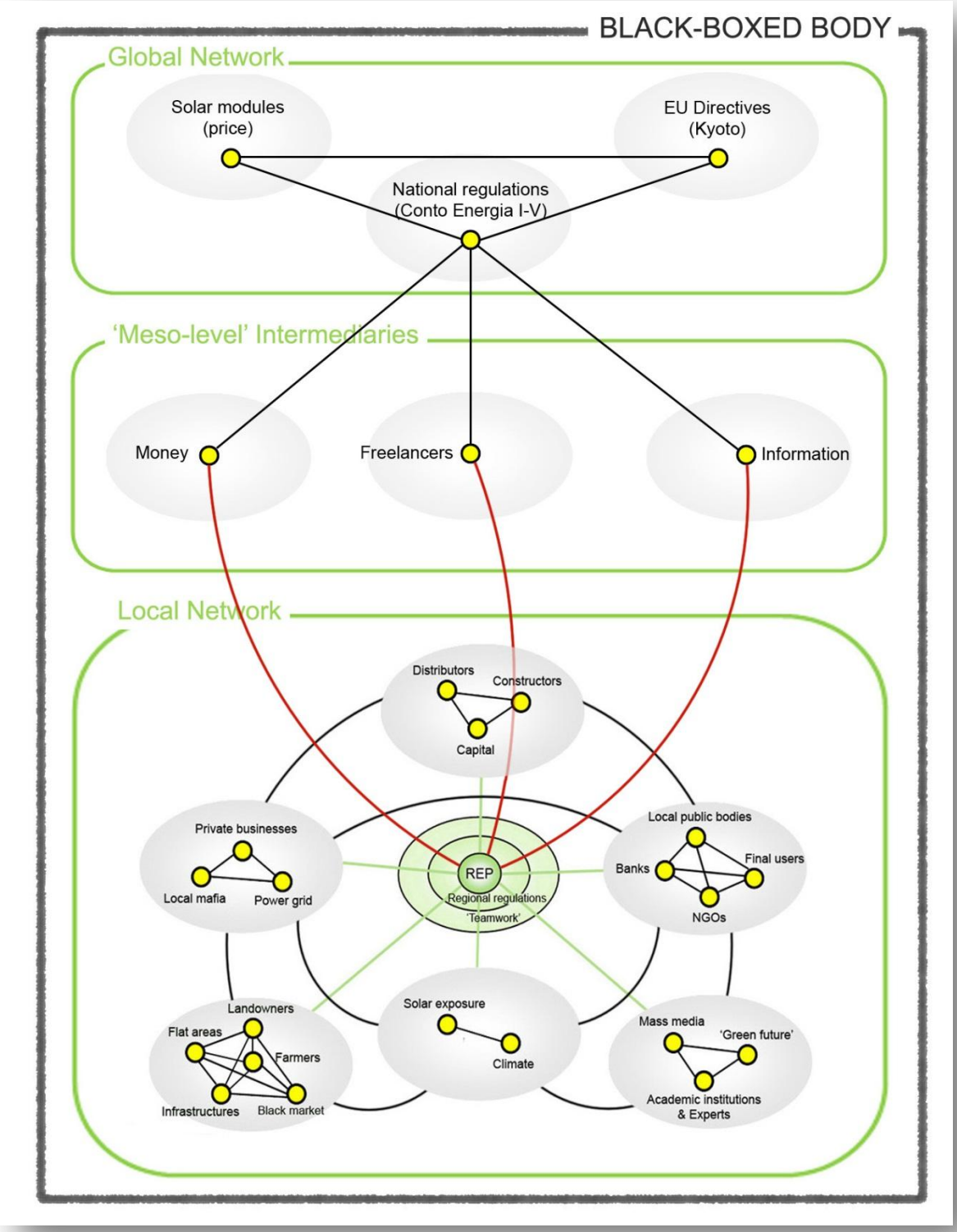


Figure 13: Local/Global graph representing the constitution and ordering established, performed and black-boxed of the Apulian PV actor-network during the period 2008-2010, that is to say, *before* betrayal occurred. The main obligatory passage point REP, together with its legislative acts (Regional regulations) and attitudes (coordinating idea of 'Teamwork'), connected a centralised *local* PV network to the *global* one by means of three *intermediaries* (Source: produced by the author).

The Apulian PV network worked smoothly as if it were one single body until betrayal occurred, that is, until the beginning of the year 2010. The moment in which a number of important actors decided at once to withdraw their commitment and participation from the PV network that pushed for large-scale development and, by doing so, embrace a competitive, small-scale variant of the same technological innovation, literally corresponded to a shock for the system drawn in Figure 13. Local public bodies, mass media, NGOs, final users and, most importantly, the spokesperson and obligatory passage point REP (together with its concept of 'teamwork') abandoned the original PV network. According to these actors' point of view, their massive runaway would be sufficient for the large-scale PV network to lose control and credibility within its local arena, a condition that would immediately cause the collapse of any form of organisation. At the same time, they also thought that their betrayal would be an act strong enough for the new-born small-scale PV network to abruptly take over. Eventually, the evolution of the Apulian photovoltaic sector from betrayal to our days demonstrated that resistance was wrong on both expectations. As Figure 14 below shows, although strongly weakened, a large-scale PV network, dispossessed of its old obligatory passage point REP and of its coordinating efforts ('teamwork'), still resists and manages to translate the interests and desires of a quite high number of actors, accomplishing the same tasks required by innovation in the three role-areas. The connections established in Figure 13 were so strong and numerous that allowed the network to lose a number of players, including its former spokesperson, without suffering from lethal consequences. The resistance's mistake consisted in not taking into early account the fact that the regional regulations (PEAR, 'RL 1/08' and 'RL 31/08'), approved in peacetime, unlike 'teamwork', could not suddenly leave the scene along with REP's betrayal. The Italian Constitutional Court's decision No. 119 of 26 March 2010 on the one hand recognised the arguments of resistance, but on the other hand acknowledged also the rights of hundreds of pending projects which had already been approved under the framework drawn by the old local legislation.

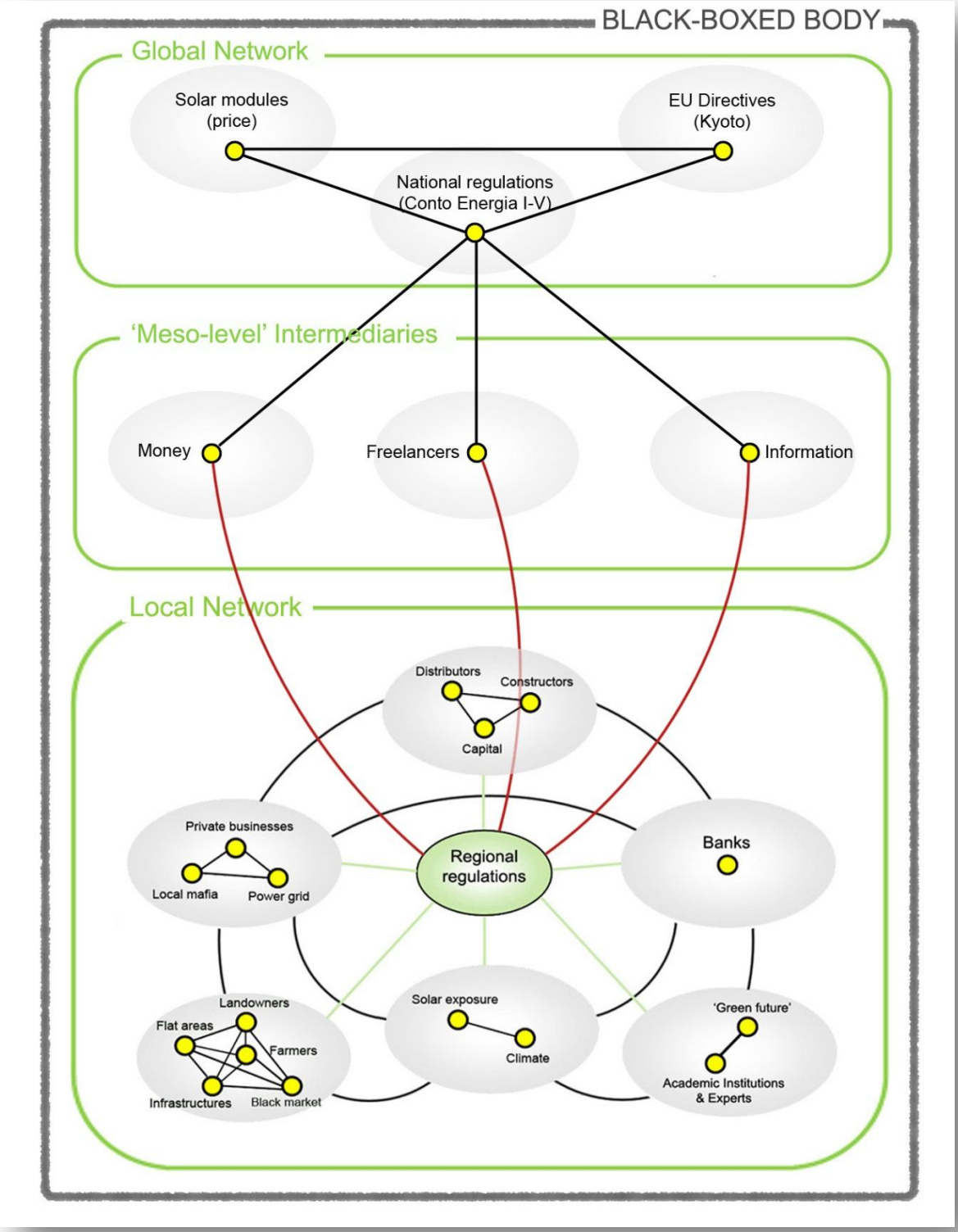


Figure 14: Local/Global graph representing the constitution and ordering established, performed and black-boxed of the Apulian PV actor-network during the period 2010-2012, that is to say, *after* betrayal occurred. Although resistance (REP, 'Teamwork', Local public bodies, Mass media, Final users, NGOs) highly weakened the network by abandoning it, a system of hybrid associations for the promotion of large-scale PV technology survived strong around Regional regulations (new manifested obligatory passage point), namely, the only actor left capable of connecting a centralised *local* PV network to the *global* one by means of three *intermediaries* (Source: produced by the author).

A comparison between Figure 13 and Figure 14 clearly shows why regional regulations became today's only large-scale obligatory passage point. It is in fact on that set of still active laws that the remaining constituents of the initial PV network heavily rely on in the Apulian courtrooms. Although my informants were quite confident that these subjects will win their on-going trials against REP, following ANT, to me it is only important to recognise their willingness to fight for the network. In doing so, they are not only trying to secure huge, actor-based profits for the years to come and extend as much as possible the generous large-scale PV season of Apulia, they are also cohesively attempting at postponing for as far as possible the already scheduled death of a socio-technical innovation network aimed at spread of large-scale PV technology.

6.2 Exploring the Dynamics of Strength

The combination of the history described in this thesis and of the comparative graphical analysis of the PV actor-network order before and after betrayal offers interesting insights that correspond with the major arguments employed by the advocates of the socio-technical view of innovation, technology and energy systems.

First of all, just like in Law and Callon (1992), this research shows both the interpretive flexibility of innovation objects and the social shaping of technology, namely, the way in which innovation objects "mean different things to different social groups" (1992:42) and the way in which these "are shaped by their organisational circumstances" (*ibid.*). More in particular, by acknowledging the indissoluble connection between the social and the technological in a social arena in which multiple negotiations, mediations, designation/variation of positions and hierarchies, and institution/re-distribution of responsibilities take place, this study demonstrates the theoretical and methodological applicability of Actor-Network Theory for exploring new organisational aspects of innovation projects. By investigating

the complex organisational aspects of this case study through the lens of Actor-Network Theory, an exclusive chain of events was highlighted by performing an intrusion into the invisible process of translation, which acted as an engine for the spread of large-scale PV technology. Understanding the origin of the strength of this network is not only to acknowledge a strong and indirect agency owned by the photovoltaic technology itself and expressed through a permanently-switching "indeterminacy of the actant" (Díaz Andrade and Urquhart 2010:363) within the enrolment stage of translation and in constant repetition of translation itself (see the three role-areas routine in chapter five); it is also to comprehend the peculiar nature of power and with that, reflect upon the overall degree of dynamicity, control and convergence of interests of the Apulian system.

Provided that power and connectivity are the two sides of the same coin, measuring and assigning power within the large-scale PV network studied here is to avoid common indicators such as size, hierarchy, social status, or possession. Instead, because power is defined by ANT as the invisible effect of persuasion, the emerging question becomes whether or not there is any actor more incident, persuasive and influencing than others, that is to ask, which actor managed to speak on behalf of the majority of the other actors and create the highest, the longest, or simply the most robust and long-lived number of connections/associations around large-scale PV technology?

The comparison of strength between Figure 13 and Figure 14 can give it an answer. If we visualise their webs of local associations side by side, as shown in Figure 15 below, the loss of internal power over time becomes an evident feature of the project.

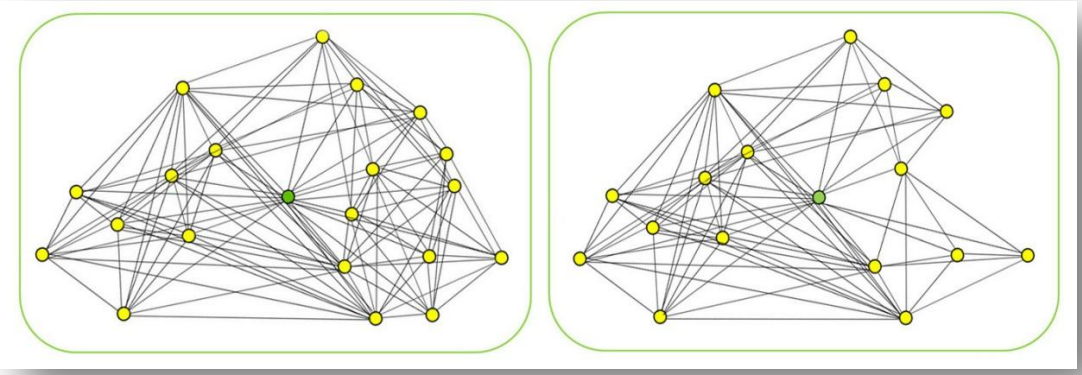


Figure 15: The complex web of heterogeneous associations amongst the yellow points on the left (each of which corresponding to an actor of Figure 13 in the text) illustrates how powerful was the local PV network that took place around REP (green point), right after completion of its first successful translation. Instead, the web of links amongst yellow points on the right (each of which corresponding to an actor of Figure 14 in the text), when compared with that on the left, provides a visual impact of the enormous decrease in complexity of associations (therefore in network strength) that took place within the same local PV network, but affected by betrayal, that is to say, the local network formed around Regional regulations (new green point) (Source: produced by the author).

Figure 15 makes it clear that betrayal produced a certain overall power loss into the network, due to a substantial decrease in number, extent and complexity of connections in support of innovation. The loss of power was concentrated and delimited by the local-network boundaries, within which resistance produced its effects. Yet, as the large-scale network demonstrated to resist the blow, REP can be defined as the most powerful actor only until it managed, with its strategies, to secure the interessement and enrolment of all other actors. Once it produced the regional regulations (PEAR, 'RL 1/08' and 'RL 31/08'), these suddenly took over its power throne. The switch was silent because, also evident in Figure 13, regional regulations shared the same central position with REP and 'Teamwork' in a centralised local network, where a change of indispensability did not provoke any visible effect to the network organisation. This is why betrayal of REP and of other actors failed in causing proclivity and still kept attached, interested, convinced, active and enrolled to the large-scale innovation a great number of hybrid actors. Accordingly, the durability of the PV network can also be said to show the relative powerlessness of REP against its own indelible regional regulations, which for most of the time turned out to hold the largest power and to run the highest number of connections in the network.

As per ANT holding power does not imply control, REP (first) and regional regulations (after) assumed an inevitably limited control over their associates. This is essentially due to the different actors' agendas, to the inexistence of coercion, and as presented above, to the circulating nature of power. As a matter of fact, saying that today the regional regulations represent the most powerful actor of the network does not mean that the other actors are not endorsed with power at all. By definition, every actor is a network itself, therefore every actor is potentially more or less empowered, too. As a result, control by REP and regional regulations, when it took place (in diverse moments, over diverse sets of actors), it did so only because groups of other actors agreed with it or chose not to oppose it.

Given this view of power and control, the Apulian PV network, just like any other actor-network, becomes a creature definable as an inherently dynamic and precarious association of hybrid entities. The occurrence of sudden betrayal attested and demonstrated the dynamicity over time of its broad range of organisational phenomena which constituted its socio-technical local actor-network, specifically, the one that employed global resources to trigger from the ground the entire large-scale innovation project object of this research.

6.3 Convergence of Interests and Trajectory of the Project

Figure 13 and 14 provide also food for discussion over the convergence of interests inside the PV network, that is, over the degree of agreement amongst its local/global actors in a set timeframe (Callon 1991). Convergence in this study is intended to refer to the result of a two-dimensional analysis of determining events occurring in the Global and Local networks, in the period 2001-2012. Their combination effects in an alignment- (or attachment-, or mobilisation-) score for each of the spheres considered, in each given time-interval. It is important to notice that all of the scores reported here must be considered as purely indicative of a trend, as they are resulting from my subjective perceived evaluation of the sole factors taken into consideration in

this case study. The outcome of this analysis finds correspondence with the event-scheme in Table 1 below. Such analysis serves as triple highlighter: of the periods in which convergence has been the highest, of the constant mutual process of adjusting between the two spheres, and of the background data for drawing a mobilisation curve, able to graphically show the degree of solidity, durability and indispensability undertaken by the large-scale PV project over time.

Code	*Time-interval*	GLOBAL Events	*Global Attachment Score*	LOCAL Events	*Local Mobilisation Score*	*CONVERGENCE SCORE (+/-)*
A	2001-2006	▪ D 2001/77/EC; ▪ LD 387/2003; ▪ Extremely high FiT (*Conto Energia I* , 2005-2007); ▪ Peak-price for solar modules.	**VERY HIGH**	▪ Preparation for adoption of Role-Areas.	**MEDIUM**	+
B	2007	▪ Extremely high FiT (*Conto Energia II* , 2007-2010); ▪ Extremely high price for solar modules.	**VERY HIGH**	▪ PEAR; ▪ Advanced preparation for adoption of Role-Areas.	**HIGH**	+
C	2008	▪ Very high price for solar modules.	**VERY HIGH**	▪ RL 1/08 (2008-2010); ▪ RL 31/08 (2008-2010); ▪ 3 Role-Areas.	**VERY HIGH**	+
D	2009	▪ Highly decreasing price for solar modules; ▪ D 2009/28/EC; ▪ L 13/2009.	**MAX**		**MAX**	+
E	2010	▪ Very high FiT (*Conto Energia III* , 2010-2011); ▪ Low price for solar modules; ▪ PAN; ▪ ICC 119/10	**VERY HIGH**	▪ Betrayal; ▪ Reshaping.	**MAX**	+
F	2011	▪ Decreasing FiT (*Conto Energia IV* , 2011-2012); ▪ Very low price for solar modules; ▪ Renewables decree.	**HIGH**	▪ Regional guidelines.	**VERY LOW**	-
G	2012	▪ Highly decreasing FiT (*Conto Energia V* ,2012); ▪ Peak-low price for solar modules; ▪ Liberalisation decree; ▪ Burden Sharing decree.	**MEDIUM**	▪ New PEAR; ▪ RL 31/08; ▪ Courtrooms.	**MIN**	-

Table 1: Local/Global event-scheme with all major events occurred in both spheres from 2001 to our days. The combination of the perceived evaluation of the two networks' mobilisation/alignment marks the overall 'convergence score' (positive or negative) of the PV network for each of the debated time-intervals (Source: produced by the author).

Initially, in the period A (2001-2006), the three actors constituting the global network were truly active. Provided the fact that, in the attempt of generating a return, they had to create the conditions for a local network to form, it could not have been otherwise. Their frenetic mobilisation started with the Directive 2001/77/EC of the European Parliament and of the Council of 27 September 2001. It acknowledged the commitments ratified in Kyoto and established the need to promote the generation of electricity from renewable energy sources in the EU internal market. Following this EU Directive, the Italian Government approved the Legislative Decree No. 387 of 29 December 2003, which in turn resulted in the enactment of two laws for the endorsement of the *First Conto Energia* (2005-2007) and the institution of the highest Feed-in Tariffs in the world for supporting electricity generation from photovoltaic technology. Despite the fact that the price of solar modules was at its peak-level, the vigorous mobilisation of the other two actors did not prevent the global network from earning a *very high* score in the time-interval 2001-2006. In this period A, the local network was still in its embryonic state. Yet, as REP had already started preparing its regional area (i.e. speeches, search for compromises, etc.) for adoption of PV innovation, the local mobilisation marked a low, but still positive score (*medium*).

In phase B (2007), the global network kept stable its commitment to the project (*very high*). The enforcement of *Conto Energia II* (2007-2010) balanced very high, but slightly decreased Feed-in Tariffs with a decreasing price for solar modules. The stable legal, financial and market resources provided by the global sphere helped REP to shape a local network, conceiving it accordingly to its intentions, which in turn reflected those of innovation. Apulia, for the first time in Italy, had a local administration adopting a Regional Environmental Energy Plan (PEAR). This act, together with major planning efforts, brought in the local network a good mobilisation score (*high*).

Period C (2008), once again, sees the global network efforts constant (*very high*), as the only news concerned a minor decrease in price for solar panels. On the contrary, big, important events occurred into the local network. Here, the widely discussed regional regulations ('RL 1/08' and 'RL 31/08') were approved in Apulia. Around them (but visibly only around REP), three role areas were also built. In turn, these generated three intermediaries, capable of pushing up the regional development of PV innovation, and by doing so, refunding in the form of 'Kyoto credits' the investments made by the global sphere. Since translation was completed only in late 2008, the local network could not earn the highest score for period C, which anyway accounted for a really positive one (*very high*).

Stage D (2009) could well be defined as the most convergent year of the entire Apulian PV project. Both global and local networks achieved the highest possible mobilisation score (*max*) as they appeared enthusiastic and perfectly synchronised, aligned and coordinated. At this stage, innovation had rapidly spread and become obvious, as if it had always been there. Within its global sphere, Directive 2009/28/EC and National Law No. 13/2009 accompanied a drastic decline in the price for solar modules. The combination of munificent FiT provided by the *Conto Energia II* (still in force), of a much lower price for purchasing solar panels, and of a facilitated bureaucratic process for application and authorisation of new PV plants (already developed by REP and its regional regulations within the local sphere in stage C), provided an incredible amount of opportunities for huge and fast economic profits to all large-scale PV investors of Apulia.

Period E (2010) accounted for decisive events in both spheres. On the one hand, the global network approved the *Conto Energia III* (2010-2011), which reconsidered Feed-in Tariffs as a function of the muted market for solar modules (cheaper price). Throughout the year 2010, Italy also approved its National Action Plan (PAN) and expressed a crucial and unappealing sentence concerning the regional regulations of Apulia ('ICC 119/10'). On the other

hand, due to pressures from some of the local actors whose level of commitment towards the path undertaken by the project had started fading over time, REP chose to 'betray' the network with them. At this point, it is important to note that the PV project never started in Apulia as a specific plan for 'large-scale' development. Yet, as this form became very soon a *de facto* condition for the entry into the network, when resistance decided to abandon it, because it only proposed an alternative type of the same innovation ('small-scale' development), it formally felt like it did not betray the project itself as it was broadly conceived in the beginning. Resistance had just dumped the *de facto*, incontrovertible large-scale path undertaken by the project. However, in the ANT eyes of the other constituents, that act accounted for a betrayal of a network that had long become mature. This condition demonstrates three things at once. Firstly, the low power and control owned by REP. Secondly, the inherent dynamicity of the PV system. Lastly, the very high convergence of the project in its large-scale form which, even if troubled by resistance, strongly resisted it, reshaped, revealed its most important obligatory passage point (regional regulations) and went on its way. For all these reasons, whereas the global sphere deserved a fairly high score because only vaguely stained by a little decrease in FiT (*very high*), the mobilisation of the local sphere, helped also by the fact that 'ICC 119/10' did not provoke any legal constraint for the entire 2010, merited for cohesion and strength shown the best possible score (*max*).

In phase F (2011) convergence suffered a drastic turnaround. The global sphere finally acknowledged the sentence 'ICC 119/10' and enacted the so-called 'Renewables Decree', which in turn resulted in the approval of *Conto Energia IV* (2011-2012). This FiT system radically cut the incentives assigned to the generation of electricity from large-scale PV plants over time. Despite such a new, more severe set of regulations, a very low price for solar modules enabled global network to keep a positive mobilisation score (*high*). The local sphere, instead, suffered a lot from the new normative intentions and regional guidelines appointed by REP (now head of resistance), which highly

committed its new-born network to defeating any future spread of large-scale PV technology, a form of innovation that initially it had supported, and that now it was rejecting because it was no longer representative of its constituents' interests. The apparent immobility of the large-scale PV project, clashing with an increasingly active resistance, resulted in a very negative score (*very low*).

Period G (2012) can so far be considered as the least convergent, aligned and coordinated phase of the entire large-scale PV project. Both in global and local spheres mobilisation decreased. At the global level, the 'Liberalisation Decree', the 'Burden Sharing' law, and especially the new *Conto Energia V* (2012-), which approved the peak-low incentives for production of electricity from large-scale PV plants, were balanced only by an extremely low price for solar modules. Such conditions resulted in a still positive global trend (*medium*), but inexorably oriented towards decline of global commitment. Locally, resistance gained even more influence than before, as it approved a new PEAR and 'RL 25/12', both modelled against the spread of large-scale projects. Yet, the initial PV network seemed to have absorbed the shock and finally counter-attacked with the only possible weapon: bringing resistance to court. As trials will take time, until sentences are pronounced, the local mobilisation is very likely to suffer from a slowdown caused by the attacks of resistance, which are putting in a position of danger the entire large-scale innovation project. As such, for all the time that it will take, local network's score will always be the lowest (*min*).

The analysis and discussion of convergence demonstrates that the Apulian PV project went through a complex series of different circumstances that managed to transform it over time and, unlike its initiator's plans and intentions, crucially put the destiny of the project "in the hands of the others" (Latour 1991:105-106). As the destiny of hundreds of large-scale PV pending cases is currently in the hands of the judiciary, recognising REP as initial obligatory passage point did not contribute to make the large-scale network stable and

'black-boxed' forever. In case of victory in trials or other positive unexpected events, a new season for the Apulian large-scale PV technology is very likely going to occur (see H1 in Figure 16 below). On the contrary, in case of defeat, death of the large-scale PV project (already programmed due to ever decreasing FiT and approximation of the age of grid parity) will be decreed ahead of schedule (see H2 in Figure 16 below).

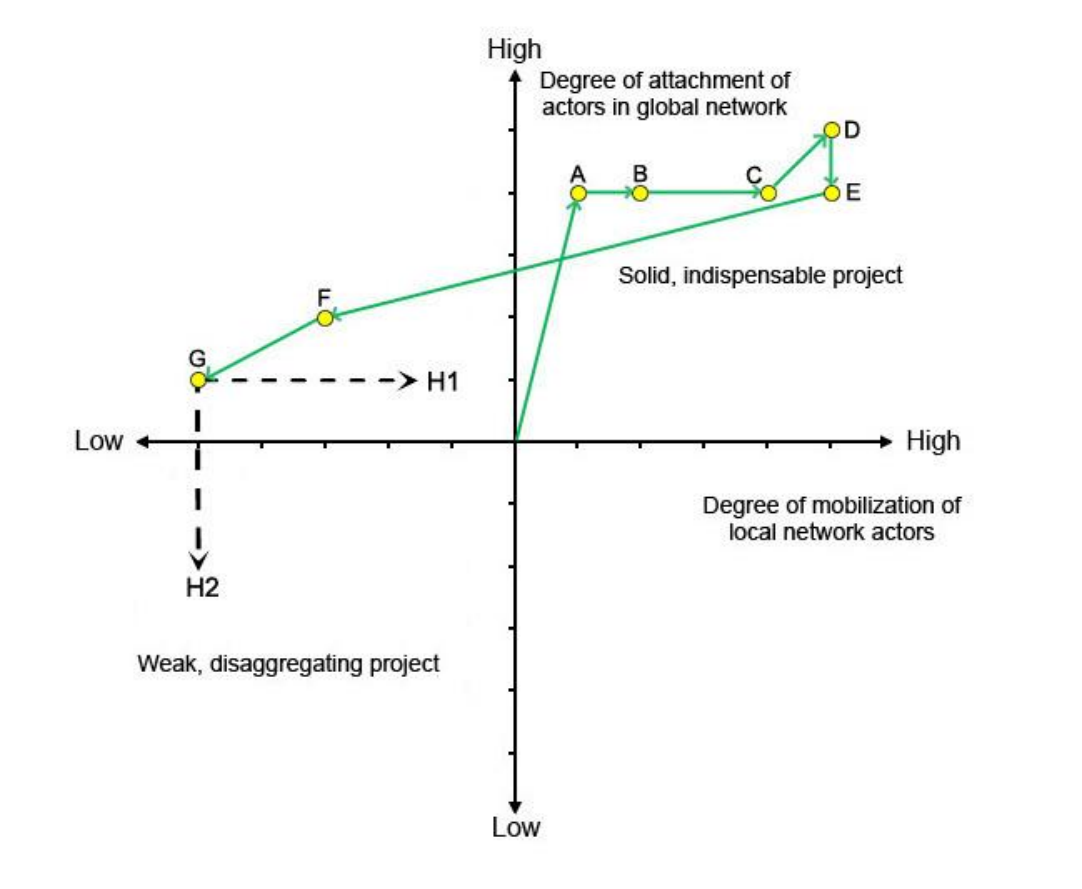


Figure 16: Local/Global mobilisation data from Table 1, if combined in a two-dimensional Cartesian graph in which the X-axis embodies the degree of local actors' mobilisation and the Y-axis stands for the degree of involvement of global actors, gives birth to a historical trajectory (drawn in green) that represents the author's perceived dynamic degree of solidity and indispensability owned by the large-scale PV project in Apulia, in the period 2001-2012 (Source: produced by the author).

The green curve represented above is a function of three dynamic and interconnected abilities of the project: involving the support of a global network to provide disparate kinds of resources in prospect of a final return, shaping a local network entirely dedicated to implementation of the project

itself, thus to the production of a return for the global sphere, and performing durability by operating as a perfect synchroniser between the two networks.

The trajectory in Figure 16 highlights life-stage 2001-2010 (A-E) as the most stable period for establishment of innovation. Within it, 2009 (D) has definitely been the most golden year for the entire Apulian large-scale PV project. On the contrary, the period 2011-2012 (F-G), due to its negative convergence score, accounts for a very weak solidity and indispensability of innovation. Such a state means today's PV project stand dangerously on the edge of an 'abyss'.

7. Concluding Remarks

The analysis and evaluation of the organisational processes of construction, maintenance and diffusion of innovation in the Apulian network object of this study demonstrated that, together with abundance of flat areas and sun exposure, there is also a complex, dynamic, fragile and interconnected number of other ingredients influencing and influenced by the adoption and spread of local large-scale PV technology.

Viewing the project through the local/global lens of Actor-Network Theory enabled me to travel back in time, open the Apulian 'PV black-box', chronologically analyse interests, alliances, strategies, arguments, contingent mechanisms of persuasion and translation, and finally take two pictures of its invisible driving forces and hybrid organisational forms. Each of these were shot in different crucial moments of its life: right after completion of the first successful 'translation' (a process in which REP advanced positions, assigned roles, set rules and finally induced its intermediaries to act in its own support), and right after occurrence of 'betrayal' (the moment in which REP and a number of other actors decided to drop their commitment to the PV project and carry out resistance in the form of a competitive network). Such detailed pictures emphasised how fluid and dynamic actors that emerge out of organisational contexts of interaction between a global and a local space are connected by means of a series of intermediaries located in a 'meso-level'.

Besides, a comparative discussion of the two snapshots not only acknowledged and confirmed the existence in this case study of socio-technical complexities and contingencies that are often ignored in traditional studies of technology (i.e. the presence of mutual relationships between innovation and society), it also consented to set out a historical mobilisation-implementation trajectory that allows reflections on the present state and guesses on the future of the PV project.

The trajectory highlighted the period 2008-2010 as the most stable one for establishment of innovation but, contrary to the latest official statistics, it also underlined a sudden decreasing solidity and indispensability trend for the last two years. Following ANT, such a negative tendency appeared to be so pronounced that today it is safe to alarm the entire large-scale PV sector of Apulia for being standing in a situation of danger for its future existence.

ANT provided me with powerful theoretical and methodological tools, through which I managed to verify three general aspects of actor-networks. First, that they cannot simply be defined as "self-evident, unproblematic and largely unquestioned conceptual frameworks" established around inputs and outputs (Cressman 2009:10, see also Blair 2004). Second, that when resistance occurs and interests are not perfectly aligned, they face a critical moment and an impoverishment which is reflected in their loss of convergence. This in turn leads to a more or less emphasised (and visible from the outside) slowdown of technology implementation. Finally, that the complex patterns responsible for spread of innovation can reveal the fragility of designing networks of power around four-stage translation processes soaked with initial enrolment freedom and lack of coercion. Freedom and natural devotion of network constituents emerged as a double-edged sword in Apulia. Here, although the lack of early restrictions was a condition that helped implementing technology at the outset of the network, the inherent dynamic state of the system turned an originally strong structure in a very fragile one due to scarce presence of coordination and severe rules. Minor changes in the global network and resistance in the local one fully proved the cohesion of the entire system which, until then, had only shown its strength. In a context of this kind, my case study demonstrates the significance of marking a positive 'convergence score', as this proved to be a factor capable of guaranteeing temporary durability and reliability of the PV innovation project, even when the fleeting degree of local (or of global) network mobilisation marked a record low for a limited period of time.

Future directions

Due to explanatory nature of ANT (Bakhshaie 2008), trying to predict future directions of the PV project is no easy task. The only certainty is that whatever comes out of the courtrooms of Apulia, it will inevitably change the trajectory of the project. Whether a compromise solution will be found or not at a local level, the outcome will anyway inexorably affect shape and durability of the whole PV network.

Next years' developments will show whether or not the most recent on-going trends[19], resulting from negotiations that are currently in place around the support of a new-born 'roof-by-roof' variant of PV technology, will pay off in terms of the enrolment of undecided constituents (currently taking part in both networks or in none of them), the successful performance of translation, and the achievement of 'black-boxing'. As one successful system precludes the existence of the other, from the small-scale network point of view, the aim will certainly be destined at deteriorating and impoverishing as much as possible the long chain of associations and connections that made the fortunes of the large-scale system in these last few years. Only in this way it may think of ultimately obtaining defeat, repulsion from Apulia, and failure of its no longer solid competitor.

The war between the two factions has just been opened and it is presently taking place into the courts of Apulia, where the general impression is that the large-scale PV system is using its last cards to ensure for itself a golden future.

My large-scale network analysis shown that the project is currently not as strong as it used to be before betrayal occurred. Therefore, its death and dissolution may very likely happen to occur in the next few months, especially if another series of local low alignment scores occurs, not accompanied by a

[19] Partial data available on 'Atlasole', the statistical portal of GSE, denote a considerable on-going turnaround of the Apulian way of developing photovoltaic technology. By the time of consultation, the average installed power in each power plant of Apulia had decreased from 95.4 kW_p (31.12.2011), to 75.1 kW_p (15.11.2012). If such temporary statistics find confirmation in the final 2012 report (to be published by GSE in mid-2013), as per ANT, the decreasing trend could well be considered as an indicator of the rapid catch up and/or overtaking employed by the Apulian small-scale PV technology/network against its dying large-scale alternative, occurred in the course of the year 2012 (Source: http://atlasole.gse.it/atlasole/).

decisive increase in contribution provided by the global network (currently far from the average level of commitment offered in the decade 2001-2010, and appearing as gradually getting closer to the small-scale network's needs), or vice-versa.

Reflections on the study

My personal description and analysis of the PV project is offered here with an attempt at being as neutral as possible. Yet, my research makes no claim to be objective. My position and subjectivist epistemological vision of the Apulian PV network informed the analysis in parallel with the presented observations, facts, statistics and information. However, I hope this study provides an interesting contribution to the field of Science and Technology Studies (STS), despite the constraints represented by its page limit. I also hope that it manages to add something to the current limited comprehension of how to track and help ensuring the success and implementation of complex, large-scale innovation projects in the renewable energy sector.

I found the employment of ANT as both captivating and frustrating. Captivating because, by working on factors that are very often ignored by traditional approaches to innovation, I could touch with my own hands its potential to explore why, but especially how we have the spread of large-scale PV technology that we do today in Apulia. Frustrating not only because it proved difficult to constantly adopt its cardinal principles and to capture and convey the opinions and interpretations of various human beings 'on the move', as they were situated in the dynamic network itself; mainly because it is always up to the analyst to choose both what matters the most in an actor-network and its degree of 'convergence score' to be assigned over time. In particular, throughout the collection and analysis of data gathered on field I often found myself in a difficult situation: I had to decide whether or not a factor mattered with the PV network that I was trying to reconstruct. In addition, another issue concerned the so-called 'periphery' of the PV system. Here, it was never easy to decide the points in which to cut the network off,

thus completely forget about interests, strategies, arguments, negotiations and roles played by actors that had consciously and deliberately been left outside my investigated world.

In conclusion, this case study can overall teach us that mitigation measures of climate change, even when emerged out of stable contexts that seem not to face any strong barrier, (if not carefully planned in advance) may go ‘too far’, and possibly transform themselves in actions that could well become for some of the players involved, paradigms of ‘unsustainable’ development.

At the moment, the Apulian *Fields of Gold* remain for the majority of the people that I have interviewed ‘fields of speculation’. However, for me they keep on being only ‘fields of successful translation’.

Appendix 1: PV in Italy

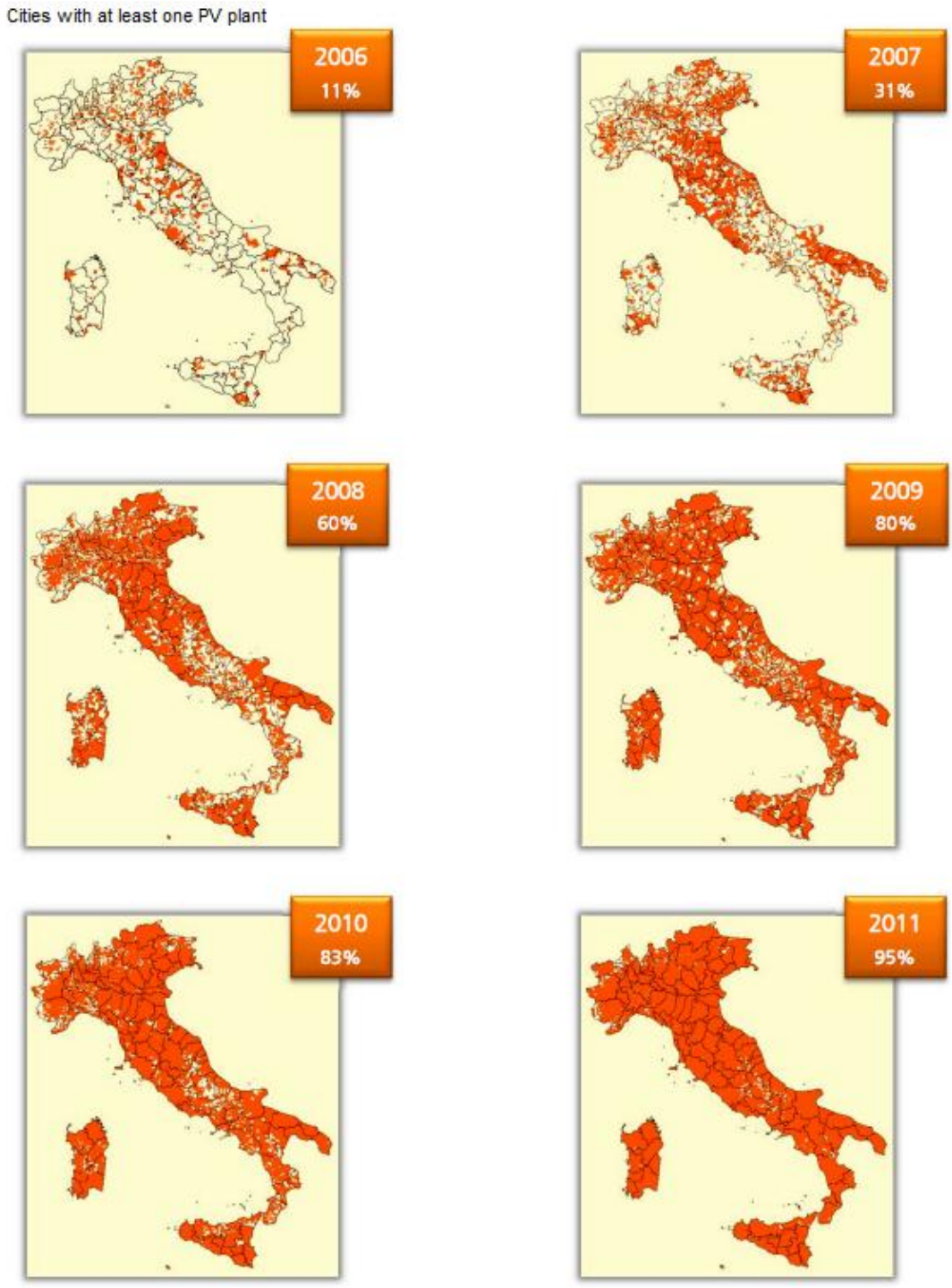


Figure 17: Penetration of PV technology in Italy (Source: adopted and translated from GSE 2012a:13).

Appendix 2: Average Solar Radiation in Italy

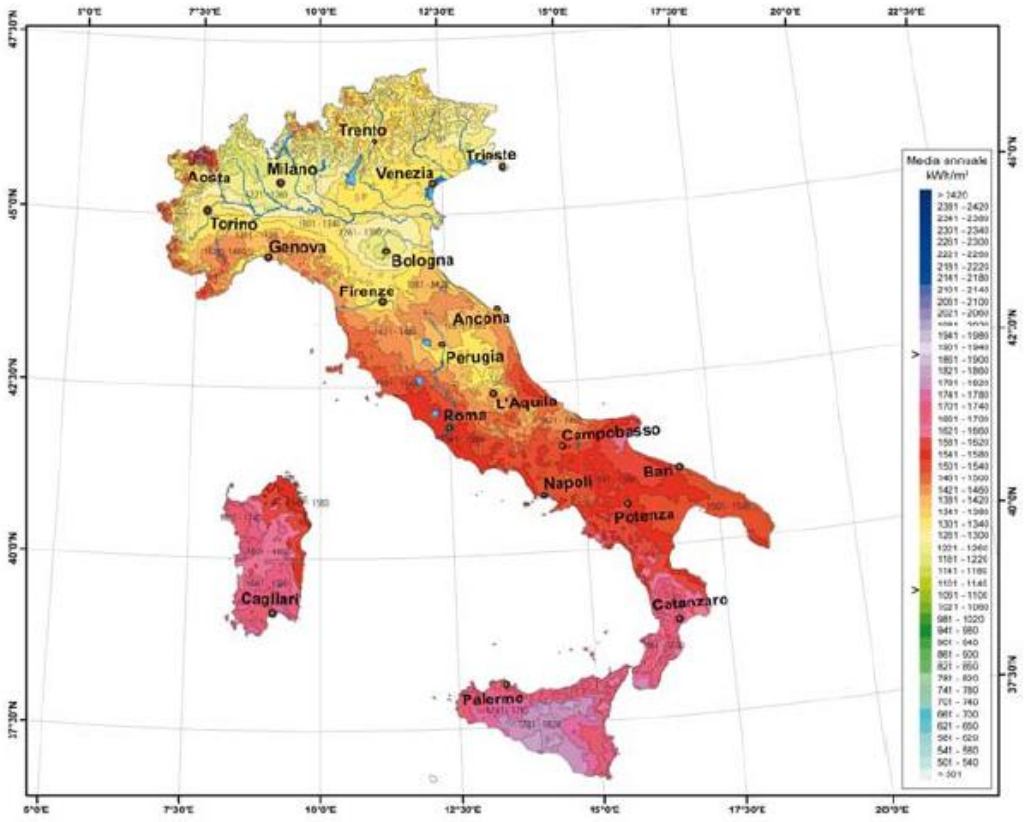


Figure 18: Average solar radiation hitting Italy in the period 1981-2000 (unit: kWh/m^2) (Source: GSE 2012a:7).

Appendix 3: List of Interviews

Respondent Code (ref. in text)	Interview Group or Institution	Audio - Written	Sex (M/F)	Individual - Pair - Group	Location (district)	Date
State and Local Government Institutions						
R1	*REP*	A	M	I	Bari	Sep 2011
R2	*REP*	A	M	I	Bari	Jun 2011
R3	*DNA*	A	M	I	Lecce	Jul 2011
R4	*PROV*	A	M	I	Brindisi	Jul 2011
R5	*REP*	A	M	P	Bari	Sep 2011
R6	*REP*	A	F	I	Bari	Jul 2011
R7	*REP*	A	F	I	Bari	Sep 2011
R8	*REP*	A	F	I	Bari	Sep 2011
R9	*REP*	A	F	I	Bari	Sep 2011
Municipal Officials						
R10	*MUN*	A	M	I	Lecce	Jun 2011
R11	*MUN*	A	M	I	Lecce	Jun 2011 Apr 2012
R12	*MUN*	A	M	I	Brindisi	Apr 2012
Academic Institutions and Experts						
R13	*EXP*	A	M	I	Bari	Sep 2011 Apr 2012
R14	*EXP*	A	M	I	Bari	Sep 2011
R15	*EXP*	A	M	I	Lecce	Jun 2011
R16	*EXP*	A	M	I	Lecce	Jun 2011

Private Sector						
R17	*COMP*	A	M	I	Lecce	Jun 2011 Apr 2012
R18	*COMP*	A	M	I	Brindisi	Jul 2011
R19	*INT*	A	M	P	Bari	Jul 2011 Apr 2012
R20	*COMP*	A	F	I	Bari	Sep 2011 Apr 2012
Media						
R21	*MM*	A	M	I	Lecce	Jun 2011 Apr 2012
R22	*MM*	A	F	I	Lecce	Sep 2011
NGOs						
R23	*NGO*	A	M	I	Bari	Jun 2011 Apr 2012
R24	*NGO*	A	M	I	Bari	Jul 2011
R25	*NGO*	A	M	I	Bari	Jul 2011
Civil Society						
R26	*CS*	A	M	I	Lecce	Sep 2011 Apr 2012
R27	*CS*	A	M	I	Lecce	Sep 2011
R28	*CS*	A	M	I	Brindisi	Aug 2011 Apr 2012
R29	*CS*	A	M	I	Lecce	Sep 2011
R30	*CS*	A	M	G	Lecce	Jun 2011
R31	*CS*	A	F	I	Taranto	Apr 2012
R32	*CS*	W	F	I	Lecce	Sep 2011

Public Meetings, Seminars, Conferences, and Other						
R33	*CON*	W	-	-	BAT	Jun 2011
R34	*CON*	W	-	-	Bari	Jun 2011
R35	*CON*	W	-	-	Bari	Sep 2011
R36	*CON*	W	-	-	Lecce	Sep 2011

Appendix 4: List of Relevant Laws

CODE (ref. in text)	ORIGINAL NAME OF THE LAW	NAME ADOPTED IN THE TEXT	YEAR OF ISSUE
D 2001/77/EC	'*Directive 2001/77/EC of the European Parliament and of the Council of 27 September 2001 on the promotion of electricity from renewable energy sources in the internal electricity market*'	Directive 2001/77/EC of the European Parliament and of the Council of 27 September 2001	2001
LD 387/2003	'*Attuazione della direttiva 2001/77/CE relativa alla promozione dell'energia elettrica prodotta da fonti energetiche rinnovabili nel mercato interno dell'elettricità (GU n.25 del 31-1-2004 - Suppl. Ordinario n. 17)*'	Legislative Decree No. 387 of 29 December 2003	2003
MD 28/07/2005	'*Criteri per l'incentivazione della produzione di energia elettrica mediante conversione fotovoltaica della fonte solare*'	*First* '*Conto Energia*'	2005
MD 06/02/2006	'*Criteri per l'incentivazione della produzione di energia elettrica mediante conversione fotovoltaica della fonte solare*'	*First* '*Conto Energia*' (integration)	2006
MD 19/02/2007	'*Criteri e modalità per incentivare la produzione di energia elettrica mediante conversione fotovoltaica della fonte solare*'	*Second* '*Conto Energia*'	2007
RES 2007/827/REP	'*Deliberazione della Giunta Regionale No. 827 del 8 Giugno 2007 del Registro delle Deliberazioni, Regione Puglia. Adozione del Piano Energetico Ambientale Regionale*'	Regional Environmental Energy Plan (PEAR)	2007
RL 1/08	'*Disposizioni integrative e modifiche della legge regionale 31 dicembre 2007, n. 40 (Disposizioni per la formazione del bilancio di previsione 2008 e bilancio pluriennale 2008-2010 della Regione Puglia) e prima variazione al bilancio di previsione per l'esercizio finanziario 2008*'	Regional Law No. 1/08	2008
RL 31/08	'*Norme in materia di produzione di energia da fonti rinnovabili e per la riduzione di immissioni inquinanti in materia ambientale*'	Regional Law No. 31/08	2008
D 2009/28/EC	'*Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC*'	Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009	2009

L 13/2009	'*Conversione in legge, con modificazioni, del decreto-legge 30 dicembre 2008, n. 208, recante misure straordinarie in materia di risorse idriche e di protezione dell'ambiente*'	Law No. 13/2009	2009
ICC 119/10	'*Sentenza Corte Costituzionale 26 marzo 2010, n. 119. Energia - Impianti a fonti rinnovabili - Autorizzazione - Lr Puglia 31/2008 - Illegittimità costituzionale degli articoli 1, 2, commi 1 e 2, 3, 4, 7, comma 1*'	Italian Constitutional Court's decision No. 119 of 26 March 2010	2010
MD 06/08/2010	'*Termini, modalità e procedure per la concessione ed erogazione delle agevolazioni in favore dei programmi di investimento riguardanti la produzione di beni strumentali funzionali allo sviluppo delle fonti di energia rinnovabili e al risparmio energetico nell'edilizia*'	*Third* '*Conto Energia*'	2010
LD 28/2011	'*Attuazione della direttiva 2009/28/CE sulla promozione dell'uso dell'energia da fonti rinnovabili, recante modifica e successiva abrogazione delle direttive 2001/77/CE e 2003/30/CE*'	Renewables Decree	2011
MD 05/05/2011	'*Incentivazione della produzione di energia elettrica da impianti solari fotovoltaici*'	*Fourth* '*Conto Energia*'	2011
L 27/2012	'*Conversione del Decreto 'Liberalizzazioni'*'	Liberalisation Decree	2012
MD 15/03/2012	'*Definizione degli obiettivi regionali in materia di fonti rinnovabili*'	Burden Sharing	2012
MD 05/07/2012	'*Incentivazione della produzione di energia elettrica da impianti solari fotovoltaici*'	*Fifth* '*Conto Energia*'	2012
RL 25/12	'*Regolazione dell'uso dell'energia da fonti rinnovabili*'	Regional Law No. 25/12	2012

Appendix 5: The *Fourth* and *Fifth Conto Energia*

Conto Energia IV

Under the *Fourth Conto Energia*, the regressive 20-year tariffs granted to large-scale PV plants (category: 'ordinary PV plants' → 'other PV plants'. See also Figure 7 below) were equal to:

Class: Nominal power comprised between 200 kW_p and 1 GW_p:

- **0.291 €/kWh** for PV plants in operation from June 2011;
- **0.276 €/kWh** for PV plants in operation from July 2011;
- **0.263 €/kWh** for PV plants in operation from August 2011;
- **0.245 €/kWh** for PV plants in operation from September 2011;
- **0.233 €/kWh** for PV plants in operation from October 2011;
- **0.210 €/kWh** for PV plants in operation from November 2011;
- **0.189 €/kWh** for PV plants in operation from December 2011;
- **0.172 €/kWh** for PV plants in operation from the 1st Semester 2012;
- **0.155 €/kWh** for PV plants in operation from the 2nd Semester 2012.

Class: Nominal power comprised between 1 GW_p and 5 GW_p:

- **0.277 €/kWh** for PV plants in operation from June 2011;
- **0.264 €/kWh** for PV plants in operation from July 2011;
- **0.250 €/kWh** for PV plants in operation from August 2011;
- **0.243 €/kWh** for PV plants in operation from September 2011;
- **0.223 €/kWh** for PV plants in operation from October 2011;
- **0.201 €/kWh** for PV plants in operation from November 2011;
- **0.181 €/kWh** for PV plants in operation from December 2011;
- **0.156 €/kWh** for PV plants in operation from the 1st Semester 2012;
- **0.140 €/kWh** for PV plants in operation from the 2nd Semester 2012.

Class: Nominal power higher than 5 GW_p:

- **0.264 €/kWh** for PV plants in operation from June 2011;
- **0.251 €/kWh** for PV plants in operation from July 2011;
- **0.238 €/kWh** for PV plants in operation from August 2011;
- **0.231 €/kWh** for PV plants in operation from September 2011;
- **0.212 €/kWh** for PV plants in operation from October 2011;
- **0.191 €/kWh** for PV plants in operation from November 2011;
- **0.172 €/kWh** for PV plants in operation from December 2011;
- **0.148 €/kWh** for PV plants in operation from the 1st Semester 2012;
- **0.133 €/kWh** for PV plants in operation from the 2nd Semester 2012.

Conto Energia V

Under the *Fifth Conto Energia*, the regressive 20-year 'overall tariffs'[20] granted to large-scale PV plants (category: 'PV plants' → 'other PV plants') that feed their entire produced electricity in the grid, are equal to:

Class: Nominal power comprised between 200 kW_p and 1 GW_p:

- **0.135 €/kWh** for PV plants in operation from the 1st Semester;
- **0.124 €/kWh** for PV plants in operation from the 2nd Semester;
- **0.113 €/kWh** for PV plants in operation from the 3rd Semester;
- **0.107 €/kWh** for PV plants in operation from the 4th Semester;
- **0.102 €/kWh** for PV plants in operation from the 5th Semester.

Class: Nominal power comprised between 1 GW_p and 5 GW_p:

- **0.120 €/kWh** for PV plants in operation from the 1st Semester;
- **0.113 €/kWh** for PV plants in operation from the 2nd Semester;
- **0.106 €/kWh** for PV plants in operation from the 3rd Semester;
- **0.101 €/kWh** for PV plants in operation from the 4th Semester;
- **0.097 €/kWh** for PV plants in operation from the 5th Semester.

[20] For PV plants up to 1 MW_p the 'overall tariffs' include for the first time both the production premium and the price for the sale of the energy produced by the PV system. PV plants with a nominal power exceeding 1 MW_p are no longer enabled to sell the electricity to the GSE, but have to sell it to the market through bilateral power purchase agreements or through the Power Exchange. Therefore, for this last category of large PV plants, the tariff reported here does not include any price for the sale of the energy produced (MWE 2012).

Class: Nominal power higher than 5 GW_p:

- **0.113 €/kWh** for PV plants in operation from the 1st Semester;
- **0.106 €/kWh** for PV plants in operation from the 2nd Semester;
- **0.099 €/kWh** for PV plants in operation from the 3rd Semester;
- **0.095 €/kWh** for PV plants in operation from the 4th Semester;
- **0.092 €/kWh** for PV plants in operation from the 5th Semester.

Differently, the regressive 20-year tariffs granted to large-scale PV plants (category: 'PV plants' → 'other PV plants') whose owners decide to self-consume the electricity produced, become equal to:

Class: Nominal power comprised between 200 kW_p and 1 GW_p:

- **0.053 €/kWh** for PV plants in operation from the 1st Semester;
- **0.042 €/kWh** for PV plants in operation from the 2nd Semester;
- **0.031 €/kWh** for PV plants in operation from the 3rd Semester;
- **0.025 €/kWh** for PV plants in operation from the 4th Semester;
- **0.020 €/kWh** for PV plants in operation from the 5th Semester.

Class: Nominal power comprised between 1 GW_p and 5 GW_p:

- **0.038 €/kWh** for PV plants in operation from the 1st Semester;
- **0.031 €/kWh** for PV plants in operation from the 2nd Semester;
- **0.024 €/kWh** for PV plants in operation from the 3rd Semester;
- **0.019 €/kWh** for PV plants in operation from the 4th Semester;
- **0.015 €/kWh** for PV plants in operation from the 5th Semester.

Class: Nominal power higher than 5 GW_p:

- **0.031 €/kWh** for PV plants in operation from the 1st Semester;
- **0.024 €/kWh** for PV plants in operation from the 2nd Semester;
- **0.017 €/kWh** for PV plants in operation from the 3rd Semester;
- **0.013 €/kWh** for PV plants in operation from the 4th Semester;
- **0.010 €/kWh** for PV plants in operation from the 5th Semester.

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