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The spatial distribution of renewable energy infrastructure in three particular provinces of South Africa

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Abstract. Renewed interest is being shown in South Africa in the promotion of infrastructure for renewable energy (RE) to supplement the country's current energy-generation capacity and to break loose from its dependency on an unsustainable fossil-fuel-based energy-provision system. The latter system not only has unfavourable consequences for the environment, but is managed by a state-owned institution which since 2008 has been incapable of providing reliable electricity. RE infrastructure - especially for the generation of solar and wind energy - is a relatively new feature in the South African landscape. This paper examines the spatial distribution of the newly commissioned infrastructures for wind and solar energy (operational and under construction) and the role they can play in the diversification of the rural economies of parts of the country's Northern Cape, Western Cape and Eastern Cape provinces. First, literature on evolutionary economic geography, path dependence and new path creation is reviewed. Second, the role of a single energy provider — embedded in a monopolistic energy policy —in inhibiting the transition from a mainly fossil-fuel-based energy-provision system to a multi-source (multi-owner) provision system is discussed. Third, the reasoning behind the siting of the infrastructures for solar and wind energy in three particular provinces is explained. Fourth, the possible roles these new infrastructures can play in the diversification of the rural economies where they occur are advanced. The paper concludes that solar- and wind-energy projects have the ability to transform the South African energy context and that these projects present some positive socio-economic impacts for rural economies in the three particular provinces. The paper also recommends that future research efforts should be aimed at the evolution of this socio-economic transformation by taking into account the pre-development context of the areas under study.

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Contents:

1. Introduction

The South African economy is energy intensive and dominated by a fossil-fuel led energy supply (Herman et al., 2015). In 2005 the South African Department of Minerals and Energy (DME) adopted an energy-efficient strategy which set a national target for improving efficiency by 12% by 2015 against the baseline year 2000 (Sebitosi, 2008). Unfortunately, this target has not been reached and the efficiency and reliability of electricity supply has deteriorated to the extent that the whole South African economy is negatively affected. According to Vavi (2015: *n.pag*) the "chronic load shedding, electricity supply shortages, a financial meltdown at Eskom (the state-owned Electricity Supply Commission of South Africa), massive cost and time overruns in the generator-building programme, maladministration within Eskom's senior management, devastating downgrading of Eskom by capital markets… and the prospect of increased electricity tariffs has deepened the far-reaching electricity crisis that gets worse every day and has a serious effect on South African lives."

Investment in renewable energy (RE) and energy efficiency is important to reduce the negative economic, social and environmental impacts of energy production and consumption in South Africa (Winkler, Mavhungu, 2002). More than 10 years ago, Bugaje (2006) argued that the success of sustainable development (1) in South Africa and the rest of Africa lies in addressing the continent's imminent energy crisis. So far, most African countries have been slow to adopt pro-renewable energy policies, but there are many signs that this is changing. South Africa is now one of the most proactive proponents of solar power. The country is experiencing regular blackouts due to breakdowns in the aging fleet of mainly coal-fired power plants which is causing a supply shortage and it has become necessary to accelerate and expand solar- and wind-energy programmes (Castellano et al., 2015). The South African electricity context exhibits similarities to the British electricity supply industry (ESI) which since 1948 has followed a monopolistic supply based on fossil fuels as well as centralised generation and distribution of electricity through a national grid network, but which post-1979 was adapted to an oligopolistic and privatised supply under the leadership of Margaret Thatcher (Simmie et al., 2014). In South Africa, Eskom is the monopolistic state-owned institution controlling the national grid network and the generation installations which are almost 80% fossil-fuel-based (Herman et al., 2015). RE infrastructure — especially for the generation of solar and wind energy — is a relatively new feature in the South African landscape. Existing scholarship on the transition of countries or regions from non-renewable to RE technologies notes that such transitions are characterised by persistent spatial and temporal heterogeneity (Asif, Muneer, 2007). Currently, RE contributes relatively little to primary energy generation in South Africa and even less to the consumption of commercial energy. South Africa is heavily reliant on electricity from fossil-fuel resources and is therefore considered to be "locked-in" to a path of non-renewable energy generation (Winkler, 2005).

Despite the crisis created by the country's monopolistic supply utility, South Africa was rated as the 13th most attractive global destination for RE investment by EY's (previously Ernest & Young) Renewable Energy Country Attractiveness Index in June 2015. The rating is a result of the success of South Africa's national procurement programme in securing 5.2 GW of renewable capacity worth an estimated US$14 billion in investment. The National Energy Regulator of South Africa (NERSA) has announced an expansion of the Independent Power Producers Programme (IPPP) to 6.3 GW under Round 4 of the procurement process, thereby contributing to the positive rating (EY, 2015). To date 66 RE projects have been approved, 47 power-purchase agreements totalling 2450 MW have been signed and 32 projects totalling 1500 MW had been connected to the national grid by February 2015 (Baker, Wlokas, 2015). The South African RE-procurement programme is unique in that for projects to qualify, developers must commit to some sort of community ownership and economic-development benefits which will diversify the economic landscape, especially in the country's rural areas.

Internationally, RE deployment has had a number of socio-economic and environmental effects. The international scholarship debates have focused on issues such as the effects of RE infrastructure on physical landscapes; the diversification of land use (Scheer, 2005; Dunlop, 2009); the impact of these structures on a sense of place (Wattchow, 2013); visual intrusion (Pasqualetti, 2000, 2001); and the greening of landscapes and the environment (US Environmental Protection Agency, 2008). Moreover, debates about the socio-economic effects of RE have centred on enterprise and regional development (Del Río, Burguillo, 2008; Kedron, 2012); tourism development (Dalton et al., 2007; Del Río, Burguillo, 2008; Michalena et al., 2009; Michalena, Tripanagnostopoulos, 2010; Frantál, Kunc, 2011); educational impacts (Del Río, Burguillo, 2008); investment opportunities (Palmer, Burtraw, 2005); policy development (Bergek et al., 2008); and, diversification of the energy supply and employment opportunities (Del Río, Burguillo, 2008).

This paper explains the spatial distribution of these new infrastructures for wind and solar energy (operational and under construction) and the role they can play in diversifying the rural economies of parts of the country's Northern Cape, Eastern Cape and Western Cape provinces. First, the literature on evolutionary economic geography (EEG), path dependence and new path creation is briefly reviewed. Second, the role that a single energy provider (embedded in a monopolistic energy policy) can play in inhibiting the transition from a mainly fossil-fuel-based energy- provision system to a multi-source (multi-owner) system is discussed. Third, the reasoning behind the siting of the infrastructures for solar and wind energy across three provinces is explained. Fourth, the possible roles these infrastructures can play in the diversification of the rural economies where they occur are advanced. Last, some conclusions are made and areas for research are recommended.

2. An evolutionary approach as theoretical point of departure

For economic geographers the concepts of 'path dependence' and 'lock-in' are key ingredients of an evolutionary approach to their subject (Martin, Sunley, 2006). Such an evolutionary approach focuses on the historical processes producing uneven patterns of economic development. Evolutionary economic geography (EEG) explains the spatial evolution of firms, industries, networks, cities and regions based on the processes of the entry, growth, decline and exit of firms, and their locational behaviour (Storper, 1997). EEG concentrates on the regional scale since development tends to be geographically bounded (Boschma, Lambooy, 1999; Boschma, Frenken, 2006). An EEG approach contributes to our understanding of development in national territories and the refining of general economic theory. EEG scholars recognise three foundations of EEG – path dependence, complexity theory and generalised Darwinism (Boschma, Martin, 2010). Evolutionary economists argue that developmental pathways originate as a result of 'historical accidents', 'chance events' or 'random actions' (Arthur, 1994; David, 1994) that do not necessarily take into account the social dimensions of development (Sydow et al., 2009). EEG can make a valuable contribution by explaining the evolutionary establishment of infrastructure for wind and solar energy in a number of rural regions (Martin, Sunley, 2010) while considering the social aspects of rural regional development. Simmie et al. (2014) propose a hybrid socio-economic theory for technological-path creation which links evolutionary economic theories with sociological explanations of new technological pathways to explain the evolution of wind-energy technologies and its local impacts.

Important and appropriate core concepts of the EEG approach are the notion of path dependence (Fornahl et al., 2012), windows of locational opportunity (Simmie et al., 2014), creative destruction (Gilbert, 2012), path creation (Simmie et al., 2014) and post-productivism (Evans et al., 2002). These concepts provide the bedrock for a study of the economic diversification and the socio-economic transformation abilities of the development of RE infrastructure in rural regions. Path dependence is intended to capture the way in which small, historically-contingent events can set off self-reinforcing mechanisms and processes that 'lock- in' particular structures and pathways of development. Geographers have been attracted by the 'lock-in' aspects of path dependence as a way of describing and explaining the 'quasi-fixity' of spatial structures of economic activity and the temporal patterns of regional development. According to Fornahl et al. (2012: 840), the causes of a new path are "first seen in chance, second in a mix of chance and limiting conditions and, third, in the deliberate and dedicated behaviour of economic actors." The second cause is often backed by the theory of windows of locational opportunity, a central concept in EEG (Martin, Sunley, 2006). Chance and small events create opportunities for regions outside existing economic centres (rural areas) to generate or attract pioneer entrepreneurs provided that certain framework conditions and basic requirements are established.

A key question, therefore, is when to speak of a truly new path and when to consider it a change of an existing path in a developmental context. A change in an existing path is supported by path-dependent processes relying to a large extent on the existing resource base to fuel the change, whereas "a new path is created by a sudden break with the past and hence a sudden break with existing technologies, products and organizational forms, which implies new future expectations" (Fornahl et al., 2012: 841). This is also an underlying principle of post-productivist paradigms. The following sections outline the reasons why the development of RE infrastructure in rural South Africa is creating new pathways for development, starting with the contribution of a conducive energy-policy environment.

3. The evolution of South African energy policy

Policy structures governing energy development can significantly foster or hamper the diffusion of RE infrastructures. Post-apartheid energy policy in South Africa was set out in the White Paper on Energy Policy for South Africa of 1998. The major objectives were to: increase access to affordable energy services; improve energy governance; stimulate economic development; manage energy-related environmental impacts; and secure supply through diversity (Department of Minerals and Energy (DME), 1998).

Once the South African RE market had drawn attention at the turn of the millennium, a new White Paper on the promotion of RE and clean-energy development was developed in 2002 which specifically looked at strategic goals, objectives and deliverables of RE deployment over the medium-term (Department of Minerals and Energy (DME), 2002). More recently (2010) the DME released an Integrated Resource Plan (IRP) which aims to have approximately 42% of the country's energy generated by renewable sources by 2030. In 2011, IPPP was launched by the National Energy Regulator of South Africa (NERSA) which requires RE developers to undertake bidding processes to obtain approval for their proposed projects (Tait, 2012). So far, three rounds of bidding have taken place with the programme now expanded to a fourth round. According to Winkler (2005: 34), if governments at national level "simply sets targets, industry has to find the least-cost way of meeting these, but are likely to pass on increased costs to consumers" so creating another barrier to the development of RE infrastructure. The latter is complicated by the situation of a single energy provider embedded in a monopolistic energy policy that inhibits transition from a mainly fossil-fuel-based energy-provision system to a multi-source (multi-owner) system. The monopolistic supply has created a lock-in to a fossil-fuel-generated energy economy which cannot adequately meet the country's growing energy demands. The current mitigation measures, which include load-shedding plans, are designed to introduce predictability into the blackouts to try to contain the economic losses felt by producers and suppliers. This load-shedding plan calls for the conversion of Eskom from a state-owned, vertically-integrated monopoly to a privatised utility with an open market for foreign investment in clean generation technologies (Attia, 2015).

South Africa's energy policy is evolving to include more renewable and sustainable energy projects in the supply mix. However, a coherent policy to enable a RE environment is still being developed. According to Winkler (2005: 34) the "key to creating an enabling environment is to allow renewable electricity technologies to compete on a level playing field with alternative options." This could point to a path-dependent type of RE development rooted in the historical deployment of fossil fuel based technologies. Ways to overcome the barriers to RE development can include power purchase agreements, non-discriminatory access to the grid, and funding for research, demonstration and development (Winkler, 2005). The Renewable Energy Independent Power Producers Programme (REIPPP) of the South African government aims to install a total of 17.8 GW electricity generation from wind, solar, biomass, biogas and hydropower in South Africa between 2012 and 2030 (Walwyn, Brent, 2015). Initially, REIPPP made no economic sense when its weighted cost of electricity was predicted to be more than triple that of coal-based electricity generation, but falling costs of power from wind and solar technologies suggest that REIPPP could reach grid parity in 2016 and become cost neutral in the South African context by 2017 (Walwyn, Brent, 2015).

South Africa's energy policy has come a long way since the first step toward diversification of the energy supply in the post-apartheid era. It remains to be seen if the present RE infrastructure can foster change in future policy endeavours and in turn affect a changed policy environment by establishing an environment conducive to RE development in South Africa. In addition to how policy shapes RE development, spatial processes can also influence the capacity for transformation as explored in the next section.

4. The spatial distribution of renewable-energy infrastructure

Energy systems present themselves spatially with components of the system embedded in particular settings and the networked nature of the system itself produces geographies of connection, dependency and control. An energy transition from conventional to renewable sources is inherently a geographic process. Bridge et al. (2013) claim that this process chiefly involves the reconfiguration of existing patterns and scales of economic and social activity. Their work makes a valuable contribution by analysing the geographies of energy transition rather than just looking at the diversification of electricity supplies, so providing a framework for analysis. This framework uses six concepts namely: location, landscape, territoriality, spatial differentiation, scaling, and spatial embeddedness as conceptual vocabulary to describe and assess the geographical implications of a transition towards low carbon energy (Bridge et al., 2013). This section uses their framework to unpack the geographies of infrastructure for wind and solar energy in three South African provinces. The first component of the transition framework involves the location of the energy infrastructure. Figure 1 shows the spatial distribution of infrastructure for wind- and solar-energy infrastructure deployment across South Africa which have either been approved and are under construction or fully operational.

Most of the projects are located in the southern part of the country with majority in the Northern Cape, Western Cape and Eastern Cape. The reasons why solar-and-wind-energy projects dominate the distribution of renewable energies in South Africa are that climatic conditions provide year-round sunshine in the largest part of the country and hundreds of kilometres of windswept coastline (Ayodele et al., 2013; Gauché et al., 2013). South Africa is currently ranked as one of the top-ten markets for solar photovoltaic (PV) generation and investment. In 2014 and 2015 six plants (totalling over 500 MW) came on line (or achieved full capacity), now representing the largest solar-PV plants on the African continent (REN21, 2015). South Africa is also breaking new ground with concentrated solar-power with the construction of the Redstone thermal solar power project in the Northern Cape, which is a first of its kind in Africa. This R10-billion plant will use molten salt to generate electricity during peak-usage periods at night (Laganparsad, 2015; Williams, 2015). Between 2014 and 2015 South Africa has also increased its wind energy capacity from 10 MW to 570 MW (REN21, 2015). This roughly corresponds to the rate at which the use of this technology is expanding globally. Because these two technologies dominate the South African RE scene, this paper addresses infrastructure for wind and solar energy only. Evident from Figure 1 is that the temporal and spatial diffusion of this infrastructure has progressed from an experimental phase pre-2010 through an operational phase from 2011 to 2015. The projects now under construction will become operational in a future phase from 2016-2018.

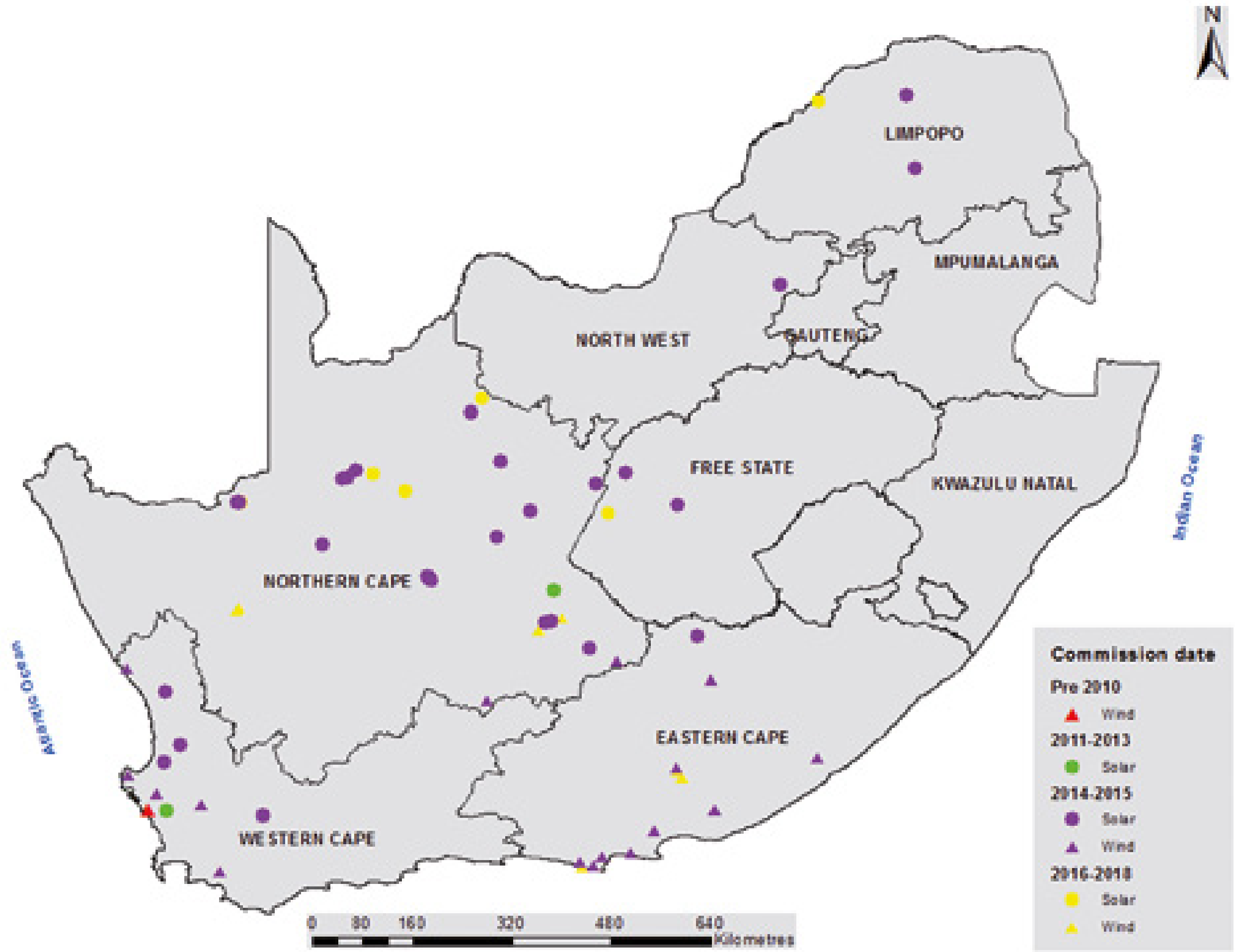

Fig. 1. Location of renewable energy projects in South Africa according to commissioning dates

Source: Authors

The promotion of renewable technologies in developing countries does not only encourage a transition from conventional fossil-fuel-based electricity supplies to technologies which are more environmentally friendly, but also establishes a diversification of the electricity supply which contributes to a spatial expansion of economic activity (Thiam et al., 2012). This introduces the second concept of Bridge et al.'s (2013) transition framework, namely landscape. "Landscape describes the assemblage of natural and cultural features across a broad space and history of their production and interaction" whereas an 'energy landscape' (energyscape) refers to the "constellation of activities and socio-technical linkages associated with energy capture, conversion, distribution and consumption" (Bridge et al., 2013: 335). RE deployment does not impact on the physical landscape, but also on the socio-economic landscape of an area. This is noteworthy for policy making because landscape represents a source of novelty and experimentation as well as a cause for uncertainty in outcomes. This raises pertinent questions about which landscapes should be constructed and for whom? The initial South African procurement programme's policy documents outline various targets for local economic development and notable they provide the basis for the revised REIPPP's implementation. These targets are: (a) rural development with an emphasis on the inclusion of previously- disadvantaged regions in the economy; (b) participation by local communities and socio-economic development; (c) job creation; (d) local content aimed at increasing local manufacturing; (e) skills development and education; (f) enterprise development through promotion of new entrants to the RE industry; and (g) participation by previously-disadvantaged citizens in the industrial economy (Walwyn, Brent, 2015). This paper concentrates on the development of rural areas which constitutes one of the targets of the REIPPP in South Africa. However, in the next sections of this paper it will become clear that the targets have the potential to overlap and therefore rural development can be influenced by all six of the other targets as well. The seven targets are in fact all aimed at diversification and transformation of economic activities.

The third analytical concept of Bridge et al.'s (2013) transition framework involves 'territoriality' of RE infrastructure by asking the question how social and political power is organised and exercised over space. The territoriality of RE development in South Africa is particularly linked to different scales and areas of political action and the spatiality of these projects. The policy on RE development in South Africa has been covered above. Discussion now turns to the cultural contingency (2) of the spatial diffusion of these infrastructures that are embedded in a rural culture and socio-economic context. Rural areas often take a back seat in discussions on regional development and they are characterised by weaker economic performance due to the "persistent out-migration of younger and better-educated people, lower educational attainment, lower average labour productivity and lower levels of public service provision. Rural economies are also often highly specialized in low-wage, low-skill occupations lacking career ladders and job security and also often lack cutting-edge telecommunications and other infrastructure" (Ward, Brown, 2009: 1238). Rural economies largely make use of their (vast) natural resources as inputs for agriculture, mining, forestry and other primary-production activities. Parts of the Northern-, Western- and Eastern Cape provinces reflect these characterisations above. Figs. 2, 3 and 4 show the Northern Cape, Eastern Cape and Western Cape respectively with their solar- and wind-energy plants overlaid on the land cover in each province. These maps expose a striking absence of urban and built-up areas which validates the need for a study of rural regional development. The solar- and wind-energy plants are primarily mainly located in the rural areas of these provinces where land cover consist of cultivated areas, forest areas, grassland, woodland, herbland and scrubland.

Thirty-one (49%) of the 63 solar- and wind-energy projects currently under construction or operational in South Africa are in rural areas in the Northern Cape, 11 (18%) are in rural areas in the Eastern Cape and 11 (18%) in the Western Cape. In the Northern Cape the projects are concentrated in the Namakwa, Pixley ka Seme, John Taolo Gaetsewe and ZF Mgcawu district municipalities. In the Eastern Cape they are in the Amathole, Sarah Baartman, Chris Hani and Joe Gqabi district municipalities, and in the Western Cape in the West Coast, Overberg and Cape Winelands district municipalities. In this context the fourth concept of Bridge et al.'s (2013) transition framework relates to how an energy transition can cause spatial differentiation and uneven development. The relevant district municipalities in the Northern Cape are scarcely populated areas where primary industries, mainly agriculture and mining, constitute their principal economic sectors. On average, one third of these districts' population is unemployed. The four Eastern Cape district municipal areas have slightly higher unemployment rate with slightly more dense population distributions, while the main economic activities are also agriculture and mining. In contrast, only 15% of the workers in the three more densely-populated Western Cape province district municipalities are unemployed. The major economic activities in these areas are in the primary sector, namely agriculture, forestry and fishing, but also include secondary activities (manufacturing) and quaternary sector activities such as finance and business services (The Local Government Handbook, 2015). The pre-development RE infrastructure contexts of the study areas thus shows uneven development and spatial differentiation. An energy transition has the potential to "re-work established economic patterns of 'core' and 'periphery' at multiple scales…that has the potential to produce new patterns of uneven development" (Bridge et al., 2013: 337). Notably, most of the projects are in the Northern Cape which is the least densely populated of the three provinces, but has relatively high unemployment rates. Because primary activities, particularly agriculture, are dominant in all three areas studied the rural character of these areas are confirmed making them conducive to the diversification of their economies.

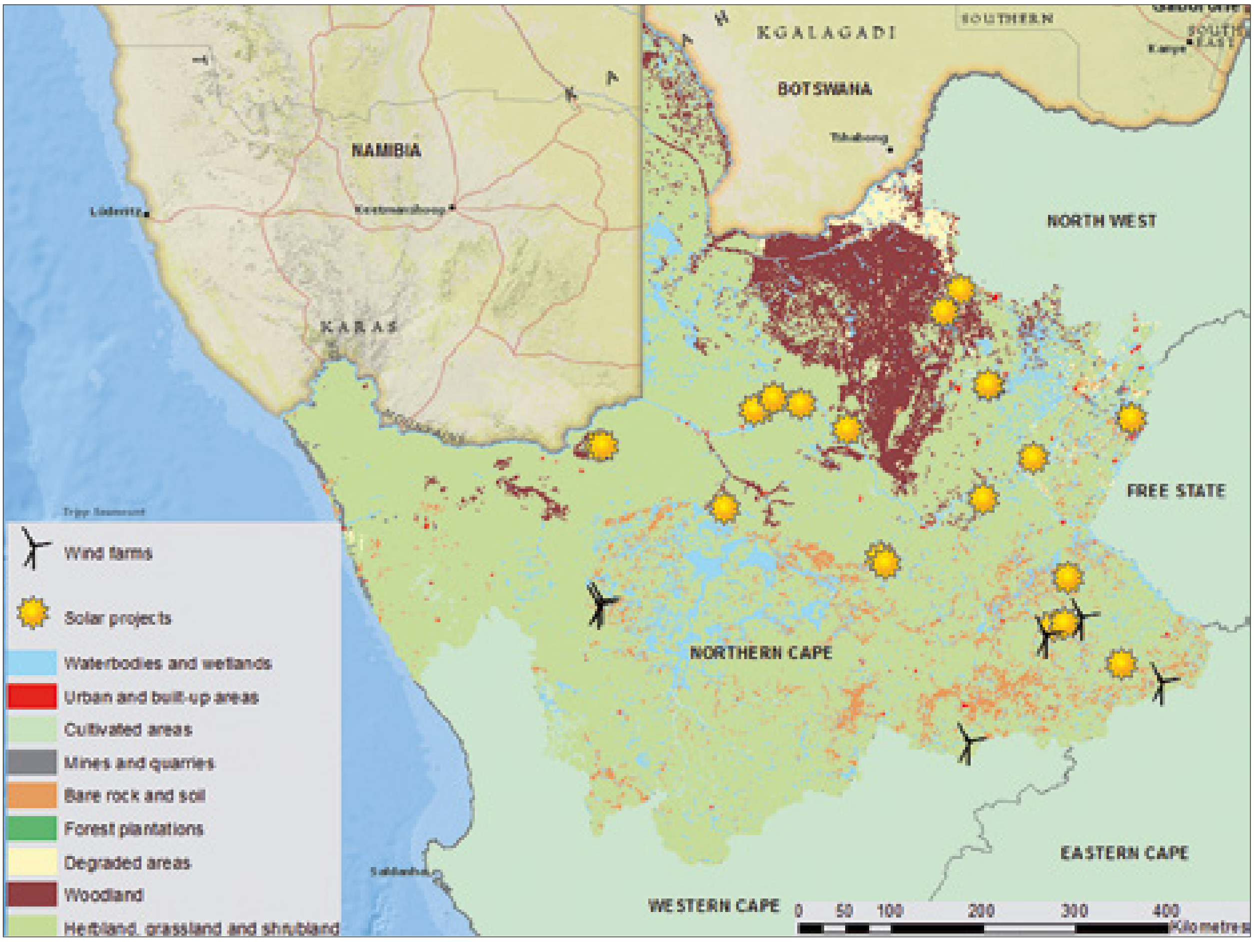

Fig. 2. Wind- and solar-energy projects in the Northern Cape province of South Africa

Source: First author

Rural development is predominantly concerned with the beneficial-exploitation of natural resources so that RE development based on the availability of natural resources, such as solar energy and constant wind power can play vital roles in the economic growth and development of rural areas. Scaling plays a determining role in the extent of this growth and is the fifth concept in Bridge et al.'s (2013) energy-transition framework. The current distribution of RE infrastructure in South Africa revolves around macro-scale deployment across entire landscapes. According to Ward and Brown (2009: 1239) rural areas are commonly viewed as "places of tradition rather than modernity, of agriculture rather than industry, of nature rather than culture, and of changelessness rather than dynamism and innova-

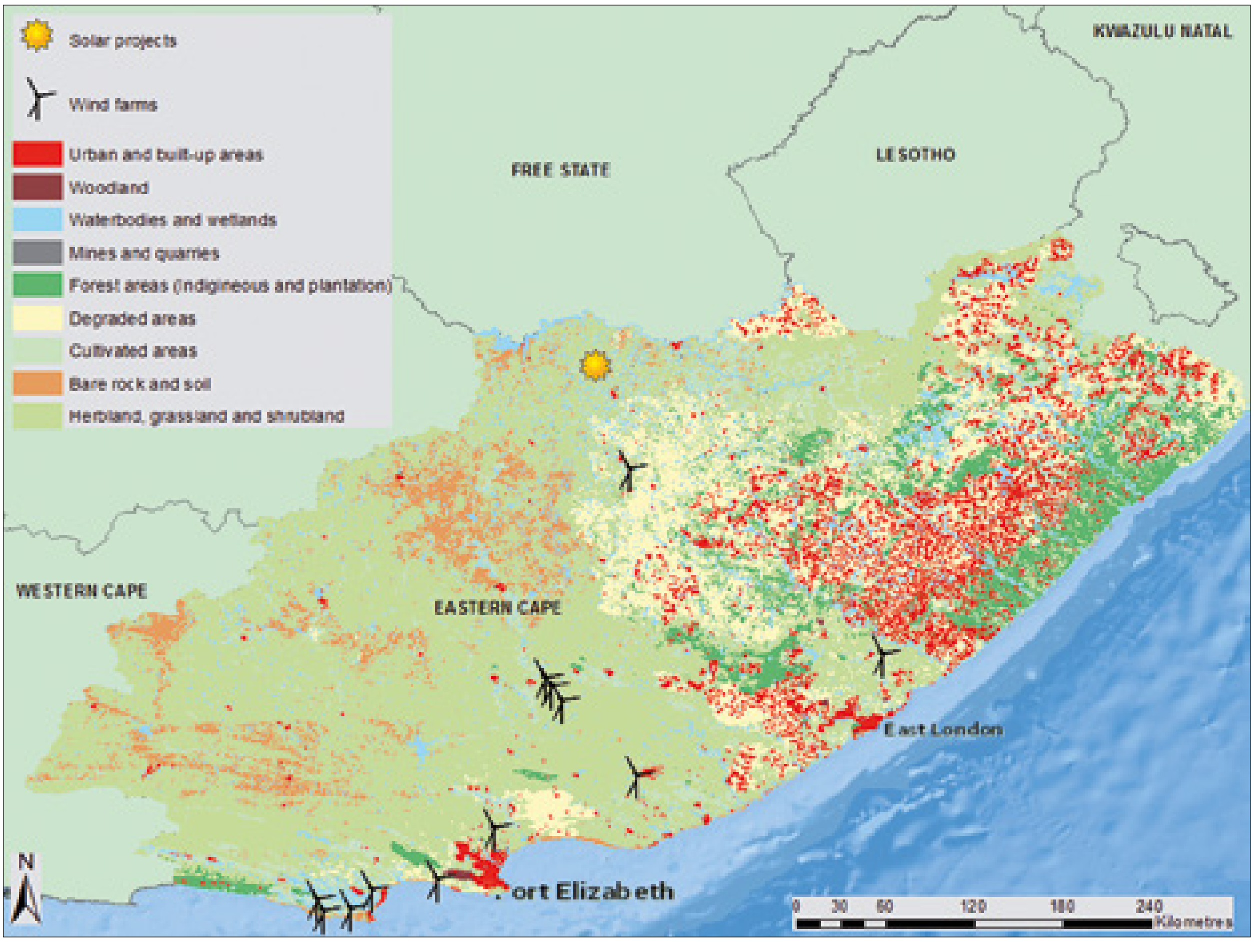

Fig. 3. Wind- and solar-energy projects in the Eastern Cape province of South Africa

Source: First author

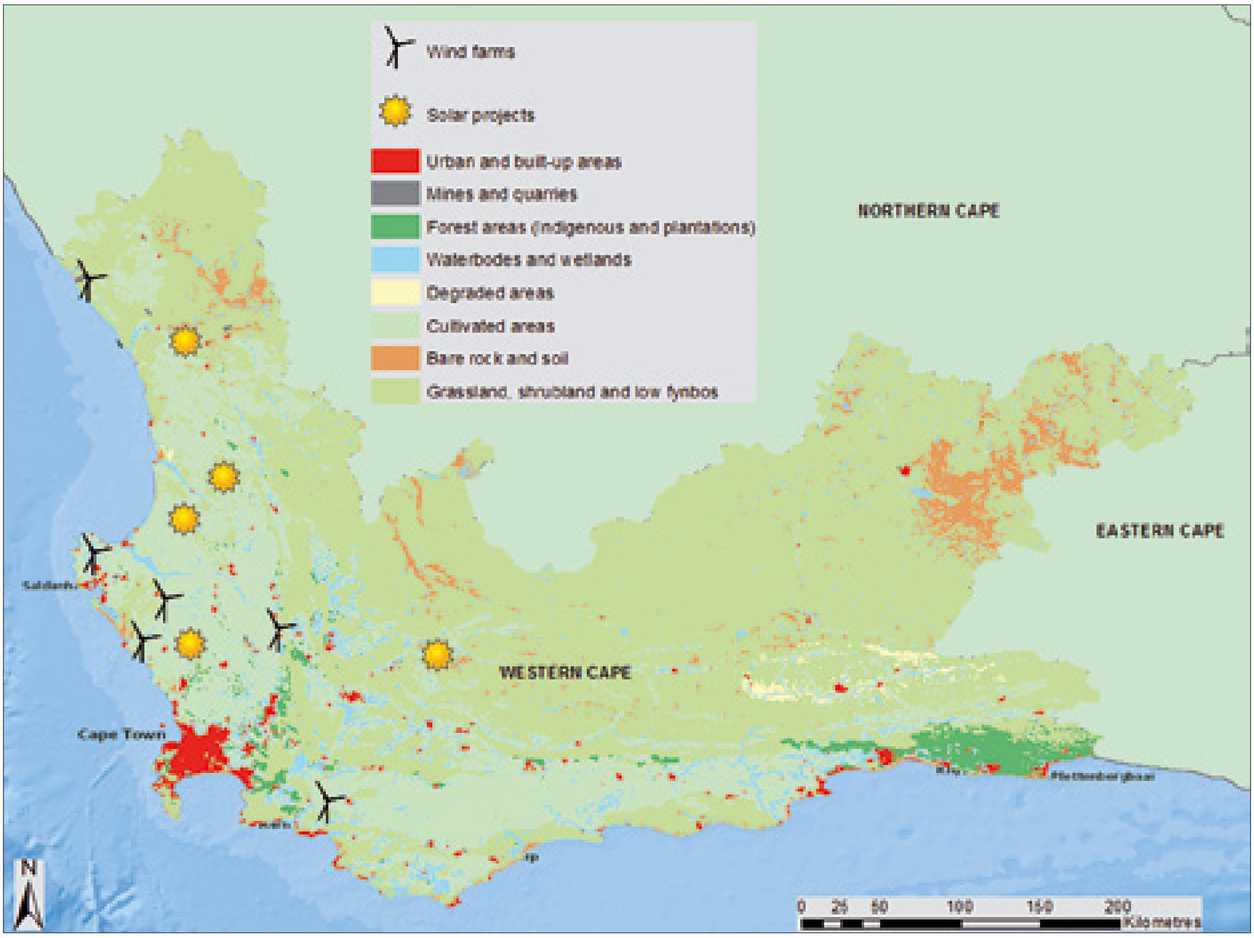

Fig. 4. Wind- and solar-energy projects in the Western Cape province of South Africa

Source: First author

tion." When one considers the past economic geography of rural areas it becomes clear that progress is always accompanied by substantial shifts in the distribution of economic activity and the population of an area. Sectoral changes accompany spatial changes as economies advance from agriculture to manufacturing and higher-order services so making policies aimed solely at supporting agriculture increasingly ineffective and inappropriate for stimulating rural development (Ward, Brown, 2009; Turok, 2012). Therefore, it makes sense that the RE-procurement programme in South Africa has rural development as one of its core components. The challenge remains whether the introduction of RE infrastructure can foster this transformation to a new pathway in the economic development of rural areas which are largely misunderstood and stigmatised as being changeless.

5. Infrastructure for renewable energy and the diversification of rural economies

The prosperity of rural areas has become increasingly dependent on the nature of their relationships with the extra-local which can be any of the following or combinations of these relationships: nearest regional population centres, the national space economy or a mimicking of international processes of socio-economic change (Ward, Brown, 2009). The latter relates to the evolution of RE technologies. RE energy sources, specifically infrastructure for wind and solar energy, present enormous potential for contributing to the sustainable development of rural territories in South Africa by providing them with a variety of socio-economic and environmental benefits. The socio-economic opportunities specifically concentrate on enhancing regional and rural development opportunities through a diversification of the energy supply, the creation of a domestic industry as well as providing employment opportunities (Del Río, Burguillo, 2008). The final concept of Bridge et al.'s (2013) energy-transition framework refers to the spatial embeddedness and path-dependency processes RE development can foster. In the quest for new pathways for sustainable development, deployment of RE infrastructure can be deeply embedded in the current socio-economic context of the spaces in which it is to function. Also, by being locked into a monopolistic, fossil-fuel-based supply a process of a path-dependent development of RE deployment can be rooted in the historical development processes related to energy supply. However, spatially-embedded and path-dependent RE development processes can also foster positive outcomes by using the economic, material and cultural aspects of the areas in which these infrastructures are deployed.

The introduction of wind- and solar-energy projects in rural areas can have direct, indirect and induced economic effects on several dimensions of the socio-economic sustainability of a given area. The direct effects mainly stem from the compulsory community development programmes developers must implement as part of a project. These range from subsidies paid to local farmers for hiring their land and 'compensation', direct investment such as funding communal gardening projects, clinics and schools for infrastructure and technology development to the establishment of community-based investment companies with external investment portfolios as well as shares in specific wind- and solar-energy projects. The latter aims at addressing ownership by local communities, one of the requirements of the RE IPPPP programme. For example, the operational Jeffreys Bay wind farm located in the Eastern Cape province, has contributed R5.5 million to local community beneficiaries between 2013 and 2014. This expenditure was spread over a number of projects which include a reading coach programme for foundation phase school learners, a saving and investment scheme for women, providing free gynaecological services to pregnant women at the Healthy Mom & Baby Clinic, the establishment of a multi-purpose centre for counselling, education and life skills training purposes, a financial contribution towards a home-based care centre for the elderly, auditing of the early childhood development centres and contributions to a sports programme for community upliftment, recycling programme as well as the establishment of a renewable energy schools awareness programme (Jeffreysbaywindfarm, 2015).

The number of direct and indirect employment opportunities created by a RE project depends on the stage of development of the project as well as the type of technology considered. Both employment and income generation during the construction stage of these projects are significant, but generally temporary in nature. Local employment generation during the operation and management phase of these projects is usually more permanent (Del Río, Burguillo, 2008). The KaXu Solar One CSP plant, commissioned near Pofadder in the Northern Cape in 2015, created 1000 positions during construction and currently employs 80 people full-time in the maintenance and operational phase (Abengoasolar, 2015). There is appreciable potential for job creation in the wind-turbine manufacturing industry in South Africa (Moldvay et al., 2013). The global average number of direct and indirect jobs created by wind-power projects is 1.7 jobs/MW, for solar PV it is 7.7 jobs/MW and for concentrated solar power (CSP) 2.0/MW (Walwyn, Brent, 2015). Table 1 lists the number of direct and indirect jobs which can be created in each province if these global averages are applied to projects in commission and those under construction. The global average number of jobs created span from the construction through to the maintenance phases and is not specific to any one part of the development process.

Table 1. Potential employment opportunities from wind and solar projects

	Northern Cape (31 projects)	**Eastern Cape (11 projects)**	**Western Cape (11 projects)**
Total wind MW	663	949	423
Total solar PV MW	918	75	135
Total solar CSP MW	500	0	0
Potential number of jobs	9196	2189	1759

Source: Authors own compilation

The number of employment opportunities created by these energy projects can have positive economic influences, especially in the Northern Cape where unemployment are markedly higher than in the other two provinces. It will be necessary to established how many of these employment opportunities are sourced locally as only 25% of the local economic-development criteria of these projects constitutes job creation. The greatest opportunity for job creation is during the construction phase which usually only lasts up to two years but regrettably there is very limited long-term potential for job creation by solar- and wind-energy projects (Baker, Wlokas, 2015). The indirect and induced economic effects of these energy projects involve demographic consequences, energy impacts, educational ramifications, influences of the project on the productive diversification of the area, social cohesion and human development, and tourism impacts (Del Río, Burguillo, 2008). Demographically the projects can affect migration to and immigration from the rural areas. One hopes that the projects could stem the out-migration of younger and better-educated people from rural areas. Migrants can affect real-estate markets in the rural areas where projects are deployed as well as the use of services and products supplied by small and medium enterprises in these areas. The energy impacts relate to rural areas usually not being self-sufficient in energy supply so that the introduction of solar- and wind-energy projects to these areas can mitigate this problem by satisfying a significant share of the energy demand in the areas with energy produced by the specific projects. The local workforce involved in the projects may need special training which will increase the education and skills level of the rural population. By introducing RE projects to rural areas production bases can be altered to lessen reliance on agriculture which for various reasons is facing an uncertain future. As an alternative economic activity that supplements traditional agricultural activities, RE projects can improve the socio-economic prospects of the younger population so increasing general self-confidence and thereby fostering social cohesion and human development. RE projects have promise for increasing visitor numbers to these rural areas, where visitors are attracted to view the novel infrastructure and 'energy landscapes'. But such tourism impacts remain contested topics which call for attention in further research endeavours.

6. Concluding remarks and recommendation

Since 2012 South Africa has embarked on a renewable-energy (RE) pathway entailing a break from a monopolistic and mainly fossil-fuel-based energy system which has been unable since 2008 to provide reliable, clean electricity. Fortunately, the country's energy system is in a process of creating a new path that will ultimately diversify some of the rural economic landscapes where new RE infrastructures are being established. The distribution of these RE projects presents a window of opportunity to lock South Africa out of a monopolistic fossil- fuel-based electricity supply. The development of solar- and wind-energy projects in rural areas can contribute directly and indirectly to the socio-economic development of these areas. Employment opportunities are being created; farmers receive subsidies for the land used to establish RE infrastructure; local communities are compensated through various development programmes and/or direct funding and investment; the demography of the areas is impacted; access to energy supply is increased; improvements in the education levels of the locals are accomplished; production activities are diversified; social cohesion is encouraged; and new tourism development opportunities exist.

Future research effort needs to map the evolutionary socio-economic transformation of these areas while paying attention to the development contexts existing prior to the introduction of the new RE infrastructures. South Africa's rural areas are in dire need of reliable, clean electricity and the diversification of rural economies to create more job opportunities can hopefully prevent the out-migration of successful school-leavers to assist in enhancing more prosperous rural economies.

Notes

(1) By using the concept of sustainable development – a contested concept (Williams, Millington, 2004) – we refer to development that delivers basic environmental, social and economic services without threatening the viability of natural, built and social systems upon which these services depend.

(2) Cultural contingency: How new energy technologies spread across space often depends on how these technologies (and the natural resources upon which they are deployed) are embedded in (national) systems of signification and cultural routines (Bridge et al., 2013: 336).

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