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A man in a dark suit and striped tie is shown from the chest up, looking surprised with his mouth open and his right hand held to his ear as if listening intently. The background is a plain, light grey.

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Pandora's box: Photovoltaic energy and economic crisis in Greece

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The Greek photovoltaic program was launched in 2006 and rebranded in 2011 as a way to repay debt and decrease national deficit. The scheme promotes new livelihood opportunities on all levels, from micro-scale home installations to macro-scale solar parks producing energy for international export. Offering potential economic stability to a nation at the fore of global neoliberal crisis, solar energy also presents an alternative to petroleum and lignite that currently dominate the energy sector. However, there are many hesitations and conflicting rhetorics surrounding the photovoltaic drive. Its success or failure as a sustainable economic pathway lies as much in understanding local nuances of social relations and historical consciousness as in governmental policy. This paper presents the findings from preliminary research that aims to “scale” all levels of the Greek photovoltaic experience and raises questions of energy policy, neoliberal rationale, and the relationship between local and global socioeconomic systems. It considers the everyday cultural complexities of implementing energy policy and assesses the contribution of an ethnographic approach to interdisciplinary energy research. © 2013 AIP Publishing LLC. [<http://dx.doi.org/10.1063/1.4807477>]

I. INTRODUCTION

The focus of this discussion derives from preliminary research into how Greeks are turning to photovoltaic energy as a salve for their drastic economic crisis, raising questions about materiality, debt and network theory, all of which are located at the interface between society and technology. Or, in a more radical formulation that eschews separation between social and technological realms, they are situated in the integrated socio-technical processes of human life where complex infrastructures of consumption and production affect and are affected by sociality (Shove, 2003; Vliet *et al.*, 2005; Lawhon and Murphy, 2012).

Introduced in the 1950s by Trist, Bamforth, and Emery (see Trist and Bamforth, 1951; Emery, 1959), socio-technical systems theory refers to the interaction between people and technology and the subsequent impact on social organization. This approach allows for uncertainty, diversification, and adaptability to be accounted for in local populations during a period of technological transition. New energy technologies entail changes “in markets, user practices, policy and cultural meanings” (Geels, 2010, p. 495) and a socio-technical frame ensures all these factors remain in view. Complex technological infrastructure, such as that which supports the production, distribution and consumption of electricity, embraces many different kinds of institutions that influence one another and their individual members in ways that have unpredictable consequences. Regimes arise to manage turbulent society-technology relationships and smooth tensions between everyday energy consumers and those who devise energy policy, govern

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energy systems, and conduct major commercial transactions. These support mechanisms gain extra significance in times of rapid technological change and political and economic uncertainty. But in contexts of technological transition, especially when combined with severe economic stress as is the case in contemporary Greece, systems can fracture, unleashing forces that are both encouraging for innovation yet fraught with the potential for societal disruption.

We argue that the explanatory power of a socio-technical perspective is enhanced by an understanding of the means by which networks that comprise both the human and the non-human can be analyzed as assemblages of relational agency (Deleuze and Guattari, 1980; Galvin, 2009; Serres, 1995a; Bennett, 2005, 2010; Latour, 2005). The hybrid assemblage is a strong challenger to the insipid and failed position that separates technology from society, and human from non-human (Latour, 1993; Strathern, 1996, p. 521). We believe that the separation of society, technology, human, and non-human detracts from a more fruitful holistic analysis of energy and society. We thus draw on the concept of “assemblage” and other theoretical ideas that we anticipate can complement one another when deployed within a socio-technical framework.

An ethnographic analysis combined with approaching the human and non-human relationship as an assemblage facilitates a comprehensive understanding of how people interact with technology on multiple social levels. It is important to comprehend the relationship between people and technology beyond merely production and consumption. Complex historical consciousness and “cultural intimacy” (Herzfeld, 2005) inform people’s relationship with new technology. Thus, the success or failure of renewable energy initiatives has as much to do with cultural perceptions as with macro-economic viability or “scientific” progress. We advocate the study of technology and society as an “assemblage” in order to facilitate a holistic view with an ethnographic base that may prove fruitful in an interdisciplinary context.

Ethnography has long been established as the most effective way of harnessing the “people’s point of view” (Geertz, 1973). However, in order for ethnographic material to be useful beyond the local level we have to find a way to “scale-up” the data. Systems theory helps us deal with complex historical, cultural and technological data in a simultaneous fashion—as an assemblage—and construct a picture of the photovoltaic initiative from the grassroots. In practice, this can inform future policy making and technological development.

The study is in its early stages and the events it tracks are fast moving, occurring on a number of different levels. What we present here is a preliminary assessment of the circumstances in Greece, the methodological issues and an exploration of what theoretical concepts might be most fruitfully deployed as events unfold and research attempts to keep up with them.

II. RESEARCHING SOLAR ENERGY IN GREECE

Greece currently imports more than 70% of its energy needs. The country’s only reliable domestic energy source is lignite, which accounts for some 70% of its internal electricity production. Plans for solar and wind power are expected to draw investments worth 5×10^9 euros by 2020, according to information provided by the Greek Ministry of Development, significantly increasing energy self-sufficiency. Overall, 7% of national energy needs could be sustained over the next decade by solar energy, with projections of over 30% solar contribution by 2030. Wind energy is expected to fulfill another 15%, and wind parks are being constructed in various Island locations and are also considered a long-term investment for transnational energy export. If one adds biofuel, geothermic, and wave energy, Greece has the ability to become a fully independent energy producer by the middle of the 21st century (Michaletos, 2011).

Oil currently represents 55% of Greece’s yearly energy consumption and is imported, barring some minimum amounts being produced in the Kavala offshore oil field in northern Greece. Oil required for central heating is exceptionally expensive during the ongoing economic crisis and people have en-mass returned to wood-burning stoves and open fires to provide warmth. Natural gas is a quickly expanding commodity around the urban centers, but for the time being its contribution to Greece’s energy total is less than 9% due to a failing policy agreement with Russia.

Dimósia Epicheírissi Ilektrismouí (DEI) is the largest power company in Greece and, despite undergoing significant privatization and restructuring in 2012–2013 in accordance with the

Troika (Troika is the name collectively assigned to the European Commission, International Monetary Fund and European Central Bank that implement Greek financial bailout packages) bailout package, produces and supplies the vast majority of energy. As of late 2011 DEI operated 34 major thermal and hydroelectric power plants, 3 aeolic parks, and 60 autonomous power plants located on the Greek islands (33 thermal, 2 hydroelectric, 18 aeolic, and 7 photovoltaic parks). The total installed capacity of DEI's 98 power plants is estimated at 12 760 MW with a net generation of 53.09 TWh.

Some major developments presently under DEI's initiative include an 800 MW natural-gas fired unit to be installed in Megalopolis, a 450 MW lignite-fired unit to be installed in Meliti, a 450 MW lignite-fired unit using fluidized bed technology, to be installed in Kozani, a 700–800 MW hard-coal-fired unit to be installed in Aliveri, and a 700–800 MW hard-coal-fired unit to be installed in Larymna.

In 2006–2007, DEI decided to divide its renewable energy production from its core business and expand into the lucrative fields of wind, solar, and alternative energy production. The company set out to produce 1540 MW from renewable energy sources by 2014, with a total budget of 1.6×10^9 euros. In this regard, one key development came when the DEI Renewable Resources Company signed an agreement with the French EDF Energies Nouvelles for the construction of wind parks, with a power capacity of 122 MW, and another with the Greek ETBA Bank for solar parks of 35 MW (Michaletos, 2011).

The DEI-backed Greek photovoltaic program was first launched in 2006, three years before the nation's fiscal problems made global front-page news. The solar initiative was primarily aimed at increasing self-sufficiency through home installations and offering a land diversification program that would be available to even the poorest Greek agriculturalist. The government always intended to expand this scope towards large-scale solar parks producing energy for international export. However, due to the complex bureaucracy and ambiguous political management, all aspects of the solar drive had relatively little impact on the livelihood of the Greek public until the economic crisis hit in 2009. In 2011, the Greek government re-launched the scheme amidst considerable fanfare at the prestigious Megaro Mousikis in Athens, branding photovoltaics as the pathway to repay debt and decrease national deficit through large-scale energy export. Solar was celebrated as a solution for economic recovery and sustainability; a literal beacon of light to provide long term security for a desperate population, to whom hunger, rocketing rates of suicide, and the disintegration of family networks are increasingly familiar features of life (Knight, 2012a, 2012b, 2013a, 2013b). (The current economic crisis is regularly framed by local people in terms of hunger and famine. Severe hunger is an everyday reality for the poorest in urban centers, whilst in rural areas decreased income and the break down of family "self-sufficiency" networks (see Theodossopoulos, 1999) means that people are eating less. On another level, historical accounts of the Great Famine of 1941–1943 punctuate everyday discourse as people recall how their ancestors suffered during the Second World War (Knight, 2012a, 2012b). This has significantly increase the anxiety of hunger even among those not directly impacted.)

The Greek photovoltaic program now ranges from large-scale solar parks producing enough energy for international export (up to 10 GW by 2050 in one park alone) to self-sufficient home installations (up to 10 kW/h). The solar drive has become a three-tier "scheme" almost by accident. When launched in 2006 nobody could envisage the economic turmoil on the horizon. As the extent of Greek fiscal troubles became apparent in 2008–2009, photovoltaics started to be promoted by the government as a "package" to help everyone by providing self-sufficiency on the one hand and international export opportunities on the other. It is now commonplace for Greeks to refer to solar initiatives as "the photovoltaic program," framing the drive as a holistic, singular scheme. Furthermore, the Greek Regulatory Authority for Energy (RAE) and international photovoltaic wholesalers alike believe that the solar drive could potentially serve as a blueprint for how other states can implement sweeping energy reform in order to repay debt and decrease national deficit in times of severe fiscal stress.

The most famous example of the ambitious solar drive is the "Project Helios" development near Kozani. This is the plan to construct a 200 MW solar park producing 10 GW of solar

energy by 2050. The solar park will be one of the world's largest photovoltaic developments, with transnational impact, significantly enhancing the European solar sector. Construction will cost 600×10^6 euros and include an adjacent panel factory, creating 60 000 jobs. Government forecasts indicate revenue in excess of 80×10^9 euros from the project over a twenty-five year period, allowing them to cut national debt by an initial 15×10^9 euros. Solar energy specialization would allow for the exportation of a skills pool, as well as technology, to neighboring states and allow Greece to rebuild its tarnished reputation as a regional leader in renewable energy technology (Spath and Rohracher, 2010).

There are also substantial photovoltaic developments on agricultural land that is nowadays deemed financially unsustainable for crop production due to the collapse of markets, a consequence of economic crisis and Troika enforced austerity. The focus of the drive for agricultural diversification has been the vast Plain of Thessaly in central mainland Greece, and smaller installations north of Thessaloniki. Most recently, photovoltaic developments have become visible in Attica (the region around Athens) due to a better infrastructure which facilitates effective large-scale energy dissemination. The solar drive has attracted investment from national and private investors in other European nations, especially Germany and Spain, as well as China, keen to buy into the idea of renewable energy as economic salvation. Locally, markets have become flooded with small and medium enterprises (SMEs) importing and installing photovoltaic panels. However, generally, macro-scale policy devised in the halls of Brussels, Berlin and Athens is rarely disseminated to the level of the everyday consumer due to inefficient bureaucratic channels, meaning energy policy and practice do not necessarily equate (Knight, 2013b). The general public is often unaware of governmental policy and policy implementation is erratic. During the course of fieldwork, a civil servant in Larisa responsible for the implementation of European Union agricultural schemes on a regional level openly admitted that he knew nothing of the solar initiative beyond what he gleaned from the local farmers who he is employed to inform. He suggested we visit the RAE in Athens, or a university research group based in the capital if we wanted "further information." His case is by no means unique, as mediators between government policy and local practice routinely offer merely elementary insights into the program.

Research commenced in April 2012 and aims to "scale" the photovoltaic initiative from macroeconomic policy to everyday energy practice and from small-scale home installations to large solar parks. Our intention is to use ethnographic methods to chart the impact of the drive for solar energy on the lives of people on the Plain of Thessaly, central Greece, one of the most prominent locations for all forms of photovoltaic installation. We have conducted previous research in Thessaly, since 2003 in the case of one of the authors, on changing socioeconomic relations, historical consciousness, and entrepreneurship. We thus have significant social networks already in place facilitating access to government institutions, universities, the construction industry, local landholders, politicians, SMEs, local and national businesses, and energy technicians. Fluency in the Modern Greek language also significantly improved the results of initial fieldwork.

Research in Thessaly was ongoing throughout 2012 and into 2013, including periods of participant observation totaling 12 weeks. Sociocultural anthropology provides an unrivalled opportunity to understand how local populations receive new energy programs, how they form often complex understandings of material artifacts, land, and new forms of social relations (cf. Rohracher, 2008; Maassen, 2009). By employing participant observation as primary research methodology perceptions of everyday energy practice can be successfully interwoven with wider data provided by the social and natural sciences. In this respect, applied anthropology can benefit the holistic understanding of renewable energy programs in both academic and corporate arenas through the construction of rich ethnography.

In addition to participant observation, approximately 40 interviews were conducted with photovoltaic companies located on the Plain of Thessaly and Greek Macedonia (namely around the towns of Grevena, Kozani, Larisa, Volos, Kalampaka, Karditsa, and Trikala), local politicians and Members of Parliament involved in the promotion of "green energy" (*prasini energeia*), academics, renewable energy research groups, landholders and locals that have installed

solar panels on private property, and technicians and mechanics who have diversified their trade during the economic crisis to work on photovoltaic installations. Archival research and media monitoring helped construct a broader picture of sociohistorical comprehension. Archival research identifies past patterns of socioeconomic behaviour, energy programs, and government policy. Historical records allow for detailed comparison between energy policy, technological advances, construction programs and consumption, and facilitate the assessment of the future success of energy programs. For example, solar developments on agricultural land in central Greece are entwined with historically embedded notions of famine, occupation, and land ownership (see [Knight, 2012b, 2013b](#)).

Media monitoring considers the portrayal of the solar initiative through the television and printed press. Understanding how actors frame and publicise their competing rhetorics is invaluable when analysing the flow of opinion surrounding both energy and economic crisis on regional, national, and international levels. The global impact of “mediascapes” surrounding both the Greek economic crisis and the photovoltaic schemes is striking. Capturing the fluid and irregular cultural flows characteristic of international capital, [Appadurai \(1990, p. 9\)](#) defines mediascapes as referring “both to the distribution of the electronic capabilities to produce and disseminate information ... which are now available to a growing number of private and public interests throughout the world, and to the images of the world created by these media.”

Local understandings of the photovoltaic drive are informed by a complex entanglement of history, culture, nationalism, European Union policy, and the global crisis in neoliberalism. Hence, the Plain of Thessaly can be seen as a microcosm through which to better analyze both economic and energy policy on an international level ([Knight, 2013b](#)). Assessing local practice in relation to global flows of capital, energy, and policy enhances academic appreciation of how local and global are entwined in mutual embrace (cf. [Miller, 1995](#)). Pointers have already emerged as to how this ethnographic setting, when studied within a wider remit of national and geopolitical contexts and set within a socio-technical framework, can reveal how renewable energy is enacted in times of extreme socioeconomic turmoil (cf. [Lawhon and Murphy, 2012](#)).

III. FROM THE LOCAL TO THE GLOBAL

The plans to construct major solar parks for energy export, such as the “Project Helios” development in Kozani, are well known to the inhabitants of Thessaly. Locals are familiar with solar as an alternative energy solution since the introduction of solar thermal in the mid-1980s. This has meant that many people are open to the introduction of new policy concerning solar energy. The familiarity with the notion of harnessing the power of the sun is, in itself, nothing new. Thus, adaptation and diversification based on photovoltaics in a crisis situation have been more successful than if applied in other cultural contexts. Although interest in the photovoltaic initiative is high, many people remain skeptical as to the long-term socioeconomic benefits of the program on both household and national levels. People raise a range of concerns, including the impact of corruption on the flow of finance for the solar projects, the sustainability of the agricultural livelihood once land is leased on a 25- or 50-year basis to energy companies, the inadequate infrastructure and over-ambitious export plan, the overcomplicated bureaucracy, and the endemic lack of political and economic trust. However, positive aspects included increased employment opportunities during a time of austerity and economic catastrophe and a chance for farmers to transform currently unprofitable land into a stable monthly income through feed-in tariffs. In western Thessaly between the towns of Trikala and Kalampaka, solar installations on agricultural land have increased five-fold in two years. Photovoltaics are at the fore of local discourse concerning the economic crisis as it is deemed “the only program that is running” (*to mono programma pou trexei*).

The social landscape of the photovoltaic drive is composed of a complex assemblage of state and state-owned companies, corporate organizations, international investors, small and medium enterprises, local community activists, Non-Governmental Organizations, and independent research groups. Energy governance, fiscal responsibility, and entrepreneurial opportunism operate within these networks. The international impact of the Greek initiative is emphasized by the

fact that Greece has surpassed its European Union 2020 goal for solar energy production (from 2009 to 2012 annual photovoltaic energy production increased from 53 MW to 1018.29 MW, biomass from 43.3 MW to 45.95 MW, and small hydro from 182.6 MW to 212.18 MW (Hatziaargyriou, 2012)). The Greek solar energy sector is also one of the few areas attracting international investment. The “7th International Exhibition of Renewable Energy, Photovoltaics 2012” was held at the Metropolitan Exhibition Centre in Athens, where the global impact was confirmed by the presence of the Ministries of Commerce and Ministries of Energy and Environment from Spain, France, Germany, and the Czech Republic, alongside transnational investors from Israel, Spain, France, Germany, Greece, United Kingdom, China, Japan, Canada, and the United States. The crisis has created a situation for foreign opportunistic investment in Greece. This opportunism has been especially prominent in the energy sector where the exploitation of natural resources in order to plug gaps in other European national markets means that most of the economic benefits are felt outside of Greece. The collapse of both small and medium enterprises and large Greek businesses provided opportunity for major foreign investors to purchase and sell-off failing companies and “colonize” the energy sector. This has more recently been packaged as part of the “privatization” program enforced by Troika which has impacted the transport (especially the ports), energy, and haulage sectors.

A. Price scaling: Small and medium scale developments

Since 2007 the Greek energy company, DEI, has been buying electricity generated by photovoltaic panels situated on houses and stretched across once fertile fields. Every six months the purchase tariff per kilowatt hour for photovoltaic-generated energy is systematically reduced by 5% on both forms of installation. For example, if a contract was signed before August 31, 2012 then the energy would be purchased by DEI at 0.495 cents per kilowatt hour for the duration of 25 or (rarely) 50 yr. With the original plan, on September 1, 2012 the purchase rate would drop by 5%, followed by a further 5% drop on March 1, 2013 (the price of photovoltaic feed-in tariffs is currently under review). The price per kilowatt hour remains at the fixed rate at the time of signing for the full term. There are different rates for home and field developments and different forms of technology. Generally, the panels are static Building Integrated Photovoltaics (BIPV) or tracker systems in fields that use high quality silicon mono or polycrystalline, although some companies offer composite thin film panels like Cadmium Telluride (CdTe). (It is commonly understood that DEI directly purchases the photovoltaic energy. However, DEI, a public company traded in the Greek stock exchange with the Greek state as its major shareholder, owns LAGIE SA (Litourgos Agoras Ilektrikis Energias AE) a “non profit organization that represents the interests of European Energy Stock Exchanges that operate the wholesale markets of electric energy, natural gas, and pollution rights; they implement mechanisms of environmental and energy policies within the context of the planning objectives of the European legal framework,” <http://www.lagie.gr/etaireia/skopos-armodiotites/>. DEI purchases the energy through LAGIE.)

The annual untaxed income on a 10kW/h development at the February 2012 price is 7200 euro, decreasing to 6840 euro with the August 2012 price. However, if the contract with DEI is signed before July 31, 2012 deadline the price per kW/h will be stable for the 25 year period. The average loans taken out by customers for the photovoltaic installations are, as of summer 2012, 25 000 euro for home developments (10kW/h), 180 000 euro for field developments (100kW/h). These prices have decreased significantly from five years previous, when an average field development (100kW/h) cost 5 00 000 euro and a home installation (10kW/h) 60 000 euros. During this research, the largest outlay on a photovoltaic installation was 7 50 000 euro; however, on a national level there are innumerable developments exceeding this amount.

Loans up to 180 000 euro can be returned over 25 yr “without repayments” (BNF Green Technologies)—this is to say that the repayments get automatically deducted from the monthly income provided by the panels. On a 25 000 euro loan the average surplus (i.e., profit) for the customer is 600 euro per month, currently more than the average agricultural wage. Many companies advertise with guarantees that all loans will be “cleared” within five years.

On a representative home development, 46 NeMo P 215 polycrystalline photovoltaic panels with 215 Wp each were installed from the German company “Heckert Solar” with one inverter “Sunny Tripower 10000TL” from German company “SMA” providing 9.89 kW irradiation. It is projected that this installation will provide 1500 kW/h of irradiation in July, dropping to 500 in December, with an annual total of 13 240 kW/h irradiation priced at 0.495 euros per kW/h. This will provide 6553.80 euros income a year for 25 yr (before deductions for loan repayments). Most installation companies advertise German products as this rhetoric sells reliability and reassures the consumer of the quality of installment. In reality, often low-cost Chinese panels are installed without the knowledge of the consumer as this provides regular maintenance work for the installation company and the panels are also cheaper to import.

A major cause of the current socioeconomic crisis in Greece was the unregulated nature of unnecessary bank loans from 1981 to 2007. Today informants comment that they are prepared to take major loans even in a time of socioeconomic risk—despite previous experience—as this is the only financially productive program currently available. As people state that they cannot “put their lives on hold,” an investment in photovoltaics is seen as a calculated risk, despite the fact that many people do not believe that DEI can honor the 25-year contract to pay at a given rate per kW/h. Directors at local DEI offices in Thessaly openly acknowledge that the organization is in poor financial shape, may not be able to honor existing contracts, and is undergoing rapid privatization as parts are sold off to foreign investors in accordance to the terms of the second Troika bailout package. In May 2013, the Greek Ministry of Environment, Energy and Climate Change (YPEKA) announced a 40 to 50% cut in feed-in tariffs, with the possibility of further retrospective reductions, significantly impacting the time required to repay an outstanding loan.

B. Diversification

The impacts of the solar drive on the everyday lives of local people have already been immense. Although unemployment is still currently at 25% across all sectors throughout Greece, and 54% among people under 25 yr old, solar energy has provided new employment opportunities. In central Greece, the primary site of this research, the unemployment figures are higher than these national averages (www.bbc.co.uk/news/business; Pryce, 2012). Thus, in the current economic climate employment diversification is both commonplace and necessary (Knight, 2012b). Local people who have trained as mechanics, electricians, and technicians have taken jobs associated with photovoltaic installation. Photovoltaic systems are unanimously perceived as relatively simple to install and require minimal extra training for people with a background in electronics and engineering. There are courses offering certificates in correct installation practice, but they remain superfluous to requirement and potential installers frequently eschew them in favour of previous experience and access to locally shared and experientially produced knowledge.

Photovoltaics have also provided a new line in “second jobs.” As well as diversification among technicians and mechanics many people have become involved in photovoltaics as a side-line to primary employment. Private businesses importing and installing photovoltaic panels and agencies dealing exclusively in preparing the significant paperwork and negotiating the complex bureaucratic channels are flourishing in western Thessaly. In the town of Trikala (population 51 862), there are fifteen private companies dedicated to importing and installing photovoltaic panels. The (lack of) regulation on free-market trade in photovoltaics appears akin to the restrictions on Greek stock market floatation before the infamous crash of 1999–2000 (Knight, 2012b). Some small businesses are subsidiaries of larger companies on the Greek stock market, whilst others have floated themselves. On enquiry with one small business in Trikala as to their relationship with a stock market company with the same name, the reply was “I will only tell you if I want to; and I don’t want to.” This reflects ongoing suspicion surrounding stock market companies since the 1999–2000 crash when small-scale investors lost an estimated 100×10^9 euro (Caporale *et al.*, 2008). (From December 1999 to March 2003, the Athens Exchange had lost 77.88% of its value (Caporale *et al.*, 2008, p. 3).) The link to international markets highlights the sometimes opaque flows of local and global agency and material interests. The flow of capital and material agency from the stock markets influences the local

entrepreneurial system that is also entwined with “traditional” business practices such as patronage and clientelism (see [Campbell, 1964](#)).

In one example, a kitchen and bathroom salesman has set up a prosperous photovoltaic company in Mouzaki. He continues with a home appliances showroom and has dedicated the top floor of the warehouse to his new business. He and a team of three technicians import and install solar panels in homes and fields. He set up his business in 2007 when he first identified a rising demand for renewable energy technology in western Thessaly. A common theme in all conversations is that the demand for photovoltaics has never been greater than in 2012. This is due to a combination of factors, including a decrease in the cost of installation, the gradually decreasing payments per kW/h, a rise in awareness of the program and a substantial feeling that this is the only way to gain a stable income during times of economic austerity. Despite initial suspicion concerning “getting money for nothing,” the financial incentives offered by embracing photovoltaics are the primary consideration, especially in times of economic turmoil and government-enforced austerity.

The opportunity for a “second” income—for both businessmen and consumers—is the driving force behind the majority of activity related to photovoltaics. This fact negates the economic risk involved with substantial loans and the uncertain future of Greek participation in the wider system assemblages of the eurozone and European Union. A potential Greek return to the Drachma is a worrying prospect for investors. Not only would loans remain intact at euro-time levels, but also repayments would be translated into drachmas, as would the income offered per kW/h. The contracts signed during the euro-era would potentially be deemed irrelevant. Furthermore, Greek companies would not be restricted by the policies of austerity imposed by Troika and a potential European Union exit would deem the program politically extinct, calling into question the validity of existing contracts on local and national levels.

Farmers are especially vulnerable to enticements that hold out promise of a second income. The financial productivity of land is currently very low. Farmers cannot sell their produce on local or national markets, making crop production unviable beyond subsistence. As such, farmers are “growing photovoltaics” (*fitronoun fotovoltaika*) on their land. The sustainability of this approach has to be questioned due to the long-term nature of the contracts. Once signed, contracts tie the land to between 25 and 50 yr for the sole purpose of photovoltaic energy. Due to the rapidly increasing popularity of the current solar program much agricultural land—Thessaly has long been known as “the bread basket of Greece”—has been taken out of circulation. This raises questions for local and national self-sufficiency in grain and cereal vital to the Greek socio-economic recovery. By encouraging energy security through the large-scale solar program, food security may be threatened (this echoes similar problems throughout the agricultural history of modern Greece). This issue will become even more pertinent should Greece leave the eurozone, return to the Drachma and potentially exit the European Union as there will inevitably be a break down in free-market trade and importation of foodstuffs, increasing poverty in rural areas.

A secondary motivation for installing photovoltaic panels on private establishments stem from environmental sensibilities coupled with Greek patriotism. Informants claim that being part of the solar program engenders feeling part of the “green nation” or “green team” (*prasini omada*). These claims resonate with older ideals of systemic nationalism and of assisting the nation in its time of need (cf. [Herzfeld, 1985, 1997](#); [Karakasidou, 1997](#)). Collective identity under the rubric of nation is itself a unique form of assemblage drawing on diverse flows of culture, history, and rhetoric ([Gellner, 1983](#), [Hobsbawn and Ranger 1983](#)). People reason that if solar energy can help Greece in both energy security and repaying national debt then it is inherently dutiful to participate in photovoltaic initiatives. The Green Party has considerable support in central Greece and renewable energy is commonly promoted as being in the national interest to provide national security against market fluctuations, to buffer Greece from the results of conflict in neighboring states, and offer “clean” environmentally friendly alternatives to petroleum and coal currently dominating the energy sector in Greece. Many people are aware that lignite—brown coal—is an especially “dirty” fossil fuel.

The “green theme” is rhetorically paramount in public events such a “7th International Exhibition of Renewable Energy, Photovoltaics 2012.” The visual images employed to sell the

solar program focus on the relationship between nature and consumer. The majority of advertising material portrays photovoltaic installations on vast agricultural plains, nestled among leafy crops, and forests. In one case, pictures of solar panels are superimposed onto the UNESCO World Heritage Site of Meteora. In response to the food versus fuel debate, the same wholesalers who purvey these images to market photovoltaic kit are paradoxically likely to insist that photovoltaic development rarely encroaches on fertile agricultural land.

There are a range of private energy companies, mediators and agents operating in the towns of Trikala, Kalampaka, Larisa, and Karditsa on the back of the photovoltaic program. In addition to SMEs specializing in ordering and installing panels, there are companies mediating between private investors and banks, government institutions and larger import/export businesses. One specialized line is agents who organize the substantial paperwork required to secure loans for solar developments, whilst another division employs surveyors and architects to assess the plausibility for new installation sites. Private business owners acknowledge that their enterprise is temporary and believe that within five years the popularity and viability of the photovoltaic drive will drastically diminish, at least in terms of local self-sufficiency.

Part of this reason is that Greece has already surpassed its 2020 goals for photovoltaic energy production yet the program continues to be popular. This has put significant strain on the national grid in mainland Greece (the islands have separate grid systems). Connecting photovoltaic developments to the grid interferes with the flow of current and pushes the grid system towards its capacity (Hatziaargyriou, 2012). In some regions, the program has been “frozen” in order for local authorities to process the backlog in applications and allow technicians to work on optimizing grid integration.

C. Governance, bureaucracy, and history

The dissemination of macroeconomic policy to everyday social practice through systems of bureaucracy and governance is problematic. There is no policy in place to systematically advertise and explain photovoltaic initiatives, either to households, private enterprises, agriculturalists or to large-scale manufacturers and consumers. This is especially evident in the section of the program deliberately targeted at those agriculturalists most obviously struggling during the crisis, offering reduced interest rates on loans and other economic incentives. For example, the director of Farming and Agricultural Affairs in one peripheral council states that his job is to disseminate European Union-led programs aimed at agriculturalists on the Plain of Thessaly. However, like so many specialist civil servants, when asked about details of the photovoltaic project he insists that he knows nothing and one must go to Athens for details about “these sorts of things.”

The result of inadequate systems of governance and bureaucracy hinders the pathway to transition and reduces dissemination of the photovoltaic message to word of mouth and personal endeavor. This bureaucratic blockage has contributed to the formation of “clusters” of solar developments on the Plain of Thessaly. Although, other historical factors also influence their distribution due to large land holdings near Larisa being the remnants of Ottoman-era estates, known as *ciftliks* (see Karavidas, 1931; Aroni-Tsichli, 2005). Word of mouth and individual internet searches are cited as the main ways people discover the photovoltaic revolution in central Greece. The visibility of solar panels is another key way information is disseminated and has led to “patches” of photovoltaic activity across the Plain of Thessaly, as clusters of villagers have installed panels in imitation of their neighbors. Social networks of friends and family play a key role in spreading the message of renewables. These information sources allow for the flow of as much mis-information as reliable detail, such as the idea that one must “have money to make money” as banks do not look favorably on loan applications made by agriculturalists. This view is readily taken up and broadcast despite it being challenged by the special terms the solar initiative lays down especially for agriculturalists, but which fails to get communicated systematically through existing bureaucratic channels.

The long bureaucratic timeframe for papers to be processed also discourages some people from pursuing the solar program. In some cases, people have to wait three years between initially registering interest and starting work on their solar developments. Currently, the average

timeframe between contacting an agent for eligibility assessment and being linked to the grid seems to be around one year for developments on agricultural land.

In Thessaly, almost without fail, people discuss photovoltaics in relation to colonization and occupation linked to the Ottoman great landed estates and the Second World War Axis invasion. This has to be understood within the wider context of economic crisis and imposed Troika austerity. Land diversification in favor of photovoltaics is also justified through historical rhetorics of famine (experienced in Greece from 1941-1943) as people believe that a stable income from solar panels will help them feed their families during a time of severe uncertainty (Knight, 2012b). This rhetoric is expanded to a national level where planned energy export schemes are framed in terms of national security and self-sufficiency in the face of international threats.

It has become increasingly apparent that a deep grasp of the socio-historical background is required to understand local people's perceptions of the photovoltaic program and the possibility for the solar initiative to have long-term socio-economic impacts on other levels. People widely believe that Greece is returning to times of colonization. This notion is related in everyday discourse either to the period of *ciftliks* or to the 1940 Italian and German occupation. The selling off of Greek assets to foreign investors and the increased interest of Germany in renewable energy initiatives is viewed with much suspicion, bordering on distain. An example of public opinion is illustrated by a resident of Trikala:

“The Germans have capitalized upon the plight of all Greeks. They have bought our companies and held us to ransom. It is history repeating itself. The Germans do not want to compromise and will take everything they can from us. They caused us famine before; they will cause it again now. They treat Greece as their private *ciftlik*. I am told that if I can't sell my grain I can install photovoltaic panels on my land, but I think these companies are German-owned and using German products. It is another colonization, they are *Ciftlikades* (landlords of great estates)... And our government is planning to export green energy to save us all (the Greeks), but really I think they are just selling-off our land and all our resources. Local people will never benefit from international energy trade. They say it is to help us out of economic crisis, but I think the only reason we have to do it is precisely because we have the crisis and no other choice available” (Giannis, 47, Trikala).

The Trikala peripheral council has requested involvement in vast “Project Helios” development from 2013 and wants to participate in large-scale renewable energy export. Most people in Thessaly are aware of Project Helios but cannot recount details beyond the scale of the development. Many believe that the project is too ambitious and will never come to fruition, primarily due to government priorities and cheaper Chinese energy and panel production. If the council were successful in their pursuit then even more land would be annexed by foreign investors, thus increasing the sense of colonization prominent locally.

There are competing claims as to the viability of the Project Helios scheme and similar large-scale solar parks planned for Thessaly, Greek Macedonia, and Sterea Ellada. Some academics and wholesalers believe that such projects are “dead in the water;” whilst government officials insist that the programs are going ahead. Project Helios has encountered problems with European Union bureaucracy on the transnational investment in energy initiatives, as well as practical issues concerning inter-grid compatibility. If, as is suggested, the electricity is to be exported—mainly to Germany—serious socio-technical problems concerning transmission across distances and national borders need to be resolved. One senior academic power engineer views the technical problems alone as insurmountable; while supporters of the project within government are confident that circumstances are so perfectly aligned for the project's timely launch that political, financial and technical issues can all be resolved. They argue that solar technology has reached the right stage of development, the state of the Greek economy cries out for a bold move and Germany's rejection of nuclear generation creates the right level of demand.

The rhetoric surrounding all levels of the photovoltaic drive is often paradoxical, incoherent, and unstructured and thus requires intense sociological interrogation. Some people claim that the photovoltaic program has reached its peak and is commencing a downward spiral, whilst others insist the future is bright for solar energy in Greece. The diverse opinions must be

considered within the context of uncertainty within which people are currently residing in Greece, with new economic policy announced on a weekly basis, new taxes arriving on DEI electricity bills every month, and Troika enforced austerity. This does not mean that paradoxes and inconsistencies should be overlooked in order to provide a fully functioning systemic assemblage.

IV. THEORETICAL PONDERINGS

A. Systems approach

When conceptualizing related levels of the photovoltaic infrastructure initiative a systems approach proves fruitful, especially when dealing with multifarious flows of rhetoric, capital, history, and energy. The focus on structure and function of institutions and policies as employed by many systems scholars is not incidental from an anthropological perspective. Meadows (2009, pp. 11–12) defines a system as “an interconnected set of elements that is coherently organized in a way that achieves something ... a system must consist of three kinds of things: *elements*, *interconnections*, and a *function* or *purpose*.” Allen states that “the structure of the whole system provides a functioning community” (Allen, 2010, p. 141; also Pratt *et al.*, 1999, pp. 13–19).

The basis of systems theory—that every system works in accordance with other systems and that each system comprises interacting parts and relationships—is similar to the cultural systems approach developed in anthropology during the 1960s and 1970s (see Steward, 1955, 1967) that was intended to explain what were conceived of as “core” components of small-scale, face to face societies. In the case of a nation-state such as Greece, systemism has to be applied to the analysis of an extremely complex entity that is “real, but partly hidden, with largely invisible and often fluid, partly symbolic boundaries” (Pickel, 2007, p. 5). Meanings flow through and animate systems, even though they are often hard to trace and their significance readily lost to view. Sociocultural systems are not always coherently organized and structure and function do not necessarily equate; they may be messy, disconnected, and paradoxical. Careful consideration of systems is required so as not to produce distorted representations of the complex experience of new social relations informed by technological change (Shove, 2009). For example, when renewable energy has been approached from an interdisciplinary systems perspective, theoretical and conceptual tools tend to be applied to qualitatively thin “ethnographic” cases with little consideration to local socio-historical understandings. (This point is highlighted in Charnley *et al.* (2011, p. 176)—one of the more qualitative studies—where 11 interviews taken from five whole systems over the course of three years is deemed “a vast amount of primary material.”) Cultural representations and practices concerning land ownership, economic relations, or the materiality of new technology are merely a selection of key variables too often passed over. The interrelations between these things have to be apprehended at close quarters through the patient practice of ethnography and resulting “thick description” (Geertz, 1973). Formulating the dynamics of systems using anthropological methodology inverts the idea of commencing with a model and making the social milieu “fit” around the theory by selectively including and excluding predetermined criteria (Boardman and Sauser, 2008). Pickel suggests that “culture needs an explicit and clearly conceptualized place in new systems thinking” (Pickel, 2007, p. 7) and we argue that it is essential to thinking systematically about the current efflorescence of solar energy projects in Greece.

Throughout the discipline of anthropology, rich ethnographic accounts facilitate deeper understandings of systems. For example, a systems analysis of the Nuer kinship system in Sudan based on ethnographic material (Evans-Pritchard, 1940) yields vastly different results from a systems approach to kinship in Elmdon, England (Strathern, 1981). An analysis of the kinship system of the Greek linguistic minority of South Italy would highlight conflicts with both the Italian and the Greek systems but would not make it any less valid (Pipyrou, 2010, 2012). In this case, scaling-up the systems approach to incorporate historical narratives of displacement, mythology and historical constructivism among the linguistic minority would explain the fascinating nuances of the current kinship system.

In Greece, the tendency to view solar radiation as a “natural resource” is not novel as people recognize its lure for northern Europeans as the basis for their hugely important tourist industry. Now, however, the availability of free, reliable and renewable sunshine has taken on a fresh significance entailing new and different kinds of investment, infrastructure, construction, enterprise and a host of other entangled activities. Social scientists were notably slow to develop an interest in the growth of mass tourism and to understand its ramifications, especially for Island Greece. They appeared too late on the scene to demonstrate how rapid, exponential growth would inevitably meet its constraints and that if “human populations do not choose and enforce their own limits to keep growth within the capacity of the supporting environment, then the environment will choose and enforce limits” (Meadows, 2009, p. 103).

In this research, we follow whole system theory to chart the complex interactions that feature in the Greek dash to operationalize photovoltaic technologies and illustrate aspects of the emergent photovoltaic socio-technical system. By adopting this approach one of our preliminary findings reveals that—although emergent and a system without precedence—the photovoltaic phenomenon’s novelty is deeply affected and shaped by historical references. There is no “year zero” that signals the beginning of the spread of photovoltaic measures in Greece, rather ethnography demonstrates an intense historical consciousness on the part of our informants with regard to their own understanding of the systems and circumstances surrounding the take-up of photovoltaic solar energy. (For a discussion of the importance of historical consciousness in Greece, see Knight (2012b), Sutton (2001), and Stewart (2012).)

The ability to deal with complexity across disciplines whilst accounting for radical differentiation in scales and flows makes a systems approach appealing to sociocultural anthropologists. As a constructive tool for analyzing complex systems and incorporating wide interdisciplinary data sets, the systems approach furthers comprehension of the socio-technical interface. Anthropology can contribute detailed ethnographic case studies that highlight cultural nuances and interaction between constituent parties, enriching the systems approach. It is not a prerequisite for systems to be tidy, coherent or complementary, neatly structured or perfectly functioning. The impact of global flows on local energy practice can be assessed, whilst maintaining the integrity of cultural and historical experience.

B. Rethinking the socio-technical: Materiality, assemblage, and agency

Our research on the Greek photovoltaic initiative aims to address the interaction between human and non-human networks, from the atom to the *anthropos*, exploring the co-configuration of the “social” and the “technical.” Going beyond socio-technical theory that considers how complex technological infrastructure inevitably affects human behavior (Shove, 2003; Geels, 2010; Lawhon and Murphy, 2012), human and non-human networks are analyzed as assemblages of relational agency (Deleuze and Guattari, 1980; Galvin, 2009; Serres, 1995a; Bennett, 2005, 2010; Latour, 2005). The research further contributes to classic anthropological theories of objects as mediators of social agency (Gell, 1998; Layton, 2003) by focusing on the materiality of energy through production, circulation, and consumption. Intricately linked to the systems perspective, the materiality of local and global flows can be assessed in relation to diverse forms of networks.

As money and land are removed from circulation during the economic crisis the energy landscape in Greece is being reshaped by new alternative flows—primarily solar as outlined here, but recently also a return to open fires and wood-burning stoves. The spread of photovoltaics across fields and farmers “growing” energy is without precedence and its effects on food security in Greece and consequences for biodiversity on the Plain of Thessaly are yet to emerge. We were reliably informed by a number of sources that the relevant bureaucratic bodies currently face a log-jam of 200 applications from landowners for photovoltaic generation licenses. Some believe that the delays are deliberate and a signal that the photovoltaic bubble in Thessaly may be about to collapse. If enough farmland is given over to photovoltaic panels for periods covering an entire generation, how will the knowledge and skills needed to return to agricultural production be retained and transmitted?

Many questions remain unanswered in a scenario full of uncertainty and unpredictability. The full effects of the proposed mega-photovoltaic initiatives will unfold only if and when they are fully realized. Presently, these plans function mainly as a beacon of hope held out to a demoralized population. At the level of micro-generation on household rooftops, their spread will depend on future levels of feed-in tariffs and DEI's precarious ability to continue payments to individual households as well as to farmers (cf. [Sauter and Watson, 2007](#)).

Our focus on materiality leads to a precise understanding of the relationship between actors and networks of energy, finance and rhetoric, thus further promoting a social-scientific appreciation of human and non-human connectivity, interaction, assemblage, and exchange. Considering this dynamism, the transformative relational materiality of solar energy is analyzed within the context of global economic crisis and Greece's struggle to repay national debt. When coupled with a systems approach, the focus on material assemblage will assist us in constructing an ethnography of "unruly complexity," defined by [Taylor \(2005, p. 203\)](#) as "the complexity of situations that build up over time from heterogeneous components and are embedded within wider dynamics and in which there is ongoing restructuring."

Approaching networks as socio-technical assemblages facilitates a more profound understanding of the contemporary picture of energy practice. It further allows us to incorporate historical understandings of energy initiatives that are firmly based within complex sociohistorical assemblages. Both social and energy networks are also assemblages of human and non-human agency, scientific engagement, technological historicity, and ideological opportunism; they are material hybrids. They are the disparate aggregate of social, scientific, and technical solutions dating from different periods. Hence an ensemble obtains contemporaneity by means of assemblage, by its design, its finish, its polytemporal agency, sometimes only by the slickness of the advertising surrounding it ([Serres, 1995a, p. 45](#)). The circulation of agency, rhetoric, and finance within the packaging of "green energy" forms constitutive parts of the "background noise" of the photovoltaic program that hold great influence over local actors, but often go unstudied within the context of material systems (cf. [Serres, 1995b, p. 13](#); [Serres and Schehr, 1983](#)). The electrical power grid is but just one example of an assemblage, a composite flowing system of material parts with imperfections that represent the interaction between human and non-human agents ([Bennett, 2005, p. 446](#)). New infrastructure networks provoke the emergence of spatial and temporal differentiation on all levels, as established complex socio-technical geometries of power are reassembled ([Graham, 2000, p. 115](#), [Castells, 2000](#)).

Human and non-human actors are continuously shaping and being shaped, meaning object and subject are entwined in mutual embrace ([Knox et al., 2006](#); [Strang, 2009](#); [Harvey, 2011](#)). The photovoltaic drive has reshaped the natural and social landscape of central Greece as raw materials change functionality and in turn redesign the livelihood of human agents. Natural resources have always been economic assets, but now they have been harnessed in an alternative manner, with their "owners" encountering highly paradoxical feelings. This shift in turn affects global flows of energy, investment capital, man-power, and knowledge domains, creating new virtual markets that beckon yet another group of transnational actors to enter the system ([Strathern, 1996](#)).

V. CONCLUSIONS

Our ongoing research in Greece points to a radical plan for sustainable energy development based primarily on photovoltaics. Impacts of the photovoltaic drive are apparent on many levels, including the possibility of Greece becoming a global leader in solar generation with an enhanced ability to repay debt and decrease national deficit. Obviously, this would have significant consequences for pan-European economic prospects and provide a blueprint for other nations under severe fiscal stress. On a local level, the initiative is rarely disseminated in an orderly fashion due to failings in policy implementation and bureaucratic channels. For local people, the photovoltaic program conjures up mixed feelings. On the one hand, they are offered a viable solution to create a stable monthly income through land diversification and new employment opportunities are available. On the other hand, this method seems unsustainable, is based on significant financial risk, and is imbued with notions of dispossession and

neo-colonialism. There is also intense competing rhetoric concerning the fate of the solar scheme, with academics, politicians and investors rarely agreeing on the current state of affairs. The future of this ambitious program at a time of intense economic crisis remains to be seen.

We are currently in an iterative process of dialogue between ethnographic findings and theoretical perspectives but remain convinced that the general principals of the socio-technical approach remain sound. A systems approach will help us address all levels of the scheme, from home installations to expansive solar parks and assess the consequences for all concerned. Our adoption of a systems approach is enhanced by the provision of rich ethnographic material. The potential contribution of ethnography as central to systems models has been regularly overlooked, yet the principals of the approach for “scaling” complex socio-technical networks are invaluable. The incorporation of more substantial ethnography will allow for more effective communication between local consumers and policy makers.

Energy sustainability is one of the greatest challenges facing the contemporary world. How this challenge is embraced by the academic community will significantly affect the livelihoods of future generations. Energy resources pose a major social and economic concern for the immediate future and we truly believe that anthropology has something significant to offer to interdisciplinary debate. Improved self-sufficiency through renewable energy is heralded as an economic saviour in times of austerity and increasing energy poverty. On a national level, renewables may provide a long-term solution to international dependency and pan-European energy security, as well as a way to lift failing economies out of financial squalor.

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