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Tracing the emerging energy transitions in the Global North and the Global South

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ABSTRACT

During recent centuries, in the Global North, every energy crisis has been overcome, sooner or later, with a transition that has led to an increase in the average per capita energy consumption. Currently, due to the environmental and social impacts of the dominant high-consumption and fossil-fuels based energy model, we are seeing some initiatives that pursue a transition towards a democratic, low-carbon and low-energy consumption level energy system. This work analyses some of the socio-cultural, technological, economic and political factors that are leading to different multi-scale transitions towards low-energy societies around the world. It examines several different cases of transition and proposals from the Global South and Global North. Furthermore, given the limitations of the local or partial nature of these case studies, we also analyse their national energy contexts taking into account the hidden energy flows. These data integrate the total energy needed to provide the goods and services consumed by citizens and indicate the sectors that should be targeted to bring about genuine change, which sometimes differ from the transition paths signposted by national governments. The specific lessons extracted from the case studies in this research may contribute to a social learning process, promoting democratic and sustainable energy models in different regions of the world: peak oil could be an opportunity; energy needs to be equitable, not only renewable; there should be more sincerity and transparency in public energy data communication; energy should be controlled in a public or cooperative way; citizens should take control of their own investments in the energy sector; energy should be a right, not a commodity; community based consumption could reduce energy consumption; and sustainable urban development should be applied in cities and towns, where energy consumers could also become producers.

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Introduction

Human beings have always needed energy to satisfy their basic requirements such as food, shelter, health, transportation, or social needs. The energy used for these purposes has been a result of a combination of the availability of a particular resource and the technological development of processing the available source. Hence, biomass energy has dominated throughout history [1]. More recently, new factors have influenced the choice of the chosen resource, related to the economic and political strategies first of countries, and then of international brands. There is no longer a direct relationship between the personal human needs of inhabitants and the chosen energy source. All these factors have generated shifts in resource use, and we call these energy transitions. However, there has been a constant trend during these energy transitions in industrialized cultures: a greater amount of energy has been consumed per inhabitant after each transition. According to Smil, the world's total primary energy supply (TPES), increased from just over 10 EJ in 1750 (taking into account that according to the UN there were 791 million inhabitants and the consumption per capita per year was 3500 kWh) to about 400 EJ in the year 2000 [2] (taking into account that according to UN there were 6.52 billion inhabitants and the consumption per capita per year was 17,000 kWh) with a 4000% increase in the total worldwide consumption of resources in the last 150 years.

This is the reason why until recent years it was considered that the historical indicator of development, GDP, had a causal relationship with the energy consumption level [3], since in the last decades of economic growth "energy use increased in almost direct proportion to the economy" [4]. With more emphasis on the Global South, the increase in GDP is still directly related to the increase in energy consumption [5] although new efforts are being made to promote low-cost and low-energy product development [6]. Nevertheless, two critical points appear here, firstly that the increase in energy consumption has been totally unfair between different countries [7], as well as among the different social classes in the same country. China is one of those countries in which these phenomena are most readily observed [8]. Secondly, if new indicators are used to measure the development of a country such as the Human Development Index (HDI), the causal relationship between energy consumption and the level of development ceases to exist in high HDI level countries. According to Martínez and Ebenhack [9] there are no countries with both a HDI above 0.7 and a per capita energy consumption (PCEC) below 400 kgoe per year (4700 kWh), and no country with both an extremely low HDI and a PCEC value superior to 800 kgoe (9300 kWh). Nevertheless, this direct relationship between HDI and PCEC is not directly proportional in "energy-advantaged nations" where excess energy is spent with no real improvement in the quality of life. This hypothesis agrees with that of Dias, who argues that there could be "a 1.2 tep (14,000 kWh) consumption reduction from developed countries with no significant life quality loss to help reduce the natural resource depletion." [7,10]. A later study by Steinberger states that to obtain a 70-year life expectancy there is a trend of a reduction in the energy required. Whereas in 1975, 100 GJ (27,800 kWh) per capita of primary energy were annually needed, by 2005 the energy required fell sharply to 74 GJ (20,600 kWh), and the same study outlines that if this trend continues, by 2030, "a life expectancy of 70 will be correlated with only 24 GJ (6700 kWh)" [11].

Apart from that, we are seeing glimpses of a new transition brought about by a new problem, namely the global impact of our present energy model. Environmental impact (especially climate change) is the main impact. According to the Intergovernmental Panel on Climate Change (IPCC) Climate Change 2014 Report: "Surface temperature is projected to rise over the 21st century under all assessed emission scenarios. It is very likely that heat waves will occur more often and last longer, and that extreme precipitation events will become more intense and frequent in many regions. The ocean will continue to warm and acidify, and global mean sea level to rise." Furthermore, the only way to avoid this effect seems to be to achieve "negative emissions", i.e., extraction of CO_2 from the atmosphere [12].

Secondly, there is the social impact caused by the unfair pattern of energy resource extraction or energy generation: in energy generation processes such as dams [13], the emotional impact caused by oil spills [14], the social impact of new electricity grids in remote regions [15], the impact of oil extraction [16], deforested and degraded land due to large plantations for biofuels [17], the impact of pipe line constructions on rural areas [18], groundwater contamination, depletion of aquifers and the effects on public health of hydraulic fracking [19] or the energy poverty arising from inequalities in the energy distribution process [20]. The current costs of external social impacts of energy production are not reflected in market prices [21].

And last but not least, there is the crisis of values derived from the emphasis on productivity in a system in which growth is the centre of all well-being [22]. The inequality and the environmental problems associated with this capitalist system have led to several global protests and an alternative global value-articulation process. The capitalist values of the Global North have forced the energy generation companies to use economic income performance as their only point of reference, and this has meant neglecting any non-production related benefits. It has been observed that in areas inhabited by First People (Indigenous People), there have been calls for less invasive uranium mining as other non-production related values were asserted by the indigenous communities [23].

Thus, it is evident that the current energy regime, highly consumption-based, profit-driven and fossil fuel-based, is in need of a shift [24,25]. The term regimes refers to the dominant structures, institutions, practices, paradigms and economics around a specific technology, ecosystem or societal function and "transitions" are defined as non-linear regime shifts [26]. Each historical energy transition has been advocated to address multiple challenges faced by previous energy systems [27]. Nevertheless, unlike the last transitions, which were driven mainly by the dominant social actors (e.g. governments or large economic-industrial clusters), the upcoming transition is not supported by the main national political and economic forces.

Confronting this dilemma, most policymakers and many transition scholars expect that 'green' innovation will be sufficient to bring about low-carbon transitions [28] and that peak-oil may trigger a transition to other energy sources, such as innovative solar or nuclear technologies [29–31]. Nevertheless, faced with this technocratic idea, other important sectors within academia are concerned, exploring the transition potential of the different existing actors, offering a social perspective on the energy problem. In these incipient research works, small-scale bottom-up movements have strong relevance [32,33], and their methods are disseminated in order to change the current energy paradigm [34]. Our research group shares this concern and attempts to figure out the feasible strategies to apply in the arising energy transition and to fill the research gap in the literature within two topics.

Firstly, there has been detected a lack of research analysing integrated energy transition in the Global North and Global South. Most cases in the literature focus on specific transition cases of northern countries. Whereas there is an absence of literature analysing the possible energy transition taking into account both global realities.

Secondly, almost all the solutions initially focusing on energy transition ultimately only focus on the electricity sector. Furthermore, the solutions mainly refer to electricity cooperatives, acting mainly on household electricity consumption (especially in the Global North), which represents just 3.35% of the energy globally consumed, or sometimes citing the global electricity consumption which still only accounts for 12.38% [35]. The integration of renewable electricity in northern countries is a well-studied topic in emerging social energy transitions: renewable electricity expansion in the UK through cooperatives, analysed with empirical case studies [36]; renewable electricity cooperatives in Toronto [37]; renewable electricity cooperatives in Denmark, Netherlands, UK, Germany and Austria [38]; the influence of cooperatives within renewable energy promotion in EU countries [39]; UK renewable energy and climate policy analysis by renewable electricity generation [40]; UK electricity system analysis with MLP (Multi-Level Perspective) [28]; renewable electricity feasibility in EU [41]; Netherlands renewable electricity communities [32] (where the heating issue has been tackled); the power for social transformation by electricity cooperatives in Germany [42]; electricity cooperatives and public management of electricity in Wales, Spain and Germany [43]; citizens' renewable electricity cooperatives, limitations and opportunities in Europe [44]; low carbon electric transitions in the UK [45]; sustainable renewable electricity communities in Spain [46]; and the German electricity transition supported by Energiewende [47]. In the Global South scientific literature dealing with the "energy transition" has generally considered this as a more far-reaching phenomenon, not just focused on the electric sector, or electricity cooperatives: energy transition in the transportation sector in Brazil [1]; new policies to support energy transition in specific sectors in Brazil [48]; the national decision-making process for oil extraction development in Ecuador [49]; the role of Cuban society in the energy transition in 1990 [50]; and small-scale renewable technologies for energy transition in Cuba [51].

In this paper, we attempt to view "energy" not only as electricity consumed by households but also as a worldwide extraction and transformation resource that keeps our production system alive. This means that a new energy model should not merely involve a switch from a fossil electricity generation source to a renewable one, or a management shift, but a "radical social change" within the whole production and service system [50]. Thus, it has been detected that there is a research gap when assessing empirically North and South mixed case studies, confronting the energy model as a global problem. It has been detected that conceptual results of a mixed case study analysis between North and South could provide new insights to help move towards a sustainable and fair global energy model. It has been considered that this research could be complementary with more worldwide generic energy transition theoretical models where future scenarios play out [50,52]. There has been previous research, exploring the impacts of a northern open economy on the Global South and the global environment [53], and this article continues with this philosophy [54] and focuses specifically on the energy sector.

To address this topic, the principal aim of this research paper is to identify some of the socio-cultural, economic, political or technological key factors bringing about different multi-scale transitions towards low-energy societies throughout the world.

The analysis of these factors has been approached by examining the challenges, successes and failures of the transitions studied, which may contribute towards a social learning process in other regions of the world. How might different countries act in order to create a new democratic low-carbon energy transition? Moreover, this analysis leads to key questions being asked regarding the organization of the energy system: What do societies use energy for? Who are the real beneficiaries of the current energy model?

The case studies to be analysed were selected based on two criteria: they represent processes towards low-carbon and low consumption systems (they are not finished transitions and some of them are civil society proposals) and they involve a democratization of the energy model through different strategies (the transition is led by civil society or the process involves the creation of a public energy system). They are very heterogeneous experiences in an aim to encompass the diversity of different paths towards energy transition. In general, they are local in scale or partial processes, which provide interesting insights but have certain limitations. In order to present a fuller picture of the cases, we have also analysed the energy data for the countries in which the case studies took place. This study analyses the energy models of Spain, Germany, Cuba, Ecuador and Brazil and the selected local transition cases. We have also added other countries' national data for comparison purposes due to their non-standard energy behaviour (Denmark and China). Hence, we have analysed the energy consumption of different sectors (as well as transformation losses, the energy industry's own consumption and energy distribution losses), the CO_2 emissions, and the sources of the energy supply. Firstly, we identified the different ways to communicate the quantitative energy goals of the different nations in their move towards a low-carbon democratic energy model. Secondly, the Hidden Energy Flows (HEF) or the Energy Debt for each country were included in the data, in an attempt to find out the total energy consumption. Thirdly, the data analysed was then regrouped in order to highlight the most critical sectors requiring change to make our future energy model more efficient.

Table 1 – Case studies analysed.

Country	Subject
Ecuador	Oil struggles in the Amazon rainforest
Brazil	Limits and impacts of the renewable hydroelectric generation
Cuba	How to face an oil shortage
Germany	Community based emerging new energy models
Spain	Electric energy market struggles

The large contextual differences and economic disparities between the Global North and South have caused differences between the ongoing energy transitions. On the one hand, in the Global North, the high levels of energy consumption require energy-decrease, as well as de-growth scenarios; as an absolute or relative dematerialization [55] with an equitable downscaling of production and consumption that increases human welfare and enhances ecological conditions at local and global level [56]. According to some research studies, primary energy use per capita in the most industrialized countries, on average, should be reduced at least four times, until reaching the current average consumption [52]. Being more specific, northern countries should limit their energy consumption to 21,970 kWh/year, which could provide a HDI of 0.78 [10]. Furthermore, a recent research study has demonstrated that in small scale communities a 90% primary energy reduction has been achieved with a communal living model actually improving levels of life quality [57].

On the other hand, in the Global South the situation is more complex as both energy consumption levels and HDI levels remain low. This is why the coming energy transition involves not one but several different transitions, based on the respect for each country's opportunities. This paper aims to contribute towards supporting a change towards a sustainable energy model, defining sustainable not only as the concept of meeting the needs of the present without compromising the ability of future generations to meet their own needs [58], but also as meaning socially fair and equal.

Finally, it should be said that this work involves more in-depth research based on an already published exploratory survey where the case studies presented here were initially analysed [59].

Methodology

In the same way, the analysis of the energy sector has normally been divided into independent disciplines such as economics, social studies, politics, geography, engineering … and “practitioners of these disciplines normally publish their research in separate journals” [60].

Special effort was taken in this research to involve political, environmental and engineering researchers in an aim to offer multidisciplinary insights into prospective transitions. Furthermore, besides academic researchers, those working within social movements have also been incorporated into the main research team.

Secondly, an attempt has been made to have a clear perspective regarding the interpretation of the data. Germany, as in the case of other northern European countries, is usually considered, socially [61,62], and academically [46,63], a country that is heading towards a sustainable energy model, a global example for other countries to follow. To avoid confusion, a comparison has been made between the data for both highly developed countries and developing countries interpreting both from different perspectives.

This work has used the case study approach, which enables us to progress with research on the diverse emerging phenomena or conceptual patterns [64]. According to Simons [65] “Case study is an in-depth exploration from multiple perspectives of the complexity and uniqueness of a particular project, policy, institution, program or system in a ‘*real life*’ context.”. In order to complete the definition of case study, Thomas [66] argues that “a case study must comprise two elements: a practical, historical unity, which I shall call the subject of the case study, and an analytical or theoretical frame, which I shall call the object of the study.”.

The selection process for the case studies has been a participatory process coordinated by the main research team, in which experts on energy at the University of the Basque Country, activists from the social movements Ecologists in Action and Engineers Without Borders and researchers from the research teams Parte Hartuz and Ekopol have participated. In the meeting different case studies were identified and what were considered the five most significant cases were selected.

Lastly, quantitative and qualitative questionnaires were conducted with the principal representative of each community/social movement. Each case was visited, and interviews carried out on location, with more than 15 people interviewed per case.

It has to be stressed that broad scope analysis, like the current one using empirical analysis, although less detailed than other studies using MLP, can provide a broader approach than MLP [40]. Although the most extensive methodology in the analysis of transitions is the MLP method, in this research it has been considered more appropriate to use the more empirical case study analysis in order to focus on the society that is generating the change, and not on the external (regional or national) actors, even though the latter have also been analysed (at a lower level than in the MLP methodology).

Preliminary analysis of the case studies framework

This section is devoted to presenting the national energy framework of the case studies, analysing in a quantitative way the energy consumption levels. More specifically, subsection Energy consumption of countries including hidden energy debt and avoiding misleading communication deals with the indicator of total energy consumption by country, while subsection Identifying the critical energy consumption sectors or opportunities for reductions addresses where this energy has been consumed.

Energy consumption of countries including hidden energy debt and avoiding misleading communication

It has often been stated that since 1990 Germany and Denmark are the countries which have best achieved the reduction percentages of emissions of greenhouse gases, in terms of $kgCO_2eq$ levels, whereas developing countries have increased their emissions. Ironically, the same data could be presented in two different ways, depending on the reality we aim to reflect. The first interpretation could be that "northern countries like Germany thanks to their energy efficiency policies have reduced their per capita emissions since 1990, Germany has reduced by 21.94% and Denmark by 30.27%, whereas, the Global South countries like China, Ecuador or Brazil have increased their per capita emissions by 241%, 90.15% and 83.74% respectively" Fig. 1. The same data could be interpreted as "in 2013, German per capita emissions are among the highest in the world, behind are the emissions of China, emitting 18.65% less, Ecuador, emitting 72.86% less, or Brazil 75.57% emissions less per inhabitant." This point shows the risk of adopting perception-based reduction strategies (such as the European 20/20/20 targets) where the most pollutant countries in 1990s, especially those from the Global North, would always have an advantage in terms of reaching reduction targets. Nevertheless, countries that are and have been less pollutant, especially those in the Global South, have more problems to reach this perception-based reduction target.

A similar effect occurs when countries like Denmark or Germany declare that their renewable integration in the electric energy production is 48.07% and 26.02% respectively, whereas in the Cuban or Chinese model the renewable integration was 4.35% and 20.56% in 2013 according to the International Energy Agency (IEA). The same data could be provided saying that each Danish and German citizen has 26,100 and 40,200 kWh/yr energy consumption coming from fossil fuels and nuclear power in the primary energy supply while Cuban and Chinese inhabitants consume an average of 10,600 kWh/yr and 23,000 kWh/yr respectively, as could be appreciate in Fig. 2. The Brazil and Ecuador cases are even better, where the renewable electricity percentage is higher than in Germany or Denmark and the fossil fuel and nuclear presence in TPES is far lower.

Furthermore, the above data does not include the energy embodied in international trade (EEIT) or the Hidden Energy Flows (HEF): the energy that a country (especially northern ones) consumes in other countries (especially southern ones) by outsourcing services and goods manufacturing. Fig. 3 shows the "territorial perspective" used by the IEA to measure the energy consumption of a country, which means that all the energy sold in a country is computed as that country's use, regardless of who is purchasing and actually consuming that energy; whereas if instead a "consumption-based" perspective is used, energy indirectly consumed by a country in other nations in the form of imported goods and services should be measured and assigned to the consumer country, not to the producer [7].

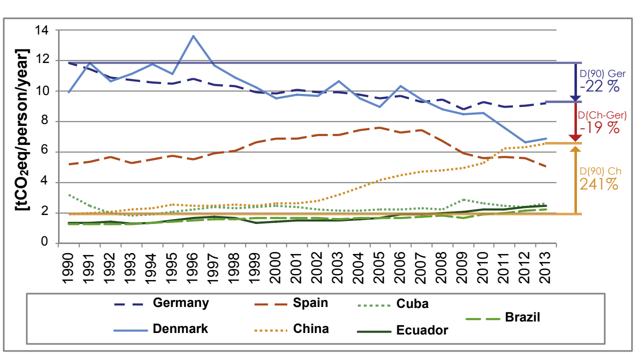

Fig. 1 – Tons of CO_2eq emission coming from the fuel consumption for the energy supply of a country (own elaboration from IEA data [35]).

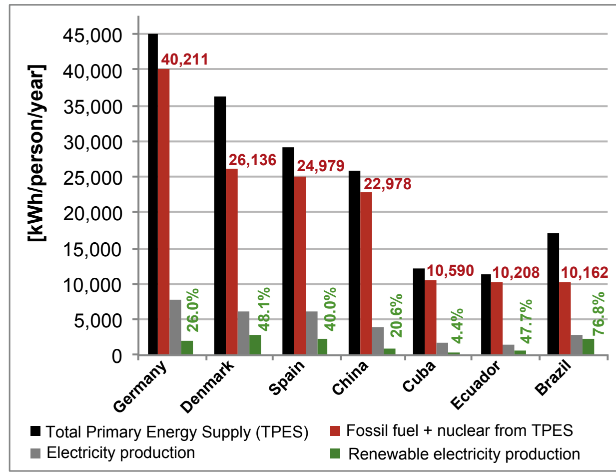

Fig. 2 – Variation in the integration of renewable energy in electric energy production versus the presence of fossil fuels and nuclear in the primary energy supply (own elaboration from IEA data).

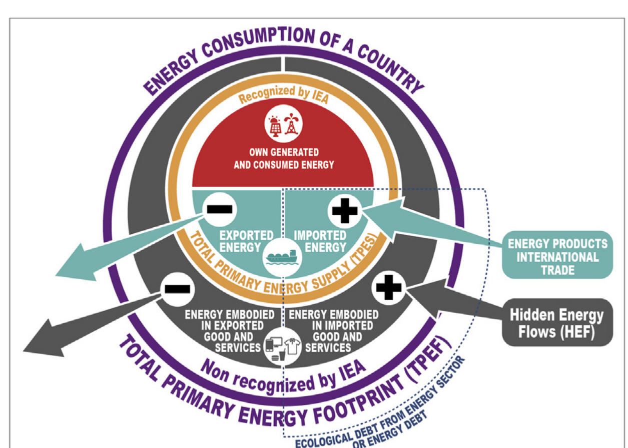

Fig. 3 – Hidden Energy Flows meaning (own elaboration).

The concept of EEIT has been initially detected as an "Ecological Debt" that the Global North has with the Global South [54,67,68]. The "Ecological Debt" recognizes the impact of northern consumerism on the southern countries' society and environment. From this generic term, within some social movements the concept "Energy Debt" has been used to refer specifically to the ecological debt of the energy sector [69,70]. "Energy Debt" is divided into two parts: the imports of energy resources from other countries, which are included in the IEA data; and the EEIT [7], not recognized as energy consumption by the IEA, as explained in Fig. 3. The concept "Energy Debt" is too abstract to quantify whereas the EEIT specifically defines the difference between total primary energy supply (TPES) and the total primary energy footprint (TPEF). Our research team uses the term "Hidden Energy Flows" (HEF) to define the EEIT, supported by the theoretical concept of indirect or "hidden flows" referring to those hidden in the imported goods [71].

If the HEF are taken into consideration, northern countries like Germany or Spain consume respectively 28.21% and 33.33% more energy than their TPES [7]. However, this northern energy consumption and the associated CO_2eq emissions are computed to the countries where the goods were manufactured. Fig. 4 shows the percentage increase from the IEA data that creates the HEF [7] (Cuba and Ecuador are integrated with other states [7]). A similar effect has been cited in technological improvements with lifecycle approaches [72].

Currently, energy literacy studies do not include this important factor [73]. Introducing the HEF data to the emission values (including them proportionally in considering that the emission rate of the increased consumed energy is equivalent to the national rate), countries that apparently have the same CO_2 emission data as Denmark per capita according to the IEA, e.g. China with 6.60 and Denmark with 6.91 tCO_2eq, in the new calculations the data changes to 5.28 and 11.52 respectively, see Fig. 5. So it could be said that in the first case "according to the International Energy Agency, in accordance with the territorial perspective, in Denmark, CO_2 emissions per capita are just 5% higher than in China per capita" or "Denmark's average emissions per capita are 218% that of China". Important reports on sustainability measurement like the *Environmental Performance Index 2016 Report*, elaborated by Yale University, do not take into account the HEF, and hence give a completely distorted view of the reality of a country considered a reference in sustainable energy [74]. Actually, in recent years the HEFs are increasing in most of the Global North Countries [7].

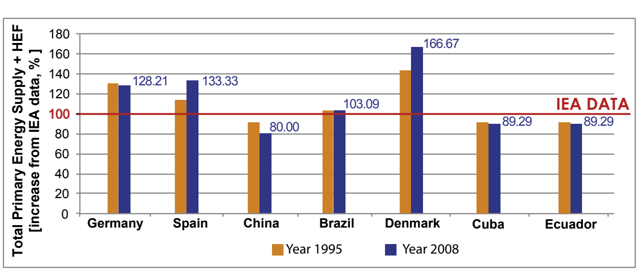

Fig. 4 – Percentage increase from IEA energy consumption data to Total Primary Energy Footprint data of the same country (TPEF) in 1995 and 2008, taking into account the HEF (own elaboration from Ref. [7]).

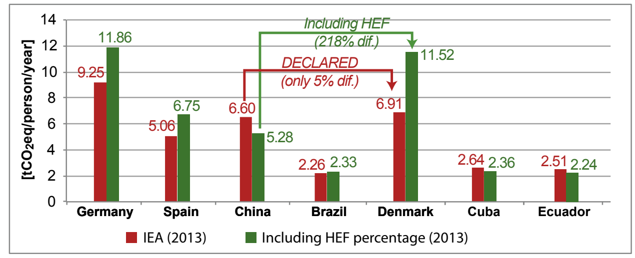

Fig. 5 – Tons of equivalent CO_2 emissions from IEA 2013 data (red), and total consumption-based emissions including the increase due to the HEF (green, own elaboration, Appendix A, Table 4, [122]). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

In general, inhabitants from the Global South countries like China, Cuba or Ecuador have less CO_2eq emissions than the real ones, whereas the Global North countries analysed produce more emissions than those stated. In the Brazilian case it could be said that the HEF balance stands at approximately zero.

Identifying the critical energy consumption sectors or opportunities for reductions

It is evident that northern countries need to reduce their energy consumption levels but it is not clear how this can be done. It is assumed that citizen awareness is directly related to behaviour and its effects [25]. However, there is no evidence that current citizen action contributes to causing an energy transition. In fact this paper seems to contradict this point. It all derives from the increasingly common basic error of mixing the terms electricity and energy. Consumed electricity constitutes the equivalent of just a small percentage of the TPES, e.g. in Germany 13.57%, Spain 15.65%, Cuba 10.95%, Brazil 14.00% and Ecuador 10.89%. The rest of the energy consumed in the country is used for other purposes.

Fig. 6 shows that home-consumed electricity is residual (ranging from 2.00% in China to 5.05% in Cuba) meaning that to implement a strategy for a new energy transition, the impact that citizens could have by controlling the electricity generation at home is superficial (Cuba and Ecuador HEF has been assumed as zero since data are missing [7]). For this reason, we could acknowledge the limitations of energy literacy in residential household energy reduction actions [75]. Instead, more profound changes need to be made to the current energy system, especially in the Global North Countries changing the focus to Hidden Energy Flows (only in the case of the northern countries, Spain and Germany in this case), transformation losses, energy needs for the generation of product and services, or the transportation sector. This thinking change is directly related with the energy literacy of society.

The sectorial disaggregation has been obtained from the IEA data, integrating the consumption of aviation and marine

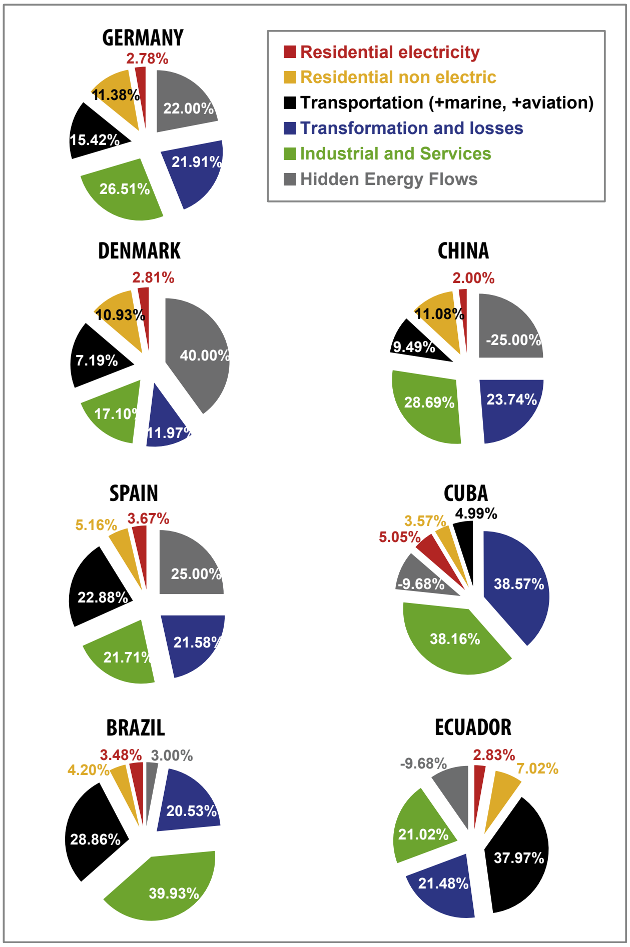

Fig. 6 – Germany, Denmark, China, Spain, Cuba, Brazil and Ecuador primary energy supply reshaping (Elaborated by the authors from the International Energy Agency data and integrating HEF).

transport to the Total Primary Energy Supply of each country. Firstly, the household electric energy consumption has been extracted, and in the same way the non-electric consumptions in private houses have been identified. Secondly, the industrial and services energy consumption, including the non-energy consumption, have been aggregated. Thirdly, the transportation section has been created, including marine and aviation transportation consumption. A new area has been added where energy transport, distribution and transformation losses, and own energy-sector consumption have been included. Lastly, the HEF have been added proportionally to each country using the most recent data available [7], with a negative or positive effect, according to the country.

Results

This section presents the findings achieved in the analysed case studies. Taking into account that core changes need to be made to the current energy model, in each case study the significant proposals which could help to bring about profound changes leading to transitions towards a democratic low-impact energy model have been analysed. These proposals or ongoing transitions are diverse: some of them are lifestyle and production changes (Cuba, Germany, Spain), others are proposals by civil society (Ecuador, Brazil); some are local or regional projects (Germany, Ecuador) and other national-scale transitions or proposals (Cuba, Spain, Brazil).

Ecuador: oil struggles in the Amazon rainforest

Petroleum became the base of the Ecuadorian economy in 1973, with the maximum percentage reaching 50%. This year Ecuador has seen a GDP growth of 24%, an unprecedented leap in both the 20th and 21st centuries. In the last 10 years, petroleum has been Ecuador's main export representing between 43% and 66% of total exports and between 43% and 59% of the total state budget [76].

The oil "boom" led to loans being made available for Ecuador: while foreign debt stood at US$ 260.80 million in 1971, in 1981 it had risen to USD 5869.8 million. This caused the crisis between 1983 and 1986, which led to the intervention of the International Monetary Fund (IMF). Subsequently the total revenue from petroleum operations was used to pay off the debt. Currently, the state has accumulated an even greater debt due to the construction of essential energy infrastructures and installations. Between 2009 and 2011 the debt with China stood at over USD 7847 million [77].

On the other hand, the remaining profit coming from the international oil trade is invested mainly in subsidies to diesel and petrol, benefiting specially people with greater resources, the ones who use most the private cars [78]. Furthermore, the electrical energy obtained from the new generation plants has not directly benefited either the country or its inhabitants. The price of electricity in Ecuador was, and still is, higher than other countries taking into account the living standards. For instance, in Northern Dakota, also an oil producer region, in 2015 the price of one kWh was USD 8.32 cents according the U.S. Energy Information Administration, instead in Ecuador, according ARCONEL the price for household electricity consumption was USD 9.32 cents. The state debt, with no direct benefits passed on to citizens, led to the political stability reflected in the 11 different governments between 1979 and 2007 as a result of mass citizen protests.

Another negative effect of the oil boom was its huge impact on the environment. Over time this led to reaction from society, which resulted in the emergence of an environmental movement. One of the organizations to emerge was Acción Ecológica which in 1995 participated in the creation of the international network Oilwatch [79]. At present, Oilwatch represents 50 tropical countries suffering the effects of the oil companies. One of their slogans was "Leave the Oil in the Soil" which despite how utopian that might sound, in Ecuador they attempted to put this into practice. Yasuní Park was the space where this proposal was to be realized.

Yasuní national park occupies nearly one million hectares of rainforest in the Ecuadorian Amazon, with 150 species of amphibians, 121 species of reptiles, 598 species of birds, between 169 and 204 species of mammals and between 2113 and 3100 species of flora. UNESCO designated it as a Biosphere Reserve in 1989. The Biosphere Reserve is home to the Huaorani indigenous people and peoples in voluntary isolation such as the Taromenane and the Tagaeri. Theirs is a society of satisfied needs, so-called "*affluent societies*" [59]. Nevertheless, below the Yasuni area soil lays USD 3268 million worth of crude oil.

In 2000, Acción Ecológica proposed a "*post-oil Ecuador*", based on concepts such as an oil moratorium, energy sovereignty, food sovereignty, renewable energy, etc. By the 2007 elections a new unified left candidacy had been created called Alianza PAÍS which, among other proposals, adopted the grassroots proposal to not exploit the petroleum in Yasuní, becoming the first oil dependent country to propose leaving the oil reserves in the ground [49]. After its victory, the Alianza PAÍS government pushed forward both the Iniciativa Yasuní ITT [80] and the offer of financial compensation for the unextracted petroleum. As a country in debt and suffering economic intervention, the richer countries, and especially those having the biggest impact on the climate and on the environment, are made to participate, to pay the compensation. Not extracting petroleum from Yasuní means preventing both the destruction of part of the Amazon rainforest and the emission of 407 million tCO_2eq. These countries have to contribute half of what Ecuador would obtain by exploiting this petroleum, approximately USD 3532 billion. The UN created the Yasuní Trust Fund to manage these contributions and to ensure they are used for the ends stipulated by the State of Ecuador. Some governments committed themselves to this: Spain, Iran, United Arab Emirates, Turkey and Germany.

However, at the same time the new Correa government had taken on new debt and the petroleum was the only asset available in the economy to pay this off. On 9 January 2010, Correa refused to sign the Trust, alleging that the conditions had been imposed by the contributing governments. Meanwhile, the government also came into conflict with the areas affected, at times resorting to force, delegitimization, which then extended to the environmental and indigenous rights movements.

YASunidos was launched in 2013 as a national movement for the defence of Yasuní and as a way to influence the government or to fight external pressure from oil companies, creditors or the IMF. "This utopia of thinking of a Yasuní in a post-oil Ecuador, of us not depending on natural resources, is beautiful and is born with YASunidos. It was an exercise in direct democracy from being in the street, speaking to people [...] and this began to make the government nervous." [6]. Hence, on 27 August 2013 the Government lashes out violently against YASunidos [81].

On 22 May 2014, the Government granted Petrobras permission to explore for oil in Yasuní. This company is now operating in Yasuní in Block 31. Despite the concession belonging to a national company, it has been agreed that the petrol is to be exported to China. The other company with a concession is Andes Petroleum, a subsidiary of China National Petroleum Corporation and SINOPEC.

Grassroots movements and the international community have continued to work towards a new paradigm where oil is left under the soil and to foster other values respecting traditional cultures and their Good Living. For this reason, the Ecuador case study is a key reference in terms of energy transition due to its proposal to leave the oil under the soil and to its being the only country in the world whose government took this proposal and tried to put it into practice on an international level. Furthermore this proposal is in line with climate change objectives. According to an article in Nature, James Hansen director of NASA stated that in order not to surpass the limit of two degrees of global warming established by the Intergovernmental Panel on Climate Change, it is not sufficient to set limits for CO_2 produced by burning fossils fuels but "we must identify a portion of the fossil fuels that will be left in the ground" [82]. A recent study confirms this theory: "a third of oil reserves, half of gas reserves and over 80 per cent of current coal reserves should remain unused from 2010 to 2050 in order to meet the target of 2 °C" [83].

Brazil: limits and impacts of renewable hydroelectric generation

The growing Brazilian economy is highly dependent on a large-scale infrastructure energy system, especially in order to satisfy the needs of its industrial sector. Furthermore, the oil and gas extraction sector, with the prominent role of the national company Petrobras, is a main supporter of current economic development, 10.4% of the Brazilian Gross Domestic Product (GDP) [84]. Nevertheless, the Brazilian state is concerned with moving towards a sustainable energy model, despite this creating a divergence in energy-dependence objectives.

What is considered to be one of the most successful [1] energy transitions occurred in the Brazil transport sector, where a coordinated State strategy has been implemented in order to shift from an oil-based transportation system to one based on sugarcane-ethanol. As a result, the percentage of alcohol-based car sales rapidly increased from less than 1% of total sales in 1979 to 96% by 1985 [1]. In 2010, Brazil had become the largest biofuel producer in the world with 492,844 b/d. In February 2015, the Brazilian government raised the ethanol blend requirement in gasoline to 27% [85]. In contrast, the transition to biofuels has been severely criticised, since although it could be a potential low-carbon energy source, whether biofuels offer carbon savings or not is highly dependent on how they are produced [86].

Yet the most controversial energy transition issue of Brazil is that towards the promotion of large-scale hydropower, which is directly related to the industrial energy consumption of the country, especially of the aluminium industry [87]. The contradictions of a supposedly renewable energy, such as hydroelectric, have set out the direction and content of the transition proposals [88]. In the country, around 34,000 km^2 of fertile land has been flooded to create over 2000 dams [89], of which 625 are hydroelectric [90]. In 2014 63.23% of the electricity in Brazil was generated hydroelectrically according to the IEA [91]. Presently, 15 large (>30 MW) hydroelectric dams are being built in Brazil and the 2012–21 Energy Expansion Plan foresees the building of another 37 generation plants [87].

In this context the Movement of People Affected by Dams (*Movimento dos Atingidos por Barragens*, MAB) was founded in the late 1970s. In the early years, they called for "*fair compensation*" for the affected people but their claims have gradually changed, evolving towards their current situation. Hydropower is considered as a renewable energy but the MAB states that hydraulic power generation in Brazil has had a major environmental impact and had also directly affected more than one million people by 2005 [92], most of whom have not been compensated yet (e.g. 22,315 people have been affected with the building of only 3 dams, Estreito, Serra Quebrada and Santa Isabel by the aluminium smelting companies [87]).

The MAB claims that it is necessary to answer the question: Who planned and organized the energy sector in Brazil? [93]. Hydroelectricity-generated problems are not only about a struggle of people affected by dams. The MAB states that the current energy model and energy policy respond to both market demand and corporate greed and aim to increase productivity and consumption with their only goal being to generate the largest amount of private profit possible. The MAB defines the current Brazilian energy system as follows (extracted from interviews):

- Privatisation and control of privately owned transnational companies concerning energy issues. The energy sector is controlled by large international corporations.
- The Brazilian electricity sector is fragmented in terms of generation, transmission, distribution and commercialisation. Each one of these areas is controlled by financial capital. The priority for each sector is to transfer wealth to shareholders and speculation occurs with assets such as rights, water and the environment, in an aim for higher profit.
- The price of electricity in Brazil was separated from the reality of production costs within the system. With the internationalisation of energy use for large industrial companies (such as the aluminium melting sector), electric energy has become one of the main national products, generating huge profits for shareholders.
- The increasing exploitation of energy workers and the violation of the human rights of those affected. Since privatisation started, there has been no increase in the total number of sector workers but two-thirds of sector workers are being paid lower salaries than before [87].
- The state organization has made the financial system and the energy system serve the interests of privately owned companies. The structure of the state is acting to depoliticize the energy debate and also to pass a set of laws and regulations whose single aim is to consolidate the high return on investment of the industry throughout the supply chain, whereby domestic consumers sustain and guarantee these high profits in the sector.

Given this general national situation, the MAB claims that "*water and energy are not commodities*" but a basic need for citizens. The Workers and Peasants Energy Platform (*Plataforma Operária e Camponesa para Energia*, POCE) was created in an aim to have an impact on national energy policy-making. The POCE was the result of discussions between organizations of farmers and local inhabitants regarding the energy model they wanted to construct. These debates began between 2008 and 2010. In 2008, the MAB organized a course on energy in Rio de Janeiro inviting several labour unions, university professors and social movements that were interested in the situation and in energy policies in Brazil. Here unions from the public oil sector met the POCE adding new claims regarding the privatisation of the oil industry. Indeed, this encounter between peasant movements affected by energy projects and workers from the energy sector is one of the key innovations and potentials in this project.

The POCE proposes a social energy project for Brazil, based on sovereignty, distribution of wealth and popular control. Women have played a remarkable role in this struggle giving visibility to social values on reproduction and the role of energy in their lives [94,95]. The proposals made by the platform can be summarized in the following points (extracted from interviews):

- Advancing the transformation and construction of national instances for more widespread democracy, popular engagement and control over the decisions concerning social energy policy.
- Making political and institutional changes to move beyond the market-driven energy model; greater state control over energy prices and energy purchasing should be made through the regulated market, with greater transparency of regulatory agencies.
- Reinforcing state energy companies with greater state participation and even the creation of a state monopoly so that gas and oil are made 100% public through Petrobras and Electrobras.
- Returning amortised power stations to state hands and a majority stake of state companies in energy consortiums.
- Developing the industrialisation of the entire energy supply chain, moving towards full technology sovereignty, incentivizing research and the petroleum potential in Brazil.
- Improving working conditions and valuing workers.
- Guaranteeing the rights of the affected areas through a national reparation policy for those affected by the dams.
- Energy integration solidarity with South America, developing this to guarantee public participation and grassroots struggles and technology transfer. The aforementioned aims to reinforce national sovereignty against transnational companies.
- Respect for the environment and minimization of social and environmental impact especially in the pre-construction stages. For this, it is proposed that public consultation be conducted, popular participation be encouraged and more environmental education programmes provided.
- Incentivizing the economy and researching new energy sources with less impact on the environment. The platform also proposes the diversification of renewable energy.

The deterritorialization and reterritorialization caused by hydroelectric plants could be an opportunity to generate points of social empowerment in order to advance towards the implementation of the energy transition [96].

Cuba: how to tackle an oil shortage

Cuba, the American Caribbean socialist island, developed its own unique expertise in social and economic subsistence, especially in the terms of energy, after the disappearance of the so-called "Socialist Camp" or "Soviet Bloc". Fuel imports decreased by 71% between 1989 and 1993, and the Cubans, actively encouraged to do so by the regime in Havana, relied on social networks and non-industrial modes of production to cope with energy scarcity [50].

Since 1960, the Cuban energy system has been constrained by two key factors that led the nation to an integral energy crisis. On the one hand the major energy dependence of Cuba on the COMECON (Council for Mutual Economic Assistance) markedly worse after the dismantling of the USSR in 1991 and on the other hand the economic blockade (intensified in 1992 with the Torricelli Act) that the United States of America has imposed on Cuba for over half a century [97]. The traumatic socio-economic situation experienced in Cuba in the so-called "special period" after 1991 is an interesting example showing an unsought energy transition imposed by the sudden collapse of its energy model.

The two factors discussed above meant that in this "special period in peacetime" (from early-to mid-1990s) Cuba lost more than 50% of its imports and more than 85% of its foreign trade. GDP fell by 50% in the period from 1989 to 1993, falling from USD 20 billion to half that amount and this had devastating effects on the population of the island. According to the EIA (US Energy Information Administration), between 1990 and 1994 electricity consumption in Cuba decreased drastically by 30.2% (from 13.24 to 9.24 TWh). In addition to power outages and mobility and transport problems, Cubans experienced a shortage of "everything", mainly food. Nevertheless, food scarcity had a surprisingly positive effect on the health of Cubans, rapid declines in cases of diabetes and heart disease accompanied by an average population-wide loss of 5.5 kg in weight [98], due to less smoking and a lower daily energy intake and increased physical activity. Later, mainly from 2002 to 2010, the population-wide increase in weight was immediately followed by a 116% increase in the prevalence of diabetes and 140% increase in the incidence of diabetes [98].

Our interest in choosing this case is to balance the positive lessons of the Cuban experience, during and after the special period. As Richard Heinberg pointed out in 2006 "Cuba survived an energy famine during the 1990s, and how it did so constitutes one of the most important and hopeful stories of the past few decades. It is a story not just of individual achievement, but of the collective mobilization of an entire society to meet an enormous challenge" [99]. Cuba showed the world that "*peak oil*" could be faced and overcome in a collective way. Although it was not a democratic decision taken by the inhabitants or a free choice by the government, in 2003 Cuba was the only country in the world to achieve a 0.8 Human Development Index value, while also maintaining the ecological footprint below the area of one world [100], and the proportional 1.5 ha per people as a demand on the biosphere [101]. For this reason it could be said that in 2003 Cuba was the only sustainable country in the world, attaining appropriate living standards within sustainable levels of ecological footprint. In 2013, although in Cuba 87.34% of the energy supply came from fossil fuels, an average Cuban citizen consumed 71.07% less fossil fuels than a German citizen and 59.48% less than a Danish citizen, without taking into account the Hidden Energy Flows.

There are many lessons and exemplary experiences we can take from the various transitions occurring in Cuba in the last 60 years, particularly in the so-called "*special period*" between 1989 and 1995. According to Julio Torres Martinez (from Cubasolar) Cuba is facing its 3rd energy transition, the first came with coal, the second with crude oil and petroleum and the third would come progressively with energy-saving and efficient renewable energies with the government aim for these to come to 24% of the primary energy supply by 2030 [59].

One of the biggest lessons we can draw from the Cuban experience is that the Cuban socialist state has ensured the viability of the project despite the US trade embargo, isolation and the hardship of the special period. However, this does not mean that Cuban society as a whole, despite being the "most sustainable" in the world in 2003 [100] has evolved culturally to make a conscious and democratically elected commitment to an energy transition based on low consumption and renewable resources.

The "*special period*" of the early 1990s led to a severe generalized stress test that the Cuban people were able to overcome due to the strong commitment of the structures of the socialist state to place universal interests above individual interests and the combined expertise of the public, farmers and scientists to manage the crisis by seeking mutual support [102].

The current situation of energy dependence on oil in Cuba and the necessary implementation of new energy policies now require a cultural shift towards sustainability and this remains a major challenge for the socialist state and for the Cuban people.

The consumerist aspirations of a vast majority of the Cuban people who crave the living standards of the middle classes of the capitalist countries show that this cultural change will not be easy and that the increase, albeit slight, in social and economic differences may endanger the fundamental achievements of the Revolution.

The energy issue is a challenge to move in either one direction or the other. If Cuba is the most "sustainable" country in the world, this is related to the control that the Cuban socialist state exerts on society and the energy issue is central to this.

As observed in this research paper, in the Cuban energy system, the main stakeholder is the state and its political institutions, with its many inherent advantages, although there are also disadvantages such as paternalism and bureaucracy.

Based on low-tech and community support, Cuba has demonstrated that it has the technical and human resources required for the production of the bio-energy equipment necessary for a fair, democratic and sustainable energy transition. But this transition will not occur if the majority in Cuban society aspire to a Global North *modus vivendi* and consumerist desires are imposed on the logic of power as a public service. That is, if energy in Cuba becomes simply a market commodity.

Germany: emerging new community-based energy models

In the German case, four different initiatives contributing to energy transition have been analysed.

First, the village of Feldheim, characterized for being the only village in Germany to be electrically self-sufficient and supplied 100% by renewable energies. Common citizens rarely have the right to choose which kind of energy technology to invest their own savings in. Electricity cooperatives have enabled individuals to decide how household electric energy is generated, but unfortunately, this affects a very limited energy sector (2.78% in Germany); as well as quite a limited economic sector (household energy expenditure), as the average electricity bill of a 3 member family raised up to €85/month in Germany in 2014 [103], less than 3% of an average single person's gross monthly earnings, according to World Bank data (€ 3973). Generally, people keep most of their savings in a bank, where this money is used to make investments in different production sectors and their respective energy model. Accordingly, the owner of the savings does not have the right to choose which kind of energy generation technology is being funded with their savings. Banks take the decision to invest in the most profitable form of energy generation and the only aspect that they communicate to their customers is the yield their money has produced. In fact, they are not even informed whether or not they have been funding forms of fossil fuel or nuclear power generation or even as to the resulting impact on the environment and on social inequality. Hence, essentially investors have no control over the energy system that they are using. In 1995 in Feldheim, the "Energiequelle" cooperative was created, supported by a student named Michael Raschemann. Today there are 47 mills with 74.1 MW installed capacity. Furthermore, they have installed different energy sources to diversify the energy generation capacity: in 2004 a 500 kW biogas plant, a biomass plant with 0.3 MW generation capacity for emergency purposes and a 2.25 MW capacity solar photovoltaic generation plant were all installed. In 2013, electricity production in Feldheim was 135.9 GWh while consumption stood at 855.95 MWh [104], only 0.63% of its electricity production was consumed. In addition they consumed 2.57 GWh of locally produced thermal energy.

Secondly, the eco-village Sieben Linden; where they approach energy transition by creating an austere community and changing the values of material consumption. Unlike many global experiences based on the "sacrifice" of rejecting the materialist luxuries of a "modern technological lifestyle", the Sieben Linden community lives "austerity" as a gain in happiness and in a high quality of life. According to their own calculations they have achieved a reduction of 77% of the primary energy supply in comparison with the German average. The first step towards low energy consumption was to reduce material and energy consumption through the communal use of resources by having a shared kitchen and dining room, reducing private space in homes to 16 m^2 and having an additional 16 m^2 in public buildings, car and appliance sharing, as well as communal food and energy generation. At the same time there have been processes to build low energy consumption houses, i.e. Villa Strohbund, built in 2002, which according to a Kassel University study conducted in 2002, had absorbed more than 15 tCO_2eq during its construction [105]. A conventional home, insulated with the same insulating properties (with heating consumption of 50 kWh/m^2 per year), is estimated to emit 10.51 tCO_2eq in its construction. This home not only has zero emissions but also becomes a fixer of the CO_2 retained in the wood and straw it is made from. The study emphasizes that the energy consumed during the construction, was between 2 and 5% of that consumed for a house of the same insulating properties [106]. The whole experience of constructing a low impact straw bale house reinforced the need to measure household energy expenditure and to set limits. The electrical engineer W.D. has become the advisor on energy consumption measurement in the eco-village. "Our goal is to live in an energy model where each person only uses its proportional corresponding part of resources of the country; we would like to ascertain that every person on this planet, and future generations as well, have the same right to use the resources" (extracted from interview). Based on this commitment, a calculation has been made in Sieben Linden regarding the amount of forestland that would correspond to each German citizen if there was an equitable distribution, in order to use the wood resources coming from this land as a heating energy resource. This is how they currently use 2200 $m^2$of sustainable managed forests per person in order to extract 1452 kWh of heat energy per year.

Thirdly, the "Solar Settlement" neighbourhood; where an energy transition has been implemented through changes in terms of architecture and urbanism. Located in the Vauban neighbourhood of Freiburg and designed by architect Rolf Dish, Solar Settlement (or Solariedlung) is one of the most internationally recognized sustainable housing complexes in the world [107]. Rolf Dish applied the PlusEnergy concept in this complex of 59 homes, a shopping centre, offices and a parking area, the first housing community in the world to present a positive energy balance [108]. Rolf Dish came up with the concept PlusEnergy in 1994, in the pilot home called Heliotrope, also located in the suburb of Vauban. PlusEnergy implies that the energy consumed in a building is lower than the energy it produces [109], the balance includes the electrical or thermal energy externally purchased and the excess of generated electricity sold to the grid. In this new energy model, consumers play a new role in the energy system, becoming energy producers due to the installation of renewable energy generation technologies. According to 2013 data, in Solar Settlement there is an average photovoltaic electric generation capacity of 6280 kWh per year per household. Furthermore, the average electric consumption per household is 2598 kWh per year and the average thermal consumption per year stands at 2821 kWh, with the two adding up to a total consumption of 5419 kWh, 13.7% lower than the energy produced.

Lastly, the Rosa Luxemburg Foundation (RLF), based in Berlin whose aim is to achieve a publicly managed democratic energy system [59]. The RLF defines the energy transition as an energy-shift, sharing the national idea of Energiewende, which can be described from two points of view, from a technical and from a political perspective. The technical part refers to the transition from the use of hydrocarbons, the use of renewable resources for energy production. Whereas the political part divides the integration of renewable energies into two groups: one that leads to large-scale installations under the continuous control of large energy companies; and another that leads to an increasingly decentralized, more democratic and socially aware energy model. The idea of public energy management, specifically that of electricity, has been analysed in depth by the RLF, by Conrad Kunze and Sören Becker who in 2014 published a survey of initiatives existing in Europe in favour of a democratization of energy [110]. This study highlights the process that took place in Berlin, to publicize the energy management supported by RLF. In 2010 the debate within social movements in Berlin started to move towards energy democracy, a concept integrating energy, climate issues and grassroots participation, stating that "the decisions that affect our lives should be taken jointly and without taking into account the profit principle". After a long process, the association Berliner Energietisch forced the Senate to hold a referendum to vote on the need for a community-based management of the public power supply. The referendum took place on 3 November 2013 with the YES vote winning. However, only 24.1% of citizens voted, below the minimum 25% required to make the vote valid [111]. The process did not achieve its goal, nevertheless the moral victory was won: a vast majority of 83% were in favour [43], and social movements continue to work towards this goal.

Spain: struggles within the electrical energy market

The regulation of the Spanish market is not very favourable for renewable energy deployment and only 14.54% of the total primary energy supply comes from renewables [35]. In Europe, major fossil fuel companies and energy utilities such as Total, Iberdrola, E.On and Enel have together adopted a dominant position in trade bodies such as the European Wind Energy Association (EWEA) and the European Photovoltaic Industry Association (EPIA) in order to slow down the transition to clean energy and to facilitate the use of natural gas [112]. Similarly, large electricity companies are acting as lobbies to curb the growth of renewable energies in Spain. This oligopoly is reinforced by the concept known as "revolving doors" whereby former government officials are hired to occupy senior positions in large firms and vice versa, in an aim to seek favourable legislation and favourable regulation of the electricity market. Over 50 politicians, among them two ex-presidents, have been found to be involved in this by the most important national newspapers, El Mundo and El País [113].

The oligopoly blames renewable energies for the tariff deficit in electricity, due to the feed-in-tariffs (FITs) they received. Renewable energy advocates blame other costs as unjustified or over-valued for the deficit (nuclear moratorium, nuclear waste management, Competence Transition Costs, CESUR auctions …) and they argue that renewable energies bring noticeable price reductions in wholesale electricity markets [114].

As a consequence, the Spanish government changed the regulations and reduced FITs by successive royal decrees (Decree Law 1578/2008 and Decree Law 14/2010) until they were eventually cancelled through Royal Decree 1/2012 and Royal Decree Law 9/2013. On top of this, Spain's government has recently imposed a "sun tax" on self-consumption systems (Royal Decree 900/2015) charging both on a capacity and a generation level. The Spanish photovoltaic industry and renewable energy advocates are outraged by this as they argue that consumers already pay charges for maintaining the grid and this is a second tax on the same aspect. The National Competition Commission and the National Energy Commission (Comisión Nacional de la Competencia and la Comisión Nacional de la Energía) consider that this tax is discriminatory and makes the projects financially unviable, causing a "serious dysfunction" against the efficiency enshrined in European Union directives [115].

Given this negative scenario, Som Energia was launched in the summer of 2010 in Girona (Catalonia) by a grassroots group aiming to consume 100% renewable energy. At that time there was no cooperative in Spain to commercialize electricity from a completely renewable origin, and as a result the inspiration came from Europe. This is a non-profit green energy consumption cooperative and its basic activities are the generation and marketing of renewable energy. It aims to achieve a 100% renewable model and energy sovereignty, i.e. a democratic system serving the interests of citizens and not a small number of companies. Currently, Som Energia supplies 156 GWh certified 100% renewable by the CNMC (Comisión Nacional de los Mercados y la Competencia) [116] to end customers with 3.3% own production and the rest purchased on the electricity market from producers of certified green electricity. In 2012 Eurosolar recognized the work of the cooperative, awarding it the European Solar Prize. Som Energia is part of the European Federation of Renewable Energy Cooperatives (REScoop).

To promote energy sovereignty, the cooperative Som Energia bases its internal operations on assembly meetings: anyone can join by contributing EUR 100 to the cooperative; partners have the right to participate and vote at the annual meeting. In the 2014 annual assembly twelve bases were established throughout the State, and topics involving new technologies were discussed and voted on [117].

The platform *"Plataforma por el nuevo modelo energético"* (Platform for a New Energy Model) represents energy cooperatives such as Som Energia and other organizations, and it is committed to campaigns in favour of renewable energy self-consumption. Feed-in-tariff schemes aside, self-consumption refers to the proportion of energy directly used in the building in which the energy generation system is located. For instance, a photovoltaic system (PV) will be sized in accordance with the consumption of the house in which it is installed, and the homeowner will be billed by the net metering (the difference between the electricity bought and the amount fed into the public grid generated by the PV panels). This practice is becoming increasingly important worldwide in the photovoltaic market [118].

Self-consumption with photovoltaic in Spain is financially viable because the price of the PV modules has fallen sharply in recent years and the cost of PV electricity is even lower than the price of the electricity available from the distribution grid. In other words, "grid parity" has been achieved. Ricard Jormet is the owner of the restaurant Lasal del Varador (Mataró, Catalonia) where PV and solar thermal panels have been installed, and in his words, it pays off:

"Hot water comes from the solar thermal panels, and it is also used for radiant floor heating, so the energy bill for the restaurant is really low. Only for electricity, I paid € 12,000 in 2012, and even though electricity got more expensive, in 2013 I paid € 5500. Therefore I am saving € 6000 per year which I can reinvest in the project." [119].

In addition to the projects based on self-consumption, Som Energia is also working on other initiatives: Generation kWh attempts to deploy self-consumption even if the renewable electricity system is not located in the same building where it is consumed. Investors will recover their investment in the electricity bill by discounting as much kWh as the electricity system has produced in accordance with their share. The initiative *Recupera el Sol* (Recover the Sun) aims to purchase installations for sale, especially photovoltaic systems, whose number has grown significantly since the Spanish government started regulating the reduction and eventual cancellation of feed-in tariffs [120].

In Spain, there are currently several green energy consumption non-profit co-operatives which have been created following the example of Som Energia (GoiEner, Zencer, NosaEnerxía …) with a total number of 35,000 members and even more electricity contracts. These are still low figures compared to the size of the electricity oligopoly but the numbers are constantly growing. Furthermore, the investments made by the green cooperatives in new projects are providing the renewable energy sector with deployment opportunities.

Discussion

Each case study in this article shows us a strategy and a different way to progress towards a democratic and sustainable energy system.

The Feldheim case study in Germany shows us how it is possible to create a local self-supply of energy and be a provider of 100% renewable energy if the necessary commitment and investment is available. In this case, it is important to highlight how the participants invested their savings in implementing a socially and environmentally sustainable project and chose to manage their funds communally as opposed to using traditional banking methods. Other German cases, in addition to the solar self-consumption and South American biomass experiences, show us that small-scale renewable energy development is possible in some cases with the available technology. Beyond communal and local experiences, progress towards increasingly renewable models in urban neighbourhoods or cities in Germany makes it clear that renewable energy development is possible in large non-rural areas. These assumptions coincide with a number of authors of the initial literature review, who assume that the consumption model has to change and use electricity of renewable origin as the main energy vector, in order to ensure the feasibility of a system based on renewable energy [41].

On the other hand, energy generation and consumption cooperatives in Spain are promoting large-scale demand for renewable energy. With this we are not stating that renewable production should move towards centralization but towards expansion and proliferation, prioritizing best practices and decentralized energy generation.

In fact, the losses due to centralized production and distribution models (primary supply that is lost before being consumed) are a significant percentage of our total energy consumption. These losses stand at 42.7% in Cuba, 23.8% in Ecuador, 21.9% in Germany, 21.6% in Spain and 20.5% in Brazil. Renewable based (avoiding fossil fuel burning) local production, to be consumed on site, would dramatically help reduce these losses.

In any case and even anticipating the most favourable scenarios regarding institutional, social and corporate commitment to renewable energy, the average energy consumption in the Global North should decrease [43] for others to be able to reach acceptable levels of energy well-being. Furthermore, it could be said that energy poverty does not only affect the Global South countries, as also in the Global North cases of energy poverty are on the increase [121]. Thus, it should be taken into account that certain specific individuals in the Global North could also increase their energy consumption, especially their residential energy consumption.

But how could Global North countries achieve an average energy reduction? There is a wall preventing end energy consumers from distinguishing those activities consuming the most energy. A wall erected partly by the extensive energy transformation supply chain existing between consumers and the origin of the resources but which is mainly the result of the constant volley of confusing messages from the media and from a financial structure which demands that energy consumption be maintained and which disseminates disinformation regarding this. We should add to this the way in which energy consumption is measured, as the energy costs in other countries regarding the production of goods, which are then imported and purchased by us, are not taken into consideration. This is known as energy debt. If we take this factor into account, the real energy consumption of allegedly sustainable Northern countries (Germany, Denmark) increases significantly. We believe that finding out the real origin of our energy consumption, and hence knowing which economic activities consume the most energy, is the first step towards planning a collective energy transition.

The average energy consumption levels indicate that, among the countries analysed, Germany (including its energy debt with other countries [7]) is the one with the highest primary energy consumption 59,800 kWh/person/yr, whereas the Global South countries consume up to 79% less energy than Germany. The most significant case is Cuba where primary consumption is 79% less than that of Germany and actually rising a high Human Development Index (HDI) close to 0.8 (Appendix A, Figure 8, [123–125]). Furthermore, we do not share the view that, in general, Germany is an example of "rapid proliferation" of renewable energy [46]. Nonetheless, it should be highlighted that in Germany there are different experiences where energy consumption is similar to the Cuban average, showing us how a change based on conscious self-containment and communal organization methods can significantly reduce consumption.

The Cuba case study shows that it is possible to have both a high HDI and low energy consumption. This is due to the fact that despite the low purchasing power and low individual energy consumption, public and universal social benefits have been maintained and these facilitate a good standard of living. In this section we share the idea that the use of renewable energies is directly linked to de-growth in consumption [43]. However, we would not want to idealize the case of Cuba as we are fully aware of not only the inequalities existing in the country but also of the energy poverty which certain communities and families have protested against. Furthermore, the decision to adopt austere energy living was not a direct choice made by citizens but rather a reflection of political decisions. Nevertheless, it is interesting to highlight the fact that maintaining public services and intensifying community bonds based on mutual help may alleviate the decrease in

Table 2 – Scheme to bring together the learnings from the five case studies with exemplary approaches.

Case studies	MAB and POCE	National Energy Transition	YASunidos	Feldheim, Solar Settlement, Rosa Luxemburg Foundation and Sieben Linden Ecovillage	Som Energia
Location	Global South	Global South	Global South	Global North	Global North
Social Character	Democratic. Triggered by Amazonia reserve endangered.	Democratic. In answer to the state energy model based on dams.	Authoritarian. Imposed by the internal and external conditions	Democratic. Triggered by particulars' ethical and environmental aspirations.	Democratic. In answer to corruption in the energy sector.
Socio-cultural goals	- There is a need to answer the question "Energy, for what and for whom?" before building a new power generation plant. - Create social meeting spaces to share energy system know-how.	- Peak Oil had been overcome with the unity of a solid community. Nevertheless, this has been a top-down process enforced on citizens and the goal would be to replicate this achievement in a voluntary way.	- The indigenous community requests leave the "Oil under the Soil", in order to maintain their "good living" values (Sumak Kawsai).		- Transversalize the energy problem, reach out to civil society and enrich the energy debate.
Economic goals	- "Water and Energy are not commodities but the rights of citizens".		- The Sumak Kawsai concept should expand to other economic sectors. - Overcome the discourse vs. praxis conflict of government with an economic alternative that dissociates itself from transnational oil companies.	- Communal investment in renewable energies to maintain control over decisions regarding investment of funds in the energy sector: controlling impact and achieving responsibility.	
Political goals	- Unity between different and seemingly opposing collectives: this shows the convergence of interests of the population in energy transition. - Inform and empower civil society by democratizing knowledge about the energy sector in order to create a critical mass able to take decisions. - Get support from politicians by raising awareness.	- Pooling citizen, farmer and scientist skills and expertise to manage the crisis and seeking the effective mutual support of the government on public terms.	- Social engagement, awareness-raising and mobilization are crucial in order to maintain the political struggle against pressure from corporations or the international community.	- Public management of energy utilities in cities and towns can be requested and achieved.	- Energy lobbies and corruption should be opposed (i.e. "revolving doors") and Cooperative Electric Providers are paving the way towards this goal. Arising the democratization of the energy system.
Technological goals	- Development and use of appropriate low-tech technologies to achieve energy sovereignty.	- Shows the capacity to maintain decent standards of living despite lower fossil fuel consumption based on changes to core production (agriculture), transport and organization and by maintaining public services.	- Non-extraction of petroleum, through effective management, as a feasible social, institutional and economic objective.	- Austere community life as an alternative to the goal of technological efficiency to sharply reduce primary energy consumption. - Applying the PlusEnergy concept in neighbourhoods and houses, consumers have the opportunity to become producers.	- Cooperatives manifest the possibility of change towards renewable energies.

quality of life as a result of a decrease in individual access to energy.

If we analyse the share of primary energy consumption (including HEF), it is observed that only 2% (China), 3% (Ecuador, Germany, Denmark), 4% (Brazil, Spain), and 6% (Cuba) of energy is consumed at home as electricity (Fig. 5). This means that residential electricity consumption is not the critical point in our energy system. As such, transformation should be more systemic in order to make a real impact on reducing total primary consumption. It is necessary to change, among other things, the production model, the approach to mobility and the logics of consumption in order to move towards real transition. Regarding this point we fully agree with Haas et al. [47] where it is stated that the current energy transition strategy (based on the Energiewende case, although the conclusion may be generalized to the cases of electricity cooperatives) is limited to an electricity transition, and that this only partially challenges the dominant ecological and societal relations. With respect to this, we do not share the analytical procedure of considering "renewable energy system" and "renewable electric power" to be the same, as occurs in certain research works [32,42].

Regarding the strategies to democratize the energy system and to socialize change, the case studies also present interesting lessons. In Spain, the proliferation of energy cooperatives and social movements linked to energy, in addition to the increase in energy poverty, has led to greater knowledge and protests concerning the issues of the energy oligopoly and the revolving doors, hence improving the national energy literacy. Furthermore, these cooperatives represent a new energy organization model in terms of their non-profit and cooperative nature and their grassroots participation.

The Brazil and Ecuador case studies show that if protests in favour of energy transition are to be influential, it is essential to create multi-sector networks, going beyond practical and local experiences, and to organize large awareness-raising campaigns with widespread participation. This way, the participation of different social stakeholders in the "Plataforma Operária e Camponesa para Energia" in Brazil managed to overcome specific problems and to introduce new elements into the energy debate: the search for a popular, fair and sustainable energy project for Brazil. In Ecuador, educational and academic work conducted on the Yasuní proposal managed to *a posteriori* form a more widespread mass movement such as YASunidos and to maintain the debate on oil extraction and possible energy transitions alive in Ecuadorian society. Even if the Yasuní case may be understood by some authors [49] as a missed opportunity in institutional or material terms, the process of the struggle still continues to show relevant outcomes in social and educational terms.Table 1.

In Cuba the situation is a little different due to the importance of the State and its specific energy history. The government institutions consider that energy is a public asset and a social right and they have incorporated discourses regarding renewable energy. However, these projects have not been developed equally in civil society and the "cultural energy revolution" is yet to take place.

All these achievements and strategies in energy transitions, extracted from the proposed five case studies, have been grouped in Table 2 with the aim of complementing a variety of actions carried out in each case study. It seems likely that only an integration of several lessons learned from the different cases could lead to a materially feasible transition, and that without a combination of several factors for change it seems difficult to consolidate a medium-scale energy transition. The regrouping has been carried out respecting the four axes of analysis that were established at the beginning of the research: socio-cultural, economic, political and technological.

In respect to the social axis, it should be noted that the case studies consider peak oil as an opportunity to change the current energy model, with special focus on a change in citizen values. Hence, there is an attempt to transversalize the energy problem to the debate on lifestyles. This implies increasing awareness of fundamental questions, such as why we need so much energy, and what for.

Secondly, the economic axis, the need to consider access to energy as a basic social right, and not as a commodity to speculate with, has been identified; or, as proposed by the Ecuadorian indigenous culture, the need to extend the Sumak Kawsay theory to the economic sector. Furthermore, it has been demonstrated that a conscious communal use of the private economy in renewable technologies could be profitable. Nevertheless, real deadlocks appear when an attempt is made to overcome the powerful extractivist economy, especially when conflicts between the discourse and the praxis emerge in national politics.

Thirdly, the political axis shows a need for transparency and information from politicians towards civil society, in order to create a joint proactive strategy to overcome the current crisis. There is also a general view of the existence of an "enemy", usually identified within transnational energy corporations and supported by the personal interests of some corrupt politicians. This phenomenon has been partially overcome on a small scale with the creation of energy cooperatives but as yet any attempts to return many municipal and regional energy utilities to public management have largely failed to succeed.

Lastly, it should be noted that the technological axis focuses more on how to integrate existing solutions than on developing new sustainable technologies with the idea that a future technological leap would resolve by itself the conflict of sustainability. At the same time, the non-extraction of fossil fuels from the soil is a clear concept to be included in the technological section, as a symbolic shift towards a less technological energy model requiring less energy consumption *per se*.

Conclusions

The energy model is so closely related to most aspects of our lives that proposing a change regarding energy involves rethinking how we consume, how we produce, how we work, how we organize ourselves, how we socialize, how we see ourselves, ultimately how we live.

The impact generated by the present energy system, especially in the Global South, is unquestionable and the current goals regarding efficiency, renewable energy integration and CO_2 emissions, centred on technical enhancements, should be complemented with social aims bringing about a democratisation of energy with two core goals: on the one hand to seek equality in the share of resources and in the search for joint solutions for both North and South, namely that of justice; and on the other hand, to reinforce community solutions whereby new energy management methods have a direct effect on lifestyle and subsequently on the use of energy.

In addition to these two core goals, this study underlines the importance of achieving energy literacy, in order to be able to develop awareness about the impact generated by our current energy system which is disguised by the fact that production is carried out overseas, by other social classes or simply because this impact seems distant in time to future generations. Energy democratization inevitably entails responsibility not only concerning the environment but also regarding the rest of society, including future generations.

Table 3 shows the specific proposals, taken from the data analysis process, which aim to avoid any confusion generated by the communication of the targets achieved by each country as they progress towards a sustainable energy model. This study considers that presenting the data more clearly (i.e. by avoiding percentage values or renewable integration or emission reduction compared to 1990) is useful to detect the countries that are currently the most sustainable in terms of energy. This might also avoid idolizing aesthetic policies that have not led to any progress in removing carbon from the national energy model.

Fig. 7 groups together all the conclusions drawn from each case study according to the four core approaches of this research: Socio-cultural, economic, political and technological. An effort has been made to further summarize the discussion section in Table 2, whereby the major trigger factors detected in the energy transition case studies have been summarized for them to be used as learning for other incipient energy transition cases. This learning, irrespective of whether it was taken from Global North or Global South case studies, could be considered for use in both contexts, hence facilitating progress towards a fair energy model where there is no need to constantly differentiate between what are commonly named "developed countries" and "developing countries".

Table 3 – Recommendations for improved interpretation of public data.

Concept	Recommendations
CO_2eq emission reduction from 1990	It is important to present the absolute current CO_2eq emissions per capita and to compare all the countries with one absolute unique value not a relative self-compared reduction from a specific year.
20/20/20 goals	It is important to have absolute targets and not percentage values. Percentage targets only perpetuate the differences between countries.
Integration of renewable energy	It is important to present the absolute value of fossil fuel plus nuclear energy consumption per inhabitant.
Energy Embodied in products	It is necessary to integrate the Hidden Energy Flows (HEF) into the national energy consumption average in order to prevent countries outsourcing their industrial production from appearing energetically sustainable. Currently this phenomenon has a generally positive effect on the Global North countries and a negative one on the Global south.

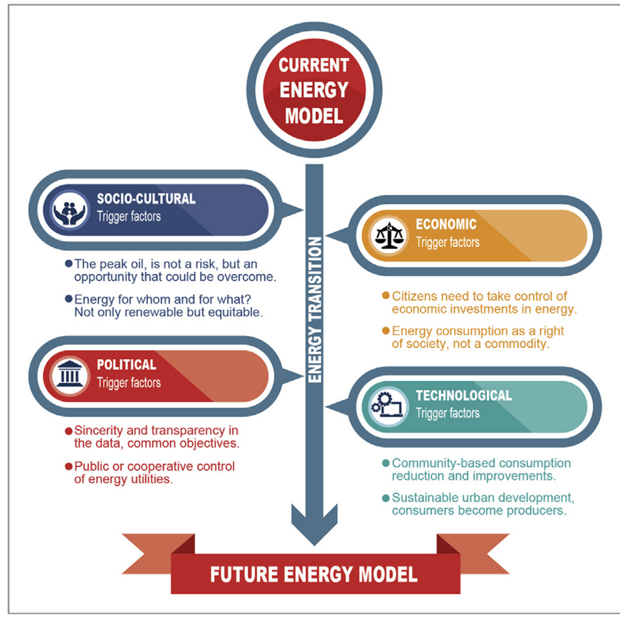

Fig. 7 – Some of the energy transition trigger factors (own elaboration).

All these conclusions and approaches may be seen as a social lesson to help progress towards a democratic and sustainable energy transition. However, we believe that each region, in accordance with its own economic, technological and socio-political characteristics, should create its own transition, bringing together some of these approaches and others not covered in this study. This issue opens up new lines of research. Indeed, further research is needed to continue exploring quantitatively and qualitatively the diversity and direction of ongoing and future energy transitions around the world.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.ijhydene.2017.04.297.

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