IEc

APPENDICES

APPENDIX A – INTERVIEW GUIDES

INTERVIEW GUIDE FOR EPA STAFF

These questions are intended to spur your thinking and responses, but it is not necessary to conduct any research prior to the conversation.

1. **Background:** Please provide a brief overview of your background and current role at EPA.
   A. What is your experience working on projects that involve renewable energy (RE) on currently or formerly contaminated lands, landfills, or mine sites (CLs)?
   B. Where does your work intersect the RE-Powering America's Land Initiative?
   C. Have you worked directly with the RE-Powering Initiative on specific sites? If yes, please describe how you became involved in the site and what your role was throughout the process.

2. **Process:**
   A. How do you consider compatibility of a future renewable energy installation with the site's remedy?
      - Extent of soil disturbance
      - Relative placement of groundwater monitoring, etc.
      - Issues of access
      - Potential changes/reconsideration of stormwater and erosion
      - Other
   B. Based on your experience working with stakeholders, what is your sense of the process, including the results and the timing, for steps used to develop RE projects on CLs from beginning to end?
      - Does the process follow a standard, sequential order? Are steps iterative?
      - Are steps specialized depending upon the type of site? Type of contamination? The cleanup program? The state? Other?
      - What are the major permitting requirements for siting RE on CLs? Are they driven primarily by federal, state, or local requirements?
      - Are there parts of the process where problems or delays are commonly encountered? (e.g., permitting, liability concerns, securing funding, etc.) If yes, please explain.
      - Are there parts of the process that seem to go smoothly? If so, please explain.
   C. What role(s) do(es) EPA play in the process currently? Would you suggest any changes to the role(s) that EPA plays?

3. **Barriers:**
   A. Based on your observations of the process of siting RE on CLs, what do you think are the most common barriers to successful completion of projects?

      Follow-up Questions:

- How have these barriers changed over the past few years?
- Do barriers differ across states, small vs. large communities, waste management programs (e.g., SF vs RCRA) or across sites (e.g., depending on the type/extent of contamination)? Which barriers have you tried to address and how?

B. How and to what extent does the RE-Powering Initiative reinforce or complement your efforts to address these barriers?

C. Are there other barriers that RE-Powering does not currently address, but you feel they could and should address? If yes, please explain.

4. Feasibility studies and RE-Powering Initiative:

As you know, on and off over the past few years EPA has been providing funds to DOE's National Renewable Energy Laboratory (NREL) to produce feasibility studies that evaluate the potential for developing RE projects on CLs. For the sites in your region that received a feasibility study:

A. How did the communities, private developers, and other stakeholders use the results of the feasibility study(ies)?

- Were they useful in moving the project forward? If so, how?
- Were they useful in understanding why a project should not move forward? If so, how?
- Were they useful in other ways?
- What would make the studies more useful to communities and other stakeholders?

B. In general, do you have any (other) suggestions to make the RE-Powering Initiative more useful or effective? If yes, please explain.

5. Interview contacts:

OCPA and IEc are trying to identify (i) communities that have considered or actually installed RE projects on CLs, (ii) private developers who have successfully completed the process for installing RE on CLs, (iii) site owners, and (iv) state and local government contacts who have played a role in supporting siting RE projects on CLs.

A. Can you suggest any communities/individuals that we can talk to? This can include communities who sited RE projects on CLs, those that did not, and those that are still in the process of deciding.

B. Can you suggest any private developers that we can talk to who have successfully developed RE projects on CLs, ideally on more than one occasion and/or developers that are building renewable energy on contaminated lands into their practice?

C. Can you suggest any site owners?

D. Can you suggest any state and local government contacts that have supported installing RE projects on CLs?

6. Final thoughts: Are there any other thoughts or observations that you would like to share

INTERVIEW GUIDE FOR STATE GOVERNMENT OFFICIALS

These questions are intended to spur your thinking and responses, but it is not necessary to conduct any research prior to the conversation.

1. Background:

A. Please describe your role and connection to siting renewable energy (RE) projects on contaminated lands (CLs) in your state.

B. What other state-level staff do you coordinate with on these projects?

C. What staff from local government have you coordinated with and for what purpose?

2. Process:

A. What would initiate your involvement in a project?

B. Does the process of installing RE on CLs in your state follow a clear process?

- What are the key phases of this process?
- Which process steps are handled at the state level, which steps are handled at the local level, and which require state-local coordination?

3. State-Level Barriers and Opportunities:

A. What do you think are the main opportunities for siting RE on CLs in your state?

B. Are there steps in the process where you have observed that state-level policy issues and/or state-level liability concerns create significant delays or barriers in projects in your state?

- Have these state-level barriers changed over time?
- Do state-level policy barriers differ in different parts of your state (e.g., by community size or by CL or remediation type)?
- Which state-level barriers does your program specifically address?

C. Are there cases where RE should <u>not</u> be encouraged on CLs? Why or why not?

D. What resources do you draw upon in the process? Which resources are the most useful to you?

E. With whom do you coordinate on state-level policy issues related to the development of RE projects on CLs? Have you accessed materials from the RE-Powering Initiative, and if so, have you found them useful for addressing the types of issues that you have most commonly encountered/ observed in your state? *(RE-Powering materials include: RE-Powering's website, Mapper, Tracking Matrix, Best Practice Guidances, Case Studies, etc.)*

4. Interview contacts: Can you suggest any contacts that we may follow up with who have been involved in considering or successfully developing RE projects on CLs within your state?

5. **Final thoughts:** Are there any other thoughts or observations that you would like to share about the siting of RE projects on CLs in your state?

INTERVIEW GUIDE FOR LOCAL GOVERNMENT OFFICIALS

These questions are intended to spur your thinking and responses, but it is not necessary to conduct any research prior to the conversation.

1. **Background:**

   A. Please tell us about your experiences with the consideration and/or installation of renewable energy (RE) on contaminated lands (CLs) in your municipality. If possible, give site locations and a status update for any projects you have been involved in.

   B. What municipal authority(ies) have a role in overseeing or otherwise implementing these types of projects?

2. **Approval Process:**

   A. Please describe the process for deciding whether to approve a RE project on CLs in your municipality.

      - What event would initiate local government involvement?
      - Do the steps follow a regular order?
      - What are the local permitting requirements?
      - Which process steps (if any) are unique or specific to your municipality? Please explain.

   B. Have there been any changes in recent years to local government policies that would affect siting RE on contaminated lands in your municipality? Please explain.

   C. What role, if any, did market incentives, cleanup requirements, and/or liability issues play in your municipality's decision about whether to install a RE system on the site(s)?

      - How (if at all) have these factors changed in the past few years? How, if at all, do these changes affect the approval process?
      - What changes do you think would encourage more sites in your municipality to develop RE projects on CLs?

3. **Municipal-level Barriers:** Based on your experience, what do you think are the most significant barriers to approving RE projects on CLs in your municipality? To what extent are the barriers that you identified specific to your municipality?

   A. Based on your experience, are there steps in the process of siting RE on CLs that take longer than others? To what extent is the process driven by municipal-level oversight, permitting, or other requirements?

   B. What are the stages that get delayed and to what extent to do you attribute those delays to municipal requirements or other factors?

4. **Resources and decision support tools**: We are trying to understand how local government officials manage the requirements for cleaning up contaminated sites and what information you find helpful.
   A. As a local government representative, what information or resources did you/your office access to inform your thinking about the site(s) we have been discussing?
      - Did any of this information come from EPA (e.g., EPA/NREL feasibility study, website, publications, direct communication with EPA staff, etc.)? If yes, please explain.
      - How (if at all) did this information help inform the local government's decisions about the project(s) that we have been discussing?

   B. Are there ways EPA could help you evaluate site clean-up options in your municipality, specifically sites that may benefit from RE installations? Please explain.

5. **Constituent contacts:** Can you suggest any constituents that we can talk to about the project(s) we have been discussing in your municipality?

6. **Final thoughts:** Are there any other thoughts or observations that you would like to share regarding the siting of RE projects on CLs in your municipality?

INTERVIEW GUIDE FOR COMMUNITY LEADERS (NON-GOVERNMENT)

These questions are intended to spur your thinking and responses, but it is not necessary to conduct any research prior to the conversation.

1. **Background:**
   A. Please tell us about your role in the community as it relates to installing RE on contaminated lands.
   B. Did stakeholders ultimately decide to install RE on a contaminated land?
      - If yes, please describe the technology/size of the RE system and the current status of development.
      - If no, have stakeholders decided to site the project somewhere else? If so, where is it being sited and why? Is the original site being used for something else?

2. **Roles and Activities:**
   A. Please tell us more about your role and activities with regard to installing RE systems on CLs in your community.
      - Were there activities that you participated in that were more or less difficult? Explain.
      - Who were the other key stakeholders?
      - When did stakeholders begin to consider the potential to develop a RE system on the site? What initially prompted the stakeholders to consider the potential to install RE on the site?
      - Were there other sites in the community where RE was installed on current or formerly contaminated lands? If yes, please explain.
      - Were there other sites considered? If yes, please explain.
      - What other use options did the stakeholders consider for the site?
      - What did the stakeholders see as the advantages and disadvantages of RE vis-à-vis other options for the site?

   B. What sources of information did the stakeholders use to assess whether/how to develop a RE project on the site?
   C. What role, if any, did you play in measuring the potential impacts of RE projects on CLs in your community?
      - Did you help assess the potential effects of market incentives, cleanup requirements, and/or liability issues? If yes, please explain.
      - Has your thinking about these issues changed at all in the past few years? If yes, how?
      - What policy or other changes would help you participate more effectively in this process?

3. **Challenges:** Please tell us more about any challenges you faced in your role with respect to the siting of RE projects on CLs in your community.
    A. What if any EPA resources or tools (and tools from other organizations) helped you, community residents, and/or local government officials overcome any of the challenges you talked about?
    B. Based on your role in these projects, have you observed any change in the types or severity of challenges over the past few years? If yes, please explain.

4. **Decision support tools:** We are trying to understand what resources community leaders currently use or need to inform their decisions about RE projects on CLs.
    A. What information do you need in order to decide whether a contaminated site in your community is a good candidate for a RE project? What sources of information do you typically consult?
    B. Have you had any contact with EPA staff or resources (e.g., RE-Powering initiative staff, *Handbook,* decision tree tool)?
        - If so, what are your overall impressions of EPA staff and/or resources?
        - Were EPA staff and/or resources helpful? If yes, in what ways? If no, why not?
    C. If a feasibility study was performed to evaluate the potential for developing renewable energy projects on contaminated lands in your community, was it useful? Why or why not?
        - How was it used?
        - What would make the studies more useful to communities and other stakeholders?
    D. Are there particular resources or technical assistance that EPA (and especially the RE-Powering Initiative) could provide that would be useful to you?
    E. Are there ways EPA could help address some or all of the challenges identified above?

5. **Interview contacts:**

    EPA and IEc are trying to identify (i) private developers who have successfully completed the process for installing RE on CLs, (ii) site owners, and (iii) state and local government contacts who have played a role in supporting siting RE projects on CLs.

    A. Can you suggest any private developers that we can talk to who have successfully developed RE projects on CLs, ideally on more than one occasion, and/or developers that are building renewable energy on contaminated lands into their practice?
    B. Can you suggest any site owners?
    C. Can you suggest any state and local government contacts that have supported installing RE projects on CLs?

6. **Final thoughts:** Are there any other thoughts or observations that you would like to share about the site(s) we have been discussing, or other topics we have discussed?

INTERVIEW GUIDE FOR DEVELOPERS

These questions are intended to spur your thinking and responses, but it is not necessary to conduct any research prior to the conversation.

1. **Background:** Please provide a brief overview of your company and your role.
   A. What portion of your company's project portfolio includes renewable energy (RE) projects? Of these, what portion of RE projects are on current or formerly contaminated lands, landfills, or mine sites (CLs)? Approximately how many sites does this include?
   B. On what geographic locations or regions does your company mainly focus?
   C. How long has your company been developing RE projects on CLs?
   D. How did your company become interested in developing RE projects on CLs?
   E. Can you describe specific examples of RE projects on CLs that your company has completed or those in the planning/construction pipeline?
   F. What is your role in the project development process vis-a-vis other partners and stakeholders?

2. **Development Process:** Please tell us more about the process that your company follows for developing RE projects on CLs.
   A. How do sites come to your attention? How do you screen sites for suitability? How do you estimate return on investment / profitability?
   B. Does your company's process follow a standard, sequential order and timing? Are steps iterative?
   C. Are steps in your company's process specialized depending upon the type of site? Type of contamination? The cleanup program? The state? Other?
   D. Who typically owns the land on which your company installs RE projects? When in the process does ownership change hands (if at all)? Does liability transfer with ownership?
   E. What are the major permitting requirements that your company faces for siting RE on CLs? Are these requirements primarily federal, state, or local?
   F. Are there any parts of the process where your company commonly encounters problems or delays (e.g., permitting, liability concerns, securing necessary funding, etc.)? If yes, please explain.
   G. Did any of the following factors influence your decision to install or not install RE on a CLs site? To what extent?
      - Opportunity cost of the land (one or more alternatives were more economically attractive than installing a RE system)
      - Desire to minimize risk/liability
      - Desire to maximize financial return
      - Provision of state or federal or other market incentives to do a RE project
      - Type of contamination/cleanup status
      - Size of the community in which the site is located

- Size of the property
- Cost/availability of open space
- Other – please specify

3. Comparison to developing RE projects on non-contaminated lands:

A. What, if any, are the main differences in the process for RE projects developed on contaminated vs. undisturbed lands?

B. What do you see as the advantages of developing RE projects on contaminated lands vs. undisturbed lands?

- What, if any, cost advantages exist for developing RE on CLs rather than undisbursed lands? In what circumstances are you able to realize these cost advantages?
- Are you able to describe in quantitative terms impacts and benefits associated with the development of RE on CLs?

C. What do you see as the disadvantages of developing RE projects on contaminated lands vs undisturbed lands?

- To what extent do liability concerns and attracting financing stand out as potential disadvantages of using contaminated lands?
- Are there costs related to updating current site infrastructure?

D. What do you see as the most significant market, policy, or technology hurdles to developing RE projects on CLs?

- How have these factors changed in the past few years?
- Are any of these hurdles "deal breakers" in your decision about developing RE on CLs? If yes, which ones?

4. Site identification and assessment: We would like to understand what information developers use to identify site "leads" and assess their economic and technical feasibility.

A. How do you identify potential sites to develop RE projects?

- Where do you look for information about potential sites?

B. What information do you use to "screen" potential sites – i.e., to decide whether or not to proceed with a full feasibility study?

- What information sources do you use to screen potential sites?
- The RE-Powering Initiative developed a RE-Mapper tool with a list of pre-screened sites. Are you familiar with the RE-Mapper tool?
  - If yes, have you used it? Did you find it useful (why or why not)?

C. How do you assess the economic and technical feasibility of installing a RE project on a site?

- Did EPA/NREL conduct a feasibility study for the site(s) we have been discussing? If yes, what were your overall impressions of the study? How did you use the results?

D. What information do you use to navigate project siting requirements?

- Have you used EPA’s siting Handbook? If yes, how did you use the Handbook? Was it helpful (why or why not)?

E. What other resources do you use to determine whether to develop a RE project on a particular site?

- Are any of these EPA resources (e.g., wind and solar decision trees, direct contact with EPA staff, etc.)? If yes, explain. Are these resources helpful (why or why not)?

F. Are there other types of information that EPA does not currently provide that would help you develop RE projects on CLs?

5. **Final thoughts:** Are there any other thoughts or observations that you would like to share about the development process or other topics we have discussed?

INTERVIEW GUIDE FOR SITE OWNERS

These questions are intended to spur your thinking and responses, but it is not necessary to conduct any research prior to the conversation.

1. **Background:** Please tell us about [name of site] and when you became the site owner.
   A. What was the site previously used for? When did you become the site owner? Who was the previous owner?
   B. Please describe the site history and topography.
   C. Were you the site owner when it was being cleaned up?
      i. If yes, please describe your involvement in the cleanup process.
      ii. If not, how long had the site been cleaned up – and what was it being used for – when you became the owner?
   D. Do you own any other, similar sites? If yes, please describe them.

2. **Consideration of RE Projects:**
   A. Please tell us more about the motivation (e.g., economic considerations, environmental considerations) for installing a RE system on your site.
   B. Did you or another party (who?) initiate the idea to install a RE system on your site?
   C. Were you the current site owner when discussions began about installing a RE system on the site?
      - If yes, what role did you play in the decision-making process?
      - If not, what was the status when you became the site owner?
   D. What other options (besides RE) were considered for your site?
      - *[For site owners who purchased the site after a RE system was installed: What other sites, if any, did you consider buying (please describe)?]*
   E. How did the potential benefits and costs of siting a RE system compare to the other options that were being considered for your site?
      - *[For site owners who purchased the site after a RE system was installed: What made this site economically attractive?]*
   F. Were there any other factors that led you to consider installing RE on this site? Please explain.
   G. What factors influenced your decision to actually install or not install RE on a CLs site?

3. **Advantages and Disadvantages of RE Projects:**
   A. What do you see as the most significant advantages of installing RE projects at your site(s)?
   B. What disadvantages, if any, would prevent or hinder you from siting RE projects at your site(s)? *[If a RE project is currently installed: What were the most significant disadvantages?]*

- Under what circumstances could (did) these disadvantages come into play?
- How does your thinking about these disadvantages influence your decision about whether to install a RE project on your site (or alternatively, your decision about whether to purchase a CL with a RE installation on it)?
- What steps did you take (or could you take) to mitigate the drawbacks?

C. *[For site owners who are installing or who have installed RE]* What are your overall impressions about the development process? What parts of the process could be simplified or streamlined to make RE a more attractive option for the site(s) that you own?

4. **Resources for Assessing Site Options:** We would like to understand what information sources owners of CLs use to assess site options (including remediation and post-cleanup use).

   A. What information or assistance (if any) do state and local governments provide to help you assess options for your site(s)?

   B. What information or assistance (if any) do federal agencies provide?

   - Did you have any direct interactions with EPA staff in your region during the cleanup process? If yes, explain. Were EPA staff helpful (why or why not)?
   - Did you access any information or tools developed by EPA's RE-Powering Initiative to help inform your decisions about RE projects on the site(s) that you own? If yes, what information did you access? How (if at all) did you use the information?
   - Did you have any interactions with other federal agencies? If yes, please explain.

   C. Did anyone help you assess the technical or economic feasibility of installing RE on your site(s)? If yes, who? How (if at all) did the information affect your thinking about the site(s)?

   D. What other information or resources would help site owners like you evaluate options for your site, including whether to install a RE project?

5. **Developer contacts:** *[If applicable]* May we contact the developer(s) who installed the RE project(s) at your site(s)? If yes, please provide their contact information.

6. **Final thoughts:** Are there any other thoughts or observations that you would like to share about your considerations for siting RE projects on CLs?

APPENDIX B - ANNOTATED BIBLIOGRAPHY

I. CURRENT STATE OF THE RENEWABLE ENERGY MARKET

Carley, S. (2009). "State renewable energy electricity policies: An empirical evaluation of effectiveness." Energy Policy **37**: 3071-3081.

Abstract: Over the past decade, state governments have emerged as US energy policy leaders. Across the country, states are adopting policy instruments aimed at carbon mitigation and renewable energy deployment. One of the most prevalent and innovative policy instruments is a renewable portfolio standard (RPS), which seeks to increase the share of renewable energy electrification in the electricity market. This analysis evaluates the effectiveness of state energy programs with an empirical investigation of the linkage between state RPS policy implementation and the percentage of renewable energy electricity generation across states. We use a variant of a standard fixed effects model, referred to as fixed effects vector decomposition, with state-level data from 1998 to 2006. Results indicate that RPS implementation is not a significant predictor of the percentage of renewable energy generation out of the total generation mix, yet for each additional year that a state has an RPS policy, they are found to increase the total amount of renewable energy generation. These findings reveal a potentially significant shortcoming of RPS policies. Political institutions, natural resource endowments, deregulation, gross state product per capita, electricity use per person, electricity price, and the presence of regional RPS policies are also found to be significantly related to renewable energy deployment.

Research Notes: An increase in the percentage of states with renewable portfolio standards (RPS) policies leads to an increase in renewable energy, both in terms of percentage and magnitude of installed capacity. This increase in RE is due to intra-regional renewable energy credit trading surrounding state RPS policies that provide incentives for states to develop renewable energy.
-Not all states are on a current trajectory toward meeting their RPS mandates; possible reasons for these shortcomings include: inadequate policy enforcement; policy duration uncertainty; and overly aggressive RPS benchmarks.

U.S. EPA. (2008). State Incentives for Achieving Clean and Renewable Energy Development on Contaminated Lands U. EPA.

Abstract: The development of clean and renew able energy on formerly used land offers many economic and environmental benefits. Combining clean and renewable energy and contaminated land cleanup incentives can allow investors and communities to create economically viable clean and renewable energy redevelopment projects. This document provides information about incentives in California that can be leveraged for clean and renewable energy and development of contaminated land. A few examples are listed in the notes.

Research Notes: The Cleanup Loans and Environmental Assistance to Neighborhoods (CLEAN) Program provides low-interest loans up to $100,000 for preliminary

endangerment assessments and up to $2.5 million for cleanup or removal of hazardous materials. If property redevelopment is not economically feasible, up to 75 % of the loan amount can be waived.
-The California Land Reuse and Revitalization Act of 2004 provides immunity from liability for response costs or damage claims to qualified innocent landowners, bona fide purchasers and tenants, and contiguous property owners.
-The Prospective Purchaser Agreement (PPA) provides a covenant not to sue for existing contamination and provides for contribution protection to purchasers or developers who are willing to clean up contaminated sites at their own expense.
-The Contamination Orphan Site Cleanup Subaccount (OSCA) Program provides financial assistance to eligible applicants for the cleanup of brownfield sites contaminated by leaking petroleum USTs where there is no financially responsible party

Jordan-Korte K. (2011). Government Promotion of Renewable Energy Technologies: Policy Approaches and Market Development in Germany, the United States, and Japan.

Abstract: Renewable energy sources will play an increasingly important role in meeting global energy demand. Katrin Jordan-Korte presents the first comprehensive comparison of government promotion of renewable energy technologies in Germany, the United States, and Japan. The author expands the ongoing discussion of renewable energy use by also including an analysis of international markets of renewable energy technologies. She shows that the success of countries on those markets is positively correlated with a dynamic development on national markets for renewable energy use.

Research Notes: The major Federal incentives that promote renewable energy in the US are: the Production Tax Credit (PTC) for private or investor-owned facilities; the Renewable Energy Production Incentive (REPI) for publicly-owned facilities; and the Business Investment Tax Credit (ITC), which gives tax credits to solar power facilities. Of the three incentives, the PTC was the most successful in stirring renewable power generation.
-The most important state policy instruments that promote renewables are renewable portfolio standards, net metering programs, and public benefits funds.
-Initially RPS was especially successful in Texas because the State had favorable transmission access rules, good wind resources, and long-term 10-25 year power purchase contracts from utilities.

Leibowicz, B. D. (2015). "Growth and competition in renewable energy industries: Insights from an integrated assessment model with strategic firms." Energy Economics **52**: 13-25.

Abstract: This article describes the development, implementation, and application of an integrated assessment modeling framework featuring renewable technology markets with producers engaged in Cournot competition. Scenario results reveal how climate policy and inter-firm learning spillovers interact with market structure to affect wind and solar PV prices, adoption, producer profits, and carbon emissions. Competitive markets yield consistently lower markups than concentrated markets, leading to significantly more adoption and lower emissions. Widespread solar PV adoption is a key component of the largest emissions reductions, but this requires substantial price reductions that only occur if the solar PV market is competitive and learning spills over across producers. Whether a leading firm has a profit incentive to facilitate or obstruct learning spillovers depends on the availability of cost-competitive substitute technologies. If such a substitute exists, the firm prefers strong spillovers that help its industry compete against the substitute; if not, the firm prefers weak spillovers that prevent competitors in its industry from seizing market share. The relationship between price and cumulative capacity is endogenous in the modeling framework. Regression analysis of scenario results yields price learning rates which are similar to unit production cost learning rates in competitive markets, but substantially lower – even negative – in concentrated markets.

Research Notes: Although wind capital costs are anticipated to remain constant through 2050, the estimated levelized cost for wind ($80/MWh) is already cost-competitive with conventional coal ($96/MWh) and conventional natural gas-fired combined cycle ($66/MWh).
-Utility-scale solar PV capital cost will decline by almost 50 percent through 2050.
-Wind and solar PV technologies diffused rapidly from 2000 through 2013. Given that prices and capacity additions increased simultaneously, it appears that strong demand (to some extent the result of climate and renewable energy policies) enabled producers to charge higher prices, and higher prices encouraged entry of new producers. New producers created more competitive markets that ultimately caused prices to fall again.

Massachusetts Institute of Technology (2015). "The Future of Solar Energy." <u>MIT Future</u>. from https://mitei.mit.edu/futureofsolar.

Abstract: The Future of Solar Energy reflects on the technical, commercial and policy dimensions of solar energy today and makes recommendations to policymakers regarding more effective federal and state support for research and development, technology demonstration, and solar deployment. Among its major themes is the need to prepare our electricity systems, both technically and from a regulatory standpoint, for very large-scale deployment of solar generation – which tends to vary unpredictably throughout the day. To this end, the study emphasizes the need for federal research and development support to advance low-cost, large-scale electricity storage technologies.

Research Notes: Grid-connected PV is growing at a rapid rate in the United States (approximately 18 gigawatts (GW) of grid-connected PV added between the beginning of 2008 and the end of 2014) driven by federal, state, and local incentives as well as falling prices of solar modules and inverters.
-As of 2014, only 0.3 percent of U.S. PV systems were 1 MW or larger, yet these utility-scale facilities account for 55 percent of the nation’s total PV generation capacity.
-The rapid growth in U.S. PV deployment is the result of a combination of improved technology and manufacturing processes and increased competition among suppliers, which led to a decline in the cost of PV modules and power inverters. In 2008, the average price for a module stood at around $4.00 per peak watt (Wp). By the end of the second quarter of 2014, the average price had fallen by 84 percent to around $0.65/Wp.
-Renewable portfolio standards (RPS) are a key driver of utility-scale installations in

many areas. Solar generation is also supported by the Federal 30 percent investment tax credit (ITC) and accelerated depreciation under the Modified Accelerated Depreciation System (MACRS), which allows solar assets to be depreciated for tax purposes, over a five-year schedule.

Menz, F. C. and S. Vachon (2006). "The effectiveness of different policy regimes for promoting wind power: Experiences from the states." Energy Policy **34**(14): 1786-1796.

Abstract: Governments at the state (and to a lesser extent, local) level in the United States have adopted an array of policies to promote wind and other types of “green” energy, including solar, geothermal, low-impact hydropower, and certain forms of biomass. However, because of different regulatory environments, energy resource endowments, political interests, and other factors, there is considerable variation among the states in their green power policies. This paper analyzes the contribution to wind power development of several state-level policies (renewable portfolio standards (RPS), fuel generation disclosure rules, mandatory green power options, and public benefits funds), along with retail choice (RET) facilitated by electricity restructuring. The empirical results support existing anecdotal and case studies in finding a positive relationship between RPS and wind power development. We also found that requiring electricity suppliers to provide green power options to customers is positively related to development of wind energy, while there is a negative relationship between wind energy development and RET (i.e., allowing retail customers to choose their electricity source).

Research Notes: The cost of generating wind power has declined consistently over the last several decades due to greater efficiency and lower production costs for wind turbines.
-New green power technologies may not be as cost-effective in the short run as conventional energy sources.
-The study suggests that two mandatory policy measures: State Renewable Portfolio Standards (RPS) and the Mandatory Green Power Option (MGPO) strongly support wind power development, while financial incentives like Public Benefit Funds and voluntary green power do not stimulate wind power development.

NC Clean Energy Technology Center (2015). "Database of State Incentives for Renewables & Efficiency®." DSIRE. Retrieved November 19, 2015, from http://www.dsireusa.org/.

Abstract: DSIRE is the most comprehensive source of information on incentives and policies that support renewable energy and energy efficiency in the United States. Established in 1995, DSIRE is operated by the N.C. Clean Energy Technology Center at N.C. State University and is funded by the U.S. Department of Energy. Follow the navigation above to read about the history of DSIRE, the partners on the project, and the research staff that maintains the policy and incentive data in DSIRE.

Research Notes: The DSIRE site offers a map of the United States that allows users to click on a state to view all of the renewable energy incentives offered by that state, as well as any incentives offered by local governments and the state’s utilities.
-Some states like California have about 196 incentives that include but are not limited to

rebate programs, solar/wind contractor licensing, loans, and green power purchasing programs for various types of renewable energy. Although none of these incentives seem to be explicitly for renewable energy development on contaminated lands, they ultimately lower development costs for renewable energy projects.

Sherwood, L. (2014). "The What & Why of Solar Trends." from http://www.irecusa.org/2014/08/the-what-why-of-solar-trends/.

Abstract: The 2014 report provides public data on U.S. solar installations in 2013 by technology, state and solar market sectors. It offers insight on the major factors affecting the solar market, such as photovoltaic prices, strong consumer demand, available financing, renewable portfolio standards in some states, and financial incentives from the federal government, states and utilities. The report includes ranking of Top 10 States in several categories. The U.S. PV market growth is continuing in 2014, with larger utility sector projects leading the way. Over the near term, the prospect for growth in solar installations is bright in all sectors. The residential sector is growing in a large number of states, and many utility sector projects are under construction or contract and will be completed in 2014 or later. For now, the market continues to be sustained by the federal ITC, state RPSs, and on-going net metering policies. If PV prices continue to fall, consumer demand will offset likely reductions in these supportive policies.

Research Notes: PV capacity installations increased by 34 percent in 2013; growth is largest for small installations (residential) and the largest installations (utility-scale).
-The Federal Investment Tax Credit (ITC) is a key foundational incentive for most solar installations. Though their impact on the total market is declining, rebates are still important state policies for smaller installations.
-PV installation and market prices are declining; when PV is less expensive, less incentive money is necessary to encourage installations.

The BCSE Clean Energy Partnership (2015). 2015 Sustainable Energy in America Fact book. <u>Sustainable Energy in America Factbook</u>, Bloomberg New Energy Finance.

Abstract: The Sustainable Energy in America Factbook documents how the US produces, delivers, and consumes energy. Over the 2007-14 period, US carbon emissions from the energy sector dropped 9%, US natural gas production rose 25%, and total US investment in clean energy (renewables and advanced grid, storage, and electrified transport technologies) totaled $386 billion. This third edition of the Factbook presents the latest updates on those trends, with special emphasis on 2014 happenings. The year saw two key developments: (1) the growth of the US economy, which has increased by 8% since 2007 and has been gaining steam in the past few quarters; advances in sustainable energy have been concurrent with this growth, and have partially fuelled it; (2) the collapse of oil prices; while there is no explicit link between oil (which in the US is used mostly for transport) and most sustainable energy technologies (which are used mostly in the power sector), the oil price shock has a profound global impact and may result in ‘second-order’ effects which could impact US sustainable energy. Finally, the Factbook highlights how the broader US ecosystem is clearly preparing for a future in

which sustainable sources of energy play a much larger role.

Research Notes: The contribution of renewable energy (including large hydro projects) to the country's electricity mix rose from eight percent in 2007 to about 13 percent in 2014. Since 2000, 93 percent of new power capacity built in the US has come in the form of natural gas, wind, solar, biomass, geothermal, or other renewables.
-Investment in the clean energy sector in 2014 was $51.8 billion, a seven percent increase from 2013. The key drivers were: the brief window of renewed policy support for wind, the acceleration of the rooftop solar business, and the emergence of 'yieldcos' (publicly listed companies that own operating renewable energy assets).
-Wind and solar have been the fastest growing technologies, having more than tripled in capacity since 2008 (from 27GW to 87GW in 2014). Hydropower is the largest source of US renewable energy at 79GW (excluding pumped storage).
-Solar installations increased by almost 50 percent from 2013 to 2014; projects have been driven by state renewable energy mandates and by the federal solar Investment Tax Credit (ITC) that expires in December 2016.
-The Production Tax Credit was renewed in 2013, leading to an increase in wind development.
-Wind energy is the lowest cost option for utilities in some parts of the US, for example, Texas, and solar energy beats the retail electricity prices paid by homeowners in many states.

II. AVOIDED OR ADDITIONAL COSTS FROM SITING RENEWABLE ENERGY PROJECTS ON CONTAMINATED LANDS

Adelaja, S., et al. (2010). "Renewable energy potential on brownfield sites: A case study of Michigan." Energy Policy **38**(11): 7021-7030.

> **Abstract:** Federal priorities are increasingly favoring the replacement of conventional sources of energy with renewable energy. With the potential for a federal Renewable Electricity Standard (RES) legislation, many states are seeking to intensify their renewable energy generation. The demand for wind, solar, geothermal and bio-fuels-based energy is likely to be rapidly expressed on the landscape. However, local zoning and NIMBYism constraints slow down the placement of renewable energy projects. One area where land constraints may be lower is brownfields; whose development is currently constrained by diminished housing, commercial, and industrial property demand. Brownfield sites have the potential for rapid renewable energy deployment if state and national interests in this area materialize. This study investigates the application of renewable energy production on brownfield sites using Michigan as a case study. Wind and solar resource maps of Michigan were overlaid with the brownfield locations based on estimates of brownfield land capacity. The total estimated energy potential available on Michigan's brownfield sites is 4320 megawatts (MW) of plate capacity for wind and 1535 for solar, equating to 43% of Michigan's residential electricity consumption (using 30% capacity factor). Estimated economic impacts include over $15 billion in investments and 17,500 in construction and long-term jobs.
>
> **Research Notes:** High and uncertain costs associated with cleaning sites up to safe standards may exceed the land's worth after redevelopment.
> -The lack of awareness about renewable energy development on Brownfields amongst communities, Brownfield re-developers, state policy makers, Brownfield authorities, and the renewable energy industry, creates risk concerns which ultimately lead to higher financing costs.

Bolinger, M. and J. Seel (2015). Utility-Scale Solar 2014: An Empirical Analysis of Project Cost, Performance, and Pricing Trends in the United States, Lawrence Berkeley National Laboratory.

> **Abstract:** With the critical mass of new utility-scale projects now online and in some cases having operated for a number of years (generating not only electricity, but also empirical data that can be mined), the rapidly growing utility-scale sector is ripe for analysis. This report, the third edition in an ongoing annual series, meets this need through in-depth, annually updated, data-driven analysis of not just installed project costs or prices – i.e., the traditional realm of solar economics analyses – but also operating costs, capacity factors, and power purchase agreement ("PPA") prices from a large sample of utility-scale solar projects in the United States. Given its current dominance in the market, utility-scale PV also dominates much of this report, though data from CPV and CSP projects are presented where appropriate. Looking ahead, the amount of utility-scale solar capacity in the development pipeline suggests continued momentum and a significant expansion of the industry through at least 2016. For example, at the end of 2014, there was at least 44.6 GW of utility-scale solar power capacity making its way

through interconnection queues across the nation (though concentrated in California and the Southwest). Though not all of these projects will ultimately be built, presumably those that are built will most likely come online prior to 2017, given the scheduled reversion of the 30% ITC to 10% at the end of 2016. Even if only a modest fraction of the solar capacity in these queues meets that deadline, it will still mean an unprecedented amount of new construction in 2015 and 2016 – as well as a substantial amount of new data to collect and analyze in future editions of this report.

Research Notes: This report does not specifically discuss the costs of siting renewable energy projects on contaminated land. However, it breaks out the cost components typical of utility-scale solar projects.
-The report also observed that costs for PV plants in the study sample steadily declined from 2011 to 2014.

Friedman, B., et al. (2013). Benchmarking Non-Hardware Balance-of-System (Soft) Costs for U.S. Photovoltaic Systems, Using a Bottom-Up Approach and Installer Survey, National Renewable Energy Laboratory.

Abstract: This report presents results from the second U.S. Department of Energy (DOE) sponsored, bottom-up data-collection and analysis of non-hardware balance-of-system costs—often referred to as “business process” or “soft” costs—for U.S. residential and commercial photovoltaic (PV) systems. Annual expenditure and labor-hour-productivity data are analyzed to benchmark 2012 soft costs related to (1) customer acquisition and system design and (2) permitting, inspection, and interconnection (PII). We also include an in-depth analysis of costs related to financing, overhead, and profit. In contrast to the first edition of this report, in this second edition we have unpacked the “other soft cost” category using a detailed “bottom-up” cost-accounting framework into five categories: transaction costs, indirect corporate costs, installer/developer profit, supply chain costs, and sales tax. Soft costs for residential and large commercial systems declined in the United States between 2010 and 2012, while small commercial soft costs increased. This second benchmarking effort characterizes all PV soft costs—which the previous edition did not—and represents the most granular analysis to date that measures progress toward the SunShot soft-cost-reduction targets. Soft costs are both a major challenge and a major opportunity for reducing PV system prices and stimulating SunShot-level PV deployment in the United States.

Research Notes: This report does not specifically discuss the costs of siting renewable energy projects on contaminated land. However, it breaks out the cost components typical of small commercial solar (<250 kW) and large commercial solar (>250 kW) projects. In particular, transaction costs related to legal fees, engineering, financing, and insurance expenses are described.

Goodrich, A., et al. (2012). Residential, commercial, and utility scale photovoltaic (PV) system prices in the United States: current drivers and cost-reduction opportunities, NREL.

Abstract: This report explores the price of photovoltaic (PV) systems in the United

States (i.e., the cost to the system owner). They explore the reasons for the apparent disconnects between installation costs, component prices, and system prices; most notable is the impact of Fair Market Value considerations on system prices. To guide policy and research and development strategy decisions, it is necessary to develop a granular perspective on the factors that underlie PV system prices and to eliminate subjective pricing parameters. Although the cost structure of PV systems designed for use in each market segment are very different, module price and performance remains a significant opportunity for future cost reductions across all PV sectors.

Research Notes: Locating projects on pre-zoned sites that are collocated with existing energy generation or industrial infrastructure can help avoid grid-related permitting costs.
-The cost of permitting a site for PV varies by region and the relevant litigation; environmental impact studies can be as low as $100,000, but also up to $5.0 million for more rigorous reviews, such as those required under the California Environmental Quality Act.
-Land acquisition, permitting, and commissioning costs are a relatively small proportion of installed solar system prices.

Jensen, B. B. (2010). Brownfields to green energy: redeveloping contaminated lands with large-scale renewable energy facilities, Massachusetts Institute of Technology.

Abstract: This thesis uses case studies of one unsuccessful, and three successful brownfield-to-renewable energy projects to identify common barriers such projects face and how those barriers can be overcome. The most significant barriers identified are those typical of brownfield development: cleanup costs, liability risks, uncertainty, technical and legal complexity, and the need to coordinate multiple stakeholders. These barriers can be overcome through strong partnerships characterized by full cooperation among developers, property owners, regulators, and local officials. Political and public support enables cooperation between public and private stakeholders. This support is driven by an expectation that brownfield-to-renewable energy projects will improve the city's image and stimulate development of the clean energy industry locally. The three successful projects received substantial public support. This suggests that locating renewable energy facilities on contaminated lands is a possible solution to the siting controversies faced by new renewable energy facilities, and by wind farms especially. Renewable energy facilities offer a reuse option for brownfields that can coexist with ongoing remediation. Carving-out less polluted parcels from large properties for phased development is a strategy that has great potential to expand renewable energy development on brownfields and provide property owners revenue that can facilitate complete remediation. The thesis concludes with recommendations for local, state, and federal actions to encourage and facilitate brownfields-to-renewable energy projects. Recommended local level actions include incorporating renewable energy into municipal comprehensive plans and brownfield redevelopment programs. Overall, recommendations emphasize facilitating the "carve-out" strategy (i.e. use the cleanest parts of brownfields for new energy projects) and modifying financial incentives to favor brownfield sites.

Research Notes: The cost advantage to siting renewable energy projects on Brownfields includes already existing infrastructure, and the availability of government programs that support cleanup and use.

-There is uncertainty surrounding the amount of pollution on some Brownfield sites; consequently, there is uncertainty surrounding cleanup and acquisition costs. This problem may be overcome if sites are added to the National Priorities List in order to access Federal Superfund money for cleanup.

-In some cases, environmental site assessments do not find any pollutants or they find severe pollution, which changes the cost of the land and cleanup. It is possible to carve out a moderately polluted Brownfield from an area of high contamination to take advantage of state voluntary cleanup programs or to split cleanup costs between the developer and the City.

-Lending costs are sometimes higher for Brownfield sites as compared to Greenfield sites due to higher risk and uncertainty.

Macknick, J., et al. (2013). Solar Development on Contaminated and Disturbed Lands.

Abstract: This report examines the prospect of developing utility- and commercial - scale concentrated solar power (CSP) and solar photovoltaics (PV) technologies on degraded and environmentally contaminated lands. The potential for solar development on contaminated and disturbed lands was assessed, and for the largest and highest solar resource sites, the economic impacts and feasibility were evaluated. Overall, levelized cost of electricity (LCOE) tends to depend on the solar resource and electricity generated per land area, which varies by location. Generally, LCOE was lower in the Southwest where the amount of electricity generated is highest. Developing solar power on contaminated and disturbed lands can help create jobs and revitalize local and state economies, and selecting these sites over greenfield sites can potentially have permitting and environmental mitigation advantages.

Research Notes: Median levelized cost of electricity (LCOE) values and ranges show that PV development on disturbed and contaminated lands with a solar resource of at least 6.0 kWh/m^2 /day had less variation when compared to PV developments in areas with a lower solar resource.

- In areas formerly used for industrial activities or other activities that required electricity infrastructure, grid connection costs could be reduced by leveraging existing infrastructure.

Mendelsohn, M., et al. (2012). Utility-Scale Concentrating Solar Power and Photovoltaics Projects: A Technology and Market Overview, NREL.

Abstract: This report serves as: (1) a primer on utility - scale solar technologies and (2) a summary of the current state of the U.S. utility - scale solar market. The second report overviews policies and financing of utility - scale solar systems; the third report assesses the impact of financial structures on the cost of energy from utility- scale systems.

Research Notes: Environmental permitting, grid integration, and site control can be less

burdensome at the distributed utility-scale.
-Development at Brownfield sites, including former mining operations and other disturbed lands, can reduce environmental oversight of project development.

Miller, C. (2013). "Transformation of Blight: Fixing the CERCLA Lessee Problem to Develop Renewable Energy, The." George Washington Law Review **82**: 1267.

Abstract: This paper discusses how the Comprehensive Environmental Response, Compensation, and Liability Act, CERCLA, fails to define the liability of a lessee for preexisting contamination – the lessee of a site could be held liable as an owner or operator of that site, and further, that lessee may be subject to joint liabilities for past contamination. Additionally, the Small Business Liability Relief and Brownfields Revitalization Act ("Brownfields Amendments") fails to extend a defense against existing liabilities to developers who seek to lease Superfund sites, it only protects those who buy Superfund sites.

Research Notes: For parties seeking to remediate contaminated land, renewable energy can provide low-cost power for cleanup activities or revenue through lease payments, offsetting the total cost of remediation.
-For developers seeking to make a profit from installing renewable energy, contaminated sites are often cheaper, contain fewer environmental resources than uncontaminated land, and provide existing infrastructure to connect and transmit electricity from the development to the purchasers.

Mosey, G., et al. (2007). Converting Limbo Lands to Energy-Generating Stations: Renewable Energy Technologies on Underused, Formerly Contaminated Sites. Golden, CO, National Renewable Energy Laboratory.

Abstract: This report addresses the potential for using "Limbo Lands" as sites for renewable energy generating stations. Limbo Lands are considered as underused, formerly contaminated sites, and include former Superfund sites, landfills, brownfields, abandoned mine lands, former industrial sites, and certain government installations. The National Renewable Energy Laboratory (NREL) conducted this study for the U.S. Environmental Protection Agency (EPA), National Risk Management Research Laboratory, Sustainable Technology Division (NRMRL-STD). The objective of this report, which provides a geographic screening of potential sites, is to address Limbo Lands that are ready for redevelopment and their feasibility with renewable energy technologies (RETs). The report discusses reasons for considering RETs (and which ones) as a redevelopment option on Limbo Lands, describes the geographic screening process, identifies high-potential limbo land sites for RET redevelopment, includes discussion of two specific types of Limbo Lands: brownfields and abandoned mine lands, and provides conclusions and recommendations.

Research Notes: Developing renewable energy on Limbo Lands with already existing transmission capacity and infrastructure from former use lowers development costs and provides economically viable reuse to sites with significant cleanup costs or low real estate development demand.

National Association of Local Government Environmental Professionals (2012). Cultivating Green Energy on Brownfields: A Nuts and Bolts Primer for Local Governments, National Association of Local Government Environmental Professionals.

Abstract: This paper offers a primer for local governments interested in investigating whether renewable energy development may be the right choice for Brownfields in their communities. This primer is not intended to serve as a step-by-step guide to the development of a renewable energy project on a brownfield for the simple reason that the process for developing a renewable energy project will depend on site specific factors. Rather, it provides a starting point for local governments to consider whether renewable energy facilities may be appropriate for local brownfield sites, tools to help navigate the economic issues that determine whether a particular project is feasible, and information about how permitting, zoning, siting, liability, and other regulatory issues affect the development of renewable energy on Brownfield sites.

Research Notes: One of the advantages of siting renewable energy facilities on previously used sites is that there is often already existing transmission and distribution infrastructure, roads and railways in place, especially where larger utility-scale projects that interconnect to the electric grid are planned.
-Local governments can provide permitting assistance or waive it and create Brownfield site friendly zoning regulations for renewable energy development.
-Regulatory requirements relating to environmental remediation can substantially add to project costs and timelines when developing renewable energy on Brownfield sites.
-Federal tax incentives like the Brownfields Expensing Tax Incentive and the New Markets Tax Credit lower costs for Brownfield-sited renewable energy projects.
-EPA Brownfield Sites grants for cleanup, revolving loan fund grants, and Brownfields-related job training grants lower costs for developers.
-Renewable energy development often poses a lower risk of exposing humans to contamination than residential or certain commercial purposes; hence, compliance in states with variable cleanup standards will generally be less costly than in states with one-size-fits-all cleanup standards.

Orrell, A. C. and N. Foster (2015). 2014 Distributed Wind Market Report, Pacific Northwest National Laboratory, U.S. Department of Energy.

Abstract: This annual report describes trends and benchmarking regarding distributed wind generation capacity. Distributed wind reached a cumulative capacity of almost 1 GW (906 MW) in the United States in 2014, reflecting nearly 74,000 wind turbines deployed across all 50 states, Puerto Rico, and the U.S. Virgin Islands; however, the state of the market is mixed. Installations of large-scale turbines (greater than 1 MW) grew almost threefold from 20.4 MW in 2013 to 57.5 MW in 2014 while the markets for distributed wind systems using small (up through 100 kW) and mid-size (101 kW to 1 MW) wind turbines continued to struggle since achieving record sales in 2008 through 2012. Small and midsize turbines added only 3.7 and 2.4 MW in 2014, respectively,

compared to 5.6 and 4.4 MW, respectively, in 2013. The outlook for distributed wind in the United States remains mixed, with market drivers including new financing schemes and certification requirements, and new export markets for domestic manufacturers. Challenges continue to be competition from solar photovoltaics, permitting and soft cost barriers, and the low cost of other sources of electricity.

Research Notes: This report does not specifically discuss the costs of siting renewable energy projects on contaminated land. However, it breaks out the cost components typical of distributed-scale wind projects (10 kW land-based wind). The report estimates O&M costs.

Trimarchi, P. (2013). "Structured Approach Can Help Solar Developers Fulfill Promise of Brownfields." Bloomberg.

Abstract: The significant potential of brownfields for commercial and utility-scale solar development in the U. S. has been recognized for some time now, and developers have spent many hours scouting former landfills and historic industrial sites for suitable project locations.

Research Notes: Brownfields are frequently close to transmission lines and utility substations, making it easier to transport to the grid the power they generate, hence lowering costs.
-Brownfields are often abandoned or owned by an entity that is eager to get rid of them, making them relatively cheap.
-Local governments are usually eager to use Brownfield sites productively, which encourages them to streamline the process of obtaining required municipal approvals, hence lowering costs.
-New York offers developers certain liability protections, a refundable tax credit worth up to 50 percent of certain remediation costs, and a refundable tax credit for up to 22 percent of the project's capital costs.
-Additional proposed regulations would exempt solar installations of less than 25 megawatts on landfills from the need to comply with the State Environmental Quality Review Act (SEQRA), a requirement that often leads to lengthy environmental impact reviews and adds significant cost to a project.

Whitbread-Abrutat, P. and N. Coppin (2012). "Renewables Revive Abandoned Mines." Renewable Energy World.com.

Abstract: How can the potential negative legacy of a mine site be converted into a positive inheritance for the wider environment and local communities? Recent imaginative renewable energy projects give good grounds for confidence that many former mine sites can be ideal locations for developing alternative energy generation facilities, simply by looking in a new light at some of the qualities that made them problematic in the first place.

Research Notes: Sites previously used as mines often already have the necessary electricity transmission lines and transport infrastructure in place; hence, siting renewable

energy projects on them lowers the capital costs needed.
-Land transaction costs are generally lower and the process can be simpler because brownfield areas tend to be owned by fewer landowners than a similar greenfield area.

III. BARRIERS AND OTHER CONSIDERATIONS TO SITING RE PROJECTS ON CLS, AND SOLUTIONS

Jensen, B. B. (2010). Brownfields to green energy: redeveloping contaminated lands with large-scale renewable energy facilities, Massachusetts Institute of Technology.

Abstract: This thesis uses case studies of one unsuccessful, and three successful brownfield-to-renewable energy projects to identify common barriers such projects face and how those barriers can be overcome. The most significant barriers identified are those typical of brownfield development: cleanup costs, liability risks, uncertainty, technical and legal complexity, and the need to coordinate multiple stakeholders. These barriers can be overcome through strong partnerships characterized by full cooperation among developers, property owners, regulators, and local officials. Political and public support enables cooperation between public and private stakeholders. This support is driven by an expectation that brownfield-to-renewable energy projects will improve the city's image and stimulate development of the clean energy industry locally. The three successful projects received substantial public support. This suggests that locating renewable energy facilities on contaminated lands is a possible solution to the siting controversies faced by new renewable energy facilities, and by wind farms especially. Renewable energy facilities offer a reuse option for brownfields that can coexist with ongoing remediation. Carving-out less polluted parcels from large properties for phased development is a strategy that has great potential to expand renewable energy development on brownfields and provide property owners revenue that can facilitate complete remediation. The thesis concludes with recommendations for local, state, and federal actions to encourage and facilitate brownfields-to-renewable energy projects. Recommended local level actions include incorporating renewable energy into municipal comprehensive plans and brownfield redevelopment programs. Overall, recommendations emphasize facilitating the "carve-out" strategy (i.e. use the cleanest parts of brownfields for new energy projects) and modifying financial incentives to favor brownfield sites.

Research Notes: The process of meeting environmental standards, ownership and liability issues, and the responsibility of maintaining site remediation systems and site controls is very bureaucratic and complicated. States and the EPA could modify voluntary cleanup programs to facilitate the division of potentially contaminated sites into smaller Brownfield parcels so that those with less contamination could be developed faster.
-When developing a Brownfield site there are complications due to the number of parties involved in remediation process.
-A study of factors that influence Brownfield site revealed lack of cleanup funds, need for environmental assessments, and liability issues as major concerns.

Levitan, D. (2011). "Brown to Green: A New Use For Blighted Industrial Sites." <u>Yale Environment360</u>.

Abstract: This article explores a few Brownfields in the U.S. that are as well suited to developing renewable energy. Communities from Philadelphia to California are discovering government support is critical to enable solar and wind entrepreneurs to make use of these abandoned lands.

Research Notes: On some sites, the options for reuse could be restricted because of the cleanup of contaminants, or a need to wait for those contaminants to disperse.
-When toxic contaminants are involved, there is risk that renewable energy developers may be held responsible for the cleanup costs at a site. In some instances the EPA can issue "comfort letters" that aim to allay those fears and provide guidance for developers to protect against liability issues.

Macknick, J., et al. (2013). Solar Development on Contaminated and Disturbed Lands, NREL.

Abstract: This report examines the prospect of developing utility- and commercial -scale concentrated solar power (CSP) and solar photovoltaics (PV) technologies on degraded and environmentally contaminated lands. The potential for solar development on contaminated and disturbed lands was assessed, and for the largest and highest solar resource sites, the economic impacts and feasibility were evaluated. Overall, levelized cost of electricity (LCOE) tends to depend on the solar resource and electricity generated per land area, which varies by location. Generally, LCOE was lower in the Southwest where the amount of electricity generated is highest. Developing solar power on contaminated and disturbed lands can help create jobs and revitalize local and state economies, and selecting these sites over greenfield sites can potentially have permitting and environmental mitigation advantages.

Research Notes: There is no common definition for "disturbed" lands, which complicates efforts to select appropriate lands.
-Siting renewable projects on contaminated lands that are located in remote areas could lead to an increase in transmission costs and other infrastructure-related costs, e.g., building roads, and temporary housing for workers.
-Certain contaminated lands may have liability and regulatory challenges associated with their development.

Miller, C. (2013). "Transformation of Blight: Fixing the CERCLA Lessee Problem to Develop Renewable Energy, The." George Washington Law Review **82**: 1267.

Abstract: This paper discusses how the Comprehensive Environmental Response, Compensation, and Liability Act, CERCLA, fails to define the liability of a lessee for preexisting contamination – the lessee of a site could be held liable as an owner or operator of that site, and further, that lessee may be subject to joint liabilities for past contamination. Additionally, the Small Business Liability Relief and Brownfields Revitalization Act ("Brownfields Amendments") fails to extend a defense against existing liabilities to developers who seek to lease Superfund sites, it only protects those who buy Superfund sites.

Research Notes: There is risk that a developer's actions may cause the migration of contaminants, making the developer liable.
-EPA guidance does not create an actual lessee liability defense against third parties

under CERCLA, so a court could still hold a lessee liable, regardless of EPA's enforcement discretion in applying the purchaser defense.
-The unique financing structure and the lifespan of renewable energy equipment require renewable energy developers to lease, rather than purchase, land; hence, the CERCLA liability issue is a major problem.

Mosey, G., et al. (2007). Converting Limbo Lands to Energy-Generating Stations: Renewable Energy Technologies on Underused, Formerly Contaminated Sites. Golden, CO, National Renewable Energy Laboratory.

Abstract: This report addresses the potential for using "Limbo Lands" as sites for renewable energy generating stations. Limbo Lands are considered as underused, formerly contaminated sites, and include former Superfund sites, landfills, brownfields, abandoned mine lands, former industrial sites, and certain government installations. The National Renewable Energy Laboratory (NREL) conducted this study for the U.S. Environmental Protection Agency (EPA), National Risk Management Research Laboratory, Sustainable Technology Division (NRMRL-STD). The objective of this report, which provides a geographic screening of potential sites, is to address Limbo Lands that are ready for redevelopment and their feasibility with renewable energy technologies (RETs). The report discusses reasons for considering RETs (and which ones) as a redevelopment option on Limbo Lands, describes the geographic screening process, identifies high-potential limbo land sites for RET redevelopment, includes discussion of two specific types of Limbo Lands: brownfields and abandoned mine lands, and provides conclusions and recommendations.

Research Notes: Data for screening Limbo Lands that have renewable energy potential are limited; there is need for combining multiple sources to conduct a comprehensive geographic screening. For data to be useful for this geographic screening, it must include parcel size, geographic locator information, and status of cleanup at the site.

National Association of Local Government Environmental Professionals (2012). Cultivating Green Energy on Brownfields: A Nuts and Bolts Primer for Local Governments, National Association of Local Government Environmental Professionals.

Abstract: This paper offers a primer for local governments interested in investigating whether renewable energy development may be the right choice for Brownfields in their communities. This primer is not intended to serve as a step-by-step guide to the development of a renewable energy project on a Brownfield for the simple reason that the process for developing a renewable energy project will depend on site specific factors. Rather, it provides a starting point for local governments to consider whether renewable energy facilities may be appropriate for local brownfield sites, tools to help navigate the economic issues that determine whether a particular project is feasible, and information about how permitting, zoning, siting, liability, and other regulatory issues affect the development of renewable energy on Brownfield sites.

Research Notes: Local governments need to reduce uncertainty and make project

development more likely by conducting (or supporting) Phase I environmental assessments of Brownfields in their communities; tailoring local regulatory remediation requirements toward renewable energy development; and advertising the potential reuse status of Brownfields in their community.
-There are liability risks surrounding litigation or regulatory enforcement for the assessment and cleanup of Brownfield sites; there is need for ancillary mechanisms for managing potential brownfield liability e.g. entering the Brownfield site into a state voluntary cleanup program (VCP), acquiring liability insurance, negotiating indemnification and cost-sharing provisions into development and operational contracts, and obtaining a comfort and status letter.

Outka, U. (2010). Siting Renewable Energy: Land Use and Regulatory Context. Rochester, NY, Social Science Research Network.

Abstract: This article takes up the increasingly important land use question of siting for renewable energy. As concern over climate change grows, new policies are being crafted at all levels of government to support renewable energy as a way of reducing greenhouse gas emissions. These policies are driving the need to site and construct new power plants that will utilize renewable resources. Historically, power plant siting has been the province of state and local governments, so the regulatory context into which renewables are being integrated varies, sometimes significantly, jurisdiction by jurisdiction. To examine this regulatory context, this article focuses on Florida – the third largest consumer of electricity in the U.S. with less than two percent generated from renewable resources. The article first provides an overview of Florida’s power supply sector and sets out the existing regulatory context for terrestrial siting of energy facilities. It then situates Florida’s most promising renewable resources within that context, identifies regulatory barriers that implicate siting, and considers the siting issues unique to each resource. As the article explains, we now have a window of opportunity in which state and local governments can plan for and guide renewable energy siting – an approach that contrasts with utility-driven planning and siting that has long been standard practice.

Research Notes: The regulatory context for permitting a project at a closed landfill or other Brownfield site involves liability considerations for site owners, renewable energy developers, and regulators; site work must ensure that known or potential contamination is not disturbed.
-Insufficient regulatory support for interconnection to the electrical grid (a basic siting prerequisite), and legal and regulatory requirements act as barriers to the physical installation of solar power systems.
Variation of regulations from jurisdiction to jurisdiction is a potential time and cost barrier, as system installers find themselves navigating multiple regulations.

Outka, U. (2012). "The Energy-Land Use Nexus." Journal of Land Use & Environmental Law **27**: 245-257.

Abstract: This Symposium Essay explores the contours of the 'energy-land use nexus' – the rich set of interrelationships between land use and energy production and

consumption. This underexplored nexus encapsulates barriers and opportunities as the trajectory of U.S. energy policy tilts away from fossil fuels. The Essay argues that the energy-land use nexus provides a useful frame for approaching policy to minimize points of conflict between energy goals on the one hand and land conservation on the other.

Research Notes: There is risk of human exposure on sites where contamination is not well documented or where contaminants may have migrated into onsite soils via surface water or groundwater flow from nearby contaminated sites.

Sigman, H. (2009). Environmental Liability and Redevelopment of Old Industrial Land, National Bureau of Economic Research.

Abstract: Many communities are concerned about the reuse of potentially contaminated land and believe that environmental liability is a hindrance to redevelopment. However, with land price adjustments, liability might not impede the reuse of this land. Existing literature has found price reductions in response to liability, but few studies have looked for an effect on vacancies. This paper studies variations in state liability rules — specifically, strict liability and joint and several liability — that affect the level and distribution of expected private cleanup costs. It explores the effects of this variation on industrial land prices and vacancy rates and on reported brownfields in a panel of cities across the United States. In the estimated equations, joint and several liability reduces land prices and increases vacancy rates in central cities. Neither a price nor quantity effect is estimated from strict liability. The results suggest that liability is at least partly capitalized, but does still deter redevelopment.

Research Notes: This paper uses econometric methods to quantitatively affect the impact of liability regimes on vacancy rates and industrial land prices. Joint-and-several-liability is shown to reduce land prices and hinders re-development in urban areas. The results show that joint-and-several liability corresponds to between a 39 percent in vacancy rates (a reduction in occupied land of 4%). Joint and several liability corresponds to 90% more brownfields, as liability rules are more important for those sites. This supports the notion of liability relief for buyers.

Sousa, C. D. (2000). "Brownfield Redevelopment versus Greenfield Development: A Private Sector Perspective on the Costs and Risks Associated with Brownfield Redevelopment in the Greater Toronto Area." Journal of Environmental Planning and Management **43**(6): 831-853.

Abstract: This paper examines the nature of the economic costs and risks involved in Brownfield versus Greenfield redevelopment in the Greater Toronto Area (Ontario, Canada) from a private sector perspective, and assess the potential effectiveness of different policies and programs designed to attenuate associated costs and risks. Through interviews, case-studies and an analysis of hypothetical development scenarios, it has been found that the perception that Brownfield redevelopment is less cost-effective and entails greater risks than Greenfield development, on the part of the private sector, is true for industrial projects in the province, but not for residential ones, which were found to be feasible, given the assumptions of the present study. Furthermore, the study has found

that the attractiveness of residential Brownfield projects can increase considerably with minor policy changes, but that promoting industrial redevelopment will require a more vigorous approach that employs a variety of environmental policy and economic development measures.

Research Notes: Common barriers include the lack of clarity and uncertainty created by different environmental laws throughout the country related to environmental liability and clean-up responsibility; the application of joint-and-several liability, whereby one party can be held liable for the entire clean-up, regardless of its specific contribution to the pollution of the site.
-The implementation of complex scientific standards governing clean-up and the limited availability of insurance options also deters investors.

Tam, E. K. L. and P. H. Byer (2004). "Estimating the Liability of Redeveloped Contaminated Lands." Journal of Urban Planning and Development **130**(4): 184-194.

Abstract: The redevelopment of brownfields has been promoted heavily in recent years to return contaminated lands to productive use. However, concerns about liability can complicate and hinder remediation efforts. The proponent of redevelopment faces possible legal action if the site poses health risks to users of the site and adjacent sites. Liability is often treated as a single factor but it is in fact composed of various elements that are interwoven with the future site use and chosen remedial action. This paper presents a structured method for estimating liability and its relationship to site use and remedial action. It critically examines the factors that contribute to liability and how the results can be integrated into the selection of the most appropriate site use and remedial action. The method offers a tiered approach for evaluating liability, starting with a simpler, uniform contamination scenario and progressing to a more complex, non-uniform situation. The resulting analysis is formatted in a matrix adaptable to multi-objective decision decision-making. A hypothetical example illustrates how liability can be examined using this method.

Research Notes: This article addresses liability barriers faced by remediation and redevelopment efforts. Liability concerns are broken down into their various elements, and the article proposes a matrix for evaluating the magnitude of liability concerns.

Tam, E. K. L. and P. H. Byer (2002). "Remediation of contaminated lands: A decision methodology for site owners." Journal of environmental management **64**: 387-400.

Abstract: Deciding how to remediate and redevelop contaminated lands should involve more than just selecting remediation techniques to clean a site to meet regulations for a predetermined site use. Owners and their consultants also need to understand aspects such as alternative site uses and liability, and how issues such as uncertainty can affect them. A methodology has been developed that provides a framework for current site owners when making decisions. It clarifies the above issues and details the type of information that is needed. It offers a step-by-step approach to improve decision making when contemplating remediation of contaminated sites by identifying the site use and remedial action combination that maximizes the current owner's net benefits. It examines

various factors in decision making--with special emphasis on the timely issues of liability and uncertainty--and how expert opinion can be used to address diverse or incomplete data. Future research should include developing a complementary methodology that incorporates community and ecological objectives, resulting in a unified decision framework.

Research Notes: Uncertainty with regard to considerations such as liability and alternative site uses can be a barrier to redevelopment. This article describes a systematic methodology for current site owners to lay out the information site owners need to gather and a framework to select remediation and re-use options to maximize net benefits.

Trimarchi, P. (2013). "Structured Approach Can Help Solar Developers Fulfill Promise of Brownfields." Bloomberg. from http://www.bna.com/structured-approach-can-help-solar-developers-fulfill-promise-of-brownfields/.

Abstract: The significant potential of Brownfields for commercial and utility-scale solar development in the U. S. has been recognized for some time now, and developers have spent many hours scouting former landfills and historic industrial sites for suitable project locations.

Research Notes: There are concerns about the project disturbing any contamination remaining at the site or impacts on the engineering controls like caps or covers.
-Liability risk – regulations generally impose cleanup obligations not only on the entity that caused the contamination, but also on the current owner and operator.
-EPA comfort letters are insufficient for addressing all potential liability, as they are often limited in their scope.
-Additional investigation, remediation and/or site preparation costs for a Brownfield site often make Brownfield projects too expensive to pursue.
-There is a lengthy regulatory approval process for projects on Brownfields.

US Department of Energy (2012). Chapter 7: Solar Power Environmental Impacts and Siting Challenges, US Department of Energy.

Abstract: The SunShot Initiative was launched in February 2011 with the goal of making solar energy cost- competitive with conventional electricity generating technologies within the decade. Achieving this goal will require dramatic decreases in the cost structure of solar technologies — on the order of a 75% reduction— across all markets including residential, commercial, and utility - scale deployments of solar. To do this most effectively, the SunShot Initiative spans the full spectrum from basic science to applied research and development. It also spans across multiple U.S. Department of Energy (DOE) offices, including Energy Efficiency and Renewable Energy (EERE), Advanced Research Projects Agency - Energy (ARPA-E) and the Office of Science (SC).

Research Notes: Although state and federal laws and policies are intended to clarify and provide protection against liability risks related to developing contaminated land, the applicability of these laws and policies depends on the specifics of each potential project.

-There is lack of cooperation between Federal and State agencies responsible for permitting and streamlining the process of siting renewables among agencies. Although several States have undertaken efforts to streamline the permitting processes with the Federal government, there has not been a region-wide effort to achieve this goal on a broader scale.

Whitbread-Abrutat, P. and N. Coppin (2012). "Renewables Revive Abandoned Mines." Renewable Energy World.com.

Abstract: How can the potential negative legacy of a mine site be converted into a positive inheritance for the wider environment and local communities? Recent imaginative renewable energy projects give good grounds for confidence that many former mine sites can be ideal locations for developing alternative energy generation facilities, simply by looking in a new light at some of the qualities that made them problematic in the first place.

Research Notes: The nature and stability of the dump material may be a challenge in constructing adequate foundations for turbines.

Whitney, H. (2003). "Cities and Superfund: Encouraging Brownfield Redevelopment." Ecology Law Quarterly **30**: 59-112.

Abstract: Abandoned industrial sites known as "brownfields" have created severe environmental problems across the United States, affecting public health and the livability of urban neighborhoods. This article starts from the basic proposition that cities-not private parties, not states, and not the federal government-are in the best position to cleanup contaminated properties within their borders. It explores the disincentives that federal Superfund law gives cities to cleanup these sites and the trouble cities have under this law recovering costs of cleanup from responsible parties. Absent congressional overhaul of Superfund, this article recommends state law solutions to supplement federal law. It shows how California's Polanco Redevelopment Act has given redevelopment agencies the ability to recover all their costs of cleanup from responsible parties and how it has enabled cities in California to cleanup brownfields within their borders.

Research Notes: Existing contamination is one barrier to re-development. Private developers are sometimes not willing to step in at a stage where the property still needs cleanup. State or local authorities have an interest in redevelopment. The article recommends empowering state and local redevelopment authorities to initiate or order cleanup of contaminated sites by owners, or to acquire sites by eminent domain in order to initiate cleanup by local authorities. These redevelopment authorities could then be reimbursed similar to CERCLA provisions for PRPs, rather than having EPA initiate the process. While CERCLA grants local and state authorities this power, only California's Polanco Act effectively exercises this option.

IV. FINANCING CONSIDERATIONS OTHER THAN COST IMPACTS

Eiffert, P. (1999). The Borrower's Guide to Financing Solar Energy Systems: A Federal Overview, U.S. Department of Energy.

Abstract: The Borrower's Guide to Financing Solar Energy Systems: A Federal Overview provides information that can assist both lenders and consumers in financing solar energy systems, which include both solar electric (photovoltaic) and solar thermal systems. This guide also includes information about other ways to make solar energy systems more affordable, as well as descriptions of special mortgage programs for energy-efficient homes.

Research Notes: Article discusses eligibility criteria, loan amounts, interest rates, and time frames set by entities that fund renewable energy in the US.

-Financing resources covered in the article include Fannie Mae, the Federal Home Mortgage Loan Corporation, the U.S. Departments of Agriculture, Energy, Housing; Urban Development, and Veterans Affairs, U.S. Environmental Protection Agency, and U.S. Small Business Administration programs.

-Funds come in the form of mortgages, loans, and securities.

-Eligible contractors include but are not limited to: Federal agencies, utilities, energy service companies, state governments, and individuals for residential energy efficiency improvements.

Harper, J., et al. (2007). Wind Project Financing Structures: A Review & Comparative Analysis, Lawrence Berkeley National Laboratory.

Abstract: This report surveys the seven principal financing structures through which most new utility-scale wind projects in the United States have been financed from 1999 to the present, excluding projects owned by investor-owned and publicly-owned utilities where the project becomes part of the utilities' internal generating portfolio and rate base. The report defines utility-scale wind projects as those designed to sell electricity directly to utilities or into power markets on a wholesale basis. The report does not cover financing structures used for smaller community-based wind power projects, though it may have some indirect utility for parties considering such projects, as several financing options used for smaller projects are derived from structures first conceived for larger projects. Finally, this report is relevant only to the U.S. market, since the presence and structure of the Tax Benefits have driven the development of financing structures in ways not applicable for other national markets.

Research Notes: This report chronicles how wind projects have been financed in the past few decades, and then discusses current financing structures. The report offers a decision matrix to determine the most suitable financing structure, given the availability of tax benefits and developer financing preferences. Project costs, investor returns, and the levelized cost of energy are compared across different financing structures.

Kollins, K., et al. (2010). Solar PV Project Financing: Regulatory and Legislative Challenges for Third-Party PPA System Owners, National Renewable Energy Laboratory.

Abstract: Many end users of electricity would like to use on-site photovoltaic (PV) generation to hedge against volatile electric utility bills and reduce climate change impacts. However, PV systems have high initial costs, and they must be properly operated and maintained to deliver expected benefits. Providing a potential solution to these cost challenges is a model in which a third-party owner uses a power purchase agreement (PPA) to finance an on-site PV system. This model—the third-party PPA model—allows a developer to build and own a PV system on the customer's property and sell the power back to the customer. In addition, the third party PPA model enables the customer to support solar power while avoiding most or all initial costs as well as responsibilities for operations and maintenance, both of which typically transfer to the developer. These advantages appeal to owners of residential and commercial buildings who would like to obtain solar PV systems.

Research Notes: Power purchase agreements (PPAs) can provide financing for the high initial costs of PV systems for end users of electricity who would like to use on-site PV solar generation. Third-party PPA models can allow developers to build and own a solar PV system on a customer's property, with the developer selling the power back to the customer. When the definition of electric utilities includes power generation equipment (such as solar PV equipment), third-party owned systems may face regulatory challenges, such as whether third-party owners will be regulated as utilities and whether net metering is available. Some states have specifically clarified these issues to facilitate third-party PPA arrangements.

Mendelsohn, M., et al. (2012). The Impact of Financial Structure on the Cost of Solar Energy, National Renewable Energy Laboratory.

Abstract: To stimulate investment in renewable energy generation projects, the federal government developed a series of support structures that reduce taxes for eligible investors—the investment tax credit, the production tax credit, and accelerated depreciation. The nature of these tax incentives often requires an outside investor and a complex financial arrangement to allocate risk and reward among the parties. These financial arrangements are generally categorized as "advanced financial structures." Among renewable energy technologies, advanced financial structures were first widely deployed by the wind industry and are now being explored by the solar industry to support significant scale up in project development.1 This report describes four of the most prevalent financial structures used by the renewable sector and evaluates the impact of financial structure on energy costs for utility-scale solar projects that use photovoltaic and concentrating solar power technologies.

Research Notes: Choice of financing structures for renewable energy depend on project size, experience and comfort with the structure, projected output, the strength of the developer's balance sheet, the ability to use tax credits, speed of the financing process, and the investor's risk tolerance and preferences.

-The two major financial support structures for renewable energy offered by the federal government are (1) investment or production tax credits (ITC or PTC), and (2) an accelerated depreciation schedule for renewable energy projects known as the Modified Accelerated Cost Recovery System (MACRS) and a "bonus" depreciation that allows for additional acceleration of the tax benefits to investors. These advanced financial structures can impact energy costs for utility-scale solar projects.

-Financial structures that include project-level debt generally yield a lower levelized cost of energy (LCOE) compared to those that rely purely on equity capital, although raising

debt at the project level can be difficult for new developers.
-Debt is generally only available at the project level to very large projects or a portfolio of projects, e.g., $25 to $50 million or larger.

Mendelsohn, M., et al. (2015). Credit Enhancements and Capital Markets to Fund Solar Deployment: Leveraging Public Funds to Open Private Sector Investment, National Renewable Energy Laboratory.

Abstract: Broader penetration of solar energy requires development of consistently - available and lower - cost capital for project finance. This can be achieved by accessing the capital markets and its broad investor base through financial structures such as as set - backed securities (ABS), yieldcos, project bonds, and various other debt products. The transition to such innovative financial structures, however, is not guaranteed. Perceived risks of the solar asset class —including those related to technology, offtaker creditworthiness, and regulatory policy— can increase the required yield, increase probability of investor loss of interest and/or principal, or both. In many cases, this is a cyclical phenomenon: risk perception is fed by lack of historical knowledge, which is in turn fed by risk perception.

Research Notes: Accessing the capital markets through financial structures such as asset-backed securities (ABS), yieldcos, project bonds, and various other debt products can enhance the deployment of solar energy. However, perceived risks of the solar asset class—including those related to technology, off-taker creditworthiness, and regulatory policy—can increase the required yield, increase probability of investor loss of interest and/or principal, or both. To gain access to credit markets, "credit enhancements" are instruments that can enable investor confidence in an asset, such as by pooling projects into portfolios.

Trabish, H. K. (2012, 11/1/2012). "Utility-Scale PV Developers Confront Future of Solar Project Business."

Abstract: This article briefly discusses cost trade-offs in renewable energy projects of various sizes. The author mentions the risks associated with developing renewable energy projects on contaminated lands.

Research Notes: Some investors are wary of financing renewables on contaminated lands as compared to Greenfields because there is uncertainty regarding contaminant levels and cleanup costs.

Trimarchi, P. (2013). "Structured Approach Can Help Solar Developers Fulfill Promise of Brownfields." Bloomberg.

Abstract: The significant potential of brownfields for commercial and utility-scale solar development in the U. S. has been recognized for some time now, and developers have spent many hours scouting former landfills and historic industrial sites for suitable project locations.

Research Notes: Banks are risk averse and hesitant to finance Brownfield site development projects.

V. PROJECT CASE STUDIES

De Sousa, C. (2000). "Brownfield Redevelopment versus Greenfield Development: A Private Sector Perspective on the Costs and Risks Associated with Brownfield Redevelopment in the Greater Toronto Area." Journal of Environmental Planning and Management **43**(6): 831-853.

Abstract: This paper examines the nature of the economic costs and risks involved in brownfield versus greenfield redevelopment in the Greater Toronto Area (Ontario, Canada) from a private sector perspective, and the potential effectiveness of different policies and programs designed to attenuate associated costs and risks. Through interviews, case-studies and an analysis of hypothetical development scenarios, it has been found that the perception that brownfield redevelopment is less cost-effective and entails greater risks than greenfield development, on the part of the private sector, is true for industrial projects in the province, but not for residential ones, which were found to be feasible, given the assumptions of the present study. Furthermore, the study has found that the attractiveness of residential brownfield projects can increase considerably with minor policy changes, but that promoting industrial redevelopment will require a more vigorous approach that employs a variety of environmental policy and economic development measures.

Research Notes: Interview responses indicated that obtaining financing for Brownfield sites is more difficult as compared to Greenfield sites.
-Interview responses indicated that legal costs associated with Brownfield projects are generally double those associated with Greenfield sites due to fees for property review, consultation with government agencies, and communication with prospective purchasers.
-Brownfield projects entail higher contingency fees, higher realty taxes, higher development fees and higher financing costs due to the associated risks.
-Costs are also higher for Brownfield projects because they have longer timelines involving compilation and review of soil research, remediation plans, and the remediation process itself - e.g., 12 months for an industrial Brownfield redevelopment versus seven months for an industrial Greenfield development.

Levitan, D. (2011). "Brown to Green: A New Use For Blighted Industrial Sites." Yale Environment360.

Abstract: This article explores a few Brownfields in the U.S. that are as well suited to developing renewable energy. Communities from Philadelphia to California are discovering government support is critical to enable solar and wind entrepreneurs to make use of these abandoned lands.

Research Notes: Stringfellow site in Riverside County in Southern California was a hazardous waste dumping ground until 1972, with more than 34 million gallons of liquid industrial waste. This site was using power from the grid to power its cleanup process, and it was an expensive proposition for the state to pay for the power that was required. A consultant's report on the site recommended a solar facility with a 250-kilowatt capacity, capable of providing nearly all the power for the cleanup.

Mendelsohn, M. (2010). "Batting for Percentage: New Development Model May Lead to More RE Deployment | Renewable Energy Project Finance." Renewable Energy Project Finance NREL.

Abstract: This article discusses the challenge of environmental impact assessments that hinder the development of renewable energy projects. The author proposes developing renewable energy projects on contaminated lands to avoid the lengthy permitting process.
Research Notes: Recurrent Energy, based in California, pursued small 5 – 20 MW projects on private Brownfield and dual-use sites such as the reservoir project in San Francisco thereby avoiding extended permitting requirements and cutting down development time with higher probability of success. In California, developing on a Brownfield site usually requires an environmental impact statement and a county-controlled California Environmental Quality Assessment (CEQA); however, the process was relatively modest because no species habitat was being threatened. To avoid drilling foundations and disturbing the already-impacted land, the company's photovoltaic projects use ballast and modest concrete pads.

National Association of Local Government Environmental Professionals (2012). Cultivating Green Energy on Brownfields: A Nuts and Bolts Primer for Local Governments, National Association of Local Government Environmental Professionals.

Abstract: This paper offers a primer for local governments interested in investigating whether renewable energy development may be the right choice for Brownfields in their communities. This primer is not intended to serve as a step-by-step guide to the development of a renewable energy project on a brownfield for the simple reason that the process for developing a renewable energy project will depend on site specific factors. Rather, it provides a starting point for local governments to consider whether renewable energy facilities may be appropriate for local brownfield sites, tools to help navigate the economic issues that determine whether a particular project is feasible, and information about how permitting, zoning, siting, liability, and other regulatory issues affect the development of renewable energy on Brownfield sites.

Research Notes: New York State voluntary cleanup program (VCP) was instrumental in supporting the transformation of a former steel plant into a 20 MW wind farm. To make the Steel Winds project possible, the developers worked with the City of Lackawanna, the EPA, the State of New York, and the Brownfield site owner to parcel 80 acres from a 1,600-acre RCRA site and enter that 80-acre parcel into the New York State VCP. By complying with the VCP and conducting limited remediation on the 80-acre parcel, the developers qualified for certain forms of liability relief, limited the scope of their potential liability, and avoided the requirement to remediate the full 1,600-acre site prior to redevelopment.
-Where possible, local governments can use a variety of land use mechanisms, e.g., zoning guidelines, land easements, ordinances, consent decrees and notices in land records to tailor remediation standards for Brownfields to the intended reuse of a site, to ease the cleanup burden. In Pittsfield, Massachusetts, the combination of tailored remediation standards and land use restrictions were instrumental in fostering the development of the Western Massachusetts Electric Company (WMECo) 1.8 MW Silver

Lake solar project on the site of a former manufacturing facility.

Whitbread-Abrutat, P. and N. Coppin (2012). "Renewables Revive Abandoned Mines." Renewable Energy World.com.

Abstract: How can the potential negative legacy of a mine site be converted into a positive inheritance for the wider environment and local communities? Recent imaginative renewable energy projects give good grounds for confidence that many former mine sites can be ideal locations for developing alternative energy generation facilities, simply by looking in a new light at some of the qualities that made them problematic in the first place.

Research Notes: Former mine sites can be ideal locations for solar energy generation, due to their often expansive and exposed positions, especially in areas with an aspect facing the sun. The Geosol solar plant at Espenhain, Leipzig, Germany, was constructed on a former lignite mine ash site. This plant generates 5 MW and saves around 3700 tons of CO2 every year. The site of the former Völklingen coal mines in Saarland, southwest Germany, has been converted into a solar energy park - the largest of its type when opened. It generates 8 MW from 50,000 photovoltaic panels covering 165,000m.
-Renewable energy developments on old mines address the problem of renewable energy variability to match demand through energy storage options. The Snowdonia, Wales, Dinorwig Power Station has six generating units with compressed air energy storage (CAES) systems that use cheaper off-peak energy to inject air underground to be stored under pressure as potential energy. When electricity is required at peak periods the air is withdrawn under pressure and used in conjunction with fuel to operate turbines.

VI. DISCUSSION OF THE RE-POWERING AMERICA'S LAND INITIATIVE

De Sousa, C. (2000). "Brownfield Redevelopment versus Greenfield Development: A Private Sector Perspective on the Costs and Risks Associated with Brownfield Redevelopment in the Greater Toronto Area." Journal of Environmental Planning and Management **43**: 831-853.

Abstract: This paper examines the nature of the economic costs and risks involved in brownfield versus greenfield redevelopment in the Greater Toronto Area (Ontario, Canada) from a private sector perspective, and the potential effectiveness of different policies and programs designed to attenuate associated costs and risks. Through interviews, case-studies and an analysis of hypothetical development scenarios, it has been found that the perception that brownfield redevelopment is less cost-effective and entails greater risks than greenfield development, on the part of the private sector, is true for industrial projects in the province, but not for residential ones, which were found to be feasible, given the assumptions of the present study. Furthermore, the study has found that the attractiveness of residential brownfield projects can increase considerably with minor policy changes, but that promoting industrial redevelopment will require a more vigorous approach that employs a variety of environmental policy and economic development measures.

Research Notes: The US EPA has sought to improve conditions for private redevelopment by reducing regulatory overlap among the different levels of government, by providing funds for pilot programs and by providing tax breaks, grants and other financial incentives.

Levitan, D. (2011). "Brown to Green: A New Use For Blighted Industrial Sites." Yale Environment360.

Abstract: This article explores a few Brownfields in the U.S. that are as well suited to developing renewable energy. Communities from Philadelphia to California are discovering government support is critical to enable solar and wind entrepreneurs to make use of these abandoned lands.

Research Notes: The EPA's Re-Powering America's Land initiative has assessed 11,000 sites, covering 15 million acres, for their renewable energy potential. The EPA has estimated that the total technical potential of energy sited on Brownfields (not taking into account practical or monetary considerations) is nearly 1 million megawatts, which is almost equivalent to the total existing U.S. electricity generating capacity.

Macknick, J., et al. (2013). Solar Development on Contaminated and Disturbed Lands.

Abstract: This report examines the prospect of developing utility- and commercial -scale concentrated solar power (CSP) and solar photovoltaics (PV) technologies on degraded and environmentally contaminated lands. The potential for solar development on contaminated and disturbed lands was assessed, and for the largest and highest solar resource sites, the economic impacts and feasibility were evaluated. Overall, levelized cost of electricity (LCOE) tends to depend on the solar resource and electricity generated per land area, which varies by location. Generally, LCOE was lower in the Southwest where the amount of electricity generated is highest. Developing solar power on contaminated and disturbed lands can help create jobs and revitalize local and state economies, and selecting these sites over greenfield sites can potentially have permitting and environmental mitigation advantages.

Research Notes: EPA is actively supporting renewable energy as a beneficial reuse and provides support to developers and system owners to address liability concerns.
-Developers could potentially reduce the risk of project delays and the possibility of litigation, as well as establish a sustainable land development policy by reusing a portion of the over 20 million acres of contaminated lands currently tracked by EPA.

National Association of Local Government Environmental Professionals (2012). Cultivating Green Energy on Brownfields: A Nuts and Bolts Primer for Local Governments, National Association of Local Government Environmental Professionals.

Abstract: This paper offers a primer for local governments interested in investigating whether renewable energy development may be the right choice for Brownfields in their communities. This primer is not intended to serve as a step-by-step guide to the development of a renewable energy project on a brownfield for the simple reason that the process for developing a renewable energy project will depend on site specific factors. Rather, it provides a starting point for local governments to consider whether renewable energy facilities may be appropriate for local brownfield sites, tools to help navigate the economic issues that determine whether a particular project is feasible, and information about how permitting, zoning, siting, liability, and other regulatory issues affect the development of renewable energy on Brownfield sites.

Research Notes: The RE-Powering America Program evaluates the feasibility of siting renewable energy projects on specific Brownfields. In November of 2011, EPA and NREL granted 26 sites technical assistance awards, an investment that will total approximately 1 million dollars. Past sites examined by an EPA/NREL assessment grant include the Jeddo Tunnel in Drums, Pennsylvania, which carries heavy metals and other toxic contaminants from coal mining operations into local tributaries.

Streater, S. (2009). "Green shoots rise from brownfields." The Daily Climate.

Abstract: This article addresses the topic of eliminating the biggest hurdle to expanding renewable energy, i.e., the need for suitable sites to place commercial-scale wind and solar farms by reusing hundreds of old mines, landfills and industrial sites.

Research Notes: The Environmental Protection Agency and the National Renewable Energy Laboratory have identified nearly 4,100 contaminated sites deemed economically suitable for wind and solar power development, as well as biomass.
-The agency plans to survey each parcel, and then craft a single environmental impact statement that establishes the criteria for reclaiming disturbed and contaminated sites in the state before reusing them for renewable energy. The BLM plans to make these sites available to solar-power developers.

Trimarchi, P. (2013). "Structured Approach Can Help Solar Developers Fulfill Promise of Brownfields." Bloomberg.

Abstract: The significant potential of brownfields for commercial and utility-scale solar development in the U. S. has been recognized for some time now, and developers have spent many hours scouting former landfills and historic industrial sites for suitable project locations.

Research Notes: The EPA prescreened 66,000 currently or formerly contaminated properties for various criteria important to renewable energy developers and also created various handbooks and guidance documents describing best practices for development on contaminated lands to make developers more comfortable with the legal risks posed by these sites.

US Department of Energy (2012). Chapter 7: Solar Power Environmental Impacts and Siting Challenges, US Department of Energy.

Abstract: The SunShot Initiative was launched in February 2011 with the goal of making solar energy cost- competitive with conventional electricity generating technologies within the decade. Achieving this goal will require dramatic decreases in the cost structure of solar technologies — on the order of a 75% reduction— across all markets including residential, commercial, and utility - scale deployments of solar. To do this most effectively, the SunShot Initiative spans the full spectrum from basic science to applied research and development. It also spans across multiple U.S. Department of Energy (DOE) offices, including Energy Efficiency and Renewable Energy (EERE), Advanced Research Projects Agency - Energy (ARPA-E) and the Office of Science (SC).

Research Notes: RE-Powering America's Land project maps and datasheets provide information about more than 2 million hectares of land with potential for utility-scale concentrated solar power (CSP) or PV installations in the western United States, although much of this land may not be suitable owing to slope or existing use.

US Interior and Energy Departments (2011). US Public Lands Solar Policy: Wrong From The Start, Solar Done Right, US Interior and Energy Departments.

Abstract: The Departments of Energy and the Interior are preparing a Programmatic Environmental Impact Statement (PEIS) to evaluate utility-scale solar energy development, to establish environmental policies and mitigation strategies for solar energy projects, and to amend relevant BLM land use plans with the consideration of establishing a new BLM Solar Energy Program. Though it is billed as a way of making solar development "Smart From The Start," the PEIS is a significant step further into a reckless, ultimately ineffective energy policy. The need to move to a renewable-based energy economy, and quickly, is urgent. Global warming threatens to unwind the relatively stable climate regime that has supported the evolution of present human and ecological systems.

Research Notes: EPA has identified millions of acres of abandoned mine lands, Brownfields, and Federal and Non-Federal Superfund sites that may be suitable for solar and other non-fossil-fuel energy projects.
-In California alone, environmental organizations have identified almost 300,000 acres of Bureau of Land Management land and adjacent private lands that would meet their stricter siting criteria for utility-scale solar.
-EPA identified contaminated sites around the country with a technical potential of 920,000 MW of solar generation and strongly encouraged BLM and DOE to seek alternatives to siting solar developments on intact public lands.

Whitbread-Abrutat, P. and N. Coppin (2012). "Renewables Revive Abandoned Mines." Renewable Energy World.com.

Abstract: How can the potential negative legacy of a mine site be converted into a positive inheritance for the wider environment and local communities? Recent imaginative renewable energy projects give good grounds for confidence that many former mine sites can be ideal locations for developing alternative energy generation facilities, simply by looking in a new light at some of the qualities that made them problematic in the first place.

Research Notes: The US Environmental Protection Agency's Re-Powering America's Land Program aims to meet a significant proportion of the nation's 31 percent growth in renewable energy demand over the next 25 years by encouraging renewable energy development on contaminated lands. The EPA has identified 480,000 such sites covering 6 million hectares across the country, of which 345,000 hectares have been cleaned up or protected long-term and are available for development.

APPENDIX C – SOLAR AND WIND PROJECT COST COMPONENTS

C.1 SOLAR COST COMPONENTS

<table>
<tr><th>COST COMPONENT</th><th>COST FOR SMALL COMMERCIAL SOLAR (<250 KW) (2012$)[1]</th><th>COST FOR LARGE COMMERCIAL SOLAR (>=250 KW) (2012$)[1]</th><th>COST COMPONENT</th><th>COST FOR UTILITY-SCALE SOLAR IN SW U.S. (25 MW-DC) (2014$)[2]</th><th>CHANGES IN COSTS ON CONTAMINATED LANDS</th></tr>
<tr><td rowspan="2">Customer acquisition (surveyed)</td><td rowspan="2">$0.13/W (2.6%)</td><td rowspan="2">$0.03/W (0.7%)</td><td>Design/ Engineering</td><td>$0.03/W (1.3%)</td><td rowspan="3"></td></tr>
<tr><td>Civil Engineering/ Grading</td><td>$0.26/W (11.0%)</td></tr>
<tr><td>Installation labor (calculated)</td><td>$0.39/W (7.8%)</td><td>$0.17/W (4.7%)</td><td>Construction Equipment and Labor</td><td>$0.50/W (21.1%)</td></tr>
<tr><td>Permitting, inspection, and interconnection (surveyed)</td><td>$0.01/W (0.2%)</td><td><$0.01/W (<0.1%)</td><td>Interconnection/ Substation/ IT</td><td>$0.20/W (8.4%)</td><td>· May be possible to avoid certain permitting costs when selecting pre-zoned sites on contaminated lands. (Goodrich et al, 2012)
· PII labor requirements were typically higher for larger systems in second NREL bottom-up analysis, given the generally greater complexity of these PII processes for larger systems. (Friedman et al, 2013)
· Regulatory requirements relating to environmental remediation can substantially add to project costs. (NALGEP, 2012)</td></tr>
</table>

[1] National Renewable Energy Laboratory, "Benchmarking Non-Hardware Balance-of-System (Soft) Costs for U.S. Photovoltaic Systems, Using a Bottom-Up Approach and Installer Survey – Second Edition," by Barry Friedman, et al., NREL/TP-6A20-60412, October 2013. This report provides a further breakdown of transaction costs, into professional services (developer legal fees, tax-equity legal fees, accountants, independent engineering), financier expenses (fees from term debt, fees from construction debt/ revolving line of credit, interest on loan/ line of credit), and additional costs (inverter warranties, system production guarantees, construction insurance, debt service reserve, and O&M reserve).

[2] Lawrence Berkeley National Laboratory, "Utility-Scale Solar 2014: An Empirical Analysis of Project Cost, Performance, and Pricing Trends in the United States," by Mark Bollinger and Joachim Seel, LBNL-1000917, September 2015.

COST COMPONENT	COST FOR SMALL COMMERCIAL SOLAR (<250 KW) (2012$)[1]	COST FOR LARGE COMMERCIAL SOLAR (>=250 KW) (2012$)[1]	COST COMPONENT	COST FOR UTILITY-SCALE SOLAR IN SW U.S. (25 MW-DC) (2014$)[2]	CHANGES IN COSTS ON CONTAMINATED LANDS
			Transmission	$0.08/W (3.4%)	· Renewable energy often poses lower risk of exposing humans to contamination than residential or certain commercial purposes, so compliance in states with variable cleanup standards will generally be less costly than those with one-size-fits-all standards. (NALGEP, 2012) · If area is remote, transmission costs could be higher (in addition to other infrastructure-related costs, such as road-building and temporary housing construction). Alternatively, grid connection costs could be reduced by leveraging existing infrastructure. (Macknick et al, 2013)
Transaction costs (modeled)	$0.36/W (7.2%)	$0.33/W (8.1%)	Other (Land, Environmental, Permit, Insurance, Legal, PPA	$0.16/W (6.8%)	· "Land transaction costs are generally lower and process can be simpler because brownfield areas tend to be owned by fewer landowners than a similar area of greenfield." (Whitbread-Abrutat, 2012) · Lending costs are higher for brownfield sites than greenfield sites. (Jensen, 2010)
Indirect corporate costs (modeled)	$0.47/W (9.4%)	$0.47/W (11.5%)			
Installer/ developer profit (modeled)	$0.94/W (18.8%)	$0.45/W (11.1%)			
Supply chain costs (Feldman et al, 2013)	$0.42/W (8.4%)	$0.42/W (10.3%)			
Sales tax, 5% (Feldman et al, 2013)	$0.25/W (5.0%)	$0.20/W (5.0%)			
Permitting fees (assumed)	$0.07/W (1.4%)	$0.04/W (0.7%)			
All characterized soft costs	**$3.01/W (60.6%)**	**$2.10/W (52.0%)**			
Total hardware costs	$1.95/W (39.2%)	$1.95/W (48.1%)	Total hardware costs	$1.14/W (48.1%)	
Total costs	**$4.97/W (100%)**	**$4.05/W (100%)**	**Total costs**	**$2.37/W (100%)**	

Definitions of cost components:

<u>Small- and large-scale commercial solar PV installations</u>

- Customer acquisition: includes system design costs and all other project-specific customer acquisition costs (lead generation, bid and pro-forma preparation, contract negotiation)
- Installation labor: based on labor hours required for installation, breakdown between skilled and unskilled labor required for installation, and prevailing wage rates
- Permitting, interconnection, and inspection: based on labor hours required for permit preparation, permit package submittal, permitting inspection, interconnection process, and financial incentive application process
- Transaction costs: includes costs associated with arranging financing with equity and/or debt providers (here authors modeled transaction costs associated with power purchase agreement financed through a sale-leaseback arrangement with a tax-equity investor)
- Indirect corporate costs: includes additional corporate costs not associated with specific projects, such as the cost of renting office space, general advertising and marketing, and other expenses
- Installer/ developer profit: based on residual amount after deducting estimated hardware and soft costs from reported prices of installed systems
- Supply chain costs: includes cost of supply chain management
- Sales tax: assumed to be 5 percent
- Permitting fees: assumed $5,000 permitting fee for systems smaller than 250 kW and $25,000 for systems 250 kW or larger (the authors note that interconnection study costs vary substantially depending on PV penetration rates and system size, and did not attempt to estimate fees associated with interconnection study costs here)
- Hardware costs: includes cost of PV module, inverter, and non-electrical hardware

<u>Utility-scale solar PV installations</u>

Note: We were not able to find information from the LBNL study on the underlying assumptions and category definitions for these cost components, nor were we able to find information about which cost components include fees.

- Design/ engineering costs
- Civil engineering/ grading costs
- Construction equipment and labor costs
- Interconnection/ substation/ IT costs
- Transmission costs
- Other costs (land, environmental, permit, insurance, legal, PPA)
- Hardware costs: includes costs of PV modules, inverter, and trackers

C.2 WIND COST COMPONENTS

COST COMPONENT	TOTAL CAPITAL COSTS (83-M TOWER 1.9-MW LAND-BASED WIND SYSTEM, WITH TOTAL PROJECT SIZE OF 200 MW)[3]	COST COMPONENT	TOTAL INSTALLATION COSTS (31-M GUYED TOWER 10-KW LAND-BASED WIND SYSTEM)[4]	TOTAL INSTALLATION COSTS (31-M LATTICE TOWER 10-KW LAND-BASED WIND SYSTEM)[2]	CHANGES IN COSTS ON CONTAMINATED LANDS
Turbine Costs: 68%					
Rotor Module	$0.28/W (16.3%)	Foundation	$0.33/W (4.8%)	$1.33/W (16.0%)	• For small turbines, "project installed costs can range widely because of site-specific issues such as foundation requirements and local installation labor" (DOE 2014).
Drivetrain/ Nacelle Module	$0.70/W (40.2%)	Turbine (including dealer markup)	$3.18/W (46.6%)	$3.18/W (38.2%)	
Tower Module	$0.21/W (12.0%)	Tower	$1.41/W (20.7%)	$1.68/W (20.2%)	
Financial Costs: 9%					
Construction Finance	$0.05/W (2.9%)				• Lending costs are higher for brownfield sites than greenfield sites (Jensen, 2010).
Contingency	$0.11/W (6.1%)				
Market Price Adjustment	$0.04/W (2.3%)				
Balance of System Costs: 23%					
Electrical Infrastructure	$0.15/W (8.7%)	Wiring Kit/ Wire Run	$0.43/W (6.3%)	$0.43/W (5.2%)	• Unit transmission costs of wind, among our sample, do not appear to increase significantly with higher levels of wind

[3] National Renewable Energy Laboratory, "2013 Cost of Wind Energy Review," by C. Mone et al., February 2015, NREL/TP-5000-63267. For 2.0 MW turbine size and total project size of 150 MW, see National Renewable Energy Laboratory, "Land-Based Wind Plant Balance-of-System Cost Drivers and Sensitivities," by C. Mone et al., May 2014, NREL/PO-6A20-61546; this report also approximates changes in costs associated with changes in project size or turbine size.

[4] U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy, Wind Program, "2013 Distributed Wind Market Report," August 2014, DE-AC05-76RL01830.

COST COMPONENT	TOTAL CAPITAL COSTS (83-M TOWER 1.9-MW LAND-BASED WIND SYSTEM, WITH TOTAL PROJECT SIZE OF 200 MW)[3]	COST COMPONENT	TOTAL INSTALLATION COSTS (31-M GUYED TOWER 10-KW LAND-BASED WIND SYSTEM)[4]	TOTAL INSTALLATION COSTS (31-M LATTICE TOWER 10-KW LAND-BASED WIND SYSTEM)[2]	CHANGES IN COSTS ON CONTAMINATED LANDS
Engineering Management	$0.02/W (1.1%)	Electrical Contractor	$0.64/W (9.3%)	$0.64/W (7.7%)	additions (Mills et al, 2009). • Unit transmission costs do not unambiguously increase in scenarios with increasing transmission length (Mills et al, 2009). • Unit transmission costs do, however, appear to increase in scenarios that added long transmission lines and relatively little new generation (Mills et al, 2009). • Equipment cost assumptions vary widely across studies in our sample (Mills et al, 2009). • If area is remote, transmission costs could be higher (in addition to other infrastructure-related costs, such as road-building and temporary housing construction). Alternatively, grid connection costs could be reduced by leveraging existing infrastructure. (Macknick et al, 2013)
Assembly and Installation[5]	$0.10/W (5.8%)	Shipping and Delivery	$0.18/W (2.6%)	$0.20/W (2.4%)	• May be possible to avoid certain permitting costs when selecting pre-zoned sites on contaminated lands (Goodrich et al, 2012). • Regulatory requirements relating to environmental remediation can substantially add to project costs (NALGEP, 2012). • Renewable energy often poses lower risk of exposing humans to contamination than residential or certain commercial purposes, so compliance in states with variable cleanup standards will generally be less costly than those with one-size-fits-all standards (NALGEP, 2012). • "Land transaction costs are generally lower and process can be simpler because brownfield areas tend to be owned by fewer landowners than a similar area of greenfield" (Whitbread-Abrutat, 2012).
Site Access, Staging, and Facilities	$0.04/W (2.7%)	Setup/ Crane	$0.40/W (5.9%)	$0.60/W (7.2%)	
Development Cost[3]	$0.03/W (1.9%)	Permitting and Miscellaneous	$0.25/W (3.7%)	$0.25/W (3.0%)	
Total	**$1.73/W (100%)**	**Total**	**$6.82/W (100%)**	**$8.31/W (100%)**	

[5] Assembly and Installation includes cranage fees; Development Cost includes interconnection and financing fees.

Definitions of cost components:

<u>1.9-MW Turbine, Part of 200-MW Installation</u>

- Rotor module costs: assumed 96.7-meter rotor diameter, includes costs of blades, pitch assembly, and hub assembly; captures wind energy and transfers it to the drivetrain (through the low-speed shaft)
- Drivetrain/ nacelle module costs: includes costs of nacelle structural assembly, drivetrain assembly, nacelle electrical assembly, and yaw assembly; provides structural interface between tower module, drivetrain module, and rotor module; provides housing for sensitive electrical and mechanical components and equipment; enables access by maintenance personnel
- Tower module costs: assumed 82.5-meter tower height; provides a support structure element that connects the nacelle, drivetrain, and rotor modules with the substructure and foundation, and has the ability to house electrical conversion equipment and provide emergency shelter
- Construction finance costs: estimated at 3 percent of hard costs, based on industry reporting; include carrying charges of expenditures on equipment and services incurred before COD
- Contingency financing costs: for the representative project, a $20.9 million contingency fund (6 percent) was assumed to cover any possible increases in capital costs; does not include contingencies set by manufacturers and contractors as part of supply contract pricing
- Market price adjustment costs: accounts for fluctuations in component costs, profit margins, foreign exchange rates, supply chain constraints, and other market conditions
- Electrical infrastructure costs: includes equipment and system installation to extract power from wind turbines via the array and transfer that power to the substation and then to the grid
- Engineering management costs: includes management activities from the financial close to the COD
- Assembly and installation costs: include assembly and installation activities conducted at the project site; assume that financial costs related to warranties, contractor insurance, SG&A, profit margin, and so on are loaded in rates for labor and equipment
- Site access, staging, and facilities costs: includes the activities and physical aspects of a staging area; elements needed to support the delivery, installation, storage, handling, and deployment of wind plant components
- Development costs: includes all activities from project inception to financial close (where financial close is the date in which project and financing agreements have been signed and all required conditions have been met)

<u>10-kW Distributed Wind Installations</u>

Note: We were not able to find information from the DOE study on the underlying assumptions and category definitions for these cost components – nor were we able to find information about which cost components include fees. (The report includes a methodology section in Appendix B, but these issues are not addressed – the focus is on the sample of installers who provided information for the study.)

- Foundation costs
- Turbine costs (including dealer markup)
- Tower costs
- Wiring kit/ wire run costs
- Electrical contractor costs
- Shipping and delivery costs
- Setup/ crane costs
- Permitting and miscellaneous costs