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Towards a participatory renewable energy transition in Latin America:

Social enterprises and the promotion of decentralized solar energy systems

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Declaration

I, Sebastian Nagenborg, declare that this thesis is a result of my research investigations and findings. Sources of information other than my own have been acknowledged and a reference list has been appended. This work has not been previously submitted to any other university for award of any type of academic degree.

Signature……

Date……

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Abstract

Renewable energies are indispensable for Latin America to reduce greenhouse gas emissions, mitigate climate change and increase energy security. To reach these goals, the countries of the region trust in large-scale projects, technological advances and sound investment conditions.

"Towards a participatory renewable energy transition in Latin America: Social enterprises and the promotion of decentralized solar energy systems" investigates the limitations and challenges of this techno-economic approach. The thesis explores why the future generation and supply of energy must be embedded in a more participatory framework to be truly sustainable and fair. The Argentinean company *Colectando Sol* embodies this vision, as it encourages a widespread involvement of citizens in the energy transition through the promotion and production of solar power.

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1. Introduction

Before starting the Master Programme in International Development Studies at NBMU, I was involved in diverse projects of development agencies and non-profit entities in Latin America that addressed the subject of renewable energies. While the paternalistic approach of the agencies aimed at advancing the share of renewables in national energy matrixes, the NGO engagements provided me with critical insight into grassroots perceptions of, and responses to such one-dimensional goals. The combination of both perspectives revealed the foundation of the transition to renewable energies in Latin America: The abundant renewable potential of the region is meant to be exploited on the base of technology transfers and the creation of economic incentives for investments in large-scale projects. This focus poses a problem insofar, as most of these projects undermine the interests and concerns of those people that are immediately affected by the social, cultural and ecological repercussions of the technological interventions. The consequences are fundamental conflicts between development and democracy or development and conservation.

Despite these contestations, the advancement of renewable energies appears to be indispensable for both the future energy security and the reduction of greenhouse gas emissions on the double continent. The need for expanding the renewable energy production becomes particularly evident when considering that in 2016, Latin America still derived 95% of its energy consumption from finite fossil fuels and large-scale hydropower (BP, 2017). Hence, the main object of investigation in this thesis is not *whether* Latin America requires an energy transition, but rather *how* regenerative forms of energy should be harnessed and *who* gets to benefit from them.

The generation of energy in the region must, therefore, focus on a different approach, which does include renewable sources and technologies, but likewise enables people to co-determine the implementation of projects. Small decentralized solar systems offer a promising approach due to their focus on locally conceived, shaped and supported solutions in both urban and rural contexts. Decisive institutions to promote the implementation of decentralized energy solutions are legislative authorities, and notably enterprises that dedicate their business mission to tackling specific problems faced by communities. The relevance of social enterprises for the decentralized generation of solar energy constitutes a theory that was born during my attendance of a practical semester on Corporate Social Responsibility in Argentina. This semester acquainted me with the responsibility of companies for social equity and sustainable

development in Latin America. It was here that I was introduced to the triple impact business model *Empresas B* and the start-up company *Colectando Sol*, which promotes social equity through solar energy solutions. The investigation of this rather unique business mission, together with the progressive political endorsement of decentralized energy systems, account for the main reasons to select Argentina as my research country.

Altogether, diverse field experiences – further nurtured by inputs from my Master studies – made me dedicate this thesis to analyzing the current patterns of the energy transition in Latin America, the benefits of decentralized solar energy systems, and the role of social enterprises in promoting the participatory generation of solar energy. The following research questions emerge as a result from this analytical focus:

1) What are the socio-ecological repercussions and democratic deficiencies of renewable energy technologies in Latin America when applied in large-scale projects?

2) How are decentralized solar energy systems key in strengthening participation in the renewable energy transition?

3) What are the critical challenges for the implementation of decentralized solar energy systems in Latin America, and how can social enterprises become a main driver of a socially inclusive energy transition? The case of *Colectando Sol* in Argentina.

1.1 Analytical framework and the organization of the thesis

The logical arrangement of the research questions implies the subdivision of the thesis in two parts: Part 1 analyzes "the dominance of large-scale projects in Latin America's energy transition", while part 2 makes "decentralized photovoltaic energy and social enterprises in Argentina" the subject of investigation.

The first part begins with background information about the situation of renewable energies in Latin America and then links to Alf Hornborg's work on the fetishization of the machine. The work of the Swedish Anthropologist allows establishing a theoretical framework for the propensity of societies to trust in techno-economic solutions for profound socio-ecological challenges. On this basis, the large-scale production of wind energy in Mexico, hydropower in Chile and biofuel in Brazil serve to illustrate that technological interventions create or consolidate power imbalances to the disadvantage of local communities and ecosystems. The main deficit of renewable technologies is determined as an inadequate involvement of affected

peoples in decision-making processes. *Participation* is therefore introduced as a key concept at this point.

Consequently, this work advocates a more drastic alternative for the future energy supply: Small-scale photovoltaic energy systems that encourage the democratic participation of people in the generation of energy, from the development of a project to the implementation and evaluation on site. Several reports and studies investigate the possibilities and properties of decentralized solar systems. However, existing literature provides few indications for how countries in Latin American could address a coherent implementation of decentralized photovoltaic systems, and for how such a far-reaching transformation may attract citizen support.

The second part of the thesis therefore links back to Latin America. It aims to empirically substantiate the opportunities and challenges of decentralized photovoltaic energy systems by investigating Argentina's renewable energy policies and the social business model of the enterprise *Colectando Sol* in Buenos Aires. The second part is introduced by a summary of the legislative project on the distributed energy generation,[1] which provides a framework for the private production and trade of energy. This political progress is, however, contrasted with high degrees of unreliability in the Argentine energy sector and a progressive impoverishment of the middle class under president Mauricio Macri. This discrepancy nurtures inevitably the assumption that only a few, and mostly wealthy, people will be able to generate their own energy from decentralized photovoltaic systems.

In this context, I conducted a quantitative survey in the Partido[2] Almirante Brown, in the south of Buenos Aires province. The purpose of this study is to examine the extent to which the urban Argentinean society is aware of, interested in, and equipped with the resources, to participate in the decentralized generation of photovoltaic energy. The research findings reveal that important requirements are missing for the participation of a broad range of population groups in the benefits of the *ley sobre la generación distribuida de energias renovables*. These requirements can be summarized as education and empowerment, thereby introducing two further key concepts to this thesis.

[1] Original title: *Ley sobre la generación distribuida de energias renovables*

[2] *Partidos* are the highest-ranking administrative units under the provincial level in Buenos Aires province

Decisive actors in promoting education, empowerment, and participation are social enterprises due to their intimate collaboration with communities. Such enterprises are currently being institutionalized in Argentina under the BIC[3] Act. Given the value of this business model for the case study, a separate chapter will outline the historical, theoretical and institutional foundations of BIC companies in Argentina. Likewise, the characteristics of this business model are accentuated, notably their pursuit of a triple bottom line and the formation of communities of practice.

Building on the main characteristics of BIC companies, *Colectando Sol* vigorously promotes the widespread participation of Argentinean citizens in the benefits of solar energy. To this end, the company puts education and empowerment of people at the center of its business operations. In this context, a second survey is conducted to examine whether *Colectando Sol*'s workshops exert an impact on the attendees' ability and willingness to engage in renewable energy issues and decentralized photovoltaic projects beyond the scope of a workshop.

The expansion of decentralized photovoltaic systems, on the other hand, faces substantial climatic, political-economic and ecological challenges. It is vital to include them in this thesis since they can compromise the widespread proliferation of autonomous energy systems within a society. Decision-makers are therefore well advised to take these challenges into account when developing policies and business models that strengthen the decentralized generation of energy.

1.2 Methodology

The subdivision of the thesis in two parts – and the usage of "participation in renewable technologies" as a connecting element between these parts – also reflect in the methodology. While the first part is based exclusively on literature review, the second part combines literature review with diverse methods of qualitative and quantitative data collection that were applied during fieldwork in Argentina.

The first part builds predominantly on empirical data provided by secondary sources. Diverse climate-related reports serve to give an overview of renewable energies in Latin America, for instance, *Climate Scope* from Bloomberg New Energy Finance. The theoretical framework for

[3] BIC is the abbreviation for *Sociedades de Beneficio e Interés Colectivo*; in English: Collective Benefit and Interest Company. They are hereinafter referred to as BIC companies.

the interpretation of the techno-economic focus of large-scale renewable projects draws mainly on Alf Hornborg's book *The Power of the Machine: Global Inequalities of Economy, Technology, and Environment.* On this basis, the examples from Mexico, Chile and Brazil are analyzed. The input for this chapter was provided by diverse literature that encompasses analytical reports, peer-reviewed journal articles, and human rights reports by Amnesty International or the Chilean Ethics Commission Against Torture. The second crucial theoretical framework for the thesis is constituted by Sherry Arnstein's model of participation stages, and more recent participation literature from Arturo Escobar and David Mosse, among others. The application of the research strategy *triangulation* at this point is important to do justice to the diversity of interpretations that surround the term *participation* within the field of international development.

Triangulation is also vital for the subsequent chapter on decentralized photovoltaic systems. The chapter seeks to highlight axiomatic, universally valid benefits of decentralized photovoltaic systems by conflating the key observations of diverse sources. These sources include the publication *Sustainable cities and energy policies*, the standard report of the International Energy Agency, *Solar energy perspectives*, as well as journal articles that draw on empirical experiences from urban case studies.

The chapter on decentralized photovoltaic systems builds a bridge between the first and second part of the thesis. The second part uses the example of Argentina and *Colectando Sol* to confront the theoretical opportunities of solar energy with its practical limits and chances in Latin America. Necessary insights and data for this case study cannot be derived from literature review. To this end, diverse qualitative and quantitative research methods were applied in a complementary manner. All data for the second part have been collected between 19 September and 21 October 2017 within Buenos Aires province, while the data revision began in the same period and stretched until the end of December.

Several individual interviews and one comprehensive survey build up the Argentinean context for the case study *Colectando Sol*. The interviews are meant to provide contextual and supplementary information to the two legislative projects that are relevant to this thesis: The *ley sobre la generación distribuida de energias renovables* and the BIC Act. The main sources for both legislative projects are constituted by the corresponding legislative texts. The interviews increase the validity of my research, as they convey personal impressions and non-

public information on the status and implications of the legislative projects. The interview partners represent some of the projects' key advocates. For the distributed energy generation, the interviewees include national congressman Juan Carlos Villalonga, as well as Carolina Estebarena, who serves as a legislator for the city of Buenos Aires. With regard to the BIC Act, I could interview national congresswoman Cornelia Schmidt-Liermann, the lawyer Sebastian Sal, and Gabriel Salvia, director of the think tank Center for the Opening and Development of Latin America (CADAL).

Unlike interviews, quantitative surveys enable the coverage of a large sample and allow to make statements with high universality. Therefore, this research method is suitable for quantifying the degree of awareness, interest and financial means in Argentina concerning the decentralized generation of solar energy. The Partido Almirante Brown was selected for this survey because it integrates all Argentinean classes and hence constitutes a microcosm of the country's society (ODSA, & Cáritas Argentina, 2011). After all, the emphasis of the quantitative survey is not placed on specific target groups or individuals, but rather on macrosocial consciousness and tendencies. The selection of respondents therefore occurred randomly. The survey included 200 anonymous subjects and was conducted between 20 and 23 September 2017 by house visits and in front of a shopping center. The results of this study indicate a clear need for *Colectando Sol*'s mission to promote citizen participation in the decentralized generation of solar power.

My research with *Colectando Sol* unites the methods of participatory observation, individual interviews, the evaluation of documents, and finally a quantitative survey. A participatory observation during two workshops at the end of September and in mid-October 2017 enabled me to comprehend why and how exactly the company empowers people to capture solar radiation; likewise, I could genuinely observe the attendees' responses to the instructions and interactions. Since detailed background knowledge, as well as feelings and thoughts on the workshops, cannot be entirely unveiled with this method, qualitative interviews and discussions were conducted with workshop attendees and Leandro Magri, director of *Colectando Sol*. As with the previous interviews, the key messages were included in the thesis and cited accordingly. In general, the insights gained through participatory observation provide the main source of information for the case study; other sources than that have been indicated appropriately.

These sources include, among others, business data and internal quality control documents provided by *Colectando Sol*: A feedback overview – which has been compiled at the end of workshops during 2017 and embraces a total of over 400 participants – serves to verify the satisfaction of attendees with the workshops and allows to identify improvement measures. Although the focus of the thesis is placed on how the business model benefits communities, the review of revenue and attendee figures is indispensable. After all, *Colectando Sol* is only able to sustain its social mission in the long run if its business model yields a financial profit.

In order to quantify the educational impact of the workshops by means of a large sample, I conducted a second survey. The purpose of this survey consists in verifying whether the collaborative and interactive nature of the workshops encourages a continuous engagement of the attendees in renewable energy issues and decentralized photovoltaic projects. The sample comprises 78 workshop attendees between 17 and 62 years. The data have been collected through anonymous questionnaires at the end of those workshops where the participatory observation method was applied. The survey is, however, limited to verifying the attendees' willingness and declarations of intent. The reason for this is twofold: Firstly, the observation of the attendees in their private realm would go beyond the limits of the research stay. Secondly, the law on the distributed energy generation has yet to be put into effect. Its impact on the Argentinean society can therefore not be studied from an empirical perspective at this stage. Accordingly, the last thesis chapter on the challenges of decentralized photovoltaic systems resorts partly to empirical evidence from regions like the USA, where decentralized solar systems already prevail.

Altogether, even though this investigation is based on empirical data, some of the conclusions are normatively coined. For after all, this thesis places an emphasis on how decentralized solar energy systems may contribute to a sustainable and equitable energy supply in Argentina and Latin America.

PART 1: THE DOMINANCE OF LARGE-SCALE PROJECTS IN LATIN AMERICA'S ENERGY TRANSITION

2. The advancement of renewable energies in Latin America

Presently, three quarters of the energy consumption in Latin America is still based on fossil fuels, as illustrated in Figure 1. In particular, Venezuela, Ecuador and Bolivia adhere to state control and distribution of fossil resources. These South American states provide generous energy subsidies and demonstrate a considerable dependence on government revenues from oil and gas exports (Arroyo Currás, 2014). Despite the continued relevance of fossil fuels, renewable energies are clearly on the rise in Latin America. Against the background of favorable natural conditions for the harnessing of renewable energies and the contributions that technologies can make to emission reduction, energy supply and economic growth, the annual capacity additions increased considerably over the past years, as shown by Figure 2.

The predominant renewable energy source in Latin America has traditionally been hydropower. While this energy form makes up for 88% of the region's renewable energy matrix, biomass, wind, sun and geothermal energy constitute the remaining 12% (BP, 2017; Arroyo Currás, 2014). The challenges of a heavy reliance on hydropower and the potential of other renewable energy forms have compelled several countries of the region to contemplate energy diversification and endorse the development of non-hydro renewables (Díaz, Cano, & Murphy, 2016). The natural landscapes and conditions in Latin America provide sound prerequisites for the generation of a wide array of renewable energies. In addition to the countless rivers that are suitable for hydropower, the Andean highlands, Patagonia and the coastlines are favourable for harnessing wind energy. The equatorial areas and Andean highlands are particularly exposed to strong solar radiation, while numerous volcanoes offer possibilities for the generation of geothermal energy. Plantations for oil palms, bananas and sugar cane emit substantial amounts of by-products, which can be used for biogas production (Arroyo Currás, 2014).

Although the region has yet to tackle diverse challenges in the production of renewable energies, the abundant potential is increasingly being exploited. This is demonstrated by the fact that renewable energy capacities increased by more than 270% between 2006 and 2013, with USD 16 billion having been invested in green power plants in 2013 (Raspe, 2015). Figure 2 shows that renewable energy investments in Latin America even accelerated in 2014. While

capacity additions of hydropower receded in that period, wind energy experienced a considerable growth of 3.5 gigawatts compared to the previous year. Despite a slight decline in 2015, Latin America and the Caribbean boasted higher renewable energy penetration than any other world region assessed in the Climate Scope 2016. By the end of 2015, biomass, wind, small hydro, solar and geothermal power projects represented 12% of the overall energy capacities in the region (Bloomberg New Energy Finance, 2016). By comparison, in Asia, these energy sources accounted for 10% of total installed capacity, whereas in Africa and the Middle East and North Africa they totaled 3% and less than 1%, respectively (Bloomberg New Energy Finance, 2016). A joint report by WWF, ECOFYS & OMA (2011) claims that ecological power plants in Latin America could generate 20 times more electricity than needed by 2050; only the potential of wind power exceeds the current electricity consumption of all South American countries. The recent capacity increases and the diversification of renewable energies in Latin America coincide with the adoption of investor-friendly policies and incentives for large-scale renewable energy projects in many countries of the region (Raspe, 2015).

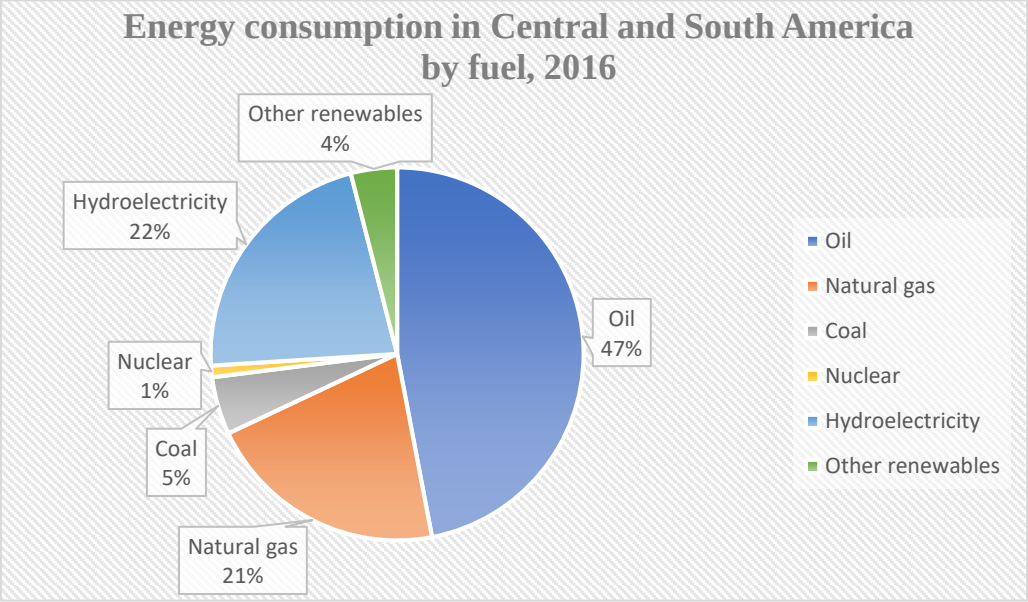

Figure 1: Energy consumption in Central and South America (including Mexico) by fuel, 2016 (BP, 2017).

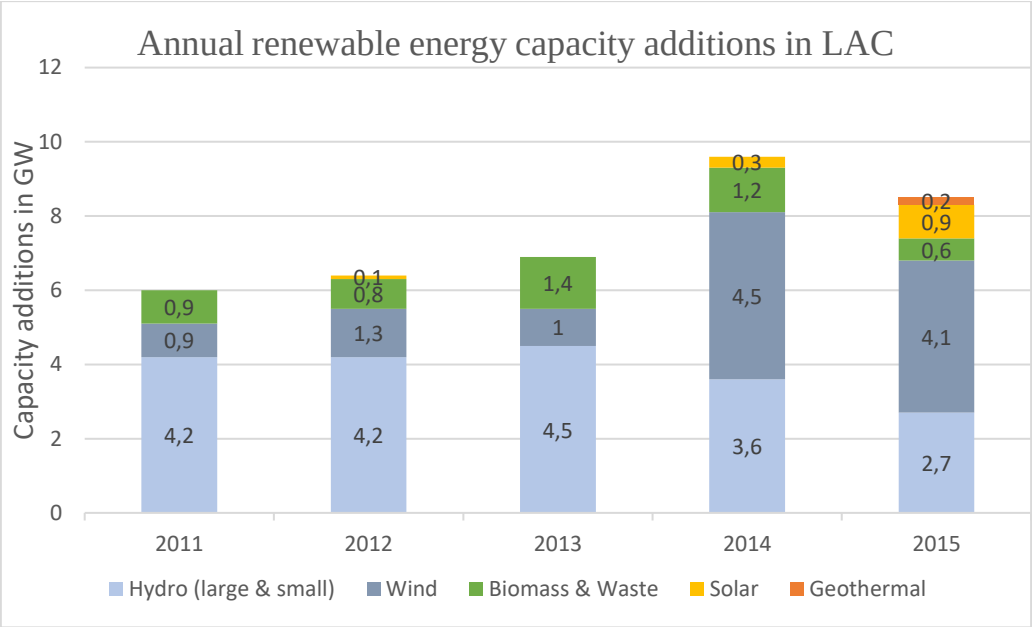

Figure 2: Annual renewable energy capacity additions in gigawatts in Latin America and the Caribbean, 2011-2015 (Bloomberg New Energy Finance, 2016).

In most Latin American countries, the opening of the energy markets, the provision of investment security for the private sector and technological progress account for the vital pre-requirements of renewable energy capacity expansions (Arroyo Currás, 2014). Such policies have been implemented in most of the region's countries: The governments in Mexico, Chile and Colombia have pursued an increasingly liberal economic course in terms of energy policies (Díaz et al., 2016). A continuation of this trend can be recognized in Brazil, after the deposition of Dilma Rousseff, and in Peru after the election of President Pablo Kuczynski. The economic policy directives in the Andean state are particularly focused on the opening and modernization of the protected energy market (REN21, 2017). In Argentina, the conservative President Mauricio Macri advocates for the dismantling of energy subsidies and private investments in the renewable energy sector (Díaz et al., 2016). One of the most drastic energy reforms of the past few years took place in Mexico in 2015. The main goal of the reform is to improve deficient infrastructure, as well as to compensate the country’s insufficient economic and technological potential with the participation of foreign investors in the energy sector, especially with regard to renewable energy sources (Huesca-Pérez, Sheinbaum-Pardo, & Köppel, 2016).

Fundamentally, it can be observed that states with low fossil fuel reserves have imposed upon themselves particularly ambitious renewable energy targets. Chile, intends to generate up to 20% of its electricity from renewable energies by 2025; in Uruguay, more than half of the primary energy mix consists of regenerative energies, whereas Costa Rica already derives more

than 90% of the current power supply from water, wind and sun (Arroyo Currás, 2014; Bloomberg New Energy Finance, 2017). The growth potential of renewable energies and the ambitious climate targets require the region's countries to adopt market and investor-friendly policies, including funding programs, tax benefits, price guarantees, legal protections and technology imports (Díaz et al., 2016). Costa Rica, Chile, Peru, Mexico, Brazil, Uruguay and Argentina are among the countries that provide the most attractive conditions for investors (Arroyo Currás, 2014). A crucial regulatory instrument for the expansion of renewable energies in these countries is public auction. These auctions award land and financial concessions for the generation of energy to the highest private bidder (Arroyo Currás, 2014). Suppliers of wind power and photovoltaics have been competing in Brazil since 2009 to offer electricity at the lowest prices (Arroyo Currás, 2014). The cost development of various auctions in Uruguay, Brazil, Peru and Mexico shows a continuous price reduction. Auctions in Peru, Mexico and Chile in recent years have yielded prices that compete with the dominant hydroelectric power (Arroyo Currás, 2014; REN21, 2017).

The price competition at auctions reveals the international interest in Latin America as a future market for renewable energies. In particular, Chinese, European and US corporations are investing in the expansion of the regional renewable energy sector (McNeish, & Borchgrevink, 2015). Chinese companies as semi-state actors can offer energy projects with very low prices. European and US companies, on the other hand, often benefit from financial aid in the form of subsidized loans from bilateral and multilateral banks (WWF, ECOFYS & OMA, 2011). China, Europe and the USA also account for the regions, where the majority of renewable energy technologies are produced; investors from those regions naturally tend to bring along required technologies (WWF, ECOFYS & OMA, 2011). Renewable energy companies from Latin America, however, rarely appear at the auctions due to technological gaps and a lack of financing options – a circumstance which obstructs the development of an autonomous Latin-American renewable energy sector (Díaz et al., 2016). In recent years, efforts have been made to reverse this development: Several states of the region have joined forces in international unions and platforms in order to cooperate on proposing energy and economic policies. The Mercosur as well as the Pacific alliance with Mexico, Chile, Peru and Colombia envisage the promotion of transboundary energy projects, policies and integration, while AILAC[4] constitutes a group specifically motivated by climate policy (Edwards, Adarve, Bustos, & Roberts, 2016). Despite these endeavors to create regional energy alliances and strengthen the contribution of

[4] The Independent Alliance of Latin America and Caribbean.

regional capital and expertise, the overwhelming share of renewable energy investments is derived from outside the region, surpassing USD 3 billion every year since 2010 (Bloomberg New Energy Finance, 2017).

Although the situation in such a vast region is fragmented, the underlying trend is clearly discernible: The opening of regional energy markets, the creation of reliable legal and investment conditions for international investors, and the dissemination of mostly foreign technology build the center of the renewable energy transition in Latin America. The enduring foreign investment, the increasing energy demand of the population and the favorable natural conditions have triggered a veritable renewable energy boom, which, however, may overshadow the more harmful repercussions of the sector's expansion for both people and the environment.

3. The fetishization of technology and the reinforcement of asymmetries

With the Spanish and Portuguese conquest in the 16th century, Latin America's role as a supplier of primary goods for industrialized countries had found its beginning. This trend – though less obvious and with certain reservations – continues into today's post-colonial times. The exploitative relationship between supplier and recipient is particularly evident when looking at minerals and fossil energy resources (McNeish, & Borchgrevink, 2015). Analogical asymmetries arise from the exploitation of renewable energy resources, as they benefit domestic elites and foreign populations, while the communities that surround the energy production sites suffer the adverse consequences. The cost-benefit calculation, to which most renewable energy ventures are subjected, fails to include the concomitant social, cultural and ecological repercussions of the technological development and application in the final balance of renewable energy projects (McNeish, & Borchgrevink, 2015). Renewable energy ventures in Latin America tend to disrupt the ecological integrity, displace indigenous peoples, compromise their traditional ways of life and deprive them of their rights to democratic political participation. These repercussions, in turn, are not sufficiently disseminated to the public sphere, and often even deliberately neglected in calculations of cost-benefit by decision-makers (McNeish, & Borchgrevink, 2015). The problems of a purely capitalist-technological approach to socio-ecological problems – in this case energy insecurity and climate change – are subsequently analyzed on the base of Alf Hornborg's work. The Swedish human ecologist and anthropologist argues that technology development and dissemination often reinforce economic asymmetries and undermine socio-cultural fabrics and ecological integrity (Hornborg, 2001).

Given that Hornborg's argument draws on key principles of dependency and world system theory, the critical aspects of this theory will be outlined hereinafter and then linked to Hornborg's thoughts. Finally, empirical examples from renewable energy ventures across Latin America will be discussed in relation to this theory.

3.1 The power of the machine

In response to W.W. Rostow's modernization theory, that proposed underdevelopment as an endogenous deficit, the Dependency School conceived underdevelopment as a product of *dependency* (So, 2010). Andre Gunder Frank considered underdevelopment in Latin America to be a historical product of persistent foreign influence, which incorporated the region in a subordinate function within the international division of labor. Unequal trade and capital relations have maintained the dependency to this day and result in a permanent value transfer from the periphery to the center (So, 2010). Frank was inspired by Lenin, who extended the distinction between the proletariat and the bourgeoisie by introducing the ratio between the periphery and center as an exploitative relationship on the global scale (So, 2010). Immanuel Wallerstein drew on Frank's and Lenin's dichotomies when defining the concept of a *modern world system* in the eponymous study from 1974.

Yet, Wallerstein suggested that the world is too complicated to be classified in a binary system that only encompasses centers and peripheries. Against this background, one of the distinguishing elements of the world system theory emerged: the belief in a semi-periphery, providing for a three-part model. Wallerstein (2011) argued that economic history could be understood in terms of uneven relations of exchange and power between core areas, semi-peripheries and peripheries. According to Wallerstein, the origin of underdevelopment in semi-peripheries and peripheries dates back to the emergence of the global capitalist system in Europe during the long sixteenth century from 1450 to 1640 (Wallerstein, 2011). The expansion of capitalism and the European conquests have entailed a progressive appropriation of spaces, resources and people, and their subjection to the need for continuous growth in market economies (So, 2010). Within this context, Wallerstein's analysis focuses on world trade and its asymmetrical structures. These asymmetric structures are reflected in the hierarchy of states, which can be divided into centers, semi-peripheries, and peripheries (Wallerstein, 2011). The countries of the center and periphery are relatively stationary, that means they remain in their superior or subordinate position in the international division of labor. The semi-peripheral countries, on the other hand, represent the moving element that oscillates between center and

periphery (Wallerstein, 2011). The following classification facilitated the inception of capitalism and the resulting industrial revolution: The countries of North-Western Europe constituted the center, whereas Latin America (as source of gold, silver and other valuable goods) and sub-Saharan Africa (as source of slaves) formed the large periphery. The naval powers Spain and Portugal embodied the prototypes of semi-peripheral countries, given that, despite their role as colonizers, they were unable to build up their own cycle of monetary capital through a productive sector (Wallerstein, 2011). Wallerstein adds that, in addition to the global dimension, unequal relationships between center, semi-periphery and periphery exist within most national boundaries. The structural differences between urban and rural areas are particularly remarkable (So, 2010).

Despite the theory's value as a tool for analyzing historical and contemporary exchange relationships on the global and national level, it gives cause for criticism. The world system theory has been challenged for its biased focusing on economic interactions and systems (Pieterse, 1988). Indeed, Wallerstein's theory recognizes well the asymmetries of the world economic system, and how these define where centers of extraction and production are located. Cultural, political and especially technological developments and actors, by contrast, play at best a subordinate role within Wallerstein's system of thought. Accordingly, his theory lacks a grasp of the interfusion of objective, material conditions, on the one hand, and subjective cultural constructions, on the other (Hornborg, 2001). This dimension is crucial to understand how the definition, production and distribution of scientific-technically produced goods reinforces society's distribution problems and conflicts. Hornborg (2001) analyzes the propensity of modern societies to trust in technological solutions for problems that are too complex to be tackled merely by machines. He describes this phenomena as the fetishization of technology. Fetishism relates to "the mystification of unequal relations of social exchange through the attribution of autonomous agency or productivity to certain kinds of material objects" (Hornborg, 2001, p. 132). Hornborg (2001) extends this Marxist notion of fetishism from the dimension of capital and commodity to the machine. The Swedish Anthropologist argues that the machine constitutes the most relevant and intransparent fetish of capitalism because it has accelerated the asymmetrical exchanges of resources and hazards between populations and ecosystems on both the national and global level (Hornborg, 2001).

The first and most far-reaching intervention of the modern machine in human life occurred with the industrial revolution, when machines, such as the steam engine and the mechanical loom,

required the exploitation of both rural labor force and raw materials on a large scale. With the spread of capitalism and the advancing European colonization, the machine expanded proportionally and left its mark in almost every field: Technological procedures facilitated, inter alia, the intensive exploitation of natural resources, the efficient transportation of slaves or the development of highly destructive military weapons (Hornborg, 2011). Technological progress has thus contributed decisively to today's degree of socio-cultural inequalities and ecological degradation. Hornborg (2001) refers to the *thermodynamics of imperialism* when analyzing how the machine has become an autonomous organism within the international capitalist system that reinforces unequal relationships and exchanges between centers, semi-peripheries and peripheries. He therefore concludes that machines must be recognized as a species of power and as "objects of our own making over which we seem to have lost control" (Hornborg, 2001, p. 147). Yet, the power and distribution issues surrounding the development, dissemination and application of technologies are rarely part of societal discourses. Instead, politicians, entrepreneurs and scientists praise greater resource efficiency through technological progress as a panacea (Hornborg, 2015). Hornborg (2001) claims that modern capitalist societies have internalized this mantra to such an extent that they are prevented from conceiving solutions to socio-economic and environmental challenges other than technological obsessions. Renewable energies in Latin America are a remarkable example for a technological obsession at the expense of social justice and ecological integrity.

As in most transformation strategies that aim at substituting scarce resources and increasing the eco-efficiency of the economy, technological innovations and resource efficiency are placed at the center of the renewable energy transition. To this end, mankind seeks to adapt to the natural currents – water, tides, wind, sun, geothermal heat and biomass – in order to take advantage of them. Pre-fossil techniques such as windmills and sailing ships already followed this logic. In modern days, engineering, computer science and other technological advancements serve to harness the natural currents without diminishing their regeneration capacity (Unmüßig, Sachs, & Fatheuer, 2012). New technologies and techniques can certainly reduce the consumption of natural resources and therefore become an important driver of sustainable societies. At the same time, the technological-economic focus of the renewable energy transition implies three pivotal deficits. Firstly, politics rarely intervene coherently. Although subsidies for renewable energies or efficiency standards for houses are increasingly enforced on a global level, such measures do not necessarily form part of coherent overall strategies (Strunk, 2015). The continuous rise of fracking and global oil drilling constitutes a striking example (Unmüßig et al., 2012).

Secondly, the rebound effects must be considered. The rebound effect occurs when efficiency improvements trigger other resource-intensive activities, which then nullify the achieved savings. A notorious example is the installation of heating systems, whose increase in efficiency is cancelled out by a larger living space. A report by the Enquete Commission "Growth, Prosperity, Quality of Life" concludes that the various rebound effects – of financial, material, quantitative and psychological nature – will prevent the political goal of keeping nature consumption within ecological boundaries (Strunk, 2015). The third, and for this work most relevant, deficit consists in the implications of the technology application itself. The largely technological conception of renewable energies; the reliance on new energies to mitigate climate change and attain energy security; and the political focus of promotional regulatory frameworks beguile into disregarding a decisive fact: Energy generation implies more than machines that initiate thermo-dynamic processes (Hornborg, 2001; Unmüßig et al., 2012). The physical properties of energy are also defined through the wider cultural, social, political and ecological implications of energy generation and consumption. In fact, renewable energy technologies push ecosystem boundaries and reinforce socio-democratic asymmetries within national boundaries as well as on the global scale (McNeish, & Borchgrevink, 2015). In order to be truly sustainable, the renewable energy transition must therefore correlate with a modification of objectives. It must render itself liable to its socio-cultural and ecological responsibility, allow broader democratic participation and enlarge the circle of beneficiaries. The following empirical examples will illustrate the imperative nature of such a modification.

3.2 Examples of renewable energy projects in Latin America

The examples outlined below embrace those three regenerative energy forms that show the highest capacity expansions, in the three countries that represent the main drivers of renewable energies in Latin America: Wind energy in southern Mexico, hydropower in the Chilean Patagonia as well as biogas and biofuel in north-eastern Brazil. Figure 3 below provides a geographic overview.

Figure 3: Map of analyzed renewable energy projects.

3.2.1 Wind energy in Mexico

The Mexican energy reform passed in 2015 aims to involve private capital in the exploitation of renewable energy resources beyond hydropower. Both the national government and international investors attach major importance to the generation of wind power, primarily through wind parks in the Isthmus of Tehuantepec in the south of the country (Huesca-Pérez et al., 2016). The region possesses enormous on-shore wind power potential due to its location between two oceans. In 2012, two thirds of the 3662 MW wind energy in Mexico was produced in Oaxaca, while it is anticipated that the region will add several GW by 2020 (Juárez-Hernández, & León, 2014). One of the most important financiers of wind projects in the region is the World Bank, which supports, inter alia, the large wind parks La Venta II and III in Oaxaca (Ledec, Rapp, & Aiello, 2011). Moreover, several transnational corporations including Walmart and the Femsa Group participate financially in the wind parks to ensure their long-term energy supply, while Oaxaca still holds the largest number of homes without electricity service in the country (Juárez-Hernández, & León, 2014). The main profiteers of the generated electricity are therefore pre-determined and seldom include those people that are exposed directly to the sphere of influence of the generators. Conversely, the expansion of the wind parks in the Isthmus of Tehuantepec and their intended amalgamation to a *corredor eólico*

interfere with local livelihoods, threaten biodiversity and integrity of landscapes, and accentuate inequalities (Déniz Mayor, De la Rosa Leal, & Verona Martel, 2012).

Dozens of regional communities are subjected to the impacts of the wind parks, many of which are inhabited by indigenous communities, including Zapotecs, Huaves, Chontales and Ikoots (Belliger, Hostettler, Heuberger, & Suhner, 2012). The Isthmus region already demonstrates one of the highest rates of intra- and inter-community conflicts in Mexico (Huesca-Pérez et al., 2016). The progressive fragmentation and appropriation of lands in the region on behalf of wind power contribute to weakening the internal cohesion of indigenous communities (Huesca-Pérez et al., 2016). The most widespread forms of collective land ownership in rural Mexico are *tierras comunales* – where land belongs to all members of a community – and especially *ejidos*. Each member of an *ejido* is awarded a piece of land and decisions that affect the entire land area are only valid if all *ejidatarios* give their consent (Déniz Mayor et al., 2012). In several cases, wind park operators have expelled people from their homes, pulled apart collective lands and played *ejidatarios* off against each other (Déniz Mayor et al., 2012). Resulting lease or purchase contracts correspond by no means to the economic value of the lands, and less so to the cultural value that the indigenous communities attribute to their native territories, and the livelihoods they derive from them (Déniz Mayor et al., 2012). Protests against the external interference with communal land distribution frequently end in repression and episodes of violence (Belliger et al., 2012).

Even if communities or individuals successfully refuse to lease or sell their lands, the ability to carry out agricultural activities is severely restrained in the surroundings of the growing wind parks. The wind generators constitute tremendous constructions whose balance must be secured by deep-reaching underground foundations. The penetration of the landscape with hundreds of these foundations affect soil-dwelling organisms and soil water balance, thus contributing to the dehydration of the ground in the long run (Belliger et al., 2012). Cattle farming is also inhibited in the constantly moving rotor shadows of the wind generators. Moreover, vast forest areas are logged to develop space for the constructions and enable the wind to blow without encountering obstacles. The cleared areas include traditional tree avenues which possess critical importance for the region's agroforestry systems, given their function of protecting the agricultural crops from strong wind gusts and the soils from eroding (Juárez-Hernández, & León, 2014; Belliger et al., 2012). The wind generators cause serious consequences for migrating birds on their routes from the north to the south. A report from the World Bank shows

that in La Venta II wind park, with its 98 generators, 6000 bats and 3200 birds were killed by collision with the rotors within a single year (Belliger et al., 2012; Ledec et al., 2011). The expansion of wind power does not refrain from invading sensitive, protected ecosystems. Recently, wind generators have been built in lagoons and on islands near San Dionisio, the native territory of the indigenous Ikoots, despite the area having been declared a valuable ecosystem by the National Biodiversity Commission (Belliger et al., 2012). The earth movements on the islands and in the shallow waters, caused by the foundations of the generators and the connecting cables, inflict serious damage on the ecosystem. As a result, the mangrove forests and other rare ecosystems are under threat, and various species of fish, crustaceans and marine mammals are decimated (Belliger et al., 2012). Moreover, the lagoons serve the indigenous people to communicate with the thunder and the sea; the sacral integrity of this site is now compromised by wind power (Belliger et al., 2012).

3.2.2 Hydropower in Chile

Approximately 40% of the Chilean electricity is generated by hydroelectric power, mainly by large projects in the water-rich Los Ríos region in the south of the country (Arroyo Currás, 2014). The Chilean government justifies the construction of dams and hydroelectric power stations with the need to become more independent from fossil fuel imports and to boost the economic development of the Chilean south. Yet, this part of the country retains less than 1% of the electricity derived from hydropower (Romero Toledo, 2014). The bulk of the electricity benefits the densely populated central regions around the capital Santiago and the copper industry in the north of the country (Susskind, Kausel, Aylwin, & Fierman, 2014). The exportation of unprocessed, refined copper ore is Chile's key industry, accounting for more than half of the country's total exports and 20% of state revenue (DIRECON, 2015). Chile's reliance on the malleable metal and the growing global demand encourage the country to increase the production and explore new deposits, which in turn requires more electricity and render additional dams necessary (Susskind et al., 2014). In addition to the unequal distribution of the electricity which is derived from hydropower, the government and involved investors neglect the unequal distribution of economic and socio-ecological costs caused by the dams and reservoirs (Susskind et al., 2014).

Firstly, the public expenditure for Chilean hydropower ventures commonly exceeds original budgets, as the concession agreements fail to allocate responsibilities for maintenance costs; these costs are then frequently passed on to the public (Susskind et al., 2014). Precise figures

on the actual costs to the government and taxpayers in Chile do not exist, yet the World Commission on Dams (2000) computed that global hydropower projects involve on average 56% more costs than indicated in the project calculations. Beyond monetary considerations, the negative impact of hydropower projects on the southern Chilean ecosystems are dramatic. The dams disrupt the flow of the widely branched river system and inundate the adjacent areas. The intervention in the natural cycle inhibits the migration and survival of the domestic fish, crab and mussel species, three quarters of which are meanwhile threatened by extinction (Romero Toledo, 2014). Moreover, the damming of longer river sections reduces both quality and quantity of the river water, thus deteriorating the conditions for farming and livestock breeding (Romero Toledo, 2014). In addition to the impact on ecosystems, hydropower plants are not as low in emissions as often claimed. Deemer et al. (2016) even claim that, taking all factors into account, hydroelectric power plants often discharge more greenhouse gases than gas power plants in order to produce one kilowatt hour of electricity. This assertion is primarily related to the fact that the flooded biomass in the water reservoirs ferments and thus releases carbon dioxide and especially methane. The latter greenhouse gas contributes disproportionately to global warming as it is approximately 21 times more harmful than CO2 (Deemer et al., 2016). On the other hand, the clearance of wooded lands and meadows diminishes the quality and quantity of natural carbon sinks. Despite these negative repercussions, the construction of hydroelectric power plants is widely regarded as an investment in climate protection. The Clean Development Mechanism (CDM) of the United Nations provides emission credits for hydropower investments through, among others, projects of the Norwegian state-run energy supplier Statkraft in Chile (Grüne Liga et al., 2011).[5]

A new venture between Statkraft and the Chilean government demonstrates that indigenous Mapuche communities bear the majority of the socio-ecological costs of hydropower projects. The venture includes a dam and hydroelectric power station on the Pilmaiquén river in Los Ríos region, which entails the flooding of at least 150 hectares of land (Romero Toledo, 2014). The project area, however, constitutes the ancestral territory of a Huilliche Mapuche community (Romero Toledo, 2014). The official plan foresees the resettlement of the community and the payment of financial compensations for the lands, yet the reality does not reflect this proposition (Susskind et al., 2014). On the one hand, the financial compensation does not meet the actual economic value of the lands (Susskind et al., 2014). On the other hand, the opposition to the

[5] Hydropower projects are expected to account for 20 percent of total CDM certificates until 2020 (Grüne Liga et al., 2011).

resettlement has been recurrently faced with forced displacement attempts by the Chilean government (CECT, 2015). The loss of their ancestral lands, however, deprives the Mapuche of their terrestrial and spiritual culture. The Mapuche regard themselves as the people of the earth and are strongly connected with the territory on which they live. If this physical connection is broken, the Mapuche cease to exist (CECT, 2015). Displacement therefore equals a genocide in their view. Concrete impacts on the Huilliche Mapuche community are twofold: Firstly, the displacements restrict the ability of the community to carry out subsistence farming on their sacred lands with alternating crops such as potatoes, wheat or quinoa. Likewise, their sheep breeding, wool harvesting and resulting textile production are at risk (Romero Toledo, 2014). Secondly, the construction of the dam and the reservoir would entail the damage of their ceremonial site Ngen Mapu Kintuante, from which the Mapuche draw spiritual power and where they communicate with their guardian spirit Ngen Kintuante (CECT, 2015). The loss of their sacred lands has naturally triggered the resistance to all resettlement attempts since 2009 (CECT, 2015). The resistance involves severe danger for the community and its machis (shamans), who embody spiritual, medical and religious authority. Many community members have been accused, mistreated, persecuted and imprisoned for no reason by the police (CECT, 2015). In 2013, the highest machi of the Huilliche Mapuche was sentenced to 18 years imprisonment for alleged arson resulting in death (Soto Galindo, 2014). Many other Mapuche suffer political persecution. The police frequently conducts violent raids that result in charges of illegal weapon possession or attempted murder against the Mapuche, even though they have acted in defense against arbitrary state violence and the forced evictions of their homes (CECT, 2015).

3.2.3 Biogas and biofuel in Brazil

The production of biogas and biofuel made from sugar cane is on the rise in Brazil. At present, the share of biomass in the national energy matrix amounts to 7.7% (Kern, 2014). More than three quarters of the biogas is obtained from sugar cane, more precisely from the sugar cane bagasse which is used to power industrial bioethanol plants (Kern, 2014). The biofuel production based on sugar cane reckons with strong political endorsement since the 1970s (Kern, 2014). Recently, this industry has experienced a consistent growth due to an increasing demand, especially from the European Union which aims to double agricultural fuel consumption by 2020 (Falck, 2015). Brazil intends to meet the demand by boosting the production and exportation of sugar and sugar-based ethanol (Falck, 2015). Industrial and political advocates of this goal pledge the creation of jobs, a socio-economic upswing, as well

as a significant contribution to climate protection, the transition to renewable energies and a sustainable transport sector (Barros, Faria, & Araujo, 2012). These claims appear doubtful when scrutinizing the situation of sugar cane in the Zona da Mata (forest zone) in the northeast of the country. The production conditions of sugar cane and the resulting impact on land use forms in the sugar-dominated state of Pernambuco cast a particularly critical light on the climate, environmental and social balance of biogas and biofuel (Cândido da Silva, 2010).

Power plants that convert sugar cane into a combustible fuel require costs in a three-digit million range. Hence, the amortization and competitiveness of such an investment requires a steady input of crops (Falck, 2015). To this end, sugar cane is cultivated in extensive monocultures that diminish both quality and quantity of humus in the soils. As a result, Pernambuco's soils are among the most exhausted in Latin America (FAO, & ITPS, 2015). Furthermore, the low nitrate content of sugar cane plants demands the intensive fertilization with synthetic nitrogen. The application of nitrogen, however, causes the release of nitrous oxide into the atmosphere, a greenhouse gas that is about 298 times more harmful to the climate than carbon dioxide (Cândido da Silva, 2010). Likewise, the industrial production of nitrogen fertilizers is very energy-intensive. A third ecological concern is constituted by the considerable water consumption of sugar cane. The production of a single liter of ethanol from sugar cane requires an average input of 2.107 liters of water (Falck, 2015). In order to meet these water needs, the sugar cane and biofuel industry divert rivers and dry out vital water sources. In this way, they disrupt the integrity of entire ecosystems in Brazil's northeast, depleting local fish stocks and depriving local populations of their livelihoods (Cândido da Silva, 2010).

The expansion of sugar cane monocultures in combination with the depletion of water sources conflicts with local food production, as well as the habitats and livelihoods of Xukuru and Tupi tribes, which are especially vulnerable since their territories lack clear demarcations (Amnesty International, 2005). According to the Brazilian landless movement MST, the resistance by smallholders, indigenous peoples and activists is faced with repression, displacement and even murder (Barros et al., 2012). Many of the marginalized smallholders find occupation as seasonal workers on sugar cane plantations, where they are exposed to working conditions that Amnesty International (2008) denounces as exploitative. The human rights organization highlights forced labor, the retention of wages and health damages due to inadequate protective equipment (Amnesty International, 2008). Pernambuco officially reports about 500 pesticide poisoning cases per year, whereas the World Health Organization suspects this figure to be 50 times higher

(Falck, 2015). The discrepancy can be attributed to the lack of studies as well as to the fact that medical examinations are performed by the company's doctors that often refrain from certifying pesticide poisonings to protect their employer's reputation (Falck, 2015). In addition to threatening human health, the vast quantities of pesticides[6] sprayed on Brazilian sugar cane plantations further compromise soils, water sources and the harvests of smallholders (Falck, 2015).

The expansion of the biofuel industry does not settle for existing plantations, but requires the development of new areas, often through the clearance of vast forested areas. The result is the excessive release of CO2 and a diminished storage capacity for this greenhouse gas. In the early 16th century, nearly 1.3 million square kilometers of forest covered the forest zone; today the area is dominated by sugar cane plantations (Falck, 2015). The sugar expansion does not even stop at the Atlantic rainforest, despite this area being declared a UNESCO Biosphere Reserve in 1993 (Falck, 2015). And it appears that the plant branches out into further delicate ecosystems: The *Código Florestal*, an enhanced forest protection act, is fiercely fought by the powerful agricultural lobby, which maintains close ties with Brazilian politicians (Falck, 2015). One of the main opponents to enhanced environmental protection is the ethanol and sugar cane lobby led by Trapiche, one of the largest and most influential ethanol producers in Brazil (Falck, 2015). The lobbying also accomplished the adoption of a draft law in 2013, which provides for the possibility to cultivate sugar cane in the regions of the Amazon rainforest, the tropical Savanna Cerrado and the wet biotope Pantanal (Barros et al., 2012; Falck, 2015). Although cultivation is meant to concentrate on already cleared areas, Barros et al. (2012) fear that the demand for ethanol will exert further clearance pressure – beyond livestock and soybean production – on these sensitive ecosystems and the inhabiting indigenous and local populations.

In addition to the closely intertwined social and ecological repercussions of sugar cane production, the ethanol production and combustion involves further concerns which are rarely included in the climate balance of this energy form. The production of bioethanol from sugar cane occurs through the alcoholic fermentation of sugar and starch, in which CO2 is released (Umweltinstitut München, n.d.). On the other hand, the combustion of biomass in a car engine or an agricultural gas plant currently produces about the same amount of emissions as does the burning of oil or coal (Umweltinstitut München, n.d.).

[6] In 2013, 77.000 tons of pesticides were applied on Brazilian sugar cane fields, many of which are banned in the EU (Falck, 2015).

4. Social and democratic implications of the techno-economic framework

The three examples above reveal a largely negative picture of renewable energy technologies and projects in Latin America. However, when analyzing the energy transition in the region, it is important to keep in mind that the application of certain technologies in certain geographical locations can be socio-ecologically compatible and therefore justifiable. Specific examples include wind energy in non-productive areas of Patagonia, small hydropower plants in the Peruvian Andes, or the use of biological waste for biogas production in Brazil (WWF, ECOFYS & OMA, 2011). Fundamentally, however, national development plans throughout Latin America envisage harnessing regenerative energy potentials through large-scale interventions that interfere with local life and ecosystems (McNeish, & Borchgrevink, 2015). Dams throughout the Amazon rainforest or wind farms in Colombia demonstrate that the three previously illustrated examples do not represent isolated cases (Arroyo Currás, 2014). Despite constituting different forms of renewable energy, the cases from Mexico, Chile and Brazil show crucial similarities that highlight the deficits of a unilateral focus on technological solutions and sound investment conditions: These deficits can be summarized as an inequitable development model and the infringement of the right to self-determination.

4.1 An inequitable development model

Renewable energies are symptomatic of the inconsistencies of the Green Economy, in which technological solutions are meant to overcome intricate societal and ecological challenges. Genetically engineered crops claim to solve the hunger problem but enable the patenting of staple food crops, while entailing not yet fully assessed ecological ramifications (Unmüßig et al., 2012). Electric cars decrease fossil fuel consumption and emissions of carbon dioxide, yet they increase electricity consumption due to their refueling systems (Unmüßig et al., 2012). Renewable Energies face an analogical dichotomy: They are meant to reduce emissions, mitigate climate change and enhance energy security, but their harnessing bears high socio-ecological costs. As other transformation strategies within the green economy, the renewable energy transition rests largely on technological innovations, efficiency and productivity. This means that the transition is supposed to occur within a system that is dominated by markets and compound economic growth (Strunk, 2015). Following on this logic, renewable energies constitute a new branch of business, that both sustains and justifies the neo-classical economy and its asymmetric structure. However, the inevitability of the transition to renewable energies,

as well as the deep anchoring of both capitalism and technology in human life conceal the two inherent problems of renewable energies and the overarching economic system.

Firstly, the focus on large-scale projects implies the continuation of the anonymous dependent relationship between consumer and supplier, which had originally been established by fossil fuels. Renewable energies therefore maintain the subordination of the citizen to dictated prices. And secondly, the unequal relationship between the generation site and final destination of renewable energies persist or are even exacerbated. These asymmetries became evident in all three examples and can be summarized in the following schema: The landscape and natural sources of energy are converted into a commodity and thus subjected to the free market (Robbins, 2011). In this way, private consortia are enabled to appropriate lands and conduct unequitable business activities under the guise of reducing greenhouse gas emissions and promoting regional development. Most of the generated energy, however, does not even benefit the region, but supplies urban areas or extractive industries, which mostly satisfy the demands of the industrialized markets. While large consumers such as Walmart in Mexico even obtain ecological certifications for fostering allegedly clean energy (Belliger et al., 2012), the socio-ecological costs of the energy generation are externalized and imposed on vulnerable peoples and ecosystems. The technological development interventions compromise traditional lifestyles, farming activities, cultural traditions and beliefs; and they threaten sensitive ecosystems and species. The logic of periphery, semi-periphery and center is clearly visible: Western countries (center) provide the technology that is able to harness the resources of an economically weaker country. Within this production country, the technology is applied and the resource harnessed in the structurally weaker rural area (periphery), from where the generated electricity is supplied to industrialized areas (semi-periphery) in order to serve its final purpose: the energy returns to the center, either in form of household electricity, or as "fuel" for the extraction of raw materials and product manufacturing for the domestic upper class and international markets. This streamlined circulatory system underlines the propensity of large-scale renewable energy projects to embody the most recent form of energy colonialism. Nonetheless, the renewable energy capacities in Latin America will continue to increase, mainly for three reasons:

1) Ambitious objectives in terms of emission reductions and renewable energy shares constitute high political and economic priorities across Latin America (Arroyo Currás, 2014). The urgency of these challenges means that viable alternatives for reaching the

high emission reduction and energy goals do not seem feasible, and covering landscapes with increasing quantities of large-scale renewable energy plants is seen as the only option (McNeish, & Borchgrevink, 2015).

2) The global economy relies on a perpetual supply of energy in order to sustain economic and demographic growth. Only in Latin America and the Caribbean, the installed regenerative capacity must therefore double to 600.000 MW by 2030, if the region's electricity consumption rises by 3% per year, as projected by the WWF (Arroyo Currás, 2014).
3) Renewable energies account for a largely untapped business area, considering that more than 90% of the global economy still runs on fossil fuels and nuclear energy (Bloomberg New Energy Finance, 2016; Unmüßig et al., 2012). A report elaborated by the Renewable Energy Policy Network for the 21st Century (REN21, 2017) calculated that in 2016, USD 264.8 billion was invested in new renewable capacities, thus doubling fossil fuel investments in the same period. These figures are bound to further increase, given that many countries draw on renewable energies as a growth engine, especially large emerging economies with vulnerable rural populations, such as Mexico, Chile, Brazil or China and India (REN21, 2017).

In view of the foreseeable expansion of renewable energies in Latin America, it becomes even more important to dismiss the illusion that technological progress and low-carbon technologies represent a panacea for the future of energy supply and climate change mitigation. On the contrary, the viability and sustainability of the energy transition relies on the compliance with the affected people's democratic right to self-determination, which implies a right to participate in decisions that interfere with their natural habitats and social fabrics.

4.2 The infringement of the right to self-determination

The renewable energy projects in Mexico, Chile and Brazil conflict directly with the lifestyles, traditions and beliefs of local peoples. These are often based not only on economic factors, but also incorporate the wider social, cultural and spiritual aspects of life. Large-scale renewable energy projects, conversely, are mostly enforced on the base of neoliberal cost-benefit calculations that do not sufficiently take into account externalities (Unmüßig et al., 2012). As a result, such projects are perceived as being imposed from the outside, since they conflict with the values of those affected by them. In fact, the self-evident intention of such local groups to participate in decisions about development and land use in their native regions is enshrined in

the Convention 169 of the International Labor Organization. The convention entered into force in 1991 and concerns indigenous and tribal peoples in independent countries, including Zapotecs in Oaxaca, Mapuche in Southern Chile, and Xukuru in Pernambuco (ILO, n.d.). Article 14 declares that,

> The rights of ownership and possession of the peoples concerned over the lands which they traditionally occupy shall be recognized. In addition, measures shall be taken in appropriate cases to safeguard the right of the peoples concerned to use lands not exclusively occupied by them, but to which they have traditionally had access for their subsistence and traditional activities. (Indigenous and Tribal Peoples Convention, 1989, p. 5)

The article further states that "Governments shall take steps as necessary to identify the lands which the peoples concerned traditionally occupy, and to guarantee effective protection of their rights of ownership and possession" (Indigenous and Tribal Peoples Convention, 1989, p. 5). The ILO Convention 169 has been ratified by the governments of Chile and Norway, Mexico and Spain as well as Brazil (ILO, n.d.). This means that the convention is legally binding in those countries that take part in the three renewable energy examples, either directly or represented by corporations. In addition to this pertinent international instrument for the protection of indigenous rights, involved actors have adopted laws, statutes and mechanisms that are meant to strengthen civil participation. Article two of the Mexican political constitution recognizes indigenous peoples as native peoples with full capacity to exercise their right to self-determination (Merchand, 2015). The Mexican energy reform reinforced this article by obliging investors and governmental entities to premise any intervention in indigenous areas on the involvement of affected communities in project design and assessment (Merchand, 2015). The Norwegian state company Statkraft declares that their involvement in renewable energy projects is based on compliance with internationally articulated indigenous rights throughout all project stages (Statkraft, 2017). The World Bank and the United Nations' Clean Development Mechanism support development interventions in indigenous communities only on the condition of Free, Prior, and Informed Consent (FPIC), as well as an increased and ongoing stakeholder engagement (Ledec et al., 2011).

The practical reality, however, often conflicts with these formal intentions: The right to self-determination of indigenous peoples has been clearly infringed by the renewable energy

ventures in Chile, Brazil and Mexico through different tactics. These tactics are particularly versatile in the context of the wind parks in the Isthmus of Tehuantepec, where investor groups and Mexican authorities circumvent and corrupt the intricate decision-making structures in the communities to facilitate the appropriation and fragmentation of lands (Déniz Mayor et al., 2012). The Swiss Program for the Promotion of Peace Processes in Southern Mexico reports several cases of bribery and falsified community polls (Belliger et al., 2012). In the municipality of San Mateo del Mar, for instance, less than half of the members of the community council were invited to decide on leasing lands to wind park operators, even though this conflicts with the ejido regime that impede agreements with individuals on collective lands (Belliger et al., 2012). The illegitimacy of the voting procedure was reinforced through the effectuation of one-off payments to the few voters. The obtained consent allowed the local agricultural authority to arbitrarily negotiate disadvantageous contracts with the operators (Belliger et al., 2012). Moreover, Déniz Mayor et al. (2012) accentuate that Spanish wind energy companies in Oaxaca impelled illiterate – and partly non-Spanish speaking – peasants into signing abusive lease contracts. The fraudulent strategies to appropriate land are further exacerbated by political pressure. The governmental program PROCEDE[7] promotes state and private land grabbings, above all in territories with unclear or disputed demarcations, of which Oaxaca possesses among the most in Mexico (Huesca-Pérez, Sheinbaum-Pardo, & Köppel, 2016; Déniz Mayor et al., 2012).

In addition to the lack of indigenous co-determination in decisions on the Isthmus wind parks, the Environmental and Social Impact Assessments of the wind turbines refrain from including local knowledge and experiences (Huesca-Pérez et al., 2016). Likewise, the absence of external monitoring and accountability for the assessments contradict the participatory intentions of the energy reform. As a result of the scarce control mechanisms, many components of the assessments are inaccurate, palliative or fail to fully evaluate the project's adverse effects on indigenous communities and biodiversity (Merchand, 2015; Huesca-Pérez et al., 2016). The dominance of subjective corporate science is equally evident in Chile, where Mapuche knowledge and objections are not incorporated into the Impact Assessments for hydropower projects in Los Ríos region (Romero Toledo, 2014). In Brazil, alliances of politicians and entrepreneurs suppress attempts of grassroot participation in political decisions about the expansion of sugar cane plantations into sensitive ecosystems and indigenous territories (Barros et al., 2012).

[7] *Programa de Certificación de Derechos Ejidales y Titulación de Solares*

In summary, contrary to various declarations that stipulate the inclusion of local communities in decision-making processes, the indigenous peoples affected by wind energy in Mexico, hydropower in Chile and biofuels in Brazil are strategically and regularly deprived of their right to self-determination. The consequential opposition to the projects is often answered with repression on part of the state or the operator, as demonstrated in the respective examples. In parallel, the protagonists of the protests are defamed by targeted media and publicity work that systematically delegitimizes the people's concerns. In the public portrayal, the problem no longer lies in the projects, the insufficient involvement of affected populations and the denial of their basic rights, but shifts to the protests themselves and the violence in which they often culminate (Barros et al., 2012; CECT, 2015; Déniz Mayor et al., 2012). In this way, the victims of human rights violations are converted into perpetrators, whose aggressions must be curbed.

The disregard of indigenous development knowledge, the breach of the legal right to self-determination and the criminalization of legitimate protests suggest that the underlying problem of large-scale renewable energy ventures is the inadequate degree of participation. This means, in contrast, that the adverse cultural, social and ecological repercussions of the projects only arise as a result of the insufficient consideration of those directly affected by the projects. The lack of participation facilitates the accumulation of land and adjacent resources by dispossessing native local populations, and therefore enables the implementation of the renewable energy ventures in the first place. This observation leads to conclude that humankind does not even have an energy and climate crisis per se; humankind does rather have a democracy crisis, which brings about dramatic consequences such as energy inequality, social marginalization, environmental degradation or climate change in the first place. Meaningful participation is therefore a critical requirement for the sustainability and long-term success of the renewable energy transition.

5. Participation in the energy transition

Participation is a catchword in international development, a term that encompasses a wide range of possible meanings and values. Many different actors draw on the language of participation, but with often divergent motivations, interpretations and objectives. The technical literature is unanimous only in that different stages of participation exist (Easton, & Van Ryckeghem, 2012). To pay tribute to these various stages, Sherry Arnstein developed a participation model in 1969. Complemented by more recent literature, Arnstein's model serves as a framework to identify the degree of citizen participation in renewable energy projects. Participation is often

mentioned in the same breath as democracy, as both concepts frequently overlap and condition each other.

The fact that a particular understanding of democracy usually correlates with the definition of participation becomes evident when comparing Jean Jacques Rousseau's model of direct democracy with the competitive democracy model of Joseph Schumpeter (Faber, 2011). Rousseau advocated a direct democracy which excludes representative elements. Accordingly, decisions are made at assemblies of the people, in which the collective will decides on the common good. (Faber, 2011). The collective will, according to Rousseau, is based on the assumption that through reason, every citizen is capable of recognizing the best for the society (Faber, 2011). By contrast, Schumpeter's competition model is based on the empirically substantiated insight that decisions are made by an elite minority of the people even in the case of democratic majority rule (Faber, 2011). Schumpeter does not believe that the citizen is able to act in the interest of the common good. Unlike Rousseau, Schumpeter suggests that the collective will materializes in the wake of the activities of a political elite. The collective will is therefore yet to be determined at the beginning of the political decision-making process (Requejo, 1991). According to Schumpeter, the common good emerges as a compromise by those individuals delegated by the people. Therefore, according to Schumpeter, every collective needs leadership that is democratically legitimized by elections (Requejo, 1991). Altogether, Schumpeter considers democracy to be a method to reach an end result, and thus as mainly relevant in the realm of politics. He does not see participation as an end in itself (Faber, 2011). Conversely, Rousseau advocates a model of democracy in which society and the state become one, and participation acquires normative character in any decision to be made (Faber, 2011).

Arnstein's interpretation of participation ideologically interposes itself between the two views. She recognizes the fact that modern democracies mainly conform to Schumpeter's approach of political representation (Selle, 1996). At the same time, she demands more opportunities for citizen involvement beyond political elections and a subsequent subjection to whatever decision the delegated powerholders may take. Arnstein considers the civil society as the predominant domain during all political processes and decisions (Selle, 1996).

5.1 Citizen power in central and decentral renewable energy projects

Sherry Arnstein's participation model (depicted in Figure 4) distinguishes between different stages, which are characterized by fluctuating levels of influence that citizens exert on the

outcomes of plans, programs and projects. Arnstein defines participation as “the redistribution of power that enables the have-not citizens, presently excluded from the political and economic processes to be deliberately included in the future” (as cited in Easton, & Van Ryckeghem, 2012, p. 17). Accordingly, participation concerns the relationship of actors to each other and the distribution of decision-making power between them (Selle, 1996). Michel Foucault emphasized that decision-making power remains invisible as long as the affected actors are in agreement. Only when divergences between these actors emerge, for instance in negotiation processes, it becomes apparent how the power is distributed and how it is dealt with (Robbins, 2011). The distribution of power and degree of participation in Arnstein's work extends over three categories that are subdivided into eight stages. The lowest category is that of non-participation in the form of disinformation or deception. In this case, the planner deliberately misleads the citizen by educating them in accordance with the objectives of a project (Haslett, Ballenden, Bassett, Godbole, & Walker, 2012). The second category, summarized as tokenism, includes actions that lead people to believe that a project deals fairly with their concerns, when in fact the opposite is true (Easton, & Van Ryckeghem, 2012). The means of information, consultation and placation are harnessed to overcome people’s aversions and doubts, and thus attain their consent (Selle, 1996). However, the disclosure of information and the possibility for citizens to express opinions or even disapproval do not yet allow any direct influence on the outcome of decision-making, and therefore fail to fulfill the criterion of genuine participation (Robbins, 2011).

The renewable energy ventures in Mexico, Chile and Brazil conflate the categories of non-participation and tokenism. Indeed, in all three contexts, channels of information and consultation between involved public authorities, corporations and communities have been established. Yet, these channels do not enable the affected people to impinge on any actual decision. More severely, the influence on the project governance is often systematically obstructed, for example when debates and consultation processes are manipulated, or when information and facts on the project are reductionist, i.e. deliberately omitted, flawed or incomprehensibly formulated. These practices are facilitated by the fact that the majority of expertise is commissioned, financed and therefore controlled by project developers and profiteers (Susskind et al., 2014; Barros et al., 2012; Déniz Mayor et al., 2012).

Poor degrees of participation in project development, implementation and evaluation in spite of ratified conventions and established participation mechanisms raise the question of whether

large-scale projects and meaningful participation are at all compatible. In the anthology *A Moral critique of development: In search of global responsibilities*, the anthropologist David Mosse (2003) explains that development projects display an unequal power structure from the outset. Long-term observations lead Mosse to conclude that non-negotiable differences often emerge as a result of this disparity between the involved actors, thus causing negotiation processes to be displaced to an informal level where they become increasingly contested between private sector, public entities and civil society (Mosse, 2003). The Colombian-American anthropologist Arturo Escobar argues along similar lines: Through the analysis of several case studies, among others a dam project in Colombia, he finds that Western-driven participatory development projects and programs entail an underlying and non-removable power imbalance (Escobar, 2003). Given such projects' alignment with an industrial purpose and their obedience to cost-benefit calculations, the affected people would inevitably see the projects as an external imposition of terms, values and behaviors; they are hence forced to participate in something that is not theirs (Escobar, 2003). This profound discrepancy implies that, even if a project deploys participation mechanisms, it is probable that "new types of conflicts arise, which are often related to what constitute legitimate forms of information, knowledge, impacts and levels of compensation" (Leifsen, Gustafsson, Guzmán-Gallegos, & Schilling-Vacaflor, 2017, p. 1044). On the basis of various studies on the governance and extraction of natural resources, Leifsen et al. (2017) conclude that participation does not equal the dissolution of dissent.

Under these circumstances, large-scale projects seem to offer insufficient possibilities in terms of satisfactory participation and negotiations on equal terms. With respect to renewable energy projects, this proposes a dilemma: Low-carbon technologies are certainly indispensable to mitigate climate change and assure the forthcoming energy supply, yet these projects override – or at least do not adequately consider – the interests, concerns and rights of local people and their natural habitats. In fact, this dilemma is by no means restricted to Latin America or non-western countries in general. The energy policies in Germany, for instance, encourage the coverage of entire landscapes with wind turbines, often contrary to original political pledges and the will of local residents (Graichen, & Redl, 2014). The increasing costs of the transition, on the other hand, are born by citizens and small and medium enterprises, while most large corporations remain exempt from this financial burden (Graichen, & Redl, 2014). This means that, despite differing implications for the concerned people, the teleological large-scale framework of the renewable energy transition implies intrinsic democratic shortcomings in all contexts.

For this reason, a different approach to the energy generation is required. An approach that disrupts the oligopolistic energy structures, and both enables and strengthens genuine participation in the energy transition. It requires an approach that does not impose projects and electricity supply on the population but is rather supported and shaped by citizens from the outset. Decentralized small-scale energy systems embody such an approach that replaces top-down by bottom-up structures. The decentralization of energy systems implies a profound and irreversible reconfiguration of energy generation and supply (Hauser et al., 2015). This idea ascribes a central function to the consumer, and is often referred to as citizen energy. Citizen energy represents the idea of a self-determined, sustainable and local energy generation for local purposes (Hauser et al., 2015), and therefore falls under Arnstein's third category of participation: Citizen power implies the transfer of decision-making power to the favor of broad sections of the population (Selle, 1996). Despite their decentralized structures, full citizen control over energy projects is certainly unlikely given the projects' reliance on established political frameworks, external financial support and perhaps even corporate expertise.

In Arnstein's participation framework, decentralized energy systems attribute decision-making capacities to citizens through partnerships (stage six) and the delegation of power (stage seven). An integral part of these new coalitions is that citizens do not acquiesce to their domination by external actors (Hauser et al., 2015). They naturally seek to maintain authority over the project because they hold both the ideological ownership of the project and the financial ownership of the project site (Capello, Nijkamp, & Pepping, 2010). A progressive decentralization in the energy sector therefore increases pressure on traditional powerholders, including corporations and investors, to engage in an equal dialogue with the formerly powerless citizens if they want to make a substantial contribution to the energy transition. The shift of power in favor of the consumer certainly bears its own risks, as tensions between different participants may emerge in terms of diverging opinions, knowledge or financial resources (Vimpari, & Junnila, 2017). Overall, however, the conflict potential is considerably lower because the project members are self-determined and self-efficacious in their intention to participate in the generation of renewable energies. Moreover, the members of citizen energy projects collaborate towards a collective goal, for which to achieve they rely on sharing expertise, costs, benefits and risks (Hauser et al., 2015). Altogether, participation in the energy generation does not merely constitute means and goal of decentralized energy systems; participation also enables the legitimization of energy technologies as part of the society.

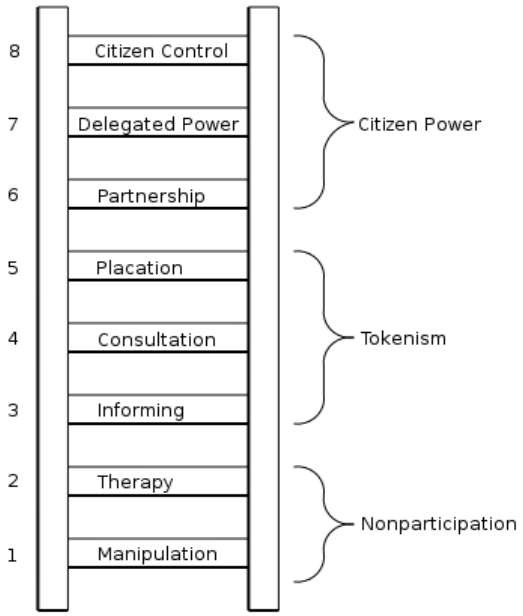

Figure 4: Stages of participation (Haslett et al., 2012)

5.2 The legitimization of technology through participation

Citizen participation in the renewable energy transition is indispensable because energy technologies create new forms of modernity that involve additional risks and uncertainties. Hornborg (2001) argues that the equation of technological progress and human progress have resulted in a general underestimation of these risks, and the inherent limitations of science. This underestimation is reinforced through pro-technological discourses that penetrate all levels of society, including media, politics, business, science and often education (Unmüßig; 2012). Concurrently, the fetishization of renewable energy technologies facilitates the debilitation of critical voices. Mankind is therefore required to analyze technology beyond its scientific and economic relevance, and disclose the underlying cultural, social and ecological implications that revolve arounds its establishment. Only in this way, the dominant role of technology in society and resulting alienations between man and nature can be curbed (Hornborg, 2001). The sociologist Ulrich Beck assumed a related stance in his book *The Risk Society*, where he broaches the subject of post-normal science (Beck, 2015). He argues that the complexity of technology, and the science behind, demand a comprehensive assessment by those facing the more profound side effects of technology-inflicted change on site (Beck, 2015). Beck (2015) therefore distinguishes between the scientific facts that determine the development of technology, on the one hand, and the values and impacts that a technology application creates,

on the other. The German sociologist finds that most scientists are no experts on values, given their primary duty consists in serving technological progress. Only rarely, scientists are restrained by ethical concerns and encouraged to consider the repercussions of their developments on the ground (Beck, 2015). Consequently, laymen must participate in the assessment of technology to determine the holistic viability and compatibility of a technology (Beck, 2015). The layman is the only domain to legitimate a technological project, since they are immediately afflicted by the resulting changes in their environment. These reflections draw on Antonio Gramsci's construction of organic intellectuals. Unlike traditional intellectuals, Gramsci defines organic intellectuals as individuals that describe social life not merely by scientific rules. They rather articulate feelings and experiences through the language of culture (Mordenti, 2007). According to Gramsci, organic intellectuals experience social changes at first hand and inevitably oppose hegemonic aspirations that may compromise their life circumstances (Mordenti, 2007).

The enforcement of large-scale renewable energy projects against the resistance of local communities denies the project its democratic legitimacy and consequently triggers anti-politics by organic intellectuals. According to James Scott, anti-politics may embody different forms of opposition to state or corporate power, which can reach from resistance in open revolts – i.e. public interactions between dominators and oppressed – to more ordinary, hidden forms of everyday resistance, which often include subtle actions that aim at attaining independence from a powerholder or project (Bailey, & Scott, 1987). Against adamant resistance, whether in public or hidden forms, no technology can permanently establish itself within society, however vital it may be. The civil society must therefore become part of the application and assessment of renewable energy technologies. This can be reached by reallocating decision-making capacities to the citizen. Decentralized photovoltaic systems constitute an example for an energy form that enables citizens to control and ultimately legitimize the impact of energy technology on their lives.

6. Decentralized photovoltaic systems

Decentralized, citizen-driven energy systems can embrace various forms of regenerative energies, including collectively operated wind farms, small-scale hydropower plants, bioenergy villages or roof-mounted solar panels (Hauser et al., 2015). While all those forms distinguish themselves by a high degree of citizen participation, decentralized photovoltaic systems stand out for various reasons: They allow the individual and collective energy generation in urban

and rural spaces and an easy integrability into any environment; not least, the sun offers an unparalleled energy potential (Hauser et al., 2015). Before outlining the key benefits of decentralized photovoltaic systems – which merge those of decentralized systems in general with solar energy in particular –, some insights into the functionality of solar energy and the potential of solar radiation will be provided.

6.1 Functionality and energy potential

Two ways to harness the power of the sun for human use exist: Solar thermal technology to convert solar power into heat and photovoltaic (PV) technology to convert solar power into electricity (Philibert, 2011). Photovoltaic systems can be divided into large, mostly ground-mounted, and small, mostly roof-mounted, plants. Large solar plants depend on the development of new lands and thus resemble other centralized energy systems. Small PV plants, by contrast, occupy idle space, for instance on rooftops or in yards (Philibert, 2011). Only the latter plants qualify for a decentralized generation and supply of energy. But how do small-scale photovoltaic systems work?

The direct conversion of solar radiation into electrical energy is based on the photoelectric effect, which was discovered in 1839 by the French scientist Alexandre Edmond Becquerel (Kamal, & Singh, 2014). Albert Einstein published the physical explanation of the photoelectric effect as part of his work on the light quantum effect in 1905 (Kamal, & Singh, 2014). According to Einstein's theorem, light is not only a wave but also possesses particle properties. The so-called photons have a certain energy charge, which enables them to transfer their energy to other particles. The energy thus generated can be used for various processes and is the basis for electricity generation through photovoltaic systems (Kamal, & Singh, 2014). Essentially, the photoelectric effect resembles the photosynthesis of plants, except that the released electrons are used directly as electricity. The first corresponding solar modules were used in aerospace to supply satellites with electricity. For domestic use today, an inverter converts the direct current into alternating current (Kamal, & Singh, 2014). Einstein's theorem not only constitutes the scientific base for the conversion of solar energy into electricity, but also implies the repercussions of the photoelectric effect on man: From a spatial point of view, each square meter can produce energy, thus implying that solar radiation constitutes a common resource that everyone should be able to access and exploit.

When reminiscing about human history, one comes to acknowledge the importance of the sun in man's life given its everlasting, daily recurring and life-determining energy (Achilles, 2011). Likewise, the sun rules everyday life in present times: The resulting energy stimulates man's metabolism and vitamin D production, shapes the rhythm of life on earth and determines weather conditions. Moreover, the sun affects all other sources of regenerative energies, including wind, water, the tides and plant growth (Achilles, 2011). Given the sun's meaning for life on earth, it is grotesque that mankind does not harness more vigorously its potential for energy generation. The sun is by far the earth's most important source of energy. Every second, it transforms four million tons of matter into pure energy; 47.5 terawatt hours per second hit the earth, that is 1.500.000.000 terawatt hours per year (Achilles, 2011). The total commercial world energy consumption is estimated at 100.000 terawatt hours per year (Achilles, 2011). The potential of the sun for meeting this demand is progressively exploited, as exhibited by Figure 5. While the total global installed PV capacity in 2006 amounted to only 6 gigawatts (GW), this value has increased more than fiftyfold within 10 years (to 303 GW). Nearly three-quarters of the 303 GW in 2016 was accounted for by China, Germany, Japan, USA and Italy, while the contribution of Latin America is still marginal (REN21, 2017). In 2016, 75 GW of solar PV capacity was added worldwide, of which only some 2 GW were produced in Latin America (REN21, 2017). Anand, & Parikh (2016), however, forecast a cumulative capacity addition of 27 GW for the region between 2016 and 2020. Even the rather fossil-friendly International Energy Agency predicts an auspicious future for photovoltaic and solar thermal power, hypothesizing that the share of solar power in the global energy matrix will increase tenfold per decade until 2040 (Philibert, 2011). The agency concludes that mankind should pursue the establishment of a solar age (Philibert, 2011). In order to reach this goal in a manner that is time-efficient, economically effective and socially encouraging, IEA and REN21 concur in demanding the participation of private individuals and residential communities in the generation of solar power (Philibert, 2011; REN21, 2017).

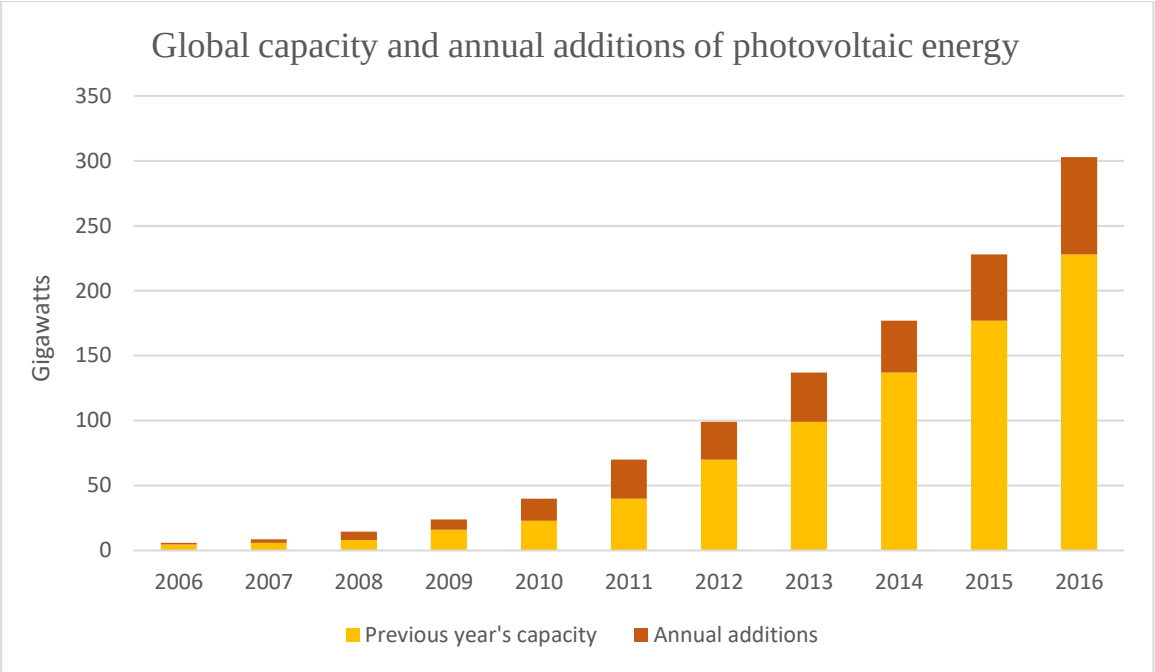

Figure 5: Global capacity and annual additions of solar PV, 2006-2016 (REN21, 2017).

6.2 Key benefits

Decentralized PV systems are premised on the belief that citizens or citizen groups assume a decisive role in the energy transition of a society. Decentralized photovoltaic energy projects are not limited to co-determination in the energy generation, but create numerous opportunities for citizens to participate in sustainable socio-economic and environmental processes – as consciously deciding consumer, energy producer, investor or as a political actor (Hauser, 2015). The increased participation constitutes a central benefit of decentralized photovoltaic systems and, at the same time, forms the basis for most of the other positive effects of this energy system, described hereinafter. These key benefits are universally valid and, although partly drawing on empirical observations from particular cases, not limited to a specific region.

6.2.1 Plurality of actors

Small-scale photovoltaic systems provide opportunities for citizens to engage – individually or collectively – in an economic, equitable and ecological energy generation and supply. This democratization of the energy market implies a potential loss of influence for the energy industry with its centralized large-scale extraction and production facilities, and therefore facilitates an unprecedented dispersion of the energy capital investment. The citizen investment in ecological power plants means that both the invested capital and derived income are distributed more broadly (Achilles, 2011). Furthermore, small-scale producers may trade or sell energy surpluses. This circumstance directly benefits the state as the assurance of a fair and

sustainable energy supply is no longer a mere governmental responsibility, but directly supported by the citizens (Capello, 2010). The integration of citizens in the energy generation therefore distributes responsibilities across several shoulders and relieves the state's financial and institutional burden.

6.2.2 Co-determination, transparency and legitimacy

Conventional energy generation patterns often have a double negative impact: While the plants tend to interfere with living environments of local citizens, consumers are provided with anonymous energy supplies that they cannot relate to. These impacts can trigger protracted debates, sharp controversies and resistance by affected people (Philibert, 2011). Small-scale photovoltaic energy systems can mitigate or even resolve potential conflicts because they are geared from the outset towards citizen participation in the planning, approval and construction of energy plants (Capello, 2010). Unlike other municipal infrastructure ventures, citizen photovoltaic projects enable people to seize the initiative and decide on their own responsibility about issues that concern the generation and supply of a critical public good. The active co-determination gives people the feeling that they are not being disregarded, but in control and able to influence things. Thereby they experience how their own actions translate into concrete positive consequences, and the energy generation becomes tangible and configurable for citizens (Vimpari, & Junnila, 2017). The local anchorage as well as collective and equitable decision-making processes constitute the fundamental pillars of transparent processes within small-scale PV projects. Each project member can inspect the status of discussion and planning, a circumstance that facilitates a transparent discussion within the investor group and therefore promotes genuine grassroot structures (Capello, 2010). The fact that co-determination and transparency form the bedrock of decentralized photovoltaic systems implies that they accrue from an already existing legitimacy and further increase it within the boundaries of a community or even beyond (Capello, 2010).

6.2.3 Identification

Active participation and transparency not only contribute to increase the legitimacy of renewable energy projects, but also stimulate identification processes. The possibility of conceptually contributing to communal development stimulates an organizational, ideological and emotional identification with the respective project and the own environment (Capello, 2010). The identification with a project and community grows notably when citizens use common spaces for a photovoltaic installation, for example a school. Such projects require

frequent and intensive communication and agreement process among the project members and therefore shape communal identity and solidarity (Achilles, 2011). Small photovoltaic projects with a community purpose can play a critical role in rural areas. They embody influenceable progress and hence may contribute to bind people to their communities, thus containing migration and urbanization tendencies (Philibert, 2011).

6.2.4 Competence gain and societal commitment

Small-scale photovoltaic systems create new opportunities for citizens to get involved and take responsibility. With regard to the development of energy projects, citizens can be divided into two groups: project implementers and project members. The implementers, out of political conviction or economic desire, seize initiative and aim at developing their own project ideas to put them collectively into practice (Achilles, 2011). This collective can be a household, an apartment block or an entire community. Unlike project implementers, who often represent generally committed individuals, the members in energy projects develop a broader interest in the energy industry and politics trough the participation in a concrete project. Their main incentive for participating in citizen-managed PV projects is to invest their money in clean energy and for a common purpose, yet with the objective of deriving individual profits and without taking major risks (Hauser et al., 2015). Especially those members who have not been engaged before, increase their knowledge and gain new competencies through the implementation of a concrete energy project, for instance when they deal with stakeholders such as authorities for approval procedures (Hauser et al., 2015). Furthermore, the strengthened individual initiative and competence in the realm of solar power are likely to sensitize citizens to other indispensable transformations in heating, transportation and consumption (Capello, 2010). The causal effect of active project participation on a generally stronger engagement of a citizen in energy and sustainability issues may be scientifically controversial. Yet, a wide range of experts claims that broad civic involvement and the resulting competence gain in essential infrastructural matters (such as energy generation) are critical for a responsible society (Testa, & Gomel, 2016; Capello, 2010).

6.2.5 Cost savings

Every dime spent on the construction of decentralized PV plants reduces peoples' reliance on and monetary liability to energy supplies. However, the citizens themselves must seize the initiative for advancing a decentralized energy transition given that most small-scale projects would hardly be realized by larger companies. The reason for their reluctance to invest in small

projects lies in the transaction costs that incur through the design and operation of a green power plant. These costs include the identification and rental of space, rights of disposal and service provisions (Hauser et al., 2015). In general, it can be said that, the smaller the investment, the higher are the transaction costs compared to the total investment volume. Due to this lower profitability, commercial investors often refrain from developing small-scale projects. Citizen PV projects, by contrast, can spare a large part of these costs, since the project members assume most transaction services for free (Vimpari, & Junnila, 2017). For instance, if apartment owners intend to mount solar modules on the common building roof, the costs associated with search and acquisition of a suitable space cease to apply. In addition, local actors often already possess appropriate knowledge, for instance, concerning the suitability of spaces for the modules. As the project develops, modules and installers must be selected, cost estimates gathered, and the grid connection requested. These tasks alone require several working days and associated expenditures for transactions and labor, which rapidly amount to several thousand dollars per year and project (Hauser et al., 2015; Vimpari, & Junnila, 2017). Members of citizen projects perform these tasks unpaid as well.

6.2.6 Contribution to local value chains

Vimpari, & Junnila (2017) expect that an increased expansion of decentralized PV systems translates into an increased local added value. Hence, the fragmentation and regionalization of energy generation not only evades costs, but simultaneously benefits the local value chain through local capital and operating income, employee compensation, and resulting tax revenues. Philibert (2011) claims that, even though the impact of solar energy on a local economy is subject to annual solar radiation and the availability of regional expertise, local investments in small PV plants could account for important sources of income and employment in most regions and municipalities in the world. The degree of the local added value, however, depends on the willingness of investors to revert to locally-based service providers when raising capital and awarding contracts (Hauser et al., 2015). Vimpari, & Junnila (2017) belief that the local anchorage of the project members – and the fact that an important communal issue is advanced – induce project members to create alliances with local stakeholders. By the same logic, it is likely that the additional local value or purchase power is reinvested on site instead of flowing into the global financial streams (Hauser et al., 2015).

6.2.7 Resource and space efficiency

Decentralized photovoltaic plants boost the locally embedded energy generation in both urban and rural spaces. They are geared to connect centers of energy generation to centers of energy consumption, and thus foster an efficient use of energy resources (Capello, 2010). The consequentially increased consumption of self-generated electricity relieves the power grids and reduces the loss of energy due to long transmission distances. The transmission loss is the difference between generated electrical power in the power plant and the electric power used (Achilles, 2011). A bulk of those losses occur due to the critical state of power grids and the natural phenomena of ohmic resistance, which refers to electricity losses by overheating, triggered by the current flow in the transmission lines (Achilles, 2011). These transmission losses are calculated into the electricity price, thus rendering long transmission routes economically unprofitable for both consumer and supplier (Achilles, 2011; Testa, & Gomel, 2016). The inefficient transmission of energy from remote generation plants to the consumer arguably poses a main concern for the renewable energy transition. After all, most generation plants are located in the countryside where regenerative resources can be harnessed at their best conditions. The progressive urbanization will demand increasing energy transfers from remote locations (Achilles, 2011). A significant advantage of small-scale photovoltaic plants consists in their ability to tap the solar radiation and convert it into usable electricity in urban areas. The modules occupy no productive space, as they are inwrought in windows or mounted on the roofs of individual houses, residential units and parking spaces (Hauser et al., 2015). The European Photovoltaic Industry Association has calculated that 40% of the electricity needed in Europe can be provided by approximately 22.000 km² of facade and roof surfaces, equipped with photovoltaic technology ("Solar PV roofs," 2010). The agency forecasts that on the global level, ever more private dwellings, social housings and public buildings will be constructed with integrated solar systems ("Solar PV roofs," 2010). In rural areas, on the other hand, decentral PV systems contribute to electrifying and supporting even remote and socially vulnerable areas, for instance through off-grid projects.

7. Conclusion Part 1 – Transition to Part 2

Hornborg (2001) argues that large-scale industrial technologies constitute a central element of hegemony because they epitomize processes of appropriation, accumulation and exploitation. With regard to the renewable energy sector, this means that large technological interventions tend to reproduce uneven relationships between private-public consortia on the one hand, and the people that experience the repercussions of the intervention first hand, on the other.

Decentralized photovoltaic technologies distinguish themselves by inhibiting – or at least limiting – the dominance of machine over man in the energy sector. Instead, this form of energy generation rests on the comprehensive participation of citizens in the planning, application and assessment of technology, thereby legitimizing the impact of solar technology on man. Energy therefore constitutes no longer an abstract concept, but rather becomes an influenceable, cultural issue within society (Capello et al, 2010). The expansion of small, decentralized PV plants implies a profound transformation of the energy paradigm, in which many citizens abandon their role as passive consumers to become active protagonists of their energy reality. This new energy paradigm promotes the integration of social, economic and ecological resources at regional and local levels.

The extent to which the benefits of decentralized photovoltaic energy systems apply in practice, relies, inter alia, on the adoption of policies that foster the collective and structural development of regional solar markets, as well as on the creation of supplementary financial incentives, public funds and favorable credits (Capello et al, 2010). Such political and financial terms are rather advanced in countries like Germany or Italy (Capello et al, 2010). In Latin America, however, despite the great solar potential of most countries, the development of corresponding public policies lags behind (Anand, & Parikh, 2016). In any event, favorable political and financial frameworks fail to constitute sufficient incentives for a comprehensive citizen participation in this form of energy generation. After all, most countries of the region placed renewable energies only recently on their agenda, and the autonomous generation of electricity is still inconceivable for most people of the region. In addition, the region is characterized by great socio-economic inequalities which inhibit a broad participation in decentralized investments (Yates, 2016). Argentina, with its recent political developments in the energy sector, is a very suitable example to demonstrate the opportunities and obstacles of a decentralized generation of photovoltaic energy in Latin America. My research in Argentina will show that the encouragement of citizen participation from all social strata is as crucial for the expansion of decentralized photovoltaic systems as the development of public policies. This approach requires actors who are determined to engage in less profitable projects and collaborate with people on equal terms. An actor to whom these features apply are *Sociedades de Beneficio e Interés Colectivo.* They account for a new entrepreneurial model that distinguishes itself by tackling social or environmental challenges faced by Argentinean communities (CAC, 2016). BIC companies can therefore play a key role in the advancement of decentralized PV energy systems in Argentina.

The following second part of the thesis is based on a research stay in Buenos Aires, which aimed to investigate the theoretical and practical potential of social enterprises as a driver of a decentralized PV energy transition in Argentina by means of recent political developments and a case study about the BIC company *Colectando Sol*. To this end, recent Argentinian policies on renewable energies and decentralized energy systems will first be outlined. The subsequent overview of the country's current energy and social situation allows to deduct why social enterprises possess such relevance as link between politics and civil society. Thereupon, the emergence and characteristics of BIC companies in Argentina will be highlighted. Finally, the case study is meant to illustrate how a company is able to spread the benefits of solar power in Argentina and, on this base, lay the foundation for a more far-reaching implementation of PV energy systems within society.

PART 2: DECENTRALIZED PHOTOVOLTAIC ENERGY AND SOCIAL ENTERPRISES IN ARGENTINA

8. Energy and inequality in Argentina

8.1 Renewable energy policies

While the Kirchner administrations barely placed renewable energies on the political agenda in Argentina, Mauricio Macri's government passed various laws and national programs to the benefit of this sector since it took office in December 2015 (Díaz et al., 2016). The ambitious goal of the current government is to quadruple the contribution of regenerative energy sources to the national energy matrix from less than 5% in early 2017 to 20% by 2025 (Artana, Natale, & Moskovits, 2017). This objective is encouraged by Argentina's participation in the Paris climate change agreement, but also stems from the imperative to reduce a vast energy deficit (Díaz et al., 2016). Since 2010, Argentina imports a rising share of its energy, mainly natural gas from Bolivia and crude oil from Trinidad and Tobago. In 2016, the share of energy imports in the country's total imports reached 17.7% (Behm et al., 2017). In order to harness its large renewable potential, the government adopted the national program for the promotion of renewable energies (RenovAr), which provides mechanisms to diversify the energy matrix (Artana et al., 2017). A major goal of the program is for the Wholesale Electric Market Management Company (Cammesa) to purchase regenerative energy from private sector

projects that assert themselves in public auctions (Artana et al., 2017). To this end, the Fund for the Development of Renewable Energy (FODER) was created in 2016, incorporating financial resources from both the national government and the World Bank. The main purpose of FODER is to provide financial guarantees for private investments in renewable energy projects (Artana et al., 2017). While FODER promotes mainly large-scale investments in hydro, wind and solar power, the Macri government also aims to promote the implementation of decentralized, private plants (Testa, & Gomel, 2016).

For this purpose, national deputies from all political fronts, including the current governing party *Cambiemos,* the previous governing party *Frente para la Victoria* and the Green Movement have elaborated a consensual legislative project (CEC, 2017). This *ley sobre la generación distribuida de energias renovables* seeks to create both the structural and financial conditions for a decentralized energy generation and the commercialization of residential energy. The bill accomplished final approval by the Argentinean congress in December 2017 and will be put into effect in 2018 ("El gobierno promulgó," 2017). The law allows natural and legal persons to produce their own electricity from any renewable source, and thus contributes to transforming the paradigm of energy generation and consumption in Argentina (CEC, 2017). The legislation contains 41 articles which establish the policies, as well as the legal and contractual conditions for the generation of electric energy from regenerative sources by users of the distribution network (CEC, 2017). This means that any end user – whether it be private individuals and collectives, farms, firms or public buildings – can install panels in their house to generate clean energy. The legislation allows any consumer to generate electricity for personal use under the terms of net billing (Testa, & Gomel, 2016). In contrast to net metering, which enables consumers to bank surplus electricity to a personal account, net billing allows solar customers in Argentina to sell any surplus electricity to Cammesa. The company then redistributes the energy to the energy providers of the respective provinces (Testa, & Gomel, 2016; CEC, 2017). In the event that the self-generated energy does not suffice to meet the demand, customers can purchase additional electricity from the respective distributors at the retail rate. J.C. Villalonga (personal communication, September 29, 2017) confirms that agreements have been reached with the energy suppliers of the Argentinean provinces about feed-in tariffs, as well as the usage fees for the national power grid. The incentive policies for the development and acquisition of equipment and infrastructure for a decentralized energy generation will be implemented through the *Fondo para la Generación Distribuida de Energías Renovables* (FODIS), to which the National Treasury will allocate 500 million pesos in the first

year (Testa, & Gomel, 2016; CEC, 2017). FODIS will provide funds and grant facilities through loans, subsidies for credit interest rates, the granting of injection incentives, or bonuses to the acquisition of generation systems (Testa, & Gomel, 2016). The sub-fund FANSIGED, on the other hand, earmarks funds for an incentive scheme, which seeks to stimulate research, design, production and dissemination of decentralization technologies. Moreover, this fund fosters investments in capital goods and installation services that contribute to the expansion of decentralized energy systems (Testa, & Gomel, 2016; CEC, 2017).

The energy form to prevailingly benefit from the legislation is solar energy (Testa, & Gomel, 2016). Carolina Estebarena (personal communication, October 19, 2017), responsible legislator for the distributed energy generation act within the federal district of Buenos Aires, estimates that up to 90% of FODIS's volume will be allocated to small-scale photovoltaic systems, given their particular suitability for decentralized energy generation and the vast potential of solar power in Argentina. This potential applies particularly to central and northern Argentina. The Andean provinces in the northwest of the country reach annual solar coverage rates of more than 2600 kWh per square meter, as depicted in Figure 6. The same map illustrates lower 1700 kWh per square meter in Buenos Aires province, yet this value greatly exceeds the average annual radiation in Germany, one of the world's leading solar energy countries (Behm et al., 2017).

Figure 6: Map of solar radiation in Argentina (SolarGIS, 2014)

8.2 Public energy services and social conditions

The political promotion of privately produced and traded solar power, as well as the institutionalization of new monetary instruments certainly constitute an important step towards augmenting the share of decentrally generated solar energy in the energy matrix. This advancement, however, contrasts with – and might be restrained by – the energy reality in Argentina. In the context of public savings and budget adjustments, the Macri government decreed the dismantling of public subsidies for electricity and gas in February 2016, thus imposing a drastic increase of electricity prices upon consumers (ENRE, 2016). The capital and province of Buenos Aires, which are home to 30% of the Argentinean population, has been particularly afflicted as the electricity tariffs rose by up to 700% (ENRE, 2016; Pérez, 2016). The price acceleration must certainly be considered in a context where hundreds of thousands of the poorest households are not charged for the first 75 kWh of every month (ENRE, 2016). Nevertheless, the rising electricity prices constitute an enormous strain for Argentina's middle class, especially in view of the price acceleration of other vital public services, reaching peak values of 100% for transport, 300% for gas and 375% for water (Pérez, 2016). Likewise, all retail prices in Argentina increased. According to the National Institute of Statistics, the overall inflation rate in 2017 reached 24.8% ("Cómo Quedó el Ranking," 2018). While this represents a decline of more than a third compared to 2016, inflation in Argentina is still almost seven times higher than the Latin American average[8] ("Cómo Quedó el Ranking," 2018). The combination of removed subsidies and notoriously galloping inflation rates has contributed to driving some 1.5 million Argentineans into poverty since Macri became president in 2015 (ODSA, 2017). In general, people in Argentina must earmark large amounts of their financial resources for electricity and other basic services. On top of that, frequent power cuts occur, especially in the summer month in Buenos Aires, and both maintenance and modernization of the outdated electricity grid proceed at a sluggish pace. Overall, the increased electricity prices, inflation and the poor state of the power grid expose at least every third Argentinean to an unreliable energy access and supply (CADER, 2015; CEC, 2017).

Evidently, many Argentineans have other problems than caring about decentralized solar energy systems. My survey in the Partido Almirante Brown in the south of Buenos Aires Province confirmed that many Argentinians will be excluded from the added value of the *ley sobre la generación distribuida de energias renovables*: Only 11% of the 200 respondents

[8] Venezuela's exorbitant inflation rate is not included in this calculation.

possess detailed knowledge about decentralized options for solar energy generation or the corresponding legislative project in Argentina. 30% of the respondents even claimed they had never heard of this energy form in the Argentinean context. Yet, when asked about their interest in participating in the decentralized generation of solar power, almost every third respondent expressed a positive opinion. Of those interested, however, three quarters affirmed that they would hardly be able to raise necessary resources. This reluctant attitude was explained with a lack of financial stability, which is indispensable for such a long-term investment. The financial instability in Argentina is a combined consequence of high inflation, unstable currency, high interest rates, and a deep-seated distrust of the country's financial institutions, which is largely fueled by the impacts and after-effects of the devastating crisis at the turn of the millennium (De Zuani, & Ruiz, 2015). Above all, the previously mentioned high inflation rates devour Argentine wages, savings and purchasing power. In 2016, the average purchasing power diminished by around 6%, resulting in 80% of the households reducing their consumption compared to the preceding year (Donato, 2017). Against the background of increasing prices and decreasing real wages, it is no surprise that people abstain from a long-term, cost-intensive investment that is implied by photovoltaic systems. The global Misery Index 2016 confirms that, of 59 investigated industrialized and threshold countries, only Venezuela faces worse conditions than Argentina in terms of inflation, interest rates and unemployment (Hanke, 2017).

It remains to be concluded that, despite enhancing the terms for citizen involvement in the energy transition, the *ley sobre la generación distribuida de energias renovables* serves mostly those people that possess sufficient previous knowledge and financial means. However, the democratic and social potential of solar energy is severely restrained when entire communities are not able to participate in the benefits of decentralized solar energy. The political promotion of small-scale solar systems and the establishment of funds and favorable credits in Argentina is therefore a necessary, but not yet sufficient step to promote a far-reaching participation of people in the generation of solar power.

9. Communities and decentralization: The role of BIC companies

Accomplishing a far-reaching participation of people in the generation of solar energy requires to enable broad sections of the population the access to knowledge about the renewable energy sector, and about the functionality of decentralized photovoltaic systems, in particular. The company *Colectando Sol* has set itself the goal to promote precisely these basic requirements by acquainting people with methods and techniques to produce solar energy in a sustainable

and economic way (Bakhsh, Ekberg, Huang, & Sevelius, 2015). To this end, the company engages in communities and arranges workshops to educate and train people in concepts and small-scale technologies that allow for harnessing the power of the sun with local resources and without the need for large investments (Bakhsh et al., 2015). In *Colectando Sol*'s vision, energy technologies should not be leveraged to rule people, but rather to capacitate them and facilitate their lives. Only by involving the grassroots and distributing knowledge within society, so believes *Colectando Sol*, the socio-democratic potential and benefits of solar energy can reach full scope, and eventually stimulate the expansion of technologically more sophisticated roof-mounted photovoltaic systems (L. Magri, personal communication, October 9, 2017). Intersections are evident between Hornborg's criticism of centralization in technology-dominated economies, on the one hand, and *Colectando Sol*'s business model, on the other: The Swedish anthropologist inferred from diverse empirical studies that traditional, decentralized social systems were better qualified to managing their environment in a sustainable and equitable manner. Modern societies, by contrast, would center their human and natural resources around technologies and are therefore more susceptible to their hegemonic implications (Hornborg, 2001). In analogy, *Colectando Sol* considers centrality and sustainable participation to be incompatible in the context of renewable energies. The company is convinced that top-down energy technologies produce structural inequities and ideological disputes that inevitably evoke irreconcilable resentments within a society. Decentralized solar technologies, by contrast, are well suited to contribute to sustainable and fairer societies (Dergarabedian, 2016). With this mindset, *Colectando Sol* promotes citizen power and participation in an energy generation that resorts to local resources for a local purpose.

Colectando Sol's business model evidently builds upon the enforcement of public interest, community development and value return to all stakeholders. The company therefore embodies the principles of *Sociedades de Beneficio e Interés Colectivo*, which aim to reconcile economic, social and environmental objectives to respond to urgent problems faced by Argentinean communities (Schmidt-Liermann, 2016). A normative framework for those triple impact companies will be provided by the BIC Act. The legislative project was given preliminary consent by the chamber of deputies in 2017, and presently awaits the final approval by the national senate, which is merely a matter of time according to Cornelia Schmidt-Liermann (personal communication, September 19, 2017), national congresswoman and one of the key advocates of the BIC Act. In order to comprehend how *Colectando Sol* pursues its social

mission, it is vital to first explain the theoretical roots of BIC companies, outline the institutional framework and elucidate its main features, especially with regard to their role in communities.

9.1 Theoretical roots and emergence of BIC companies

BIC companies are key in advancing sustainable development in Argentina for two reasons: Firstly, the public confidence in the problem-solving ability of political institutions is low, which is attributable to the widespread political corruption, as well as the lack of coherent and transparent decision-making (De Zuani, & Ruiz, 2015). In 2010, more than 63% of the Argentineans did not trust in any of the three levels of public administration[9] (De Zuani, & Ruiz, 2015). Transparency International confirms this high degree of distrust by ranking the country on position 95 out of 176 on the 2016's Corruption Perception Index (Transparency International, n.d.). Secondly, the need for BIC companies arises from the accountability of entrepreneurship for the extreme social inequalities in Argentina. The private sector in Argentina exercises direct control over the majority of natural resources and generates approximately two thirds of the country's wealth and three quarters of the jobs (ODSA, 2017; Abramovay, Correa, Gatica, & van Hoof, 2013). Resources, wealth and employment however, are unevenly distributed: Argentina not only yields one of the highest income disparity rates in the world (Yates, 2016). The country also demonstrates great inequalities in terms of access to material, biotic and energy resources, as well as public services, including education and health (ODSA, 2017; Yates, 2016). Altogether, 76% of Argentinean consumers demand that companies must contribute to formulating strategies that address socio-environmental problems in the country (Sistema B, n.d.-a). However, such a shift in the entrepreneurial focus requires a different business model that orients towards social responsibility, transparency and credibility. C. Schmidt-Liermann (personal communication, September 19, 2017) underlines that such a profound transformation in corporate governance must be based on the private sector's self-initiative, but requires encouragement through political incentives. Gabriel Salvia (personal communication, October 16, 2017), director of the think tank CADAL, adds that the vital advantage of BIC companies consists in their ability to exert a straight impact on the fair allocation of Argentina's abundant resources, without undergoing cumbersome and erratic bureaucratic procedures that often hamstring the prompt implementation of policies.

[9] The three levels of public administration in Argentina embrace nation, province and municipality.

Companies with a social mission were neither invented in nor are they limited to Argentina. They rather build upon diverse theoretical roots of sustainable economics and the adoption of responsible entrepreneurial practices. Already the authors of antiquity were concerned with the question of sustainable economics. Aristotle argued in his first book of politics that economic activity was not a separate and self-sufficient sphere for accumulating wealth, but a means for a virtuous and righteous life (Vogel, 2006). As capitalism and industrialization advanced, diverse critique emerged. Along with Marxist humanists, it is even Adam Smith himself who restrains the liberty of business. In his work on *the theory of moral sentiments*, Smith stipulates that the pursuit of self-interest is only legitimate to the point where it compromises the opportunities of fellow humans (Robbins, 2011). Postcolonial economics since the mid-20th century have denounced the asymmetric relationships within the global economy: Representatives of the dependency theory in Latin America postulate a regionally embedded production that serves regional purposes such as social justice and widespread employment (Abramovay et al., 2013). Since the publication of the Brundtland report on sustainable development in 1987 and the celebration of the first Rio Earth Summit five years later, public discourses increasingly prompted economic activities to subordinate to social and ecological welfare (Schmidt-Liermann, 2016).

Despite the advocacy for ethical business practices over centuries, in particular over the past 30 years, corporations that prioritize utility maximization for shareholders over social and ecological concerns have asserted themselves as the dominant business form. Milton Friedman's shareholder approach serves as a formative source for this business vision (Vogel, 2006). Friedman argues that profit maximization should be the main goal of any corporate operation, while he discredits social commitments for their propensity to undermine corporate revenues (Vogel, 2006). BIC companies firmly oppose this business approach by leveraging the power of the private sector to promote equity among all stakeholders of a company. BIC companies therefore draw upon the stakeholder theory, which implies a more humanist corporate model (Abramovay et al., 2013). The stakeholder theory is a concept, according to which the company management should take into account the interests of all stakeholders, without renouncing the pursuit of profit maximization (Goel & Ramanathan, 2014). The group of stakeholders is heterogeneous and includes employees, customers, shareholders, suppliers, communities, the state and the environment. The company is considered an organization, in which all those stakeholders are grouped together (Goel & Ramanathan, 2014). The task of a company is to mediate between the different groups, in order to secure cooperation in the

context of entrepreneurial service and to reach compromises about the distribution of the company's revenues (Vogel, 2006). Accordingly, the overarching goal of a company should be the long-term value creation for all stakeholders, whereby value can refer as much to financial profits as to social welfare or a healthy environment.

The reference to the stakeholder theory implies a direct criticism of John Elkington's *ethics of complacency*. Elkington claims that the combination of philanthropy and compensation for negative externalities constitutes the maximum that can be expected from the socio-environmental responsibility of a company (Abramovay et al., 2013). BIC companies recognize that the scope of this approach is limited as it mostly implies one-off campaigns for a specific purpose – for instance, the support of a school or hospital – instead of a fundamental change in corporate culture (Vogel, 2006). The persistence in business as usual, flanked by measures that attempt to absorb the negative impacts of corporate activities, may rectify singular damages, but fails to provide a sustainable solution. Argentina, as well as any other country, therefore needs a regenerative economy, which explicitly seeks to restore degraded ecosystems and fix social fabrics that have suffered under an economic system that focuses on compound growth and shareholder satisfaction (Abramovay et al., 2013).

BIC companies embody such a business transformation by creating comprehensive stakeholder value not through measures segregated from the key business, but rather through a strategic alignment of corporate culture with responsible business operations (Goel & Ramanathan, 2014; CAC, 2016). In short, BIC companies aim to change how companies make their money and not how they spend it. Even though this intention resembles practices of Corporate Social Responsibility (CSR) in their objectives, they are fundamentally different in their approach: CSR practices embrace a pool of voluntary measures that are adopted after a company's constitution and may be abandoned at any stage (Abramovay et al., 2013). Likewise, the external assessments and sustainability reports represent voluntary actions. CSR is therefore susceptible to companies that abuse the concept to enhance their reputation, a practice which is commonly known as Green Washing (Vogel, 2006). Despite endeavors to institutionalize and certify good corporate governance – for instance, within the framework of the UN Global Compact –, as well as an overall increasing social commitment by the private sector, the enduring impact of CSR practices is limited (Goel & Ramanathan, 2014). Furthermore, under existing law, companies remain vulnerable to shareholder lawsuits and hostile takeovers if they do not make shareholders their sole priority (Vogel, 2006).

Jay Coen Gilbert and Bart Houlahan experienced this detriment first hand: Their firm Ben & Jerry's pursued high employment and socio-environmental standards and collaborated with several charity organizations in social projects (Abramovay et al., 2013). Although the co-founders were reluctant to sell their company, the shareholders legally obliged them to accept a takeover bid by Unilever (Abramovay et al., 2013). The company sale and subsequent revocation of many important social practices represented a key moment in generating a new entrepreneurial model that puts socio-environmental concerns at the heart of corporate governance (Abramovay et al., 2013). In 2006, Gilbert and Houlahan co-founded the non-profit entity B Lab in the United States (Abramovay et al., 2013). B Lab's mission embraces the creation of an environment that favors the establishment and expansion of companies that use the power of the private sector to generate benefits for people, environment and the company (Abramovay et al., 2013). Most importantly, B Lab certifies such companies as B Corporations. For this purpose, the NGO created a system to evaluate the social and environmental performance of soliciting companies (Abramovay et al., 2013). The B Certification serves a double purpose: 1) It enables a company to promote its social mission and obtain access to contacts and services provided by B Lab and partner organizations; and 2) It provides consumers with tools to differentiate between marketing tactics and truly positive corporate actions (Abramovay et al., 2013; Caravedo, 2016). After its emergence in North America, the community of B Corporations has spread across Latin America. Sistema B, a branch of B Lab, is the organization that coordinates and interconnects *Empresas B*[10] on the subcontinent since 2012 (Caravedo, 2016). Today, the B Community in Latin America embraces 353 companies (Sistema B, n.d.-b). The overall growth of the B Community, illustrated in Figure 7, is remarkable: While by the end of 2011, 500 companies had obtained the B Certification, this number almost quadrupled until 2016.

[10] *Empresas B* is the Spanish-speaking equivalent to B Corporations.

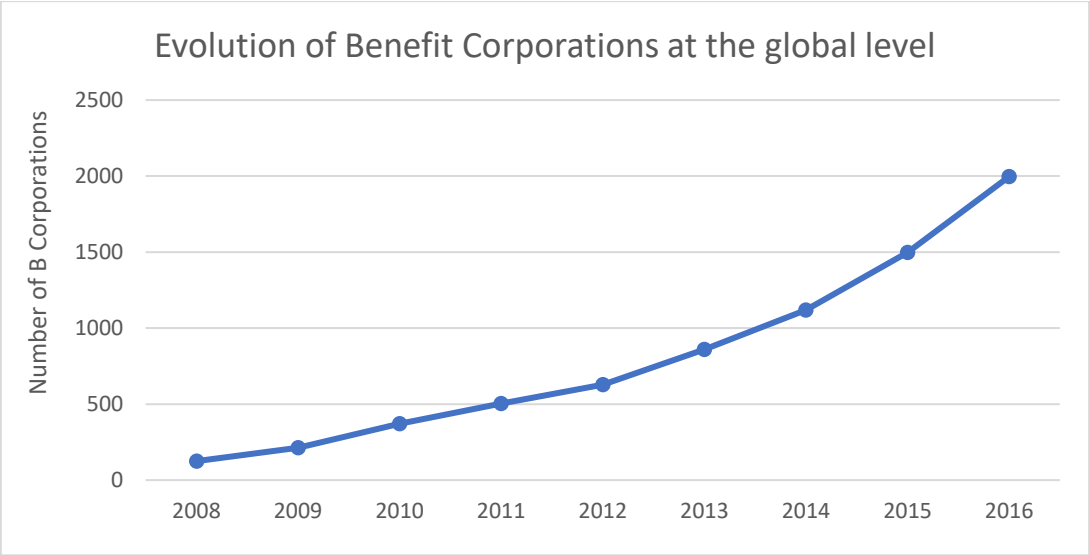

Figure 7: Evolution of Benefit Corporations at the global level (CAC, 2016)

The expansion of the B Community also reflects in Argentina: in 2016, the number of issued B Certifications totaled to 46, which corresponds to a duplication since 2014 (CAC, 2016). Presently, the B Community is perpetually growing, with dozens of companies awaiting their certification (Schmidt-Liermann, 2016). Most of Argentina's *Empresas B* are small and medium-sized, with an average annual turnover that roughly equals EUR 120,000 (CAC, 2016). Figure 8 indicates that they engage in diverse business sectors, including services – many of which concern the energy sector –, trade and the production of food and clothing. The continuous expansion of this new business model demands the creation of an adequate regulatory framework.

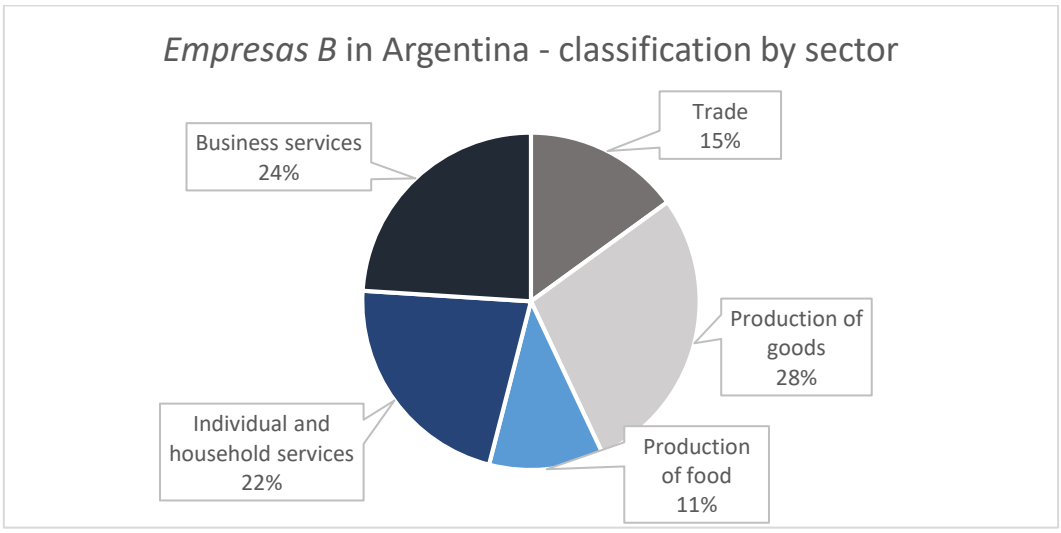

Figure 8: Classification of *Empresas B* by sector (CAC, 2016)

9.2 Institutional framework

Although the B certification helps enterprises with a social or environmental purpose in Argentina to stand out of the mass of regular companies, Sistema B admits the indispensability of providing a legal framework for *Empresas B* (Abramovay et al., 2013). The organization therefore promotes the legislative recognition of public purpose enterprises with the help of its legal team – the designated *Grupo Jurídico B* – and national congress deputies, especially Cornelia Schmidt-Liermann (Schmidt-Liermann, 2016). In nearly two thirds of the US states, congruent legislative projects were already approved (Abramovay et al., 2013). Likewise, several Latin American countries pursue the adoption of according laws, among which Argentina's BIC Act, however, stands out due to its advanced stage and widespread political endorsement (CAC, 2016).

Today, triple impact companies in Argentina must operate as non-profit entities or commercial companies, despite representing neither of these legal forms (Schmidt-Liermann, 2016). In fact, both forms conflict directly with the purpose of *Empresas B* to generate economic, social and environmental profits: Being a non-profit entity deprives them of the right to pursue financial gains, while being a commercial company submits them under the conventional market logic that obliges to prioritize the profit maximization for investors over the pursuit of public objectives (CAC, 2016). The BIC Act is a fundamental step in giving a normative framework to a sector that strives for transforming the economy and benefiting the society as a whole. The establishment of *Sociedades de Beneficio e Interés Colectivo* as a new legal entity pursues several goals: Firstly, it enables the juridical demarcation from commercial enterprises and NGO's, and the clear identification by the public and investors. Secondly, the mission of BIC companies is both protected and promoted by the national government. And finally, the legal recognition compels compliance with the triple impact and renders companies liable in case of a breach (CAC, 2016; Schmidt-Liermann, 2016).

The legislative project highlights three distinguishing features of BIC companies that include purpose, duties of the company administration, and transparency (Schmidt-Liermann, 2016). Firstly, the BIC companies align any business decision and operation with the overall social or environmental purpose in order to create an enduring impact. This means that ethical concerns guide and determine business operations and decision-making in any area of corporate governance (Schmidt-Liermann, 2016). BIC company's take into account the medium and long-term interests of all stakeholders, including employees, communities, shareholders, the

state and nature. The success of BIC companies is not merely measured by turnover and shareholder return, but as much by the value they generate for society and environment (CAC, 2016). The second commitment obliges the corporate administration to enshrine the commitment to a beneficial, specific and verifiable social and environmental impact in the company statute. Partners or associates who carry out acts contrary to this premise shall be dismissed, provided that the company indicates the grounds for the exclusion. A modification of social, environmental or economic purposes and the according statute of the company demands a favorable three-fourths majority of the members with voting rights (Schmidt-Liermann, 2016). In this way, the triple impact is hedged against changes in corporate management and a company can grow, obtain capital and gain profits, without abandoning its social mission (CAC, 2016). The third commitment requires a company to implement transparency standards and provide comprehensive annual reports, which accredit the actions carried out to fulfill the company's triple objectives. To this end, a company must submit the report to the Public Registries of Commerce of each Argentinean province who conduct an audit and check the company performance for compliance with the three obligations. The company must subsequently disclose the report to the public (Schmidt-Liermann, 2016; CAC, 2016). A breach of obligations will lead to the revocation of the status as a *Sociedad BIC* in the terms and conditions which, according to C. Schmidt-Liermann (personal communication, September 19, 2017), will be established within 2018.

Overall, BIC companies extend the duty of managers and shareholders to include non-financial interests, commit themselves to generate a positive impact on society and the environment, and operate with high standards of transparency, while seeking the best possible financial performance (CAC, 2016). In fact, their pursuit of a triple bottom line classifies BIC companies as a hybrid between non-profit entities and profit-seeking companies. With clear missions, visions and objectives, they aim to contribute consistently to build a new economy, where ethics compose the main axis and path to take when making business decisions (Schmidt-Liermann, 2016). In order to encourage more companies to associate themselves with this objective, the Argentinean government intends to provide financial incentives for BIC companies. Cornelia Schmidt-Liermann (personal communication, September 19, 2017) emphasizes that current efforts are put into a supplementary legislative project that provides tax relieves for BIC companies. Moreover, so the politician, the World Bank contemplates the mobilization of financial resources to support social enterprises in Argentina during their start-up phase (C. Schmidt-Liermann, personal communication, September 19, 2017).

9.3 BIC companies and communities of practice

BIC companies regard themselves as part of, and not apart from, a complex social fabric (Schmidt-Liermann, 2016). They recognize that a company benefits from a community in which it operates, for instance through the provision of labor force and natural resources. Two conclusions can be deducted from this determination: Firstly, in order to sustain the business base in the long run, a company must handle human and natural resources responsibly (Abramovay et al., 2013). Secondly, a company has to offer something in return in order to earn respect, trust and support from the community (Vogel, 2006). BIC companies therefore aim at contributing to a sustainable economy where companies create employment and prosperity, and where they form part of collective environmental and social solutions. For this purpose, they develop innovative and transformative practices of corporate culture that place communities and their concerns at the center (Schmidt-Liermann, 2016).

Such a transformative practice is the abolition of corporate hierarchy and the creation of transcendental and equitable connections among the actors within a community. This intention refers to *communities of practice*, a concept which has been coined by the social anthropologists Jean Lave y Etienne Wenger (Wenger, McDermott, & Snyder, 2002). “Communities of practice are groups of people who share a concern, a set of problems, or a passion about a topic, and who deepen their knowledge and expertise in this area by interacting on an ongoing basis” (Wenger et al., 2002, p. 4). Communities of practice generate expertise and transformations through the continuous and equal exchange of knowledge and ideas. This implies that social structures, roles and hierarchies dissolve or at least merge into each other. Knowledge does therefore not constitute a static object in communities of practice, but rather manifests itself in social processes and interactions (Wenger et al., 2002). The deeper meaning of communities of practice for companies is to involve community members directly in the solution of a problem. In this way, the company supports the community in solving a problem or creating benefits. To this end, companies empower people, promote their capacities and provide opportunities (Pyrko, Dörfler, & Eden, 2016).

For BIC companies, the base of a community of practice is constituted by equitable and transparent relationships between community and company (Wenger et al., 2002; Abramovay et al., 2013). BIC companies stand in constant dialogue with community members and therefore obtain continual feedback, which allows them to effectively measure their public impact. By being deeply entrenched in communities and intimately collaborating with community

members, BIC companies constitute a catalyst for the building of a fairer society (Abramovay et al., 2013). The fact that the corporate mission of BIC companies is guided by a specific public concern, ultimately legitimizes their business operations and impact within communities (Schmidt-Liermann, 2016).

Colectando Sol seeks to establish partnerships within communities to distribute knowledge about methods and technologies that capture solar radiation (L. Magri, personal communication, October 19, 2017). In this way, the company aims to tackle energy poverty, encourage a broader participation of citizens in the advancement of solar energy, and constrain the dominance of large-scale technologies in Argentina's transition towards renewable energies. The following case study examines the principles, relevance and impact of *Colectando Sol*'s business model and mission.

10. Case study – Colectando Sol

Colectando Sol is a company that is based in the Argentinean capital Buenos Aires and engages a handful of employees and various volunteers. It was constituted in 2013 as one of the first *Empresas B* in Argentina. The founder and director of the company is Leandro Magri, a chemical engineer, who until 2012 worked for a large Argentinean energy company in Buenos Aires. When his contract expired, he intended to implement his professional vision by promoting an energy transition that benefits communities, environment and the climate. In 2012, he discovered the B Movement during a local event. As a result, he and his partner joined the movement by constituting *Colectando Sol* under the motto "solar energy with a triple impact" (L. Magri, personal communication, October 9, 2017). The certification as *Empresa B* distinguishes *Colectando Sol*'s mission from other companies in the sector. From a legal point of view, however, the company operates as a *Sociedad Responsable Limitada*. Accordingly, it is equated with conventional small enterprises, despite its contribution to the public welfare (L. Magri, personal communication, October 9, 2017). *Colectando Sol* has therefore actively endorsed the BIC Act and will adopt this corporate status once the law enters into force. The distinction as a BIC company will allow the company to distance itself from competing companies in the energy sector, most of which aim at participating in the profits of the recently thriving renewable energy market in Argentina. L. Magri (personal communication, October 9, 2017) is convinced that the adoption of the BIC status will provide a boost to the company's mission and help to draw both public and political attention to the importance of decentrally generated solar energy for Argentina.

Colectando Sol's business goal is to make a contribution to rendering fossil fuels obsolete, reducing climate-damaging emissions and increasing energy security in Argentina through the advancement of an energy transition that is based on photovoltaic systems. This goal is not meant to be accomplished by large-scale solar parks, but rather by small, decentralized plants that involve citizens in the generation and supply of solar energy. This socio-ecological vision penetrates the company's operations in the four business areas: workshops, social activities, projects and installations, and consultancies. Public measures that benefit *Colectando Sol*'s mission have been initiated with the enactment of the *ley sobre la generación distribuida de energias renovables* which enables energy consumers to inject electricity, produced by their own photovoltaic systems, into the national grid. However, *Colectando Sol* recognizes that vital societal pre-requirements for the upcoming legislation are not in place. These shortcomings were previously explained and embrace the socio-economic conditions in Argentina, the unequal distribution of financial resources, and the low degree of knowledge about solar power within the society.

Colectando Sol is therefore convinced that the development of society with solar energy is only possible if all citizens and all social strata are included in this transition. The company firmly believes that every human being should possess the right to harness the energy of the sun, similar to being entitled to breathe fresh air or drink clean water. The solar potential that surrounds every human being must only be exploited. *Colectando Sol's* means to convey the necessary knowledge are workshops and related social activities, which consequently constitute the company's main work area. The workshops focus on education, research and training to allow broader levels of the population to benefit from decentralized photovoltaic systems. The workshops pursue two precise goals: On the one hand, they seek to develop knowledge that serves to manufacture solar devices autonomously and with accessible resources. On the other hand, the collaborative nature of the workshops is meant to encourage continuous learning processes within the renewable energy sector, thereby laying the foundation for decentral photovoltaic projects that integrate various residential units. Hence, the workshops welcome anyone who is interested in participating in Argentina's energy future (Dergarabedian, 2016).

10.1. Workshops and social activities

Colectando Sol's workshops deal with the manufacture of solar devices that are optimized for everyday life at home. The workshops resemble one another, but place emphasis on diverse

devices that capture the energy of the sun, including solar collectors, lumiducts, stoves and ovens. The workshops bear according titles such as *Taller de Colector Solar Autofabricable* or *Taller de Autofabricación de Cocinas y Hornos Solares*. They take place between one and three times per month, depending on the demand, and mostly occupy weekends in order to be accessible to as many people as possible. The participation fee includes materials, a technical compendium, a participation certificate and meals. Early bird and group discounts apply, while scholarships are allocated to participants with poor financial resources or particular skills.

A principal goal of the workshops is for the course participants to manufacture solar devices that function in contexts, where access to basic energy services is restrained or volatile due to limited resources or grid failures. *Colectando Sol*'s devices distinguish themselves by being easily manufacturable, and by using economically affordable and recyclable resources. The workshops consist of interactive and mostly practical activities that convey concepts of solar and thermal energy, as well as domestic solar systems for water heating and air conditioning. All manufactured devices resemble roof-mounted photovoltaic panels in their functionality, as they absorb and process direct solar radiation. The only difference is that the resulting electrical power is not fed into the grid, but rather directly catalyzed through the device.

The self-manufacturable solar collector is based on the design of the Brazilian civil engineer José Alano. It constitutes a system that is capable of producing hot water for sanitary uses, including personal and household hygiene. The manufacturing settles for easily accessible materials, including polyethylene terephthalate bottles (i.e. regular water bottles), polypropylene pipes, expanded polystyrene, aluminum foil and black paint. In addition, *Colectando Sol* teaches to build flat plate collectors for solar-powered domestic hot water systems, which are made from more sophisticated techniques and materials, such as copper, aluminum sheet and polycarbonate. Another example for a self-manufactured device is the solar cooker, which is equipped with a bar in the middle to attach a cooking utensil. The cooker is heated up via solar rays that reflect off the metal. Vegetables can be cooked within three minutes, while meat needs roughly ten minutes to be cooked. The device not only enables to cook without using electricity from the grid, but also helps to reduce common in-door pollution that results from cooking over an open fire. At the end of the workshops, the participants conduct outdoor tests to verify the proper performance of the manufactured devices.

The learning progress during the workshops arouses curiosity and induces participants to engage in vivid energy-related debates. Most of these debates deal with issues of energy consumption and conservation. Unlike energy efficiency, which implies technological changes to use energy more effectively, energy conservation targets a behavioral change. For instance, few simple actions can considerably diminish domestic energy consumption. Given that the dominant share of household electricity in Argentina is derived from fossil fuels and nuclear power, energy conservation not only relieves the financial burden of households, but also minimizes the individual ecological footprint. A crucial method to conserve energy is to pull the power plug when electronic devices are not used. Vimal Raj, Sudhakaran, & Anand Raj (2009) calculated that household appliances consume up to 50% of the regular energy when in standby mode. In Argentina, this superfluous consumption is estimated to render necessary the operation of an entire nuclear power plant (Greenpeace, 2008; Rodríguez, 2017). The astonished reaction of workshop attendees to these facts suggests a great unawareness of dispensable energy consumption in Argentinean society. *Colectando Sol* explains that conserving energy implies yet another positive side effect in Argentina: It allows for circumventing the new electricity tariffs, as these reward energy savings with price discounts. For instance, a household that diminishes its electricity consumption by 10% compared to the previous year reduces its electricity bill by almost one third (ENRE, 2016). Alejandro Flores (personal communication, October 21, 2017), a workshop participant, admits that this incentive may turn out to be the advantage of the increased electricity tariffs, given that it impels Argentineans to become more responsible energy consumers. Upon completing the workshops, discussions between attendees continue frequently. A. Flores and Pedro Arce (personal communication, October 21, 2017), for instance, argue how the renouncing of plastic bags and packaging weakens the demand for crude oil, and why individual water saving measures diminish the need for energy-intensive sewage treatment. The bottom line is that, by involving people in learning processes about solar energy, the workshops become more interactive and reach beyond pure energy efficiency issues. In this way, the workshops not only contribute to increasing energy knowledge and independence within communities, but also sensitize the attendees to the economic, macrosocial and environmental costs of energy production.

In order to extend the benefits of its learning activities and reach weaker social strata, *Colectando Sol* conducts diverse activities, which are directly linked to the workshops. On the one hand, many workshop participants opt for bestowing the self-manufactured devices on social projects with underprivileged households, schools and community centers in both urban

and rural Argentina. One of these projects supports *Escuela de la Familia Agricola LL 156*, a public agricultural college in Santiago del Estero, one of the poorest but sunniest regions in Argentina. Many of the solar collectors that were tailored in *Colectando Sol*'s workshops, are now part of the college's water heating system. However, the company not only delivers the devices, but also acquaints the attendees of the college with the manufacturing concepts and procedures to encourage replication. Most of *Colectando Sol*'s solar devices are channeled through accountable organizations, especially the NGO *Engineers Without Borders Argentina*, since the company lacks the capacities to handle the distribution of devices on its own. Beyond the collaboration with non-profit entities, *Colectando Sol* offers activities in underprivileged communities in Buenos Aires province – among others, in the Southern Partido Avellaneda –, which do not charge any participation fee. Their accomplishment is only possible due to the assistance of volunteers and interns from previous workshops, community centers and technical colleges. One of these activities deals with the manufacture of solar cookers, most of whose raw materials are collected in joint recycling efforts. This approach serves the double purpose of disposing waste and providing people with the skillset to turn it into something handy, thus substantiating the viability of circular economies on the small scale.

10.2. Reception and impact of the workshops

Colectando Sol defines its corporate success by the continuous up-scaling of the socio-ecological impact, which is originated by the contents of the company's workshops and social activities. However, the social mission can only be viable and successful in the long run, if it yields a financial profit, thus compelling *Colectando Sol* to pursue a triple bottom line (CAC, 2016). The self-perception of BIC companies proposes that, by doing good for society and the environment, they obtain reputational gains[11] that translate into financial profits (Abramovay et al., 2013). Although this is certainly not always true, numerous studies suggest a causal relationship between enhanced socio-ecological performance and enhanced profits. For example, Nielsen's *The Sustainability Imperative* found that the sales of consumer goods with a demonstrated commitment to sustainability have grown more than 4% globally, while conventional sales grew less than 1% (Stammer, 2016). At the following it is demonstrated to what extent the proposition of a business case for social enterprises applies to *Colectando Sol*.

[11] Such reputational gains include customer and employee satisfaction, attraction of responsible-minded consumers and talented staff, brand differentiation, attractiveness for impact investors and partners, recognition and advertisement in the media, as well as the participation in a visionary community (Abramovay et al., 2013).

More precisely, the example of customer satisfaction serves to illustrate how a positive public impact translates into financial gains, and how these gains flow partly back to the community.

At the end of each workshop in 2017, the participants filled out a questionnaire which serves *Colectando Sol* as impact assessment and which yielded predominantly positive ratings. The workshop contents received an average of 4,4 out of 5 and were found to be didactic and useful (Colectando Sol, 2017). The instructors received a 4,7 out of 5 and were generally appreciated for their great deal of expertise, clear explanations and permanent availability for queries; yet, differences in teaching pace led some attendees to suggest a division of workshops according to the knowledge degrees of participants (Colectando Sol, 2017). Both the quality of the learning materials and the venue was rated with a 4,3 out of 5. Several participants, however, recommend the publication of online learning material before a workshop begins, so that they can become familiar with the course contents (Colectando Sol, 2017). The venue was regarded as appropriate, although some attendees complained about a lack of work space. L. Magri (personal communication, October 19, 2017) confirms that the high degree of customer satisfaction and word-of-mouth advertising, in combination with social media outreach, have led to a disproportionately high increase in participant numbers: Alone between January and September 2017, almost 800 persons attended the workshops, and thus already as many as in the first three years of the company together (2013-2015). The outlook for the first quarter of 2018 suggests another rise in attendance. This trend is further nurtured by requests for workshops from other Argentinean provinces, especially the sunny and economically weaker north-western provinces of Salta, Jujuy, Catamarca and Santiago del Estero. Encouraged by suggestions of attendees and interceders, *Colectando Sol* works on enhancing social media outreach and even contemplates online courses, as well as workshops in technical colleges to train a future generation of solar lecturers (Colectando Sol, 2017).

High customer satisfaction and progressive participant numbers imply a rising financial income for *Colectando Sol*. Since the company foundation in 2013, the income derived from workshops has risen annually; between 2014 and 2016, it increased six-fold. The overall revenue of the company has increased almost proportionally (Bakhsh et al., 2015; L. Magri, personal communication, October 19, 2017). This profitability is essential for the company to be able to enduringly pursue its social business mission. Furthermore, the financial gains allow *Colectando Sol* to enhance its public impact since considerable parts of the profits are reinvested in the company and communities: The creation of a position that attends to a new quality control

system for the corporate operations is considered for 2018/19 (Bakhsh et al., 2015). Since reaching stable cash flows in 2016, *Colectando Sol* earmarks shares of its annual revenues for community projects and additional scholarships in order to expand both number and diversity of workshop participants. The financial gains therefore enable the company to widen the access to knowledge and skills that empower people to harness the energy of the sun in a decentralized way. This means that the expansion of its business model reinforces *Colectando Sol*'s capacity to create public value.

10.3. Analysis of the social business mission

10.3.1 A corporate promotion policy to fight energy poverty

According to Amartya Sen (2013), the lack of access to modern energy services can be considered a form of poverty, since it constitutes a deprivation of the capacities and liberties that help people fulfil themselves and achieve their objectives. When there is no availability of affordable modern energy services to meet basic human needs, or when people do not have a sufficient income to satisfy these needs on a regular basis, people or communities find themselves in what is known as energy poverty (Sen, 2013). The workshops and social projects intend to tackle the problem of energy poverty, and therefore constitute an instrument of poverty reduction that can complement the state responsibility in this sector. In terms of antipoverty policies, one may distinguish between protection and promotion policies: Protection policies seek to protect people from poverty by providing them with a supplementary income, service or object. Such policies may mitigate poverty in the short term, but generally maintain the recipient's dependency on external support (Ravallion, 2016). Promotion policies, in contrast, seek to encourage wealth creation by providing people with means and knowledge that help to free themselves from poverty, thus creating a more long-term impact (Ravallion, 2016). Empowerment is thus a key concept, referring in this context to strategies and measures designed to increase the degree of autonomy and self-determination in the lives of people or communities, and enable them to represent their interests on their own authority and responsibility. According to *Colectando Sol*'s business approach, empowerment can only be achieved on the premise of education. Education in the workshops refers to the collaborative solution of a common problem through knowledge acquisition and sharing. The interactive environment of the workshops is particularly effective for learning processes since the gathered know-how becomes applicable and tangible.

Colectando Sol's educational endeavors can evidently be summarized as a promotion policy or rather an instrument to fight energy poverty. After all, the company does not simply dispense and implement technology, but rather collectively develops knowledge and skills that empower people to manufacture the technology by resorting to their own means, hands and local resources. In this way, the citizens are directly involved in the problem detection and solution. This means that not the company creates a benefit for the people, but rather the people for themselves and their community. The main message behind *Colectando Sol*'s workshops and activities is that the solar resources can be tapped anywhere and by anyone, regardless of their educational, social or ethnic background, and independently from industry, energy suppliers and changeable and time-consuming political decision-making. Education and empowerment therefore serve as means to make the generation of energy more participatory and inclusive. It can thus be concluded that the social power of solar energy does not only refer to more sophisticated roof-mounted photovoltaic systems, but already begins at the grassroots with immediately available means.

By devoting business operations, resources and missions to mitigating energy poverty, providing people with stable energy, empowering Argentineans with capabilities to generate income and even start their own social enterprises, *Colectando Sol* contributes to improving the standard of living in social contexts with lower resources in urban and rural Argentina. The basis of this devotion is the firm belief that people can produce their own energy by autonomously tapping the sun through self-manufactured devices. These devices, whether used individually or donated to social projects, increase energy self-sufficiency and provide households and communities with unprecedented expertise and tools to generate electricity and heat. Moreover, self-manufactured stoves or solar collectors can add to energy conservation due to their capacity to replace outdated energy-inefficient appliances.

However, one has to invoke an evident restriction: The self-manufactured devices do not suffice to guarantee a satisfactory energy supply for households, as their functionality depends on the availability and intensity of solar radiation. Furthermore, several vital appliances such as fridges can only be used through the power grids. The application of self-manufactured devices is therefore limited to specific occasions. In *Colectando Sol*'s eyes, they consequently fulfil a second function: They visualize that participation in the energy transition is something that any citizen can leverage instantly. A principal goal of the workshops is therefore to familiarize people with scenarios and possibilities that previously had been inconceivable and intangible:

A comprehensive involvement of citizens in the generation, supply and conservation of energy. L. Magri (personal communication, October 9, 2017) admits that the actual impact of the self-manufactured devices may be restrained by nature, but emphasizes that, at the same time, they exemplify the possibility of a different energy future. The workshops therefore initiate a process of continuous learning and knowledge distribution to further the overarching aim of establishing more photovoltaic systems on the country's roofs through individually and community-operated PV systems.

10.3.2 Continuous learning, continuous engagement

Colectando Sol's definition of empowerment does not restrain itself to a one-time attendance of a workshop or social activity, and the implied educational progress in terms of energy efficiency and conservation. The company rather considers empowerment to be a process of interactive, on-going engagement in energy-related issues beyond the offered educational events. Continuous learning in collaborative environments therefore constitutes a vital pre-requirement for a broader, genuine participation in the decentral expansion of photovoltaic systems in Argentina. But do the workshop participants care for continuous engagement and do they consider roof-mounted PV systems to be a future option, or do they rather content themselves with scratching the surface of solar energy by attending one educational event? Wenger et al. (2002) found evidence that the active involvement in the transfer of knowledge stimulates peoples' endeavor to keep on learning and share their knowledge with fellow humans. My survey among 78 participants confirms this assumption: Before attending the workshop, only every seventh participant had had an idea of the possibilities the sun offers as an energy reservoir and of how this energy source can be harnessed. After concluding the workshop, 86% of the participants indicated that they would further educate themselves in the issues that were broached by *Colectando Sol*, with nearly half of the participants looking for courses in community colleges. Consequently, when asked to suggest improvements, several participants asked *Colectando Sol* to offer courses for different expert levels, as well as courses that build upon previous contents to encourage further training (Colectando Sol, 2017). These results suggest a strong willingness to make an enduring commitment to a participatory energy transition in Argentina. This commitment is further buttressed by the fact that 95% of the workshops participants indicate that they take home important key messages – especially concerning the manufacture of solar collectors with plastic bottles and energy conservation methods – and intend to spread those in their communities. In this way, the sharing of knowledge produces new learning groups and attracts more people to the workshops, as the

influx of attendees testifies. L. Magri (personal communication, October 19, 2017) summarizes that many participants show great eagerness in keeping in touch with the issues and cooperating with *Colectando Sol* and its projects on a voluntary basis. It remains therefore to be concluded that the workshops certainly add to the participants' determination to continuously engage in the acquisition, application and further redistribution of solar energy knowledge.

However, the verification of an actual correlation between the workshops and the participation in decentralized grid-connected PV systems is intricate, especially since the terms of the *ley sobre la generación distribuida de energias renovables* have not yet been finalized. Consequently, *Colectando Sol*'s engagement in roof-mounted photovoltaic installations is so far limited to one off-grid project that aims to increase the self-sufficiency of the energy company, where Leandro Magri was employed before founding *Colectando Sol* (L. Magri, personal communication, October 9, 2017). Yet, diverse evidence suggests that the collaborative and result-oriented nature of the workshops exerts a direct impact on the people's willingness and ability to participate in the decentralized generation of PV energy. Almost every third of the 78 surveyed attendees indicated their determination to engage in decentralized projects that involve photovoltaic panels; the share among the 17 to 40 years old attendees even exceeds 50%. Guillermina Fernandez (personal communication, October 21, 2017), a female attendee in her early thirties, stated that the workshop encouraged her to persuade her neighbors to cover a part of their common energy supply with the help of PV panels on the roof of their several-party building. And she is not alone: half of the requests for PV panel installations that the company received in 2017 are attributable to former workshop attendees. Numerous examples beyond *Colectando Sol* substantiate a causal relationship between education and engagement. For instance, a community of 20 neighbors in the Spanish city of Malaga installed a photovoltaic system that generates 63% of the electrical energy consumed annually (Cabezas, 2017). This decision was preceded by years of educational work on the part of an engineer that lives in the same community. Nowadays, the residents advise neighboring communities on procedures and benefits of decentralized energy supply (Cabezas, 2017). A drastic break with human energy habits may therefore take time but is certainly likelier to happen on the condition of educational advertisement. Finally, various empirical investigations within behavioral and social psychology corroborate the validity of the given research and examples by suggesting that collaborative settings tend to encourage a positive interdependence of people. Laal (2013) and Bossche et al. (2006) concur in emphasizing that collaborative methods of learning and

problem resolution often unleash a positive group dynamic that translates into a solidary solution for a shared concern.

10.3.3 Participation in the energy transition

At first glance, *Colectando Sol*'s contribution to the energy transition in Argentina may appear to be limited given the company's small size and scope. It is, however, crucial to take into account the ground-laying need of *Colectando Sol*'s business model: According to Hornborg (2001) and Beck (2015), the civil society constitutes the only domain that is able to critically assess and eventually legitimize the impact of technology on man and nature. Promoting the participation of citizens in the application of renewable technologies is therefore a desirable goal. Escobar (2003), Mosse (2003) and Leifsen et al. (2017) observe that conventional participation mechanisms have proven unable to disrupt power imbalances between "developers" and those that "must be developed". The authors therefore demand a reorientation of development policies and interventions. Escobar (2003) proposes the involvement of local people in the development of participation mechanisms to reconcile different views on what participation entails. This would imply that any decision affecting the future of a community is aligned with local needs, knowledge and decision-making structures.

Colectando Sol's business model can be considered as the implementation of this thought system, as it benefits local communities through the development and distribution of local knowledge. The workshops equip citizens with the power and ability to access Argentina's solar resources, and thereby enable them to assume a leading role in the country's energy transition. The decisive factor is that citizens are not being forced into participating in a project that is based on external goals and values; they rather participate in a collective project on a voluntary basis and therefore establish an intimate relationship with the goals of this project. In other words, *Colectando Sol* leverages solar technology to enable citizens to determine their own energy future.

The company's business model with a focus on collaborative and continuous learning hence creates the precondition for a society-wide participation in the bottom-up approach that characterizes decentralized solar systems. In this way, the workshops and social activities prevent the participation in the generation of solar energy from degenerating into an elitist privilege, whose assets and incentives only benefit those people and entities that possess sufficient financial resources or previous knowledge. The transfer of knowledge to, and the

empowerment of citizens is therefore as important as the establishment of favorable political and financial framework conditions. In order to include as many people as possible, it is crucial for *Colectando Sol* to further impart knowledge within all social stratums. For this purpose, the company intends to scale up social activities and expand the workshop contents to different regions, institutions and media. Overall, the progressive inclusion of people in collaborative energy education, civil empowerment and autonomous energy generation make the workshops an ideal bedrock for the expansion of decentralized solar technologies in Argentina.

10.4 Colectando Sol and decentralized photovoltaic systems – an outlook

Colectando Sol addresses the impending rise of the solar sector in Argentina by engineering two measures: The organization of a particular workshop, and the creation of synergies with other sectors to put projects into practice. The *Taller Solar Fotovoltaico* constitutes a workshop, where participants develop the capacity to assemble solar panels, solar cell phone chargers and solar lighting. Even off-grid systems for remote areas, including solar-powered irrigation systems for smallholders, are occasionally placed on the agenda. First and foremost, however, the workshop encourages on-grid photovoltaic projects that will benefit from the *ley sobre la generación distribuida de energias renovables*. To this end, *Colectando Sol* conveys knowledge about the functionality of the technology, on the one hand, and, on the other, advises about the upcoming political-economic opportunities and monetary incentives for the decentralized generation of energy. Additionally, the company envisages to provide consultation services to help interested citizens with the application for investment loans. Once the law enters into force, the company will implement small photovoltaic plants in collaboration with citizens, primarily in projects that unite various residential units that share costs, risks and benefits. In this context, *Colectando Sol* forwards synergies with crucial partners from the construction industry and other sectors. One example is constituted by a strategic cooperation with the foundation *Energizar*, which offers courses in sustainable architecture and collaborates with structural engineers to provide energy-efficient and sustainable solutions for social housings, residential compounds and individual houses. Besides green roofs and thermal isolation, roof-mounted photovoltaic plants account for a key element of *Energizar*'s vision regarding energy-efficient buildings.

The *Taller Solar Fotovoltaico* and the creation of synergies constitute concrete measures for the expansion of decentralized solar installations across the country's roofs. According to *Colectando Sol*'s vision, this transformation will ultimately result in the amalgamation of

individual energy systems to a collective energy reservoir, whose resources can be used for the municipal energy production (Bakhsh et al., 2015). The upcoming years will show how many Argentineans will participate in the benefits of the distributed generation of solar energy, and to what extent *Colectando Sol* and its workshops contribute to this goal. In any event, the increasing influx of attendees, and the participants' eagerness to share acquired knowledge and further engage in energy topics reveal a growing societal interest and a progressive contribution of *Colectando Sol.*

Added to that is the fact that *Colectando Sol* is by no means alone in working towards a society, where citizens constitute the main domain of solar energy generation. Over the past years, the educational and commercial interest in sustainable, decentralized energy systems experienced a substantial growth in Argentina. Technical trainings, academic programs and courses have been developed specifically for the preparation of professionals in an interdisciplinary and sustainable way (Testa, & Gomel, 2016; Behm et al., 2017). Sebastian Sal, lawyer and associate of congresswoman Schmidt-Liermann in the development of the BIC Act, confirms the interest in sustainable solar solutions among prospective entrepreneurs. Sal organizes projects at the Economic Faculty of the University of Buenos Aires that require students to conceive the idea and concept of a social enterprise. Approximately half of the participating student groups over the past two years selected a topic within the field of renewable energies, most of which dealt with the communal generation of solar power (S. Sal, personal communication, September 27, 2017). These entrepreneurial commitments will receive a further boost in the face of the law on the distributed energy generation and associated funding mechanisms. The subsidies from FANSIGED, for instance, promote the development of decentral energy systems by incentivizing and strengthening innovation, production and education in Argentina (CEC, 2017). In addition, the government works intensely on the adequacy and expansion of the electricity grid (Testa, & Gomel, 2016). Overall, political endorsement, as well as social and corporate commitment to decentralized energy systems are indubitable on the rise in Argentina. However, this discernible development involves its own particular challenges.

11. Challenges for decentralized photovoltaic systems

The expansion of decentralized photovoltaic systems entails substantial challenges that may affect *Colectando Sol* as a company, the solar industry as a whole, and the Argentinean citizen who endeavors to participate in the generation of solar power. Empirical evidence for these challenges is rare, given the infancy of decentralized PV systems in Argentina. However, the

country's persistent political-economic instability, the properties and implications of decentralized solar energy systems, as well as experiences from other regions suggest the nature and scope of potential challenges. These challenges – which are explained in the following last thesis chapter – receive naturally little attention by politics and industry, given the early stage of decentralized photovoltaic systems in Argentina. It is, however, extremely important for public, private and community sector to factor these challenges in from the beginning in order to prevent that they compromise a far-reaching implementation of decentralized PV systems.

11.1 Climatic conditions

Weather conditions impinge on the functionality and effectiveness of both self-manufactured devices and technologically more sophisticated photovoltaic modules. However, contrary to frequent assertions, solar systems also provide electricity in cloudy or rainy conditions. In fact, the efficiency of solar cells decreases when exposed to heat (Righini, & Grossi Gallegos, 2011). For the winter season, this means that the solar yield can be high despite shorter days and less sunshine (Righini, & Grossi Gallegos, 2011). In Argentinean winters, PV modules reach between one third and one quarter of the summer performance (Behm et al., 2017; Righini, & Grossi Gallegos, 2011). The effectiveness of the plants can be further increased by adjusting the alignment of the modules to the generally lower sun level, as well as by the regular removal of dust particles and foliage. After all, the more direct sunlight the modules receive, the more energy can be generated (Righini, & Grossi Gallegos, 2011). Nonetheless, the amount of electricity obtained from solar radiation fluctuates significantly according to the climatic conditions and day-night circles. Like all regenerative energy sources, the sun will therefore always constitute a variable resource that must be complemented by other energy forms (Righini, & Grossi Gallegos, 2011). Nonetheless, Testa, & Gomel (2016) and Behm et al. (2017) assume that decentralized photovoltaic systems could cover up to 50% of the national energy demand in Argentina. As a result, large-scale renewable energy projects could be limited to unproductive regions without land conflicts, including wind farms in the southeastern pampas or solar parks in the mountainous steppes of the northwest. Controversial hydropower ventures in Patagonia and the subtropical northeastern provinces of the country could even be rendered redundant (Testa, & Gomel, 2016; Behm et al., 2017). However, even the expansion of decentralized photovoltaic plants does imply critical challenges of political-economic and ecological nature.

11.2 Political-economic challenges

11.2.1 Financial expenditures

A sustained growth of decentralized PV systems in Argentina demands substantial household and public expenditure. The challenges of private solar energy investments in view of considerable socio-economic uncertainties have been illustrated previously. After all, however, financial relief for such investments is partly in prospect as various sources predict significant price decreases for PV modules in the near future, especially in regions with favorable climatic conditions. The International Renewable Energy Agency projects a 59% cost reduction for PV generation per MWh on global average by 2025, based on current costs (Clover, 2016). A report by Bloomberg New Energy Finance suggests the similar price drop by 2040 (Clover, 2016). The decreasing costs for the technology, in combination with the prospect of evading increasing energy prices, may incite people and communities in Argentina to strongly consider investments in small-scale solar systems (Behm et al., 2017; Dergarabedian, 2016). The expansion of decentralized solar systems is likewise premised on the long-term political and financial commitment of the state. This commitment, however, is subject to uncertainty in Argentina: The reinforcement of FODIS beyond 2020, for instance, will depend on fiscal developments and priorities of the government (Behm et al., 2017). On the other hand, the Macri administration is actively seeking financial participation of investment funds and multilateral development institutions in the provision of services and resources linked to decentralized energy generation, including municipal funds for citizen-driven energy projects (Testa, & Gomel, 2016). Moreover, J.C. Villalonga (personal communication, September 29, 2017) argues that Argentina's regressive public expenditure in the energy sector – a result of declining energy subsidies and energy imports – will provide financial leeway, which could be allocated as additional resources to the promotion of decentralized energy generation.

11.2.2 Opposition from traditional powerholders

Alf Hornborg observes that technology-based industries aim to defend their hegemonic position through the preservation and expansion of their asymmetric business model (Hornborg, 2001). The broad implementation of decentralized PV plants in Argentina would be likely to diminish the revenues of the long-established powerholders in the energy sector. Energy suppliers are particularly challenged by decentralized energy systems (Behm et al., 2017). After all, the more solar panels the citizens install on their roofs, the less they spend on their electricity bills. Although initial agreements with the monopolistic energy suppliers of Argentinean provinces have been reached within the framework of the *ley sobre la generación distribuida de energias*

renovables, various international examples demonstrate that dissents in the long-term implementation cannot be precluded. Experiences from the US state Nevada evidence power and influence of former monopolists very clearly: In 2015, the regulatory authority (PUC) of the state took a decision, which makes photovoltaic systems uneconomical for private consumers – despite 350 sunny days a year and a thriving solar market (Pyper, 2016). PUC decreed that by 1 January 2016, the energy supplier NV Energy may triple the fees that customers with roof-mounted solar systems pay for the use of the public electricity grid (Pyper, 2016). At the same time, NV Energy is allowed to cut the price of electricity that solar customers produce and feed into the grid by three quarters. Consequently, by 2020, citizens receive only 2.6 cents instead of 11 cents per kilowatt hour of electricity (Pyper, 2016). The increase in fees and decrease of electricity prices were even meant to have a retroactive effect, thus punishing thousands of residents who had conditioned their investments on stable fees and tariffs for a minimum of 20 years (Pyper, 2016). The new regulation obligates them to pay more than conventional energy customers, even though they produce almost all their electricity themselves (Pyper, 2016). In response to the decree, several solar companies have withdrawn their capacities from Nevada. The Commission of the PUC justified its decision with the necessity of fair payments for the use of the public grid. SolarCity and civil society representatives, however, consider the underlying calculations to be strongly influenced by the NV Energy lobby (Pyper, 2016). Nevada may become a precedent for how former monopolists attempt to restore their dominant market position, as the guidelines for net metering are currently being revised in about half of all US states (Pyper, 2016). On the other hand, the collective resistance from companies, consumers and civil society organizations in Nevada demonstrates the possibility to defy the lobby of traditional powerholders in the energy sector: In the wake of protests and complaints by SolarCity and the national consumer protection authority, NV Energy conceded exemptions from the legal disposal for consumers who had already signed long-term contracts for the use of the public power grid (Pyper, 2016).

11.3 Ecological challenges

11.3.1 Commodity procurement

Decentralized solar systems imply the diversification of actors and participation of citizens in energy projects. However, the manufacturing of the technology, and especially the exploitation of necessary raw materials is still embedded in highly centralized processes that affect people and ecosystems (Hornborg, 2001). A striking example is constituted by lithium, which constitutes the key commodity for lithium-ion batteries. In order to enable a more flexible use

and effective storage of solar energy, new battery technologies will play a critical role in Argentina's energy future (Behm et al., 2017). Rechargeable lithium-ion batteries are lighter, more environmentally friendly, more durable and possess higher storage capacities than lead-acid batteries (Philibert, 2011). Lithium-ion batteries are hence more suitable for compensating daily and seasonal fluctuations in the solar energy generation. These benefits diminish in value when taking into account the socio-ecological repercussions of lithium exploitation. At least 17 million tons, and therefore the majority, of the world's accessible, high-quality lithium reserves are concentrated in the salt lakes in Bolivia, Chile and Argentina (U.S. Geological Survey, 2012). The distribution conflicts and environmental damages caused by these reserves become particularly evident around the Salar de Uyuni in Bolivia: Lithium is an alkali metal, which is mostly obtained in evaporation processes. The remaining solution is converted into lithium carbonate in a chemical plant. The sewage waters resulting from the mining and further processing are mostly discharged into the environment without former removal of hazardous substances (Ströbele-Gregor, 2013). Moreover, the lithium treatment consumes enormous amounts of energy and water. The direct impacts on the surrounding municipalities comprise water scarcity, soil contamination and compromise of agricultural activities (Ströbele-Gregor, 2013). These repercussions will arguably aggravate in view of the skyrocketing international demand and competition for lithium by solar and car industry, hi-fi technology, and other sectors (Ströbele-Gregor, 2013). It remains to be concluded that the decentralized generation of solar power is entirely sustainable and fair, only if it involves a critical scrutinization and amendment of the production conditions of solar technology throughout the supply chain. One essential approach is the embedment of solar technologies in a circular economy.

11.3.2 Recycling

The increased use of photovoltaic technology in Argentina entails challenges in raw material procurement, as well as manufacturing and disposal of PV modules. The increase of harmful PV waste, the scarcity of resources and the value of processed components make organized recycling ecologically vital and economically viable (Weckend, Wade, & Heath, 2016). PV modules integrate finite and partially poisonous compounds, including sand, plastic, rubber, metals and high-purity semiconductor materials, such as the potentially poisonous crystalline silicon or cadmium telluride (Weckend et al., 2016). Recycling inhibits the loss of rare and the release of toxic compounds, and therefore refers to both the disposal of production residues and the continued use of old modules (Öhrlund, 2011). An expansion of PV modules in Argentina entails the accumulation of waste and the necessity of establishing a circular economy.

Although specific data for Argentina do not exist, the report *End-of-Life Management: Solar Photovoltaic Panels* provides a forecast for the global waste generation through photovoltaic modules by 2050. The worldwide installed PV capacity amounted to 222 GW by the end of 2015 and is expected to grow to 4500 GW by 2050 (Weckend et al., 2016). This considerable capacity increase could extend the amount of PV waste to 78 million tons by 2050 (Weckend et al., 2016). The authors of the report estimate the value of recyclable "waste" to more than USD 50 billion and calculate that the material inflow could produce two billion new solar modules (Weckend et al., 2016). In parallel to the waste accumulation, the strong growth of the solar sector and the high price pressure require increasing inputs of raw materials that are already scarce. A study commissioned by the European Parliament therefore encourages the development of secondary resource strategies for materials that are essential for the PV industry, including silicon, silver, indium and lithium (Öhrlund, 2011). The study concludes that, if such strategies were not developed, bottlenecks would arise in the provision of low-carbon technologies (Öhrlund, 2011). Hence, the sustainable expansion of PV technology relies on recycling. In addition to the economic benefits, recycling has a positive impact on the overall energy and eco-balance of PV technology: While generating the same amount of electricity, modules with solar cells made of virgin silicon need three times as long to generate the energy required for their production as those modules that contain recycled silicon (Weckend et al., 2016).

The environmental responsibility of the solar industry for the separation of its growth from the reality of resource consumption is apparent, especially in the view of growing solar power contributions to the energy portfolio. The positive news is that the circular economy is already feasible for the solar industry: While typical recycling rates amount to 45% for information technology and 75% for automobiles, the first PV modules already reached recycling rates of 90% (Weckend et al., 2016). Weckend et al. (2016) emphasize that 95% of PV module components can soon be recovered cost-neutrally or even profitably, and subsequently converted into new modules as well as dozens of other products. Figure 9 depicts a possible circular economy for solar modules, demonstrating the need for synergies with other industries, including electronics, aluminum and glass. Given the life span of photovoltaic modules that reaches from 25 to 30 years (Öhrlund, 2011), few have been discarded in Argentina. Accordingly, politics, industry and research have undertaken no relevant measures to encourage or implement recycling at this stage (L. Magri, personal communication, October 19, 2017). In order to facilitate the separation and reuse of the individual components, corresponding

recycling techniques should be developed and factored in from the beginning. In this way, Argentina could promote the long-term resource stability and the environmental compatibility of the solar industry, as well as the involvement of citizens in sustainable supply chains.

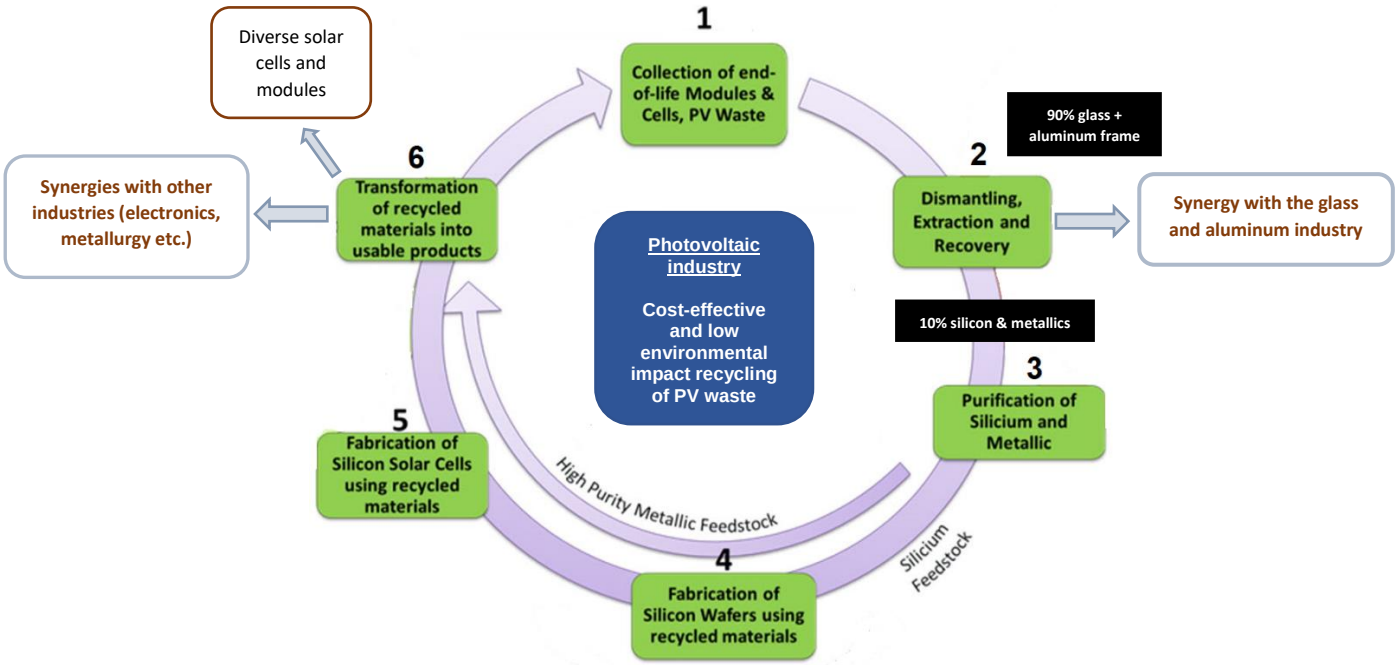

Figure 9: A potential circular economy in the photovoltaic industry (Sintef; 2015; Weckend et al., 2016)

12. Conclusion

A transition towards renewable energies is indispensable for Latin America given the region's ambitious emission reduction goals and reliance on fossil fuels. This transition is meant to be primarily implemented on the back of large-scale projects that obey the principles of economic value creation. However, this teleological approach involves intrinsic democratic shortcomings, as the project consortia tend to invade the natural habitats of indigenous people by depriving them of their right to self-determination. The energy transition in Latin America must therefore incorporate itself into a holistic framework, which includes citizens in decision-making processes, and takes into account – and raises consumer awareness for – the social, cultural and ecological costs of the transition to renewable energies.

Colectando Sol demonstrates a promising approach to a socially inclusive and democratically legitimized energy future. The company leverages technology as an instrument for the participation in the energy generation, as well as for the mitigation of social inequalities in the

energy sector, thus opposing large-scale projects that often imply the dominance of a technological intervention over local communities and ecosystems. The key instrument for *Colectando Sol* to promote this mission are interactive workshops and social activities that produce knowledge about solar energy concepts, the manufacturing of solar devices and methods of energy conservation. Knowledge distribution and the formation of communities of practice therefore serve to provide people with opportunities, capabilities and the willingness to engage in a solar-driven energy transition. On this basis, people from different social backgrounds are empowered to participate in the benefits of solar power in two different ways.

On the one hand, in a country like Argentina with its extreme social disparities in terms of income and access to public services, innovative solutions and applicable knowledge can make considerable contributions to improving the living conditions of many underprivileged people instantaneously. The self-manufactured devices qualify people from any social background to determine parts of their energy supply and alleviate their dependence on energy policies and social services. On the other hand, the interactive learning methods of the workshops provide for an enduring impact, since they motivate attendees to further engage in sustainable energy issues, particularly in roof-mounted, decentralized photovoltaic projects. The focus of the workshops on team efforts encourages to implement such projects collectively. In this context, it would be scientifically interesting for a future study to examine the extent to which *Colectando Sol*'s workshops impact on the attendees' actual investments in decentralized photovoltaic systems, especially within the framework of the *ley sobre la generación distribuida de energias renovables*.

Altogether, *Colectando Sol*'s focus on the collaborative and continuous acquisition and application of knowledge constitutes a necessary pre-requirement for a comprehensive proliferation of roof-mounted photovoltaic energy systems. In this way, the company fosters a participatory energy transition in Argentina, whose distinguishing features reflect in a dual value synthesis: Firstly, individualism and common good conflate because the autonomous use of photovoltaic energy expands individual freedom, without restricting the opportunities of others or threatening ecosystems that surround the solar energy plant. The second synthesis concerns ideal and material values. Photovoltaic energy satisfies man's material interests by integrating local people and resources with a collective purpose. Economic concerns certainly assume a prominent role in decentralized photovoltaic projects, yet the workload, resources, costs, risks and generated wealth are evenly distributed among all project members.

The conversion of the consumer into a main protagonist of energy generation and supply implies a cultural paradigm shift in the energy sector. The radical nature of this transformation is, however, detrimental to profit margins of powerful stakeholders. On the one hand, these powerholders encompass energy suppliers, whose business model is challenged by the competition of private consumers that feed energy into the power grids. On the other hand, a focus on small-scale energy generation may compromise the long-term energy supply of those industries that greatly benefit from the electricity generated by large-scale energy projects; examples include the copper industry in Chile, the retail sector in Mexico, or the bioethanol production in Brazil. In addition, challenges emerge concerning the sustainable commodity procurement for photovoltaic modules and the fluctuating availability of solar resources. Decentralized photovoltaic systems in Latin America are therefore neither free of conflicts, nor able to satisfy the current level of human energy consumption, nor sufficient for building a fair and sustainable energy future.

For these purposes, parallel measures must be taken in business, politics and civil society to make the transition to renewable energies more sustainable and participatory. These measures must include a fundamental reconsideration of energy projects in terms of participation mechanisms and structure. Likewise, actions are required to reduce society's overall energy consumption through the promotion of responsible consumption patterns and the redefinition of economic success. In view of these enormous challenges, *Colectando Sol*'s business model represents a first step in the right direction. The company's mission is a blueprint for how to circumvent entrenched structures and enhance decision-making capacities of citizens in the energy sector, thus converting them into an actor of political and economic relevance. Moreover, *Colectando Sol*'s educational approach to energy generation possesses tremendous expansion potential due to its replicability in diverse media and world regions, notably in poor but sunny countries.

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