Distributed Renewable Energy Generation and Landscape Architecture: A Critical Review

Osmer DeVon Beck
Utah State University

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DISTRIBUTED RENEWABLE ENERGY GENERATION AND LANDSCAPE ARCHITECTURE: A CRITICAL REVIEW

by

Osmer DeVon Beck

A thesis submitted in partial fulfillment of the requirements for the degree of

MASTER OF LANDSCAPE ARCHITECTURE

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Committee Member

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UTAH STATE UNIVERSITY
Logan, Utah

2010
ABSTRACT

Distributed Renewable Energy Generation and Landscape Architecture: A Critical Review

by

Osmer DeVon Beck, Master of Landscape Architecture
Utah State University, 2010

Major Professor: Keith Christensen
Department: Landscape Architecture and Environmental Planning

Governments and utility organizations around the world have mandated and provided incentives for new distributed renewable energy generation (DREG) capacity, and market projections indicate strong growth in distributed renewable energy generation installations in the coming years. New distributed renewable energy generation utilities, by definition, will be primarily located in built environments near consumers; these utilities are often planned and designed by landscape architects, yet no evidence-based, distributed renewable energy generation research is explicitly done by landscape architects or recognizes the role landscape architects play in planning and designing these spaces. The research and analysis provided by this study indicates that distributed renewable energy generation lacks a strong foundation as an independent concept which could benefit from clear broad phraseology linked to organized sub-terms/phrases for specific forms of DREG, that there has been some research done on topics familiar to landscape architects, that more needs to be done to meet important research questions and
recommendations already posed, and that landscape architects are positioned to contribute to future distributed renewable energy generation research.
ACKNOWLEDGMENTS

I gratefully acknowledge the exceptional help and support of major professor, Keith Christensen, and the quality input and expectations of committee members, Dr. Bo Yang and Dr. Michael Dietz. I also thank family, friends, and colleagues for prayers, encouragement, and confidence in me along the way.

Osmer DeVon Beck
## CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABSTRACT</td>
<td>iii</td>
</tr>
<tr>
<td>ACKNOWLEDGMENTS</td>
<td>v</td>
</tr>
<tr>
<td>LIST OF TABLES</td>
<td>vi</td>
</tr>
<tr>
<td>LIST OF FIGURES</td>
<td>viii</td>
</tr>
<tr>
<td>PROBLEM STATEMENT</td>
<td>1</td>
</tr>
<tr>
<td>INTRODUCTION</td>
<td>2</td>
</tr>
<tr>
<td>METHODS</td>
<td>9</td>
</tr>
<tr>
<td>RESULTS</td>
<td>16</td>
</tr>
<tr>
<td>Article Summary Results</td>
<td>21</td>
</tr>
<tr>
<td>Explicit Future Research Recommendations</td>
<td>26</td>
</tr>
<tr>
<td>DISCUSSION</td>
<td>29</td>
</tr>
<tr>
<td>Foundation</td>
<td>29</td>
</tr>
<tr>
<td>Current DREG LARR</td>
<td>30</td>
</tr>
<tr>
<td>Future DREG LARR</td>
<td>32</td>
</tr>
<tr>
<td>Landscape Architect Contribution Opportunities</td>
<td>34</td>
</tr>
<tr>
<td>Limitations of this Study</td>
<td>38</td>
</tr>
<tr>
<td>CONCLUSION</td>
<td>40</td>
</tr>
<tr>
<td>REFERENCES</td>
<td>42</td>
</tr>
<tr>
<td>APPENDIX</td>
<td>48</td>
</tr>
</tbody>
</table>
# LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>State-by-state DREG initiatives, adapted from Hoffman (2008)</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>DREG search terms/ phrases, bold terms/phrases are represented in relevant articles</td>
<td>9</td>
</tr>
<tr>
<td>3</td>
<td>LARR search terms/ phrases, bold terms/phrases are represented in relevant articles</td>
<td>10</td>
</tr>
<tr>
<td>4</td>
<td>Landscape architecture related research term/phrase definitions</td>
<td>13</td>
</tr>
<tr>
<td>5</td>
<td>Publications of overlapping articles</td>
<td>19</td>
</tr>
<tr>
<td>6</td>
<td>Geographic region where research was conducted</td>
<td>20</td>
</tr>
</tbody>
</table>
# LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Article sorting rules.......................................................... 11</td>
</tr>
<tr>
<td>2</td>
<td>Number of relevant LARR articles by primary term/phrase .................. 17</td>
</tr>
<tr>
<td>3</td>
<td>Number of relevant DREG articles by primary term/phrase .................. 18</td>
</tr>
<tr>
<td>4</td>
<td>Number of relevant articles by year........................................... 19</td>
</tr>
<tr>
<td>5</td>
<td>Number of relevant articles by DREG type..................................... 20</td>
</tr>
<tr>
<td>6</td>
<td>Percent relevant articles compared to percent <em>Landscape Journal</em> articles .......... 21</td>
</tr>
</tbody>
</table>
PROBLEM STATEMENT

Citing climate change and other concerns associated with current fossil fuel energy generation, governments and utility organizations around the world are mandating and providing incentives for new distributed renewable energy generation (DREG) capacity. Market projections also indicate strong growth in DREG installations around the world in the coming years. New DREG utilities, by definition, will be primarily located in built environments near consumers. These spaces are often planned and designed by landscape architects. Strangely, no evidence-based, DREG research is explicitly done by landscape architects or recognizes the role landscape architects play in planning and designing these spaces. There may, however, be future research and professional roles where landscape architects can contribute to the effective incorporation of DREG.
INTRODUCTION

The scope of this study will be focused on distributed renewable energy generation (DREG). DREG is an overlap of distributed generation (DG); “small, modular, decentralized, grid-connected or off-grid energy systems located in or near the place where energy is used” (U.S. Environmental Protection Agency 2010) and renewable energy (RE); energy that is “naturally replenishing but flow limited” (Energy Information Administration 2010). Major DREG sources include: biomass, micro hydro, geothermal, solar, and wind. DG offers lower initial investment costs over centralized generation, greater flexibility matching supply capacities with actual demand, shorter return on investment, transmission and distribution savings, and over 200 more benefits identified by Lovins (2002). RE offers increased energy security, climate change mitigation, and lasting supply.

In light of these benefits and others, governments and utility organizations are mandating and providing incentives for new DREG capacity. For example, The Asia Pacific Partnership on Clean Development and Climate (2009), a task force made up of seven countries, expects to incentivize 1.8 GW of new RE and DG capacity by 2014. The US federal government has placed into effect a 30% tax credit, viable until 2016, for all newly installed residential RE. Japan has set a target of 30% of all households to have solar panels by 2030 (Energy Information Administration 2009a). Germany has established a 27 cent per kilowatt hour feed-in tariff to incentivize small scale renewable electricity generation (Energy Information Administration 2009a). There are four funding sources for distributed RE projects in Australia including a “Low Emissions Technology
Demonstration Fund,” “Renewable Energy Development Initiative,” “Solar Cities,” and "Renewable remote Power Generation Program” (Newton 2008). Thailand is working toward a 2400 MW DREG by 2011 goal (Sukkumnoed 2003). In the UK, all new office buildings constructed between 2010 and 2014 must have greater than 15% on-site RE and that will increase to 20% or greater between 2015 and 2020 (Simms, Djokic, and Murray 2008). Many states are making efforts to push DREG (Table 1).

### Table 1. State-by-state DREG initiatives, adapted from Hoffman (2008)

<table>
<thead>
<tr>
<th>State</th>
<th>DREG Initiative</th>
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<tr>
<td>California</td>
<td>3000 MW distributed solar and 50% of new homes equipped with solar electric capacity by 2020 (California Energy Commission 2007). One Million Solar Roof Initiative to install solar on one million homes and business’ by 2018 (National Governors Association 2008)</td>
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<tr>
<td>Washington</td>
<td>2X multiplier for distributed forms of renewable energy</td>
</tr>
<tr>
<td>Nevada</td>
<td>1% solar by 2015 with a 2.45X multiplier for distributed PV</td>
</tr>
<tr>
<td>Arizona</td>
<td>4.5% customer-sited distributed renewable generation by 2025</td>
</tr>
<tr>
<td>New Mexico</td>
<td>1.5-3% distributed renewable</td>
</tr>
<tr>
<td>Colorado</td>
<td>0.8% solar electric by 2020 with half customer sited</td>
</tr>
<tr>
<td>Maryland</td>
<td>2% solar by 2022</td>
</tr>
<tr>
<td>Pennsylvania</td>
<td>0.5% PV by 2020</td>
</tr>
<tr>
<td>New York</td>
<td>0.15% distributed generation by 2013</td>
</tr>
<tr>
<td>Delaware</td>
<td>3X multiplier for PV before 2015 and 2.005% PV by 2019</td>
</tr>
<tr>
<td>North Carolina</td>
<td>0.2 % solar by 2018</td>
</tr>
<tr>
<td>DC</td>
<td>0.386 % solar electric by 2021</td>
</tr>
<tr>
<td>New Hampshire</td>
<td>0.3 % solar electric by 2014</td>
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</tbody>
</table>

Many power companies are also making the shift. Western US based Rocky Mountain Power offers incentives for home and business installed solar (DSIRE 2009); Austin Energy in Texas intends to have 100 MW of customer owned solar energy installed by 2020 (Hoff et al. 2006); WE Energies in Wisconsin is promoting DREG by
using several models including: community wind models, multi-party ownership models for anaerobic digesters, third party ownership models, a project aggregation model, renewables-as-appliance model, and a new construction model (ICF International 2007). Many other municipal, state, country, utility, and non-profit organization incentives, mandates, programs, and rebates exist around the world. Some directly promote DREG like the ones mentioned above and many others generally promote RE and or DG thereby indirectly promoting DREG.

Similarly, market projections indicate strong growth in DREG installations around the world in the coming years. Pike Research (2009) forecasts that the DREG market will more than double in value between 2008 and 2013 reaching $60.6 billion. In a global market study at the end of 2008, the American Wind Energy Association (2009) predicted 30 fold growth in the small wind turbine market within five years. The UK small and micro wind systems sector has been growing at an annual rate of 80% and is expected to continue (Renewable UK 2010). The most recent September 2009 International Energy Agency issue of “Trends in Photovoltaic Applications” presented graphs illustrating exponential growth between 1992 and 2008, with 2008 growth adding another 5.56 GW of photovoltaic (3.34 GW distributed photovoltaic), or a 150% increase over 2007 with no signs of slowing.

All these new incentivized, mandated, and projected DREG utilities, by definition, will be primarily located near consumers. General energy consumption categories include residential, commercial, transportation, and industrial (Energy Information Administration 2009b). These general consumption categories correlate with
the built environment categories often planned and designed by landscape architects. The American Society of Landscape Architects (2010) describes the types of built environment which landscape architects work on to include, academic campuses, corporate and commercial, gardens and arboreta, historic preservation and restoration, hospitality and resorts, institutional, land planning, monuments, parks and recreation, reclamation, residential, streetscapes and public spaces, transportation corridors and facilities, and urban design. The occupational information network describes the work of a landscape architect to include: “parks and other recreational facilities, airports, highways, hospitals, schools, land subdivisions, and commercial, industrial, and residential sites” (O*Net Online 2009).

Even though possible DREG locations and the sites that landscape architects plan and design are conceptually the same, it appears that no evidence based (peer reviewed) DREG research is either explicitly done by landscape architects or recognizes the role landscape architects play in planning and designing the built environment.

To determine whether or not evidence based DREG research is either explicitly done by landscape architects or recognizes the role landscape architects play in planning and designing the built environment; a systematic search of published literature was conducted through various search databases including Ebsco Host, Google Scholar, Scopus, and Scopus Web. For Ebsco Host, all 49 available databases were selected for full text search including the Avery Index to Architecture Periodicals and Academic Search Premier. In Google Scholar and Scopus/Scopus Web the searches were performed with default settings. One hundred and twenty-six searches for each database were
performed based on a matrix of 43 possible DREG phrases and landscape architect, landscape architecture, and ASLA (American Society of Landscape Architects, the field’s professional organization). Each article was reviewed for use of landscape architect, landscape architecture, or ASLA in context with DREG.

Three hundred and seventeen articles containing the qualifying terms/phrases were identified and reviewed for relevancy. Only 14 non peer-reviewed articles had any reasonable relevance. Two articles were about ASLA design awards that included on-site energy generation in the plan, but lacked evidence based research support (American Society of Landscape Architects 2008a; American Society of Landscape Architects 2008b). Two articles were product evaluations; one for a residential scale wind turbine and the other for solar powered irrigation equipment (Sorvig 1994; Thayer and Hansen 1988). One article identified the landscape architecture of a site as an opportunity for biomass production (Bergfeld 2009). Two articles and one conference program referred to the presence of landscape architects on design teams who worked on plans that included DREG (The University of Massachusetts 2008; ECE Connection 2008; European Wind Energy Association 2003). One article cited the responsibility of landscape architects in siting trees so as to not inhibit solar access. One article cited an unpublished master’s thesis that mapped solar potential (Flanders et al. 2009). Two other master’s theses made mention of DREG; one made brief mention of DREG in a larger sustainability context (Topping 2005) while the other extensively addressed DREG as part of a more broad discussion on the incorporation of RE, large and small, into the landscape of the Netherlands, yet provided little to no evidence based support for DREG
specifically (Boekel 2008). Two articles on large wind generation made mention of a specific landscape architects qualifications including large and small wind energy generation site aesthetic design experience (National Research Council of the National Academies 2007; The British Wind Energy Association 2006). The most relevant article was a pamphlet produced by a landscape architect on how to site a residential micro wind turbine in Vermont, although it was lacking evidence based support (Vissering 2005).

While the search returned no evidence based research explicitly mentioning landscape architecture, or being done by landscape architects, the non-evidenced based research indicates landscape architects are incorporating DREG into site designs, consulting on siting DREG projects, participating in groups that address DREG, landscape architecture students are considering DREG in personal research, DREG market professionals are looking to landscape architects as clients, and that the landscape component of a site may provide opportunities for DREG.

In addition to the reviewed literature, the Leaders in Energy and Environmental Design (LEED) criteria and Sustainable Sites Initiative (SSI) address DREG. Landscape architects are core practitioners in SSI and LEED certified projects. The New Construction & Major Renovations energy and atmosphere (EA) credit 2 requires 1-13% on-site RE (U.S. Green Building Council 2009a), the Neighborhood Development EA credit 11 requires 5-20% on-site RE (U.S. Green Building Council 2009b), the Existing Buildings EA credit 4 requires 3.12% on-site RE (U.S. Green Building Council 2009c), the Homes EA credit 10 offers up to 10 points for on-site RE (U.S. Green Building Council 2008), and the Core & Shell EA credit 2 requires at least 1% on-site RE (U.S.
Green Building Council 2009d). Most LEED projects will need to incorporate some level of on-site RE generation. Furthermore, the American Society of Landscape Architects is the lead author on the SSI with credits 5.9, 5.10, 8.4, and 8.5 all requiring on-site RE or the purchase of off-site RE. Of note, credit 8.5 specifically requires 50% of landscape energy needs to be provided by on-site RE or 100 % by off-site RE (American Society of Landscape Architects, Lady Bird Johnson Wildflower Center at The University of Texas at Austin, and United States Botanic Garden 2009). As these two rating systems become more accepted and as more agencies, companies, and individuals require the use of these systems, landscape architects will increasingly be exposed to and need to participate in DREG planning and design.

Given this, it is reasonable to suggest that landscape architects should be active in DREG-related research. The following is an examination of the most likely places where that can happen.
METHODS

Using Ebsco Host, all 49 available databases were selected for full text, peer-reviewed search including the Avery Index to Architecture Periodicals and Academic Search Premier. In total, 2666 searches were performed based on a matrix of 43 possible iterations of DREG (Table 2) and 62 landscape architecture related research (LARR) topics identified in Powers and Walker’s review of *Landscape Journal* articles (2009, 100) (Table 3).

Table 2. DREG search terms/phrases, bold terms/phrases are represented in relevant articles

<table>
<thead>
<tr>
<th>DREG Search Terms/ Phrases</th>
<th>Relevant Articles</th>
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</thead>
<tbody>
<tr>
<td>&quot;Small wind&quot;</td>
<td>&quot;Independent electric generation&quot;</td>
</tr>
<tr>
<td>&quot;Microgrid&quot;</td>
<td>&quot;Distributed renewable energy generation&quot;</td>
</tr>
<tr>
<td>&quot;Renewable energy&quot; &quot;Distributed generation&quot;</td>
<td>&quot;Distributed renewable generation&quot;</td>
</tr>
<tr>
<td>&quot;Small scale wind&quot;</td>
<td>&quot;Distributed cogen\ration&quot;</td>
</tr>
<tr>
<td>&quot;Micro-hydro&quot;</td>
<td>&quot;Distributed energy network&quot;</td>
</tr>
<tr>
<td>&quot;Micro generation&quot;</td>
<td>&quot;Renewable remote area power systems&quot;</td>
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<tr>
<td>&quot;Embedded generation&quot;</td>
<td>&quot;Clean DG&quot;</td>
</tr>
<tr>
<td>&quot;Rooftop solar&quot;</td>
<td>&quot;Decentralized energy planning&quot;</td>
</tr>
<tr>
<td>&quot;Distributed energy resources&quot;</td>
<td>&quot;Regional energy plan&quot;</td>
</tr>
<tr>
<td>&quot;Dispersed generation&quot;</td>
<td>&quot;Renewable distributed energy generation&quot;</td>
</tr>
<tr>
<td>&quot;Building integrated photovoltaics&quot;</td>
<td>&quot;Distributed multi-generation&quot;</td>
</tr>
<tr>
<td>&quot;Micro wind&quot;</td>
<td>&quot;Distributed micro-power&quot;</td>
</tr>
<tr>
<td>&quot;Distributed utility&quot;</td>
<td>&quot;Demand side generation&quot;</td>
</tr>
<tr>
<td>&quot;Distributed energy sources&quot;</td>
<td>&quot;Residential scale generation&quot;</td>
</tr>
<tr>
<td>&quot;Decentralized generation&quot;</td>
<td>&quot;Consumer generated energy&quot;</td>
</tr>
<tr>
<td>&quot;Renewable distributed generation&quot;</td>
<td>&quot;Active electric power&quot;</td>
</tr>
<tr>
<td>&quot;Decentralized electricity generation&quot;</td>
<td>&quot;Residential energy storage&quot;</td>
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<td>&quot;On site energy generation&quot;</td>
<td>&quot;PVACCEPT&quot;</td>
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<tr>
<td>&quot;On-site renewable generation&quot;</td>
<td>&quot;Photovoltaic–fuel cell hybrid system&quot;</td>
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<tr>
<td>&quot;Personalized energy&quot;</td>
<td>&quot;Micro-level energy planning&quot;</td>
</tr>
<tr>
<td>&quot;Clean distributed generation&quot;</td>
<td>&quot;Regional integrated energy plan&quot;</td>
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</tbody>
</table>
Some of the LARR terms/phrases were slightly modified to better reflect explicit, in text usage such as “social and psychological factors” being changed to “social factors” and “psychological factors.” Searches were then performed for all of the 2666 possible overlaps.

The results were narrowed for relevance by excluding book reviews, review essays, editor’s intros, abstract lists, product reviews, opinion pieces, and publication end notes. Coding rules shown in (Figure 1) were used to determine if the article was actually referring to DREG, an aspect of LARR, and if the two were connected. The LARR terms/phrases were evaluated according to the definitions in Table 4.

<table>
<thead>
<tr>
<th>LARR Search Terms/Phrases</th>
<th>Aesthetic</th>
<th>Sense of place</th>
<th>Social factors</th>
<th>Psychological factors</th>
<th>Gender</th>
<th>Social class</th>
<th>Behavioral factors</th>
<th>Ethnicity</th>
<th>Historic preservation</th>
<th>Cultural landscape</th>
<th>Biography</th>
<th>Landscape archeology</th>
<th>Religion</th>
<th>Garden design</th>
<th>Vegetation</th>
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</thead>
<tbody>
<tr>
<td>Aesthetic</td>
<td>Horticulture</td>
<td>Design process</td>
<td>GIS</td>
<td>Post occupancy</td>
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<tr>
<td>Sense of place</td>
<td>Climatic factors</td>
<td>Hermeneutics</td>
<td>Phenomenology</td>
<td>Computer analysis</td>
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<td>Picturesque</td>
<td>Design and build</td>
<td>Community planning</td>
<td>Ecological design</td>
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<td>Social factors</td>
<td>Stormwater</td>
<td>Water use</td>
<td>Neighborhood design</td>
<td>Long-term monitoring</td>
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<tr>
<td>Gender</td>
<td>Resource management</td>
<td>Open space</td>
<td>Parking</td>
<td>Waste</td>
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<td>Social class</td>
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<td>Garden design</td>
<td>Design theory</td>
<td>Film</td>
<td>Role play</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vegetation</td>
<td>Design method</td>
<td>Computer programs</td>
<td>Studio project</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Figure 1. Article sorting rules**

<table>
<thead>
<tr>
<th>Is it Renewable?</th>
<th>Does the title and or abstract explicity state or imply any of the terms renewable energy, biomass, wind, solar, or hydro? If no abstract is available refer to any other preface material. Where no abstract or preface material exist, make determination based on the title alone.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Is the renewable energy the primary focus of the title and or abstract?</td>
<td>Yes</td>
</tr>
<tr>
<td>Record as High Renewable Energy Content</td>
<td>Record as Medium Renewable Energy Content</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Is it Distributed?</th>
<th>Does the title and or abstract explicity state or imply any of the terms distributed, small, residential, or similar words implying generation on a distributed scale? If no abstract is available refer to any other preface material. Where no abstract or preface material exist, make determination based on the title alone.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Is the renewable energy the primary focus of the title and or abstract?</td>
<td>Yes</td>
</tr>
<tr>
<td>Record as High Renewable Energy Content</td>
<td>Record as Medium Renewable Energy Content</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Is it Distributed Renewable Energy Generation?</th>
<th>Is renewable energy imlicity linked to distributed generation in the title and or abstract?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Keep article</td>
<td>Remove article from review</td>
</tr>
<tr>
<td>Can a connection be made between RE and DG anywhere in the document?</td>
<td>Yes</td>
</tr>
<tr>
<td>Keep article</td>
<td>Remove article from review</td>
</tr>
</tbody>
</table>
Articles deemed relevant on the above grounds were coded further to extract primary DREG phrase, primary LARR term/phrase, year, publication, primary country of research, and primary RE type. Summaries of the relationships were recorded where they existed. The relevant articles were reviewed to identify future research recommendations based on questions or explicit identification of such. The recommendations were recorded in full. The coded information was used to identify the most common LARR terms/phrases, the most common DREG phrases, the publication years and trend, the
<table>
<thead>
<tr>
<th>Term/Phrase</th>
<th>Definition</th>
<th>Term/Phrase</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aesthetic</td>
<td>Dealing with the quality of the visual appearance, memorability, uniqueness, and associative experiences</td>
<td>Phenomenology</td>
<td>Of or relating to the understanding of human experience</td>
</tr>
<tr>
<td>Sense of Place</td>
<td>Intangible perception of tangible environmental stimuli often layered over time</td>
<td>Community Planning</td>
<td>Planning for physical and non-physical aspects in a given area that bring about the association of individuals into a group</td>
</tr>
<tr>
<td>Picturesque</td>
<td>High visual quality, environmental framing to highlight view of scene</td>
<td>Neighborhood Design</td>
<td>The process of designing so as to build the canvas for a smaller associative group</td>
</tr>
<tr>
<td>Social Factors</td>
<td>Factors involving the relationships between people as influenced by the environment</td>
<td>Streetscape</td>
<td>Area adjacent to street which varies width depending on street type and location</td>
</tr>
<tr>
<td>Gender</td>
<td>Sex of a person</td>
<td>Parking</td>
<td>Area associated with the parking of automobiles</td>
</tr>
<tr>
<td>Ethnicity</td>
<td>Human ethnic heritage</td>
<td>Photography</td>
<td>Act of photographing</td>
</tr>
<tr>
<td>Preservation</td>
<td>Preservation of structures, landscapes, or other important features in a state as close to the original as possible, historical designation is associated with different requirements in different locations, so it qualifies if it is explicitly stated as such</td>
<td>Music</td>
<td>Auditory composition</td>
</tr>
<tr>
<td>Biography</td>
<td>Written history of an individual</td>
<td>Storytelling</td>
<td>Verbally recounting experience either fictional or real</td>
</tr>
<tr>
<td>Religion</td>
<td>Explicitly stated in reference to a person's formalized belief system</td>
<td>Poetry</td>
<td>Written and verbal arrangement of words so as to communicate an idea artistically</td>
</tr>
<tr>
<td>Garden Design</td>
<td>General description for the practice of designing primarily the soft-scape of a single site</td>
<td>Drawing</td>
<td>Visual form of communication and expression</td>
</tr>
<tr>
<td>Vegetation</td>
<td>Living plants generally and associated descriptive massing</td>
<td>Film</td>
<td>Technology which associates visual and audible sensory information into a meaningful arrangement that can be shared</td>
</tr>
<tr>
<td>Horticulture</td>
<td>Discipline of plant propagation</td>
<td>Computer Programs</td>
<td>Software</td>
</tr>
<tr>
<td>Climatic Factors</td>
<td>Factors associated with temperature, air, or precipitation or combinations of the three</td>
<td>GIS</td>
<td>Specific software used for geographic modeling and mapping</td>
</tr>
<tr>
<td>Design and Build</td>
<td>General description for the practice of overseeing or directly participating in the designing of a site and building of a site as designed by the same individual or group of individuals</td>
<td>Post Occupancy Evaluation</td>
<td>Evaluation of design goals and objectives for a period of time following construction</td>
</tr>
<tr>
<td>------------------</td>
<td>---------------------------------------------------------------------------------</td>
<td>--------------------------</td>
<td>----------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Stormwater</td>
<td>Accumulation of precipitation following storm events</td>
<td>Computer Analysis</td>
<td>Use of a computer and associated software to analyze inputs</td>
</tr>
<tr>
<td>Water Use</td>
<td>How water is used in the landscape generally</td>
<td>Ecological Design</td>
<td>Design sensitive to and or using principles of the naturally functioning landscape</td>
</tr>
<tr>
<td>Landscape Assessment</td>
<td>Inventory and analysis of a specified geographical area</td>
<td>Long-Term Monitoring</td>
<td>Observing the use of a space over time to determine given criteria</td>
</tr>
<tr>
<td>Resource Management</td>
<td>Formalized plan for the use of resources given specified goals and or objectives</td>
<td>Bioregionalism</td>
<td>System of areas representing distinct natural traits and associated or further defined for given objectives</td>
</tr>
<tr>
<td>Open Space</td>
<td>Space devoted to uses beside architecture beyond two thousand square ft</td>
<td>Waste</td>
<td>Unused portion of available energy</td>
</tr>
<tr>
<td>Shoreline</td>
<td>Edge between water and land, width varies according to location</td>
<td>Garbage</td>
<td>Disposed of material</td>
</tr>
<tr>
<td>Land Use Planning</td>
<td>Planning for specific patterns of use in a given geographical area</td>
<td>Sustainability</td>
<td>System that provides a loop for energy with minimal input indefinitely</td>
</tr>
<tr>
<td>Land Use Policy</td>
<td>Guiding direction supporting land use planning</td>
<td>Health</td>
<td>Level of physical human well being</td>
</tr>
<tr>
<td>Wildlife</td>
<td>Free roaming fauna</td>
<td>Pedagogy</td>
<td>Study of teaching principles</td>
</tr>
<tr>
<td>Mining</td>
<td>Practice of extracting resources from beneath the natural surface</td>
<td>Creativity</td>
<td>Organizing of previously unrepresented associations</td>
</tr>
<tr>
<td>Design Theory</td>
<td>Guiding principles behind design practice</td>
<td>Gaming</td>
<td>Form of entertainment associated with some form of interaction and associated objective</td>
</tr>
<tr>
<td>Design Process</td>
<td>Application of principles and techniques to create a design</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

publication source, and the research location. Where multiple LARR terms/ phrases, DREG phrases, or DREG forms appeared in one paper with nearly equal representation,
all were associated with that article. The articles were sorted according to CELA conference paper tract categories and compared to Powers and Walker’s *Landscape Journal* “percentage of published subjects by category” graph (2009, 104). All of the synthesized summaries were reviewed for trends, related research, types of research, and possible relationship to landscape architecture. Based on this review, recommendations are discussed and proposed.
RESULTS

Two hundred and twenty-five of the 2666 possible overlaps in the search matrix resulted in 612 articles (see Appendix) containing 1437 possible combinations of DREG and LARR terms/phrases. A review of the 612 articles yielded only 30 which contain an actual overlap. Of those, only four scored high in all three categories of RE, DG, and LARR search terms/phrases according to the code rules (Figure 1).

“Waste” was the most common LARR search term, showing up in 23% of the relevant articles, and “health,” second most common, showed up in 22% of the articles (Figure 2). A result of a partial article indicates the equal use of at least two terms/phrases in the article where it appeared. “Micro hydro,” the most common DREG search phrase, was found in 37% of the relevant articles, and the primary search phrase in 27% of them (Figure 3).

The 30 remaining articles were the result of 15 out of the 43 possible DREG iterations (Table 2 phrases in bold) combined with 22 out of the 62 possible LARR terms/phrases (Table 3 terms/phrases in bold).

The first year a relevant overlapping article appeared was 1994. A trend line indicates that, up to the present, the number of articles has increased on average; however, 2008 and 2009 both showed fewer articles than the previous year (Figure 4).

Papers were published in 23 different journals. Sixty-six percent of the journals had published just one overlapping article. Five of the identified 30 articles were published in Energy Sources Part B: Economics, Planning & Policy, three in Local Environment, and two in Journal of Power and Energy (Table 5).
Articles contained research conducted in 12 different countries. The United Kingdom was cited in seven articles as the primary geographic location of research while 10 articles were more general in nature and could not be associated with a particular location. The United States and Australia were associated with two articles each (Table 6).

Wind, solar, biomass, and micro hydro were each represented in some of the relevant articles. Solar was the primary renewable source in 24% of the articles, micro hydro and general RE each appeared in 18% of the articles, and 9% of the articles made reference to numerous forms of RE equally (Figure 5).
Figure 3. Number of relevant DREG articles by primary phrase

A comparison between *Landscape Journal* “percentage of published subject by category” prepared by Powers and Walker (2009, 100) and this study’s percentage of published subject by category showed few similarities. This study’s articles represented 6 out of the 10 categories. The most obvious comparisons included: 45% of this study’s articles were in the “sustainability” category compared to 5% of the *Landscape Journal* articles, and 25% of the *Landscape Journal* articles were in the “history and culture” category compared to 0% identified by this study (Figure 6).
Figure 4. Number of relevant articles by year

Table 5. Publications of overlapping articles

<table>
<thead>
<tr>
<th>Title</th>
<th># of Occurrences</th>
<th>Title</th>
<th># of Occurrences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy Sources Part B: Economics, Planning &amp; Policy</td>
<td>5</td>
<td>Environment</td>
<td>1</td>
</tr>
<tr>
<td>Local Environment</td>
<td>3</td>
<td>Focus on Geography</td>
<td>1</td>
</tr>
<tr>
<td>Journal of Power and Energy</td>
<td>2</td>
<td>Global Environmental Politics</td>
<td>1</td>
</tr>
<tr>
<td>Advances in Applied Ceramics</td>
<td>1</td>
<td>International Journal of Innovation Management</td>
<td>1</td>
</tr>
<tr>
<td>Annual Review of Energy &amp; the Environment</td>
<td>1</td>
<td>International Journal of Sustainable Energy</td>
<td>1</td>
</tr>
<tr>
<td>Area</td>
<td>1</td>
<td>Journal of International Affairs</td>
<td>1</td>
</tr>
<tr>
<td>ASHRAE</td>
<td>1</td>
<td>Journal of Urban Technology</td>
<td>1</td>
</tr>
<tr>
<td>Australian Geographic Studies</td>
<td>1</td>
<td>N.Y.U. Environmental Law Journal</td>
<td>1</td>
</tr>
<tr>
<td>BioScience</td>
<td>1</td>
<td>Planning Theory &amp; Practice</td>
<td>1</td>
</tr>
<tr>
<td>Colorado Journal of International Environmental Law and Policy</td>
<td>1</td>
<td>Turkish Journal of Electrical Engineering &amp; Computer Sciences</td>
<td>1</td>
</tr>
<tr>
<td>Disasters</td>
<td>1</td>
<td>Widener Law Journal</td>
<td>1</td>
</tr>
<tr>
<td>Ecos</td>
<td>1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Table 6. Geographic region where research was conducted

<table>
<thead>
<tr>
<th>Geographic Location</th>
<th># of Articles</th>
<th>Country</th>
<th># of Articles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not Applicable</td>
<td>10</td>
<td>Denmark</td>
<td>1</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>7</td>
<td>India</td>
<td>1</td>
</tr>
<tr>
<td>Australia</td>
<td>2</td>
<td>Malaysia</td>
<td>1</td>
</tr>
<tr>
<td>United States</td>
<td>2</td>
<td>Nepal</td>
<td>1</td>
</tr>
<tr>
<td>Africa</td>
<td>1</td>
<td>Turkey</td>
<td>1</td>
</tr>
<tr>
<td>Canada</td>
<td>1</td>
<td>United Arab Emirates</td>
<td>1</td>
</tr>
<tr>
<td>China</td>
<td>1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Figure 5. Number of relevant articles by DREG type
Figure 6. Percent relevant articles compared to percent *Landscape Journal* articles

**Article Summary Results**

The summaries are presented by CELA conference paper tract category, then by the search term/phrase used to locate the article, and finally by groups of similar articles.

*Human and Environment Relationships: Aesthetics.* In describing the way in which the US should proceed in promoting solar energy generation, reference is made by Detsky to work done by Australian energy officials to teach professionals best practice and aesthetic principles as it relates to siting solar utilities. It suggests that Australia has either gathered research in this respect or has done some of their own research (Detsky
In a study on building integrated photovoltaics, it is proposed that building integrated photovoltaics are a great aesthetic solution for distributed solar generation (Li and Lam 2008). In an extensive article titled “The Aesthetics of Wind,” Brisman (2005) makes a few passing references to smaller distributed forms such as the obvious height differences between small and large turbines, the history of traditional distributed wind power near residences or other places power was needed including the associated visual acceptance of these forms, and a brief mentioning of a few incentives associated with small wind. One challenge to wind is that some communities have passed laws that prohibit the use of wind in residential areas primarily due to the aesthetics of the utility (Pimentel and Rodrigues 1994). A general study focused on understanding user preferences toward the uptake and use of DREG mentions the need for installers, policy makers, and particularly designers to take an active role in matching the utility to the users’ non-functional related preferences (Pimentel and Rodrigues 1994).

**Human and Environment Relationships: Gender.** Two articles addressed the idea of gender in relation to DREG utilities. The first study explores the introduction of micro hydro into Indian villages. The study does not consider gender extensively but does imply that access to electricity increases gender equality (Uitto 2008). A second study on community perception and attitudes toward wind power and other distributed utilities considers gender among other socio-demographic attributes. The author concluded that there are not any perception or attitude differences toward wind that can be associated with gender (Devine-Wright 2005).
**Human and Environment Relationships: Sense of Place.** In a conceptualization of what a solar city might be like, Beatley (2007) suggests that solar utilities can and should play a role in the overall creation of “place.” Little to no other direction is explicitly offered.

**Human and Environment Relationships: Social Factors.** Reference to “social factors” in Rankine, Chick, and Harrison’s (2006) study on life-cycle assessment of a rooftop wind turbine point out the need to research the social factors associated with rooftop wind power in order to understand the full sustainability of that form of utility.

**Landscape Design and Implementation: Vegetation.** Two “micro hydro” studies consider the adjacent riparian vegetation. The first is a broad discussion on climate change with one of the strategies including provisions to protect the riparian corridor and riparian vegetation near micro hydro installations (Rojas Blanco 2006). The other study is focused on “micro hydro” and emphasizes the need to care for the health of the riparian system, including the vegetation, in a larger corridor context as more “micro hydro” units are installed (U.S. Green Building Council 2009d). A third study looks at the effect of rain forest vegetation on solar access in remote areas of Australia. They determined that there needs to be a break in the forest vegetation of at least 40 meters and an array height of 7 meters to allow optimal solar access on a standard site while a north facing slope needed a gap of 100 meters or more and a 4 meter high array (Curtis and Turton 2002). In a study on sustainable development, Kaygusuz (2007) mentions the possibility of using solar and or wind power to pump water for energy crops which in turn could also increase wildlife diversity in these areas.
Landscape Planning and Ecology: Land-use Planning. A study on the possible planning issues that need to be addressed in the transition to urban sited wind turbines acknowledges the many challenges associated with land use planning and distributed wind utilities. The prescription of the study in relation to land use planning is one of circumspection and caution (Peel and Lloyd 2007). A second article, discussing some of the ways climate change will affect planning professions, makes reference to how proper land use planning can lead to increased use of distributed RE (Campbell 2006).


Methods of Inquiry: Computer Programs. Two studies incorporated the use of computer programs to optimize the overall efficiencies between energy production and energy use. One focused on hydrogen as the main energy source but both addressed the use of photovoltaic panels on a single residential structure (Golding and Blyton 2007; Li and Lam 2008).

Methods of Inquiry: GIS. Two studies focused on GIS as a method of inquiry. The first is a study done by Miranda (2006) that offered a discussion on a number of GIS modeling techniques that can aid in finding solutions to many of the common challenges of siting distributed wind energy generation. In a second study, Möller (2003) used GIS to model a system with maximized efficiency between wood chip distribution sites and distributed biomass energy generation sites. The result is some suggestions for a better
wood chip transport system and some discussion about challenges that may come in the future if proper planning is not done now.

**Sustainability: Health.** Seven studies made mention of the associated health benefits and challenges of DREG. Two studies made mention of the negative impacts associated with in home biomass combustion and the associated air pollution (Kaygusuz 2007; Pimentel and Rodrigues 1994). The other articles implied that the driving forces for distributed renewable in remote areas is the associated health benefits of refrigeration and other energy requiring medical facilities and equipment (Martinot et al. 2002; Peterson 2006; Yüksel 2007). Some studies just say that electricity is associated with better health (Kammen 1999; Pokharel et al. 2008).

**Sustainability: Waste.** The highest percentage of articles was on waste. Phillips, Beyers, and Good (2009) proposed a way to use the waste heat of a distributed solar thermal system to cool a house and to heat water. Beatley (2007) seconds this idea by saying that properly incorporated solar can capitalize on waste streams. Maryland offers tax incentives for individuals who use municipal solid waste to generate electricity and provide net metering for the same (Reiley 2009). Walker and Cass (2007) talk about agricultural waste being an important home cooking and heating DREG resource. In another document, Walker et al. (2007) talks about the growing amount of community power being produced from waste. Kammen (1999) mentions the use of waste on an industrial scale. In looking at future biomass potential in Australia, Bennett (1999) promotes the idea that waste wood will be profitable for combined heat and power generation provided gasification technology increases. Khan, Chhetri, and Islam (2007)
talk about the possibility of using waste cooking oil for solar thermal applications. Lovins and Lotspeich (1999) talk about the prime position that developing countries are in to avoid the wasteful infrastructure associated with extensive transmission and distribution networks by simply planning for DREG. Rankine (2006) offers insight into how small wind turbines compare to large ones in a detailed study on life cycle assessment. The results illustrate that, per kWh, small wind turbines are quite comparable to large ones and the recommendations tell how small turbines could be even better than they currently are (Rankine, Chick, and Harrison 2006).

**Explicit Future Research Recommendations**

Six articles explicitly made mention of future research needs and the following list is a recounting of each of them.

- “published studies of income generation and economic benefits from renewable energy are still limited and call for further research” (Martinot et al. 2002, 340)
- “… research is needed on successful experiences and business models, social benefits and income generation, technology applications that meet user needs, and sectoral policy lessons from emerging policy successes and failures - grounded in the specific culture, politics, institutions, and history of each country.” (Martinot et al. 2002, 340)
- “… a key question is whether or not the outcomes of government support for small-scale, localized community energy projects can add up to more than the sum of the “small parts” of renewable energy generation and carbon reduction” (Walker et al. 2007, 78-79)
- “Are there impacts more subtle, distant in space and time or accumulative, which a multiplicity of small projects can help realize?” (Walker et al. 2007, 78-79)
- “…how (do) renewable energy technologies take on different meanings and associations, how the public does or does not differentiate between socio-technical configurations, how multiple public roles are interconnected, how learning mechanisms operate, and how the expectations of the public held by other actors shape technology and system development.” (Walker and Cass 2007, 467)

- “… geography needs to be involved, integrating analysis of space, identity, inequality, agency and structure into our understanding of the emerging social patterning of what might constitute a low carbon energy system.” (Walker and Cass 2007, 467)

- “… further research probing links between respondent’s political ideology, their memories or representations of past development in the locality, levels of trust in public and private sector organizations and their support for future local energy development would be useful.” (Devine-Wright 2005, 66)

- “It is certainly the case that future research is required to investigate how widely shared these beliefs are in support of local aspects of renewable energy development across locations of diverse socio-economic status.” (Devine-Wright 2005, 66)

- “There is surprisingly little information on such important matters as long-term performance, the economic costs and benefits, the effectiveness of subsidies, and the social consequences of renewable energy.” (Kammen 1999, 35, 40)

- “To date, urban wind-turbines are still relatively exceptional, and involve new learning and understanding by all involved.” (Peel and Lloyd 2007, 352)
- “Should this type of industrial structure (urban wind-turbines) become the norm in the city, would the impact still be of ‘graceful and majestic structures with a modern and clean image’?” (Peel and Lloyd 2007, 352)
DISCUSSION

The research and analysis indicate that DREG lacks a strong foundation as an independent concept; that some research has been done on topics familiar to landscape architects; that more DREG LARR is needed; and that landscape architects can expand the reach, depth, and scope of DREG LARR.

Foundation

DREG lacks a strong foundation as an independent concept due to strong associations within DG and RE separately, and no consensus on phraseology.

In 9 of the 30 relevant articles, the most common DREG search phrase was a combination of “Distributed Generation” and “Renewable Energy” (Figure 3). The high number of associations with this phraseology indicates strong ties to separate realms of research. Articles tended to focus on either renewable energy in the larger context with passing mention of distributed generation (Beatley 2007; Brisman 2005; Golding and Blyton 2007; Martinot et al. 2002; Reiley 2009; Walker et al. 2007; Detsky 2003), or to focus on distributed generation with only passing mention of renewable energy (Miranda 2006; Möller 2003).

Beyond the use of “Distributed Generation” and “Renewable Energy” separately, many other phrases are used to describe DREG (Table 2). Some of the most common phrases identified in this study are associated with specific types of renewable energy such as “Small Wind,” and “Micro Hydro” (Figure 3). The diversity of challenges associated with each form of DREG validates the use of separate phrases, for example, research on the visual effects of a wind turbine will differ from research on the visual
effects of a photovoltaic panel, yet those sub-terms/ phrases should fall under a broader organizational framework and clear DREG phraseology. The remaining phrases in Figure 3 indicate no consensus on what that phraseology should be. Not only does the lack of clear phraseology make it difficult to find DREG related research, the lack of clear phraseology excludes it from isolated data collection. Currently, DREG data is often lumped in with all renewable energy or with specific forms such as wind or solar, which often includes larger centralized utilities.

DREG research progress will depend on identifiable general and sub terminology/phraseology, and a well developed and accepted conceptual foundation including disassociation with distributed non-renewable energy generation and centralized renewable energy generation. The ideal framework will consist of a phase such as “distributed renewable energy generation” that inherently relates to the primary aspects of distributed and renewable combined. Sub-phrases should also be composed to reflect the scale of the distributed utility and the type of renewable energy such as community wind turbine or residential wind turbine.

**Current DREG LARR**

Research on topics familiar to landscape architects has been on the rise in recent years, has focused on a few key LARR terms/ phrases, has focused on a few important DREG LARR overlaps, and has included most DREG forms resulting in a budding pool of best practice knowledge.

Increased interest and promotion of DREG in recent years has been mirrored by increased DREG LARR. The first know instance of DREG LARR occurred in 1994 and
has increased on average to the present. Over two thirds of the DREG LARR has occurred in the last five years (Figure 4). The results did indicate a decline in ’08 and ’09 possibly due to economic slowing and a possible lack of research funding.

The growing amount of DREG LARR has been focused on a few key subject areas. The most common subject area was waste (Figure 2). A distributed utility that can capitalize on a waste stream and turn it into energy could provide tremendous savings, and the site where that occurs is a step closer to sustainability. The related subject area of health was the next most common (Figure 2). Increased health is considered an outcome of the displacement of non-renewable forms by renewable ones and the way in which distributed utilities can provide electricity for improved health services in remote areas. Aesthetics was also a common LARR term/phrase (Figure 2) which can be associated with the impending increased visual impact of more utilities near users. Research focus on a comparatively small number of LARR terms/phrases indicates both a lack of overall research to cover all the subject areas and the importance of the ones getting attention.

Of the major sources of DREG, solar, wind, biomass, and micro hydro were all nearly equally represented in the DREG LARR, a few articles addressed DREG generally (Campbell 2006; Caird and Roy 2008; Kammen 1999; Reiley 2009; Lovins and Lotspeich 1999; Walker and Cass 2007), and no articles directly represented geothermal (Figure 5). Solar was the most common and seems to be the broadest application for DREG (Figure 5). Solar is represented by two energy generation strategies; thermal and photovoltaic. Wind energy is somewhat limited in its distributed smaller forms due to technological challenges, however as those challenges are decreasing, more siting
challenges are becoming apparent. Biomass fell a little lower on the number of articles in which it was the primary form of DREG (Figure 5) perhaps because there is not a definite differentiation between centralized and distributed forms, however it is possible this is the DREG form that could relate most to landscape architects. Landscape architects deal with soft-scape and vegetation; that could be planned and designed to include energy crops and efficient biomass energy systems. Micro hydro was a common form of DREG for remote areas, yet little discussion was given to how micro hydro could be used in more urban streams and waterways.

Evolving technology makes it challenging to study individual DREG forms. For example, the visual forms of wind turbines and photovoltaic panels have been much the same for many years, but outputs, economics, and perceptions have not. The space needed to power a home on PV generated power is greater today than it will likely be in 5 years. It is important with this type of research to incorporate some type of update mechanism so that DREG constants can be applied to changing variables.

The growing collection of DREG LARR on a few key subject areas such as waste, health, aesthetics, and vegetation has resulted in momentum for future research, a focus on key subject areas, and some important best practice guidance (see article summary results) which can be carried forward and added to.

**Future DREG LARR**

Many of the DREG LARR articles cite increased research needs, particularly for studies conducted in the most common DREG LARR geographic locations.
Six articles included either questions or specific future research recommendations (see explicit research recommendation results) (Martinot et al. 2002; Walker and Cass 2007; Walker et al. 2007; Devine-Wright 2005; Kammen 1999; Peel and Lloyd 2007). These questions and recommendations could total more than 50 individual study foci multiplied by various scales ranging from specific sites and geographic locations to global ramifications. A few of the main research concepts include questions about visual impacts, public expectations, social impacts, economics, business models, meaning, political systems, implementation, public vs private associations, technology performance, and perceptions.

Nearly a quarter of the studies were conducted in the UK (Table 6). An analysis of these articles indicate that a primary driving force behind research and the need for future research lies in the slow acceptance of DREG by the public. Six out of the seven articles were aimed at understanding community values, finding appropriate scales, and finding appropriate methods of implementation as it relates to DREG (Campbell 2006; Caird and Roy 2008; Devine-Wright 2005; Peel and Lloyd 2007; Walker and Cass 2007; Walker et al. 2007). Another force driving research seems to be focused on understanding if DREG will meet the goals for which it is intended, as illustrated by the study that focused on the life cycle costs to understand if a small turbine would meet the goal of carbon reduction equal to that of a large turbine (Rankine, Chick, and Harrison 2006). Research in other countries such as the US may be hindered by the lack of a national focus on DREG and associated research funding.
Future DREG research will be needed to meet government mandated goals and answer questions associated with installation of these utilities from very specific sites to global networks. Immediate research is particularly needed to understand public acceptance, issues of scale, and visual preferences.

**Landscape Architect Contribution Opportunities**

Landscape architects are positioned to move DREG LARR forward by broadening the audience, by adding expertise to areas being researched, and by expanding the scope of research.

As landscape architects become involved in DREG research, the literature forum for the dissemination of knowledge will broaden. Currently, no DREG related research exists explicitly in *Landscape Journal*, and out of the over 40 publications identified as key for landscape architecture scholarship (Erickson 2009), only *Local Environment* is associated with past DREG LARR (Devine-Wright 2005; Peel and Lloyd 2007; Peterson 2006). As landscape architects select publications for future DREG LARR it is likely that much of this will be in journals where DREG research has not been reported previously. The journals where DREG LARR has been occurring (Table 5) are important for improved collaboration discussion, including discussion on the professional role of landscape architects as it applies to DREG. A broadened audience may increase the research and improve the dissemination of knowledge such that best practice can be implemented more quickly.

In addition to a broader forum for research publication, landscape architects can add to the research that has been done. Past landscape architect scholarship on LARR
subject areas as evidenced by *Landscape Journal* publications, is within 15% of, or exceeds similar DREG LARR, with the exception of the subject category of “Sustainability” (Figure 6). Where DREG LARR has been occurring, landscape architects may provide additional insight, for example, where past DREG LARR on micro hydro sites may illustrate riparian vegetation degradation, a landscape architect may add to that discussion by recognizing the ecological and aesthetic role of the vegetation and perform research on how to best integrate the two with the needed function of the micro hydro utility.

Many more questions and future directions posed by landscape architects will expand the scope of DREG where it overlaps with LARR terms/ phrases. In the cases of “History and Culture,” “Design Theory,” “Communication and Visualization,” and “Design Education and Pedagogy,” no DREG research has been done (Figure 6). Nor has DREG research been done on other LARR terms/ phrases (Table 3). Landscape architects may pose and contribute to questions like:

- What effect does a community wind turbine located in a public park have on sociological and psychological park experience?
- What will be the plant palette for a yard focused on producing enough biomass fuel to power an automobile or home?
- How does the installation of DREG modify or change the “sense of place” associated with a given site?
- Which forms of DREG are the most influential in creating a sense of place or destroying it?
- Will it actually save water to heavily irrigate a residential energy crop that could be used for biomass energy generation rather than rely on coal fired electricity which uses a lot of water?

- How do DREG utilities affect the psychological perception of a space?

- Are there gender preferences for particular applications of DREG and how should design respond?

- Are there ethnic preferences for particular applications of DREG?

- How does DREG affect the perceptions of a historic site?

- What is the process for seamlessly incorporating DREG into a historic site?

- Do DREG utility applications differ by social class?

- How can DREG utilities be employed to influence behavior?

- How does DREG change cultural landscapes, and how could it be seamlessly incorporated?

- What vegetative patterns improve DREG?

- How can vegetation be employed to screen DREG utilities without inhibiting productivity?

- Does landscape microclimate effect DREG efficiency?

- What is the best resource mix for maximized DREG?

- How can public or private open space be maximized for DREG production?

- What is the public perception and preferences associated with open space DREG?

- How does micro hydro impact stream ecology?

- How does landscape and planning design theory relate to DREG utility design?
-What are the most appropriate methods for the design of DREG utilities?
-How can DREG be incorporated into community planning?
-How is the best way to incorporate DREG into neighborhood design?
-How can streetscapes be employed to incorporate DREG?
-Does an urban plaza with installed DREG affect public acceptance of the utilities?
-What opportunities exist for DREG incorporation into parking lot design?
-What is the best medium for illustrating the visual changes created by DREG?
-What computer programs can be used to model optimal combination of DREG given multiple best practice inputs?
-What data layers are needed for planning and designing DREG utilities with GIS?
-What are the lessons learned from DREG utility post occupancy evaluations?
-What should be the long term monitoring protocol for DREG utilities?
-How do ecological design principles apply to DREG design?
-How do bioregions relate to DREG placement?
-What are the most appropriate waste streams for DREG utilities to capitalize on?
-What are the links between health and DREG?
-How should DREG design be incorporated into landscape architecture curriculums?

Where landscape architects participate in DREG research, more professionals will be exposed to the results, additional insight will be added including new approaches for existing research focuses, and the scope of research will expand.
Limitations of this Study

While all efforts were made to ensure accuracy and quality, there are a few limitations to this study.

It is possible that there could have been higher percentages of geothermal and biomass articles had clear distributed terminology/phraseology been available for these forms. In the search matrix, solar and wind specific terms/phrases out-numbered biomass, micro hydro, and geothermal terms/phrases (Table 2). Despite going to great lengths to incorporate as many DREG phrase variations as possible into the search for articles, it became evident as the evaluation of the articles went along that there are additional variations such as “small turbine” meaning “small wind turbine,” “distributed renewables” for “distributed renewable energy generation,” “distributed solar generation,” “distributed wind generation,” “rooftop wind,” etc.. Many of these phrases are not key phraseology but may have led to a few additional overlaps.

By limiting the search to the topic terms/phrases identified by Powers and Walker (2009, 100) which they attributed to each CELA subject category (Table 3), some applicable research may have been missed. There are, for example, variations in the idea of aesthetics. Aesthetics could refer to terms/phrases like visual quality, visual experience, and appearance. Additional terms/phrases could also have been added to headings. For example, under the “sustainability” heading, “energy cycling” or “life cycle assessment” could have been added. Using the CELA headings themselves could have returned a broader set of results. For example, the category term “sustainability” may
have returned articles that could have gone beyond a discussion of waste, garbage, health, bioregionalism, and ecological design.

A few relevant articles may have been overlooked where the correlation was not explicit enough. Identifying all implicit connections were beyond the scope of this research but may be of value in more direct study of specific research categories in the future.

Some initial effort was made to quantify the quality of overlap in the articles as part of the sorting process, but due to the small number of articles containing an overlap, this assessment was largely left out of the analysis. No effort was made to differentiate the quality of the research in the articles.

It is possible that research was missed because it was published in a journal not available in the searched data bases or under different search terms/ phrases. Finally, there may have been relevant articles in other languages that were not included in this study.
CONCLUSION

In conclusion, this study contributes to the profession of landscape architecture an awareness of the current gap in research and suggestions on how to fill that gap. The research and analysis indicate that DREG lacks a strong foundation as an independent concept which could benefit from disassociation with the broader, more established fields of RE and DG and from clear broad phraseology linked to organized sub-terms/ phrases for specific forms of DREG. There has been some research done on topics familiar to landscape architects, which has been increasing in recent years, has focused on a few select LARR terms/ phrases, and has included most of the primary forms of DREG. Despite the efforts that have been made, more needs to be done to meet important research questions and recommendations already posed, and to understand how to best meet the goals and mandates set up to promote DREG. Landscape architects can expand the reach of DREG LARR knowledge into multiple publications where none has been previously, can add to the depth of DREG LARR that has been done, and can broaden the scope of DREG LARR by asking new questions about overlaps that have not yet been addressed.

In addition to the prescribed steps just mentioned, possible next steps may include a survey of landscape architecture professionals to catalog research questions they have and how they are currently involved in DREG; a survey of landscape architecture professors to establish a more formal research agenda; and a survey of current DREG researchers to understand their awareness of landscape architects, the type of work landscape architects do, and future collaboration opportunities.
Now is the time to be foresighted in researching best practice so the built environments of the future, which will include DREG utilities, take forms that maximize efficiency, minimize environmental impact, and enhance human experience.
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APPENDIX
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