DOE OFFICE OF INDIAN ENERGY

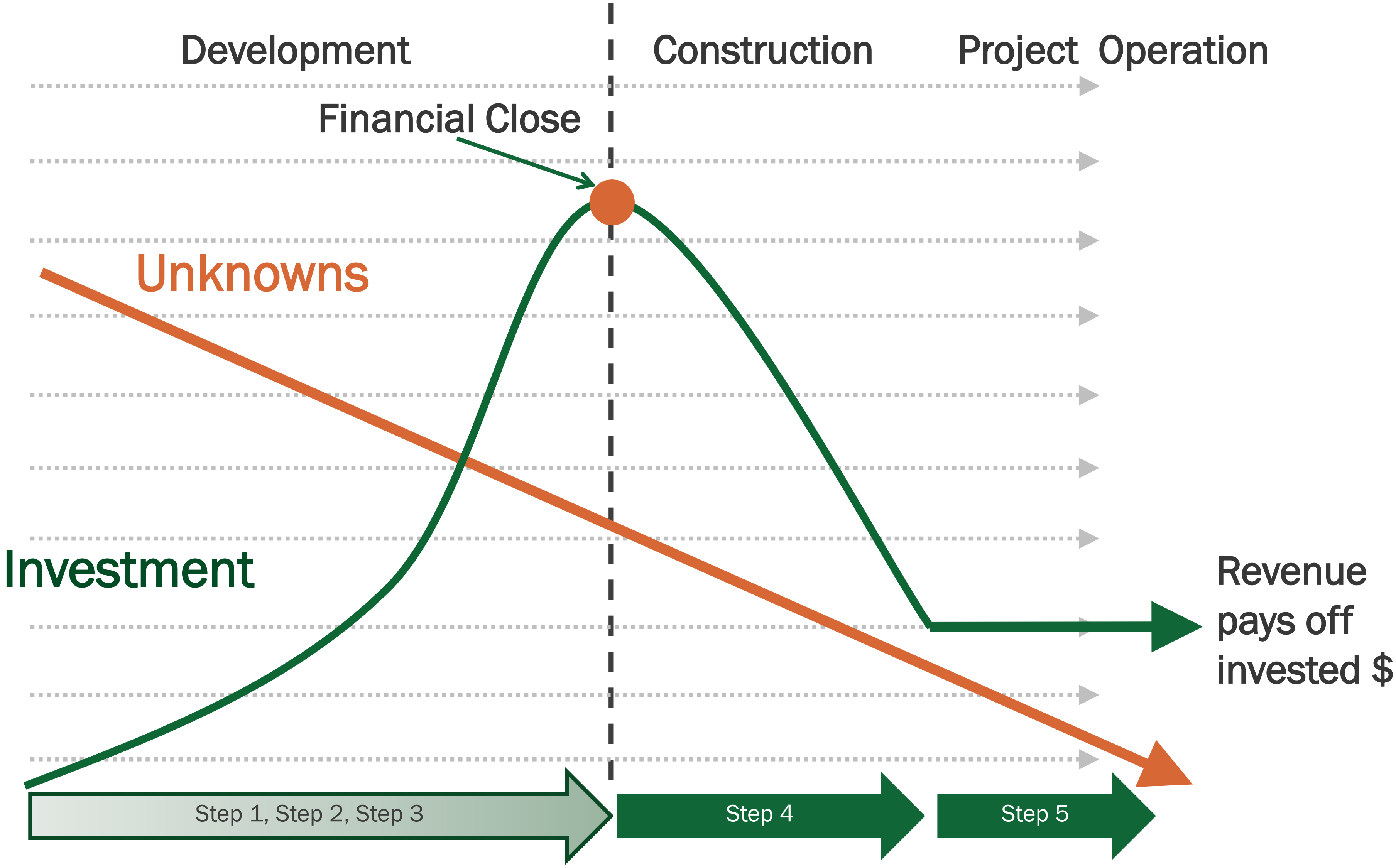
The Five-Step Process Framework for Project Development

U.S. DEPARTMENT OF ENERGY | Office of Indian Energy

Project Development Process: What Is It?

- Framework based on **experience**
- Focuses on key **decision points**
- Shows that project development is **iterative**
- Emphasizes that delaying or deciding against a project that does not meet current **goals** is a viable outcome and option

Project Uncertainty/Capital at Risk




Comprehensive Energy Plan
1 PROJECT POTENTIAL: Data Collection and Opportunity Assessment
Council Check-in
2 PROJECT OPTIONS: Strategy and Detail
Council Check-in
3 PROJECT REFINEMENT: Planning and Development
Council Check-in
4 PROJECT IMPLEMENTATION: Financing and Construction
5 PROJECT OPERATIONS AND MAINTENANCE
Project Development and Financing Strategy

1
Potential


2
Options
3
Refinement
4
Implementation
5
Operations & Maintenance

Step 1: Site, Scale, Resource, and Community Market Potential

Potential | Options | Refinement | Implementation | Operations & Maintenance

Purpose: Determine whether basic elements for a successful project are in place

Tasks:

1. Identify possible **sites** for project locations
2. Determine the **energy load/demand** for these sites using past electric bills for these facilities
3. Confirm renewable energy **resource**
4. Review tribal facility electric cost data, regulations, and transmission and interconnection requirements
5. Evaluate community market potential for renewable sales. **Your community is the marketplace/energy –user.**
6. Assemble or communicate with the right team—those in positions or with knowledge to facilitate, approve, and champion the project

Sizing Your Renewable Energy System

Current Load

- Use your past monthly energy bills to determine the demand. Start with your strategic energy plan
- Consider your scale: residential, commercial, or industrial
- Consider the current tariff structure (how the energy is metered and billed)

Future Load

- At which energy scale does your community expect the most growth in energy demand?
- How much will you need?

Other Limiting Factors

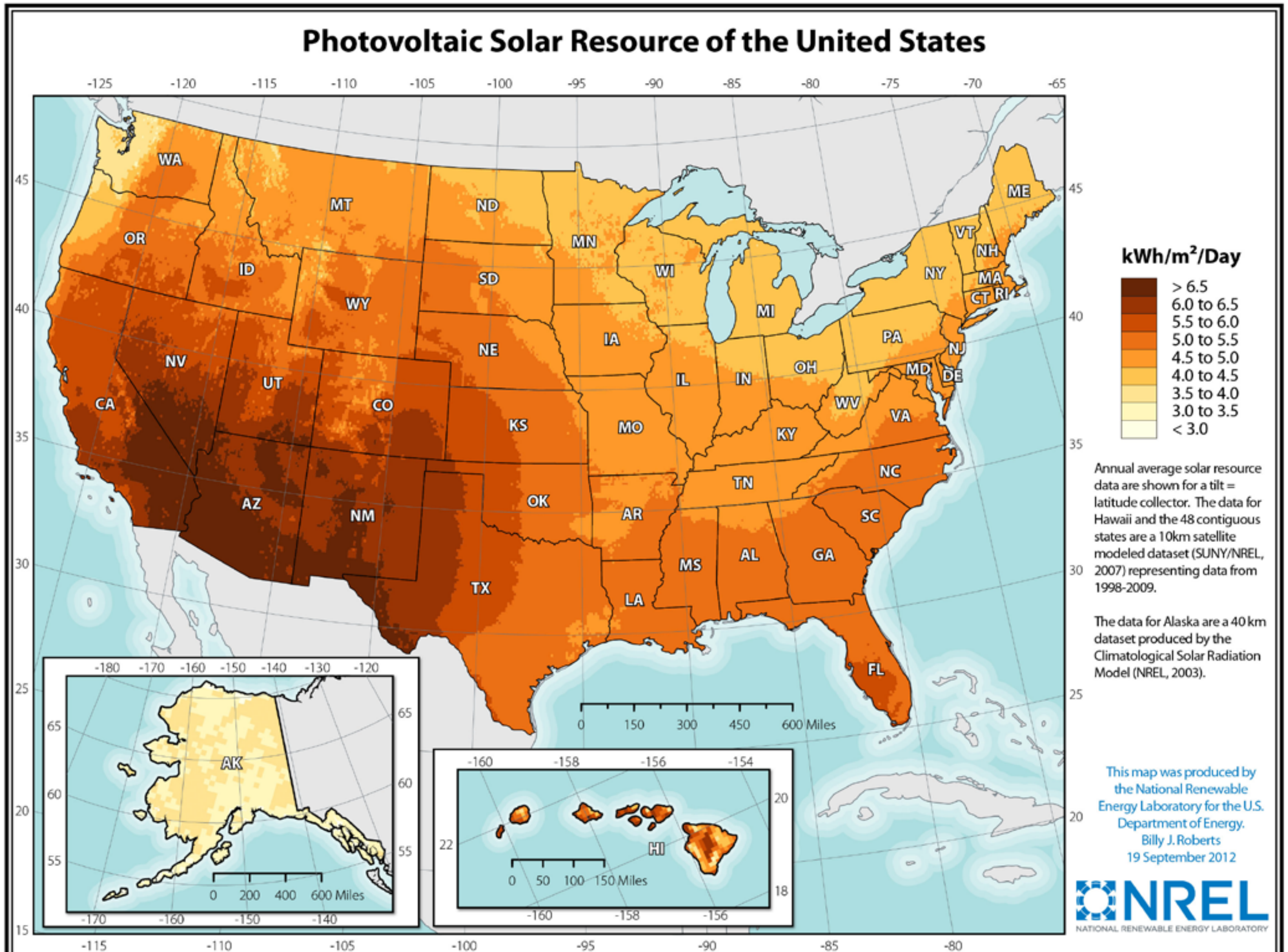
- Interconnection
- Net metering cap
- Rebate limits

Resource, Production & Savings

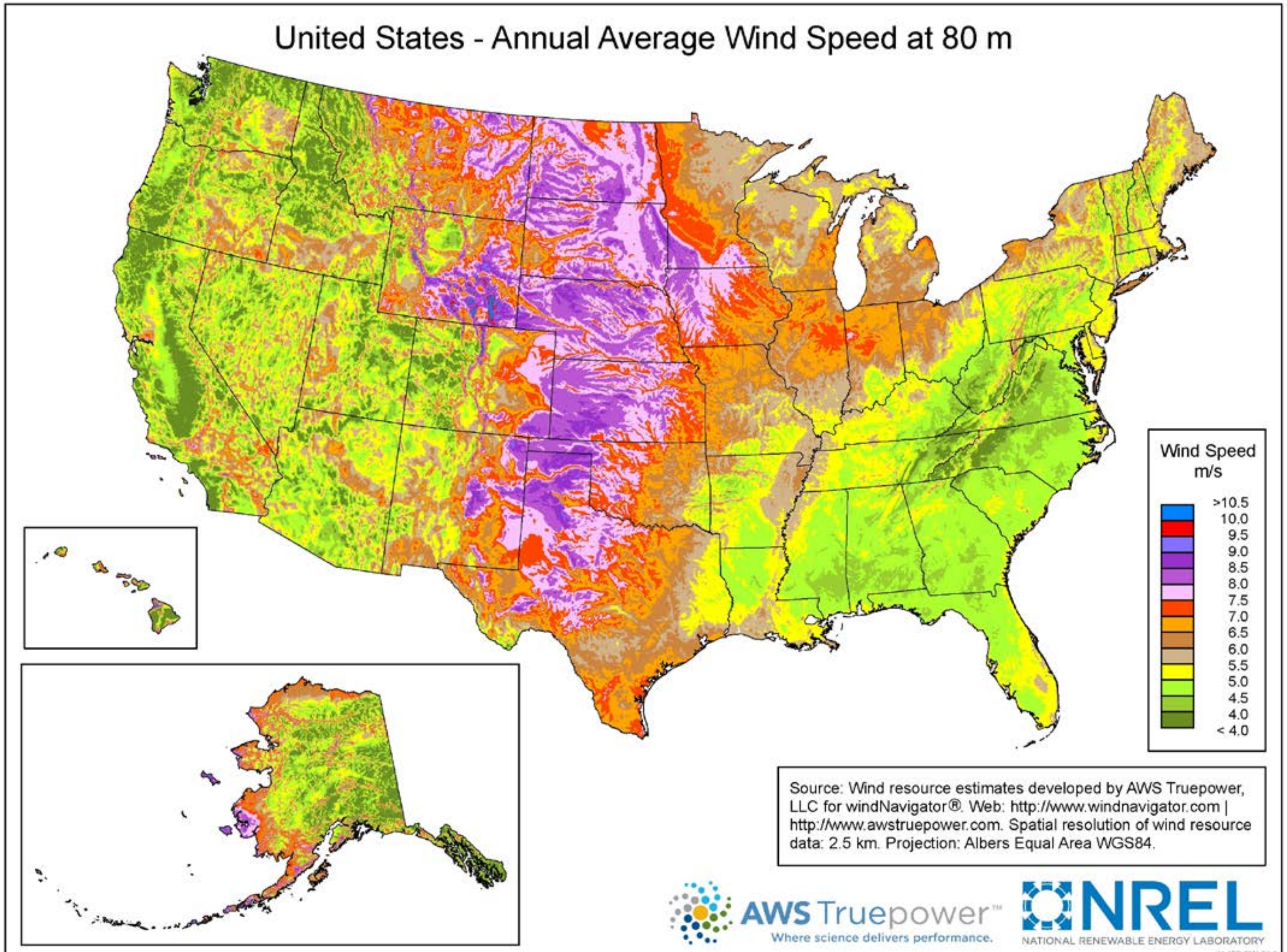
Assess available local energy resources

- Production
  - Online tools (PV Watts)
  - Field based measuring equipment
  - Resource maps

Solar PV Energy Resource Mapping



Wind Energy Resource Mapping: 80 m



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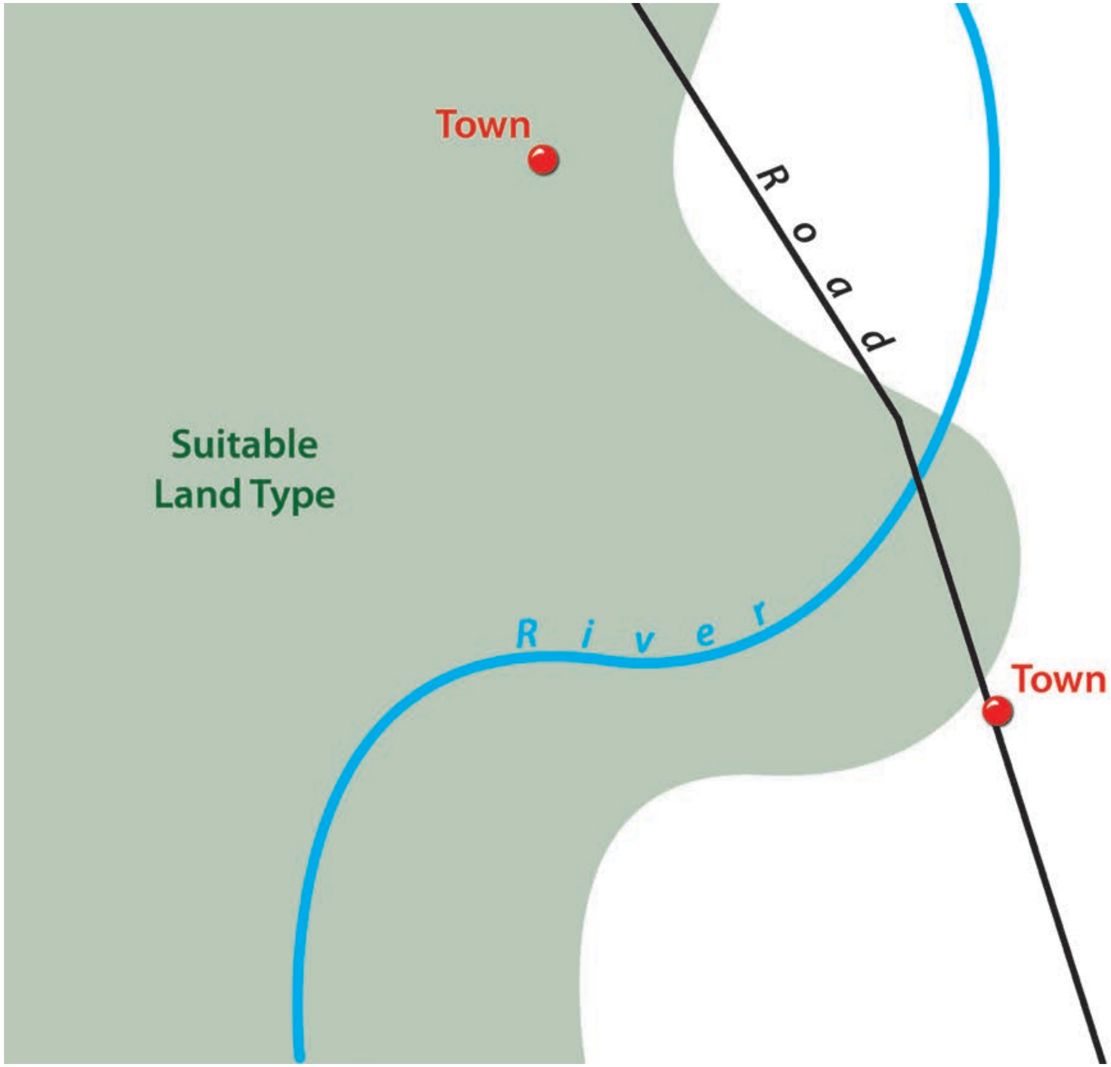
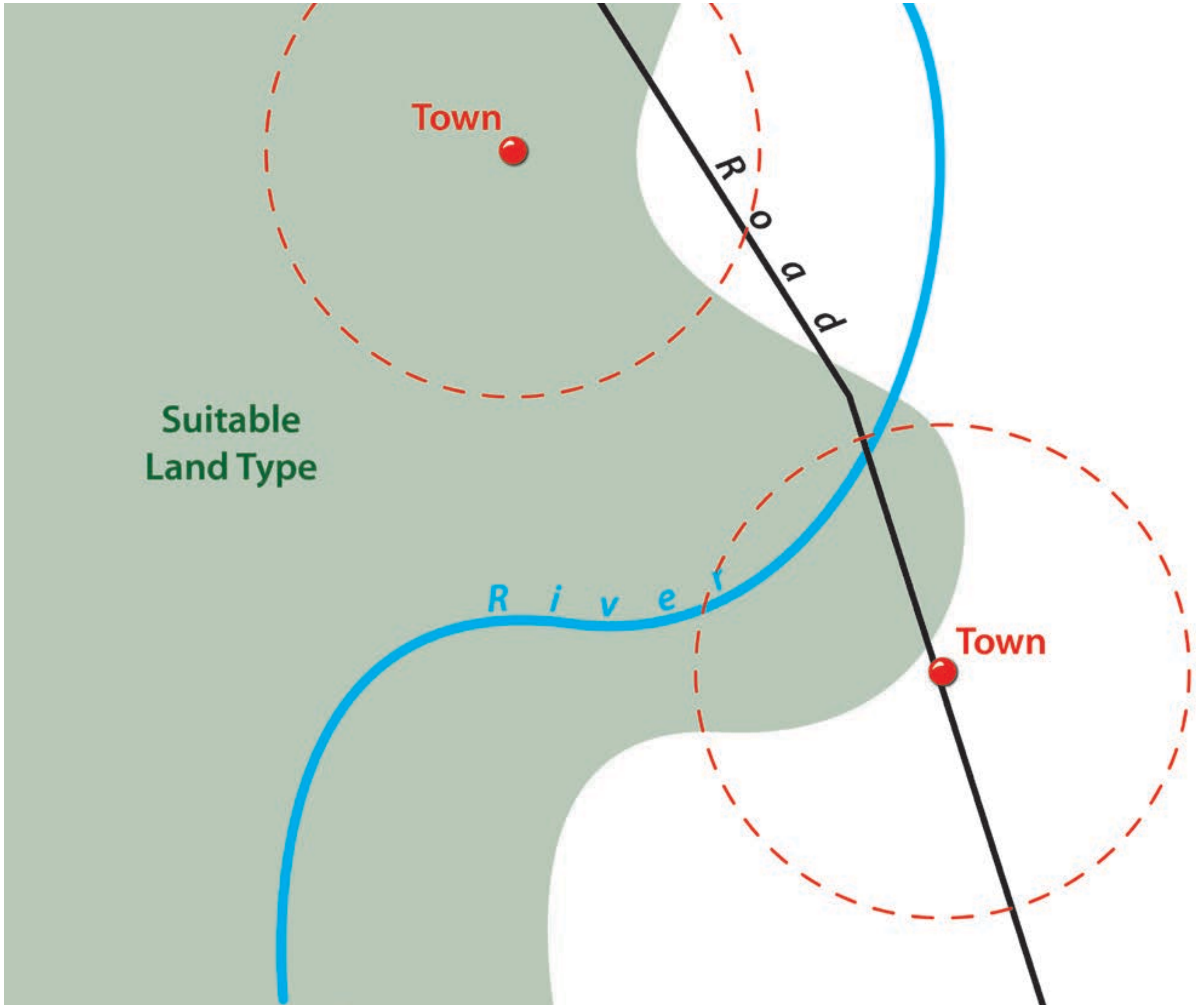
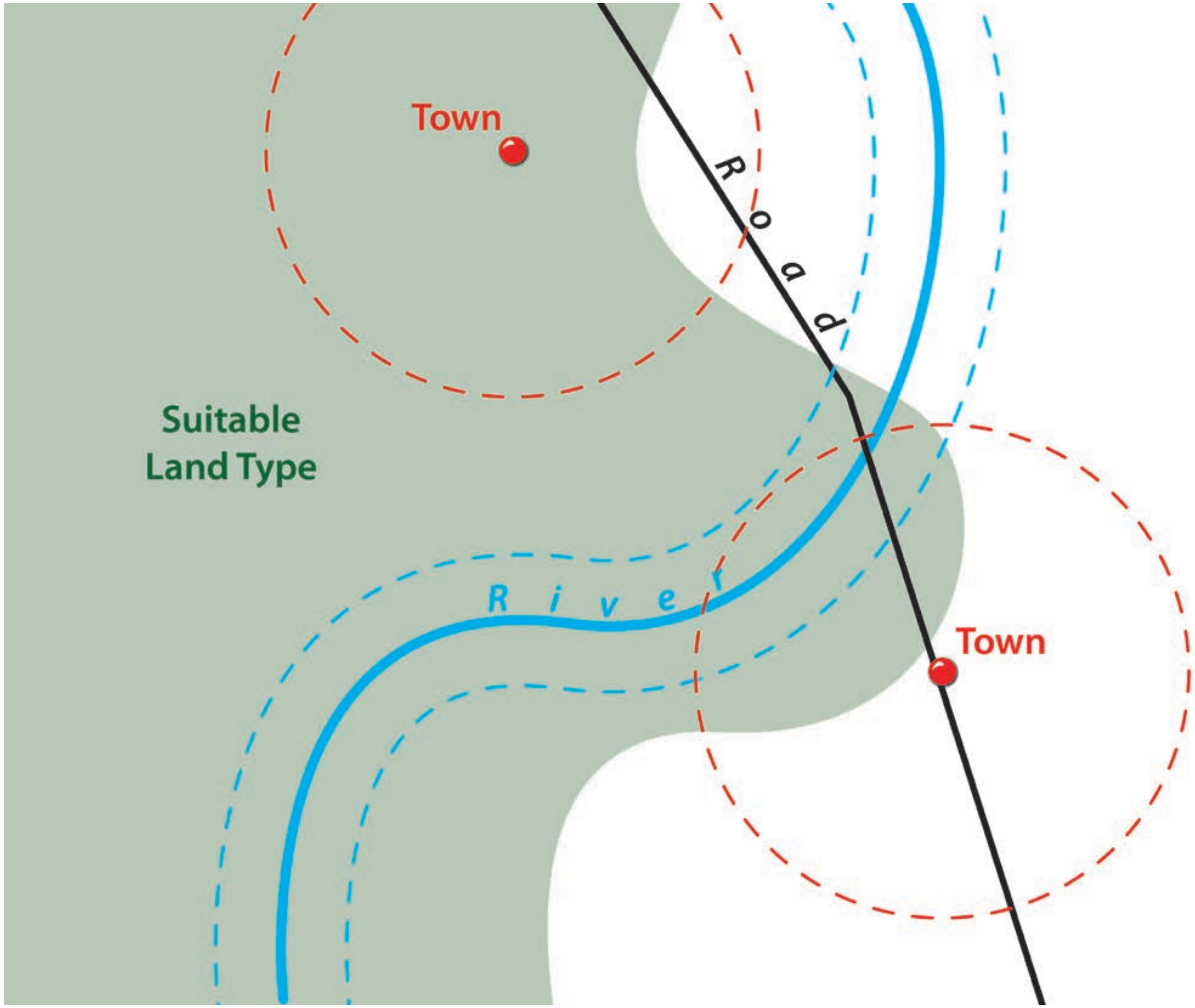
Local Site Considerations



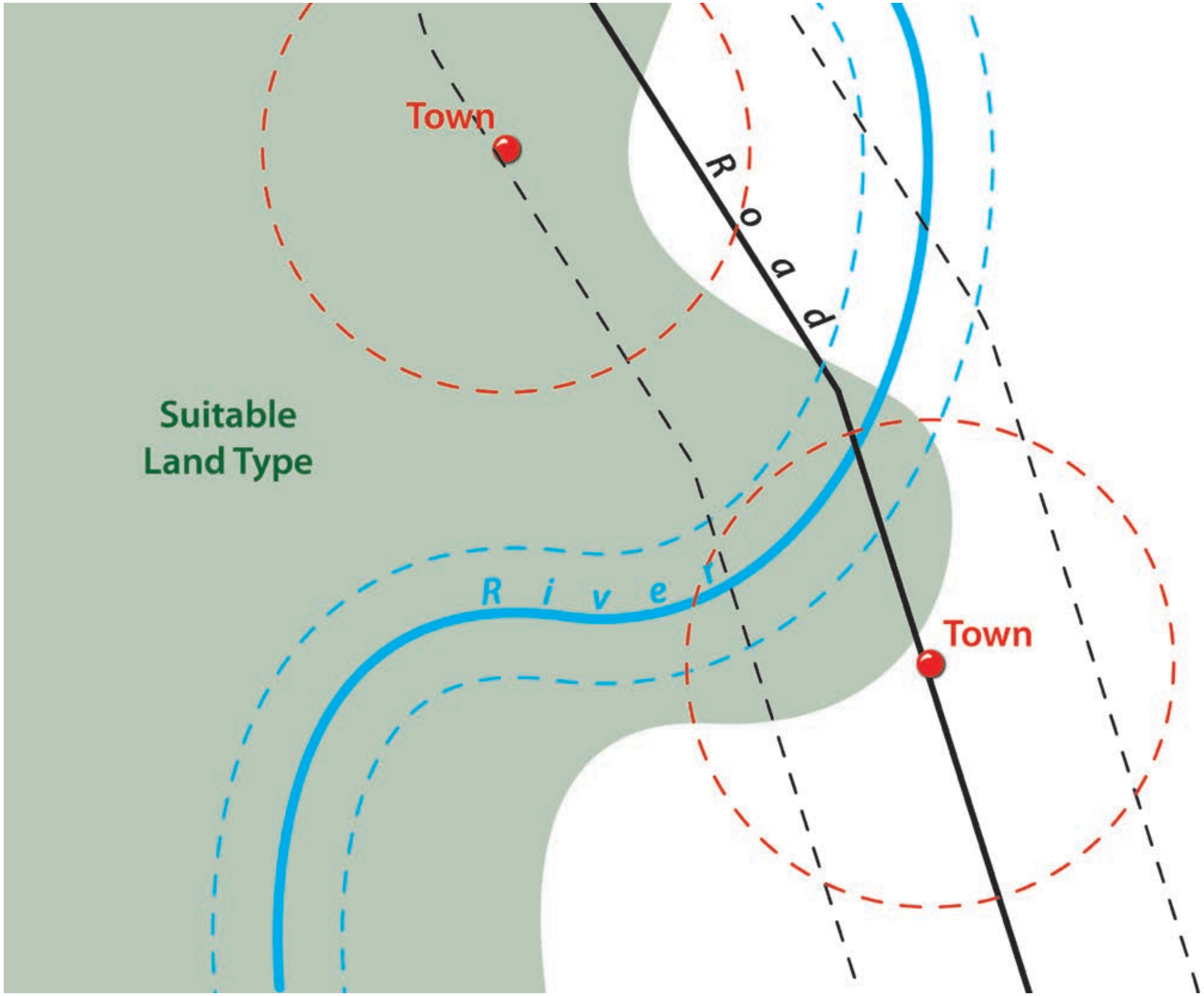
Local Site Considerations — Urban Centers



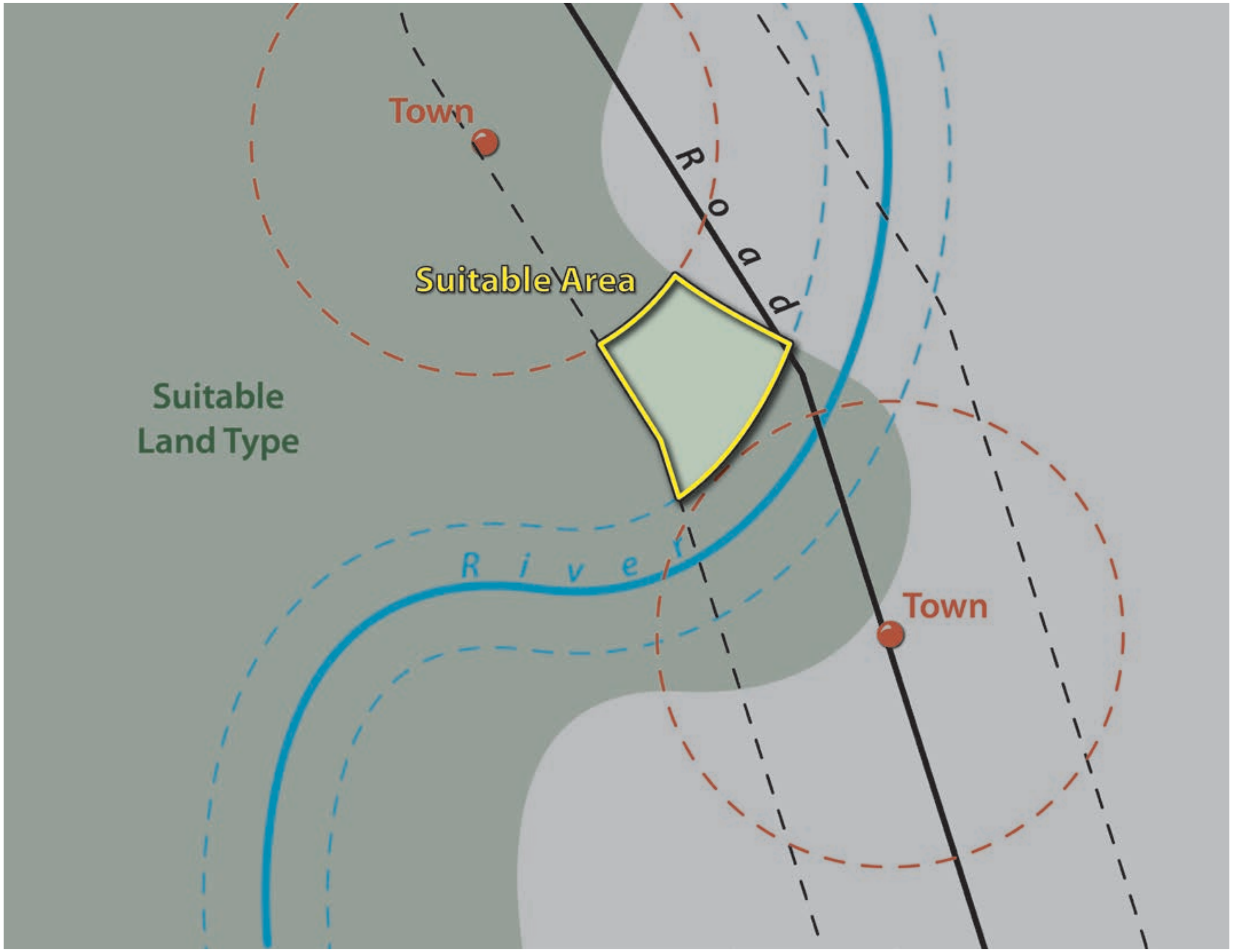
Local Site Considerations — Rivers



Local Site Considerations — Road Access

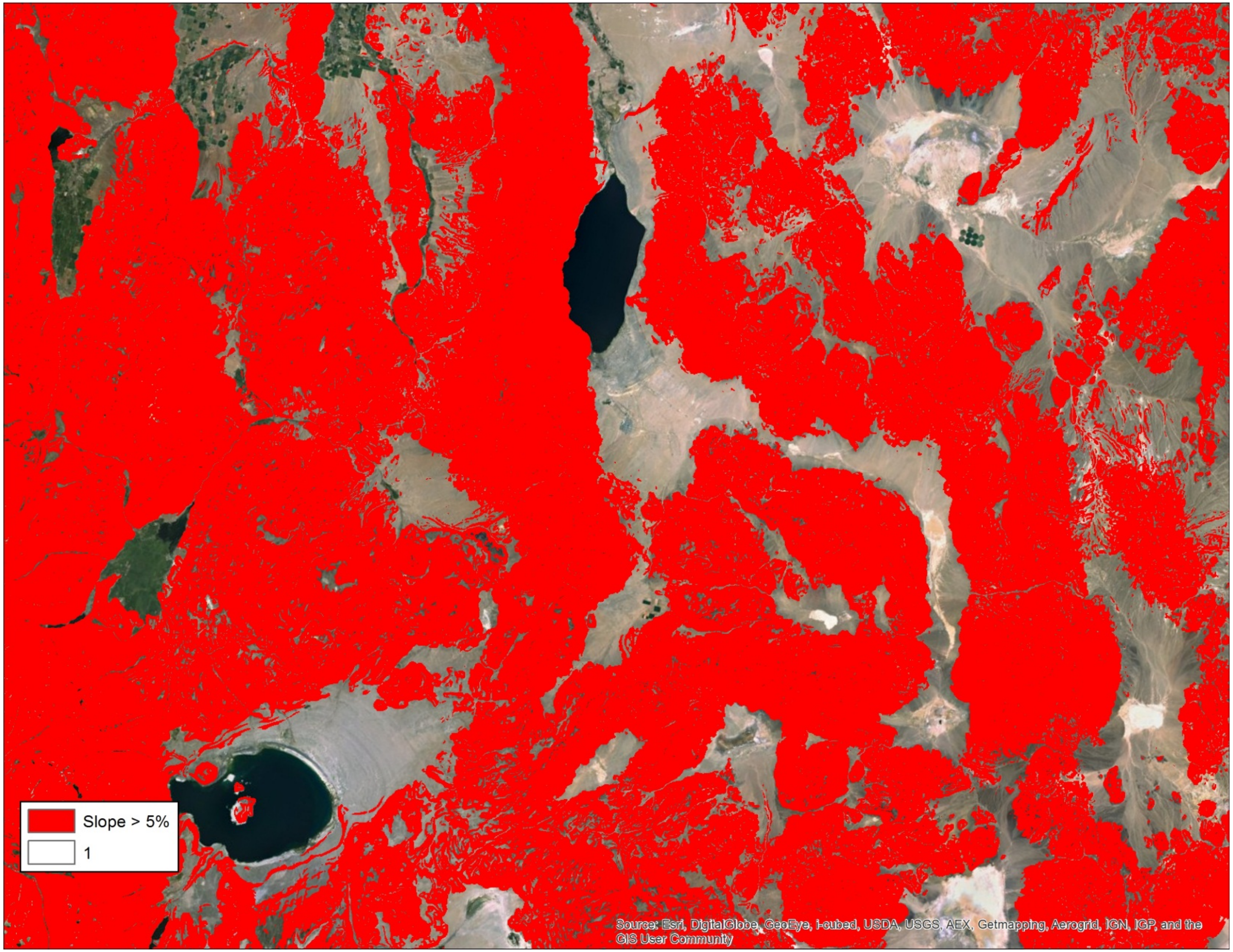


Local Site Considerations — Suitable Area

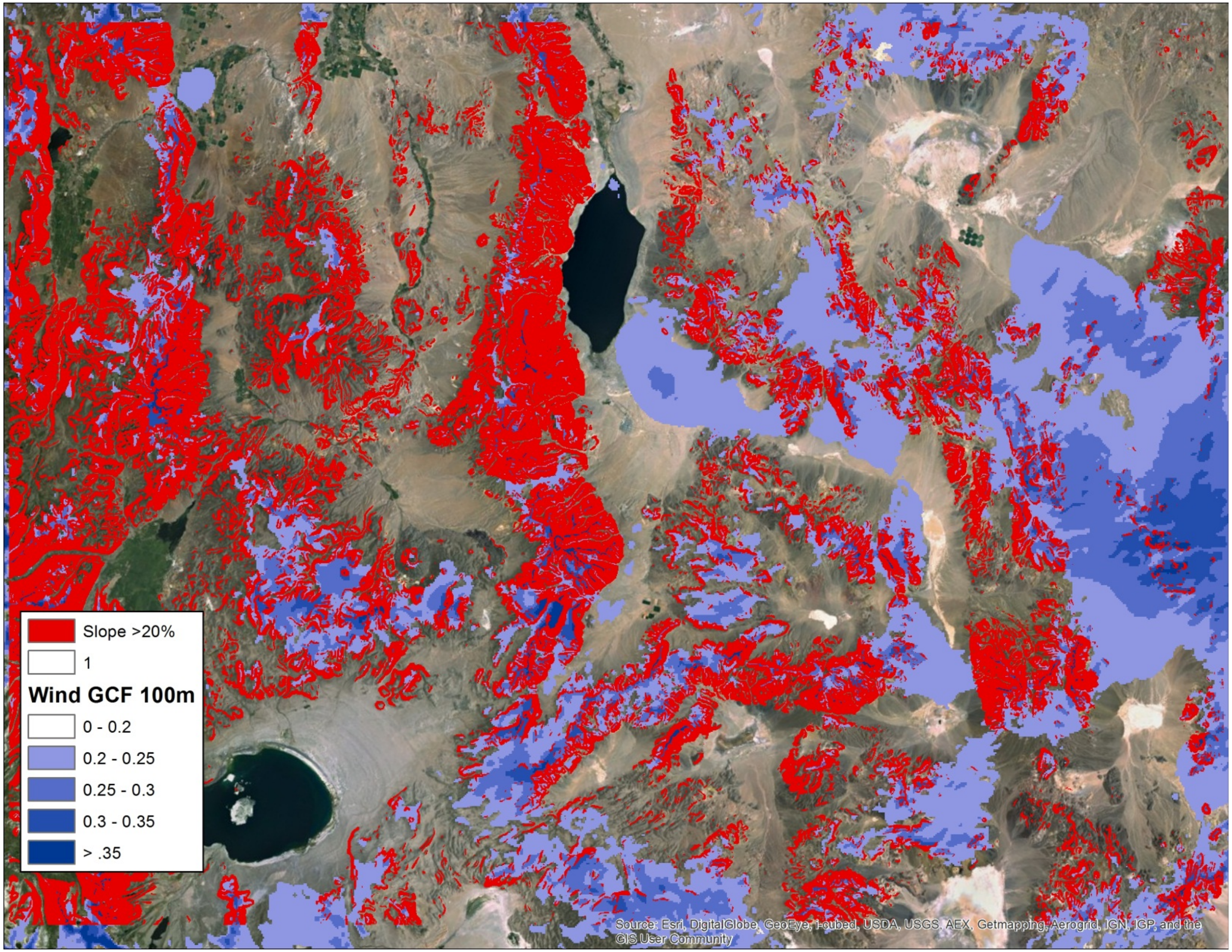


Initial Site Considerations — Example

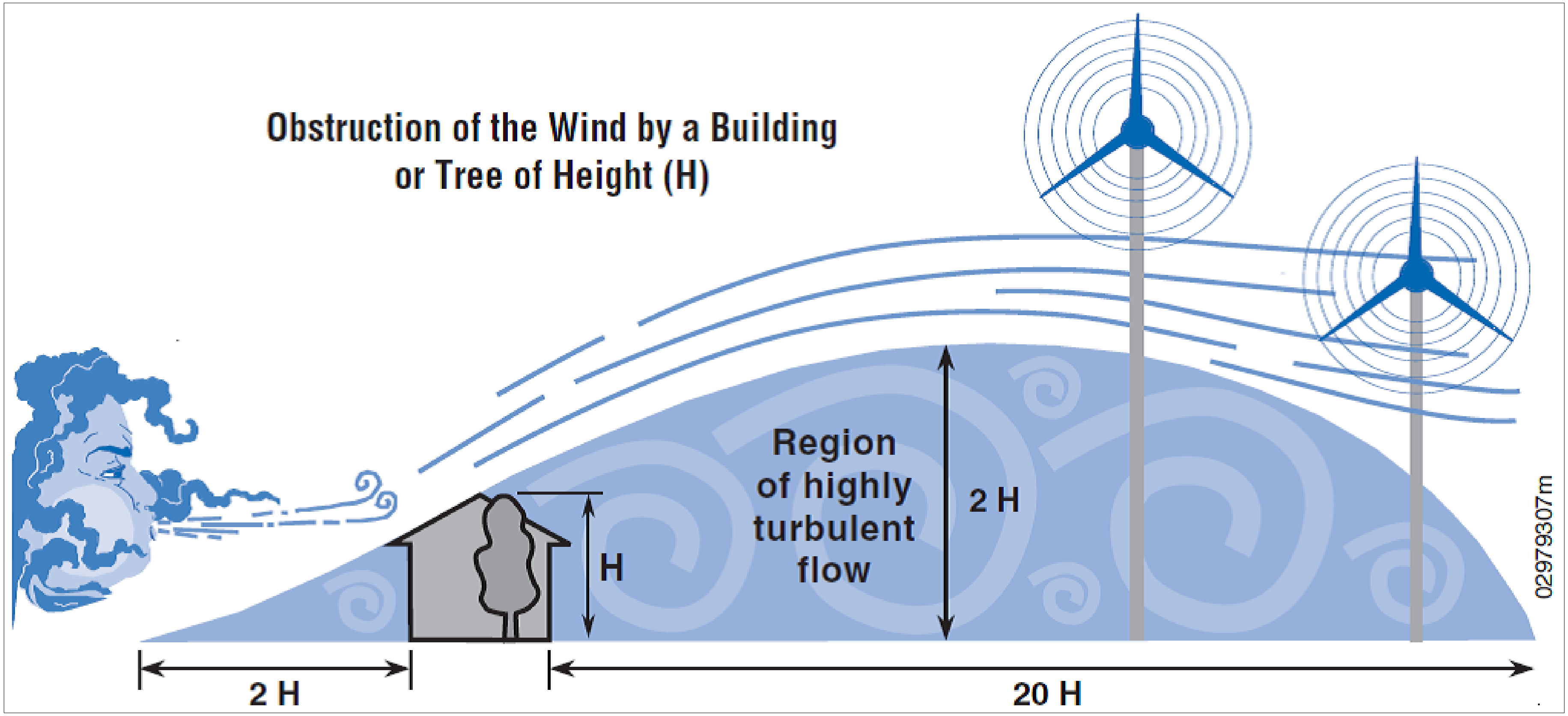
Initial Solar Site Considerations — Slope> 5%



Initial Wind Site Considerations — Slope>20%



Wind Siting Obstructions



Source: OpenEI, http://en.openei.org/wiki/File:ObstructionOfWindByBuilding.png

Priorities: Where to Install Solar

- On the "built environment" where unshaded:
  - Existing building roofs that have an expected life of at least 15 more years and can accept added load - typically 2-4 pounds /ft^2. Reduces solar load on building
  - All new buildings – all new buildings should be "solar ready
    - See *Solar Ready Buildings Planning Guide*: http://www.nrel.gov/docs/fy10osti/46078.pdf
  - Over parking areas– energy generation and nice amenity

- On compromised lands such as landfills and brownfields
  - Saves green-fields for nature
  - If installed on green fields, minimize site disturbance; plant native low height vegetation as needed

Solar PV Placement

PV Panels on Grand Ronde Tribal Housing Authority carport. Photo by GRTHA, NREL 11659046

Photo by Michael Deru. NREL 10075381

Facility Scale Hybrid System, NPS Range Station, San Miguel Island, CA.
Photo by Kent Bullard, NREL 6325496

Ballasted PV System on ESIF. Photo by
Dennis Schroeder, NREL 13163640

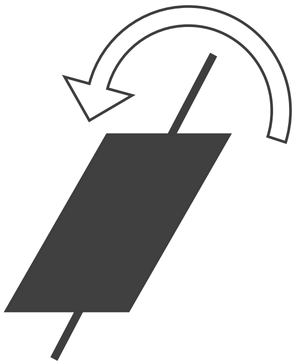
Solar Photovoltaics (PV) Fixed Tilt/Tracking

Fixed Tilt Facing Equator

tilt=latitude

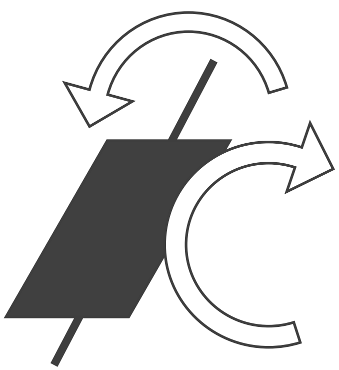
tilt<latitude for summer gain

tilt>latitude for winter gain



One Axis Tracking

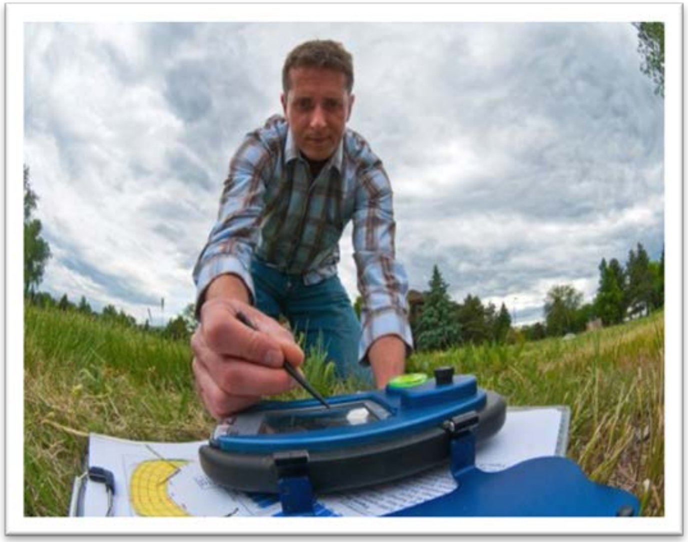
around axis tilted or flat



Two Axis Tracking

both azimuth and altitude of sun around two axes

Solar Assessment: PV is VERY Shade Sensitive



Shade Analyzer

Once preliminary site assessment has been completed, you want to know:

- Estimated system size
- Estimated production (kilowatt-hour [kWh]/yr)
- Estimated cost
- Some economic analysis

Photos top to bottom: NREL 10314 and 17509

PVWATTS Tool for Basic PV Modeling

Free interactive map-based tool allows you to:

- Estimate expected monthly and annual solar resource values
- Quickly obtain performance estimates for grid-connected PV systems
- Get a first cut of potential solar output
- Can identify potential incentives that a PV system in a particular area may be eligible for

Activity

- Resource Map/Siting

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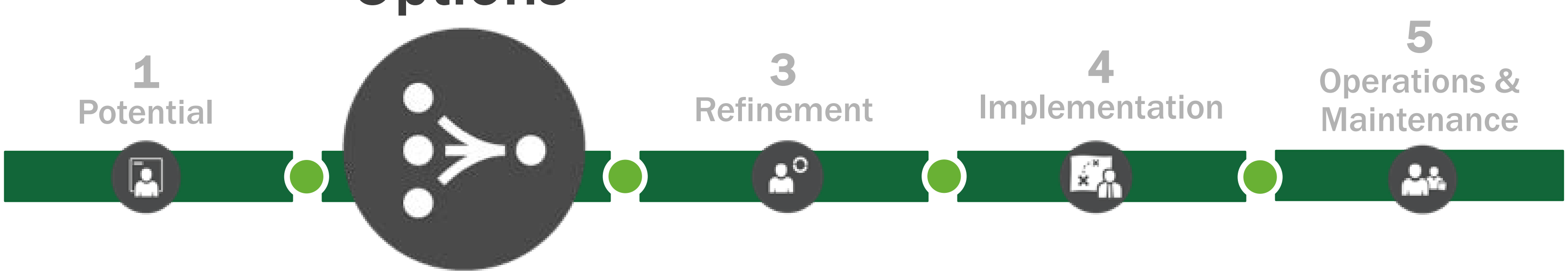
2 Options



1 Potential
3 Refinement
4 Implementation
5 Operations & Maintenance

Step 2: Roles, Business Structures, & Regulatory Considerations

Potential | **Options** | Refinement | Implementation | Operations & Maintenance

Purpose: Determine ownership structure and permitting considerations if any.
(Note: It is likely that internal tribal permitting is required if developed on tribal lands, however, state and federal permitting may be required if the Tribe is dealing with fee or trust land outside the tribal land holdings.)

Tasks:

1. Understand tribal role(s) and risk allocations/business structure
2. Identify permitting needs and site use considerations
3. Identify interconnection rules and net metering options with the local utility

Outputs:

1. Clarify tribal roles
2. Decide on business structure
3. Understand the permit needs and process
4. Understand interconnection and net-metering options

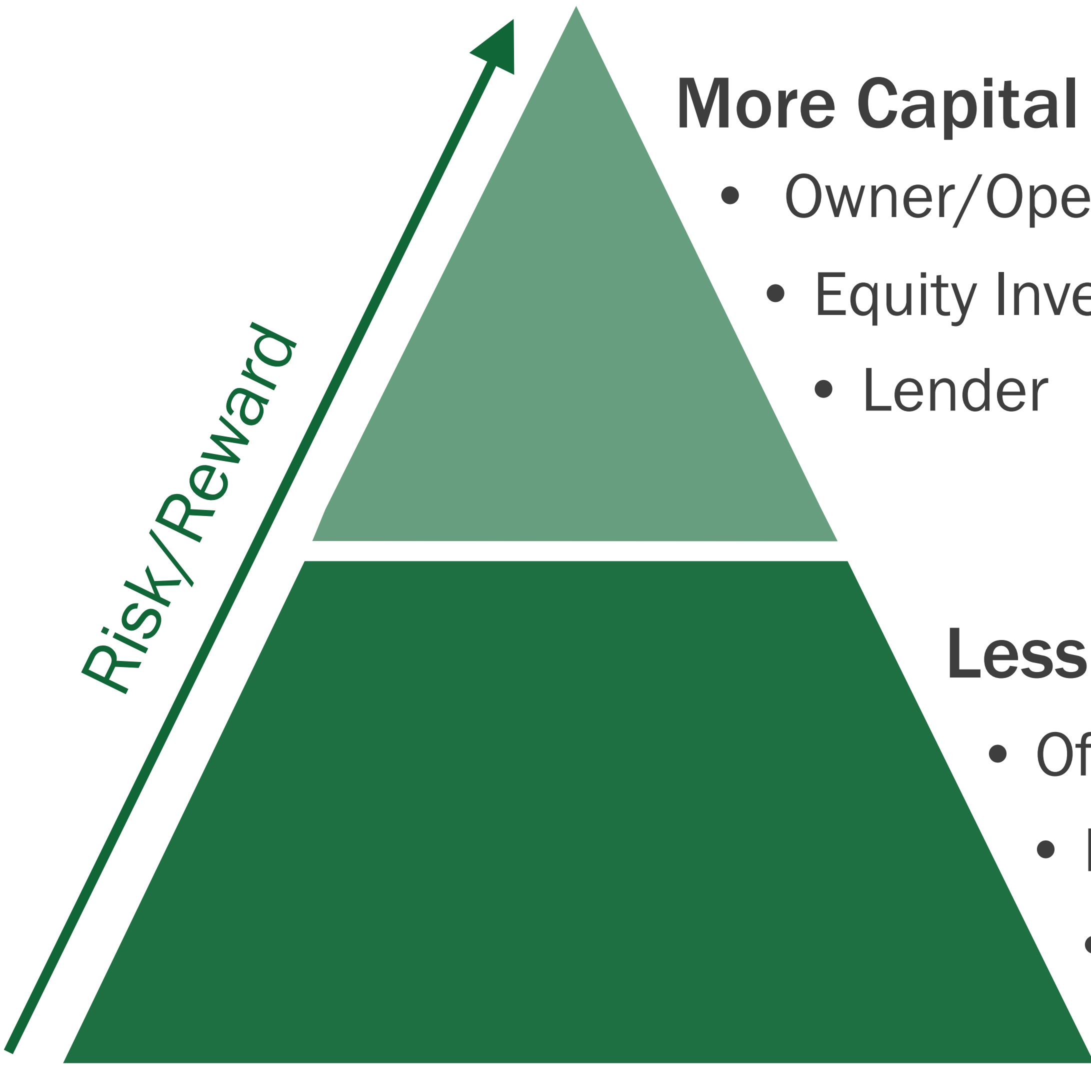
PROJECT MEMBERS AND ROLES

Potential Team Members

- Tribal Members
  - Leadership, staff, community members
  - Attorneys, engineers, professionals
  - Energy champions (key success component)
- Developer
  - Business managers, engineers, permitting specialists, investors, banks
- Utility
  - Attorneys, planning specialists, operations specialists, regulatory specialists, finance.
- Government
  - Tribal government, federal, state and local entities, regulating bodies (public utilities commission), Bureau of Indian Affairs, DOE.

The Role of the Project Champion

Tribal Roles



More Capital Intensive

- Owner/Operator
- Equity Investor
- Lender

Less Capital Intensive

- Off-taker
- Land Owner
- O&M subcontractor

PROJECT OWNERSHIP OPTIONS

Importance of Choosing the Right Ownership Structure

- Protect tribal assets
- Preserve tribal sovereignty
- Minimize potential liability
- Facilitate project construction

Photo by Brian Hirsch, NREL 20893

Evaluating Ownership Options

Business Structure Option	Simplicity and Quick Formation	Shield Tribal Assets from Business Liabilities	Avoid Federal Income Taxes	Separate Business from Tribal Control	Ability to Secure Financing
Tribal Instrumentality*	●		●		●
Political Subdivision*			●		●
Section 17 Corporation*		●	●	●	●
Tribal Law Corporation*	●	●	●	●	●
State Law Corporation	●	●		●	●
LLCs/Joint Venture		●	●	●	●
LLC (only if Tribe is sole member)	●		●		

*(*Can be protected by tribal sovereign immunity)*

Ownership Structure Resources

- **Renewable Energy Development in Indian Country: A Handbook for Tribes** (Douglas MacCourt and Ater Wynne LLP)
  http://www.nrel.gov/docs/fy10osti/48078.pdf
- **Tribal Business Structure Handbook** (The Office of the Assistant Secretary – Indian Affairs U.S. Department of Interior)
  http://www.irs.gov/pub/irs-tege/tribal_business_structure_handbook.pdf
- **Structuring Tribal Business Enterprises and Joint Ventures** (Kathleen M. Nilles, and Karen J. Atkinson)
  http://apps1.eere.energy.gov/tribalenergy/pdfs/course_biz0904_nilles.pdf
- **Tribal Energy Development Primer** (Quapaw Tribe of Oklahoma)
  http://www.cwlaw.com/wp-content/uploads/2010/03/Indian-Tribal-Energy-Development-Primer1.pdf

INTERCONNECTION & NET METERING

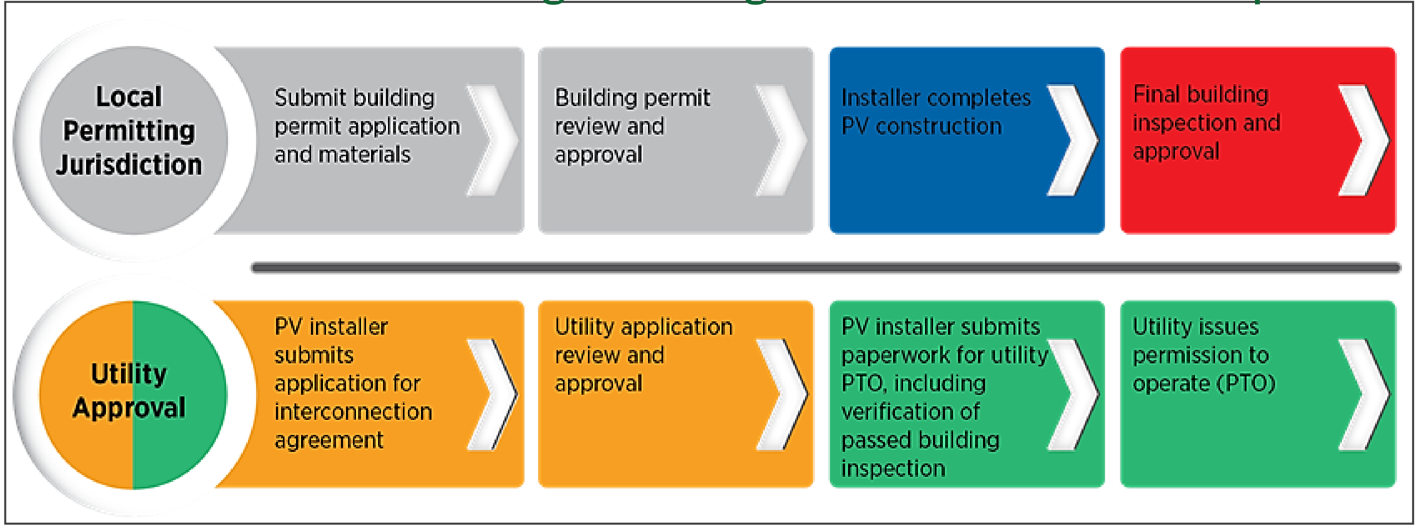
What Is Interconnection?

- An agreement required to connect your facility- or community-scale system to the grid
- Distribution-level interconnection is largely the domain of state policy
  - Rules and regulations are highly variable between states
- Involve your utility *early* and *often* in the project development process
  - Many utilities have their interconnection procedures and the necessary contacts posted on their website
- Time, Technical Requirements and Cost

Interconnection

- Installing a renewable energy project requires multiple approval and process steps, including local permitting jurisdiction, installer, and utility.
- Four distinct steps:
  1. Utility interconnection application review and approval process
  2. Construction
  3. Final building inspection and paperwork submittal to utility
  4. Utility permission to operate
- Usually takes approximately 15–20 days for residential and/or small commercial projects.
- Typically, one must obtain a building permit from the local jurisdiction and sign an interconnection agreement with the local utility.

Process for PV Building Permitting and Interconnection Example



Retrieved from Ardani et al., "A state-level comparison of processes and timelines for distributed photovoltaic interconnection in the United States." http://www.nrel.gov/docs/fy15osti/63556.pdf

Net Metering

- Simple way for utilities to encourage customers to deploy on-site, grid-connected generation (owned by the customer or a 3rd party) and maximize value
- Excess generation flows to the grid and can be credited back to the customer at the wholesale rate, retail rate or a higher incentive rate (or sometimes not at all)
- Often credit for net excess generation can be carried over to future months
- Can improve the economics of small-scale renewable power systems; may be a critical element in determining project economic feasibility

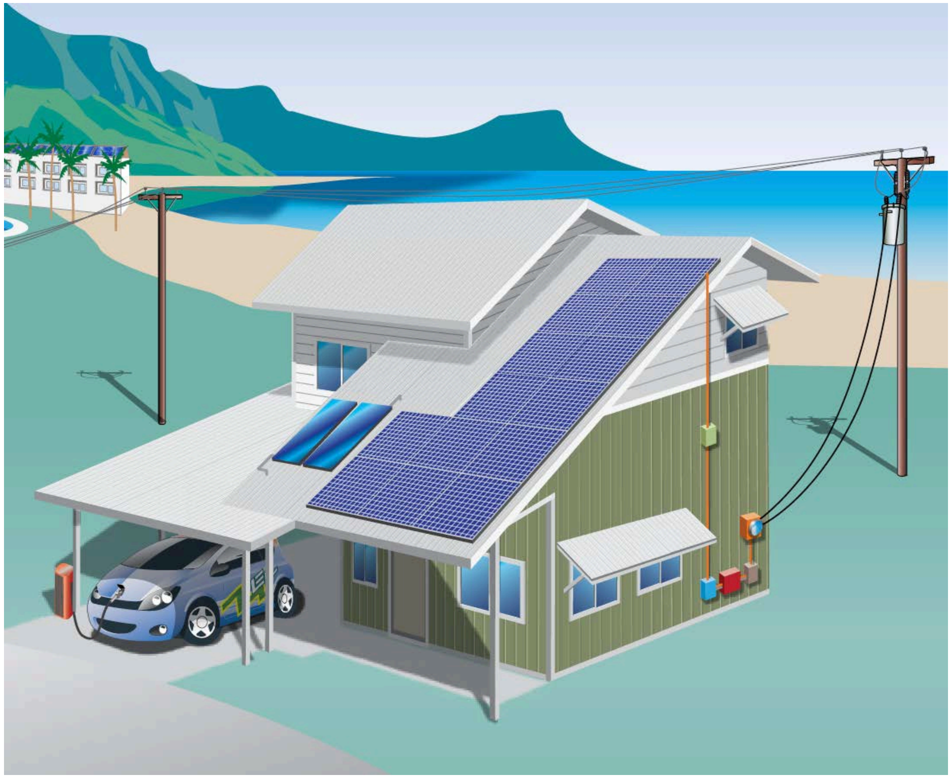


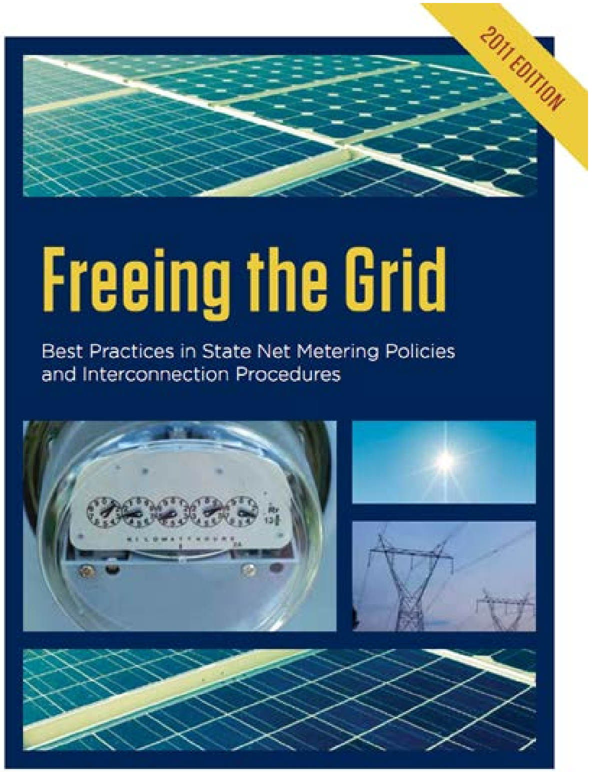
Illustration by Ray David, NREL

"Spinning the meter backwards"

Net Metering Design Components

Design Considerations

- **Eligibility**
  - Allowable technology
  - Customer type
- **System size limitations**
  - Limits on size of eligible residential and commercial systems
  - Is oversizing of systems allowed?
- **Period of crediting**
  - Monthly, annual, or continuous
- **Crediting of net excess generation**
  - Retail or wholesale rate
- **Cap on aggregate net-metered capacity**
- **Additional fees (if any)**
- **Renewable energy credit (REC) ownership**



PERMITTING

Permitting and Regulatory Key Considerations

Action	Applicability	Timeline	Contacts
Interconnection	If on grid (with a utility)	Communicate with utility early; this should be one of the first topics that is discussed and finalized before construction	Local utility
Net metering	If available in state (check)	Communicate with utility before construction	Local utility
Local tribal and non-tribal permitting	• Internal tribal process approvals • For off-reservation projects, state permits may apply	Determine permitting requirements early	Tribal Historic Preservation Office (THPO) and local tribal government
Environmental	Impacts to: • Wetlands/waterways • Wildlife, habitat, flora • Cultural resources	• May not be necessary • Determine applicability early	Applicable federal agency

Site Due Diligence

Consideration	Applicability	Resources
Wetlands/ waterways	• Are there wetlands, water bodies, washes, arroyos, drainage considerations, or floodplain on site?	http://www.fws.gov/wetlands/Data/Mapper.html https://msc.fema.gov/portal/search
Soils	• Soil conditions impact structural design and site feasibility • Caliche or bedrock may require costly drilling • Sandy soils may require deeper post embedment to meet wind and snow loading requirements • Corrosive soils can require measures to protect embedded posts	http://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx
Wildlife/ habitat/ flora	• Check for critical habitat, riparian areas, and endangered species of flora or fauna that may be impacted	http://ecos.fws.gov/crithab/flex/crithabMapper.jsp?
Driveway/ access	• Is a new driveway required? If so, is access available (limited access highways may not allow a driveway)? • Can equipment and materials be safely delivered to the site with no obstructions such as overhead utilities, trees, or vehicle weight limits?	Check local, state, or federal transportation department or equivalent

Site Due Diligence cont.

Consideration	Applicability	Resources
Easements/ encumbrances/ rights-of-way	• Are there easements or rights-of-ways for pipelines, utilities, or railroads that will be crossed or impacted? • Are there plans for road expansions or improvements, new pipelines, or future utility rights-of-ways at any time during the life of the project?	Check with land management authorities, transportation plans, USGS maps
Cultural resources	• Are there known cultural resources on or near the site? If not, are further studies required?	Tribal Historic Preservation Office http://nrhp.focus.nps.gov/natreg/docs/Download.html (Google Earth layer)
Land use and building permits	• Building permit requirements • Land use/zoning permits—Is the facility allowed as a primary or accessory use? Is a special or conditional use permit or re-zoning required? • Rights-of-way permits, including interconnection line, driveway, drainage	Local tribal government
Storm water	• Is the site one acre or more? If so, a construction storm water permit and mitigation measures are required • Are measures such as retention ponds or swales required for erosion and sediment control or storm water mitigation during and after construction?	http://water.epa.gov/polwaste/npdes/stormwater/EPA-Construction-General-Permit.cfm

When Will NEPA Apply to Tribes?

The National Environmental Policy Act (NEPA) requires all federal agencies to assess environmental impact of proposed actions

- Federal funding may trigger assessment for tribal projects (federal nexus, e.g. federal grants, BIA initiated/approved projects)
- Each federal agency may have its own particular NEPA procedure (check with appropriate agency)
- Timeline: Approx. 1–3 years depending on project size and complexity (unlikely for community scale)
- Recommendations:
  - Draft the Environmental Impact Statement concurrently with other applicable federal statutes and regulations
  - If necessary, work with NEPA experts to determine and prepare required analysis

NEPA cont.

Three types in order of complexity and time:

Types	Complexity	Timeline
Categorical exclusions (CX)– Categories of actions that federal agencies have determined do not have a significant effect on the quality of the environment and neither an environmental assessment (EA) nor an environmental impact statement (EIS) is required.	Does not require any public reviews, hearings, and unless any 'extraordinary circumstances' exist, an EA or an EIS is not required.	The Categorical Exclusion Exception Review (CEER) conducted by the BIA is an internal two step process and mainly involves a simple check-box form.
Environmental assessment (EA)– The document that provides sufficient analysis for determining whether a proposed action may or will have a significant impact on the quality of the environment and therefore require the preparation of an EIS.	Usually requires a 30 day public commenting period and may also require a 14-30 day scoping period upfront.	Generally allow 6-9 months for this process before issuing either a FONSI or proceed with an EIS.
Environmental impact statement (EIS)– If an action is expected to have significant impacts, or if the analysis in the EA identifies significant impacts, then an EIS will be prepared.	Requires more rigorous and expanded review including public involvement, public meetings and hearings.	Generally should allow 18 to 24 months for completing this process.

http://www.bia.gov/cs/groups/xraca/documents/text/idc009157.pdf

Categorical Exclusion Examples

CATEGORICAL EXCLUSION DETERMINATIONS

B5.16: Solar photovoltaic systems

- The installation, modification, operation, and removal of commercially available solar photovoltaic systems located on a building or other structure (such as rooftop, parking lot or facility, and mounted to signage, lighting, gates, or fences), or if located on land, generally comprising less than 10 acres within a previously disturbed or developed area. Covered actions would be in accordance with applicable requirements (such as local land use and zoning requirements) in the proposed project area and would incorporate appropriate control technologies and best management practices.

Recent Tribal Examples

- The **Santo Domingo Tribe** (Tribe) would utilize DOE and cost share funds for the planning, installation, and system performance evaluation of an approximate **115 kW DC ground mounted solar photovoltaic (PV) system** that would power the Tribe's community water pump and treatment (WPT) facility located at the Santo Domingo Pueblo in New Mexico

- The **Tonto Apache Tribe** (TAT) would utilize DOE and cost share funds to install **commercially available solar thermal and solar photovoltaics (PV) at four of the tribe's facilities.** Under this project, the installed solar systems would be a mixture of roof mount, ground mount, and solar shade structure arrays on and around the four tribal buildings. The project would be located on the Tonto Apache Reservation in Payson, AZ at the Community Center, the Tonto Market, the Water Treatment Facility, and the Water Tower.

- **Oneida Tribe of Indians of Wisconsin** to install up to **695 kilowatts of grid-connected, solar electric modules on the roofs of up to 9 Tribal facilities** located in central and eastern portions of the Oneida Reservation.

http://energy.gov/nepa/categorical-exclusion-determinations-b516

3
Refinement

Step 3: Project Refinement

Potential | Options | **Refinement** | Implementation | Operations & Maintenance

Purpose: Validate decisions and finalize project structure

Tasks:

1. Finalize ownership structure and project team identification
2. Finalize permitting, including environmental reviews, net metering, and interconnection
3. Finalize technology, financing, and development costs

Outputs:

1. Proposed financing/commitments and organization structure
2. Detailed economic models
3. Vendors selected
4. Completed environmental reviews and finalized permits
5. Net-metering and interconnection agreement
6. Transmission finalized, if necessary

FUNDING OPPORTUNITIES & FINANCING OPTIONS

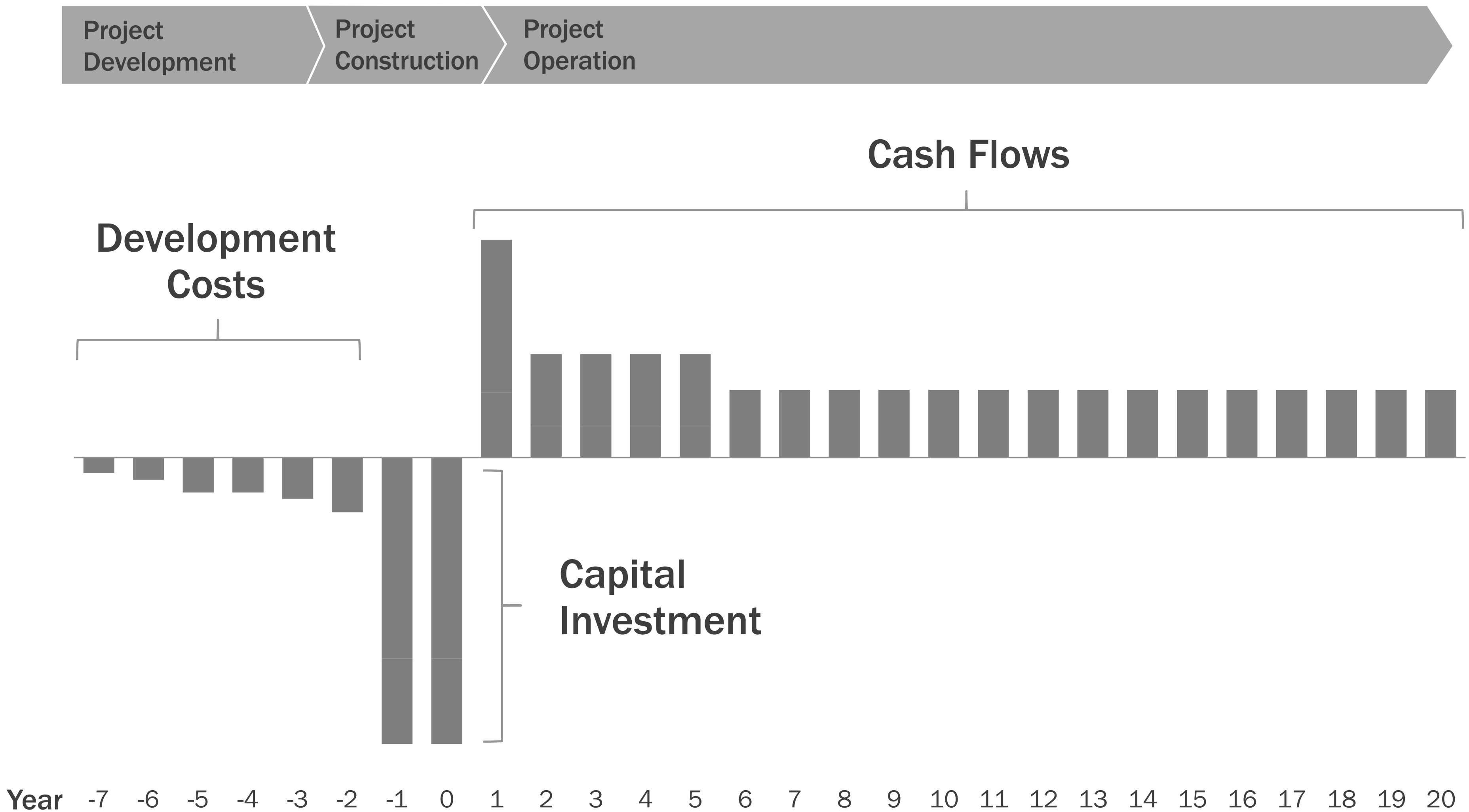
Paying for the Project

Three Major Costs to Develop a Project

- Feasibility – this is the project potential analysis
- Preconstruction – permitting, environmental
- Construction – engineering, procurement of equipment, and actual construction of plant

PV panels installed on Grand Ronde Tribal Housing Authority carport.
42 kW: Combination of tribal funds and state incentives
Photo from GRTHA, NREL 31797

Project Costs



Project Ownership

Financing structure is highly dependent on size of the project and the capital available for a given project:

- Tribe owns the project
- Tribe hosts the project and buys the electricity
- Tribe partners with private sector and co-develops the project

Direct Ownership Structure

Primarily for facility and community-scale projects

Project

Tribe purchases a renewable energy system with its own funding and possibly other sources like grants.

Over time, investment recouped from utility bill savings

Tribe and Electricity Users

Payments

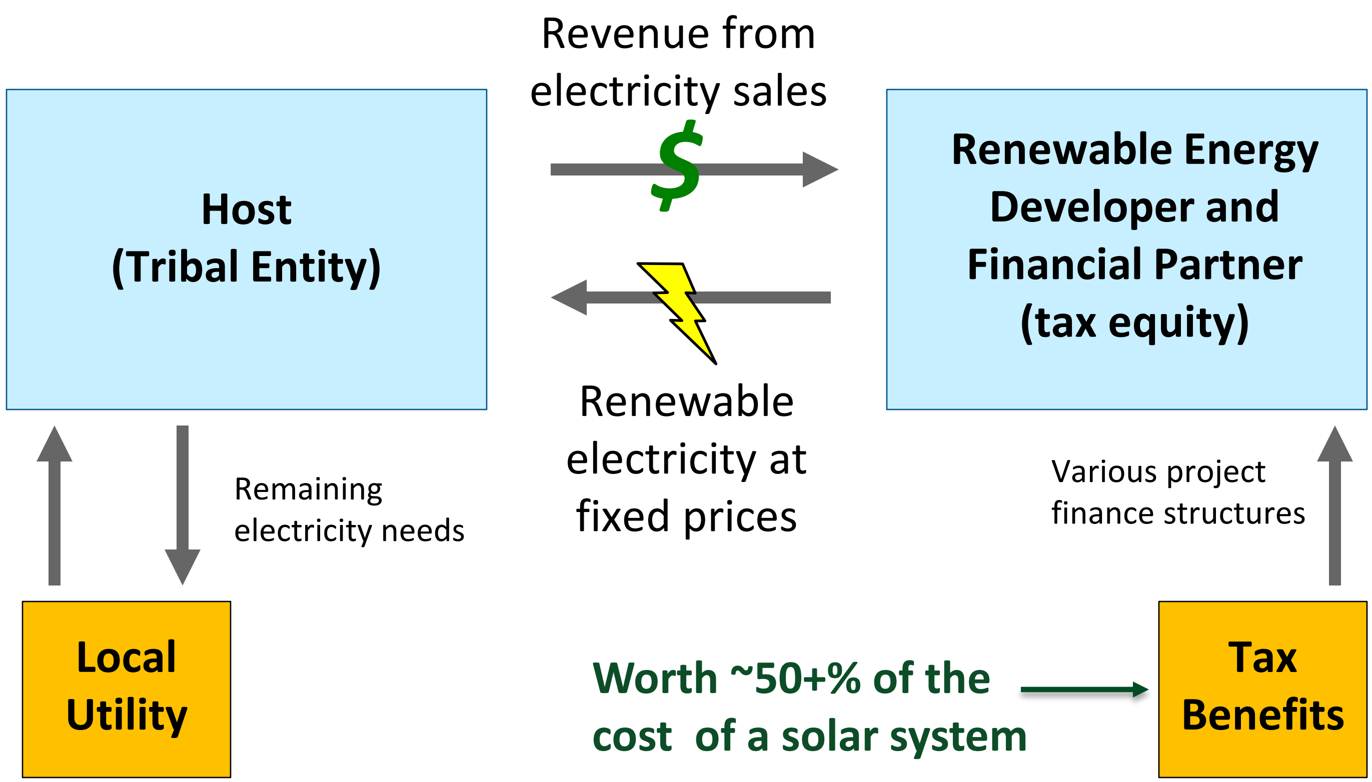
Remaining Energy Needs

Utility

The Tribe is the owner in this structure and self-generates its electricity

Third-Party Power Purchase Agreement (PPA)

The customer agrees to **host** the system and **purchase** the electricity



Community Project PPA: Eventual Tribal Ownership Example

Developer and investor form a project company (LLC) to develop a wind or solar project

- Tribe as the host signs a PPA with the LLC to purchase the electricity
- At end of 6 years (ITC) or 10 years (PTC)
  1) Investor ownership “flips” from 99% down to 5%
  2) Developer buys investor’s 5% ownership stake
  3) Developer now owns 100% of the project
- Developer can then sell project to Tribe
  – Project price is substantially reduced compared to the initial upfront cost of the project

Community (or Shared) Solar

- Usually an off-site solar project
- Taps into new markets of customers
- Various ownership options
- Participants make a one-time up-front payment or monthly payments
- Participants receive a bill credit
- Example pricing:
  - $780 per solar panel
  - $3.15/Watt
  - $3 per 150 kWh per month
- National Community Solar Partnership

"shared solar could represent 32%–49% of the distributed PV market in 2020"

Financing Options and Sources of Capital

- Internal tribal funds
- Grants
- Incentives (state, local, utility)
- Debt/loans
- Energy saving performance contacts (ESPCs)
- Tax equity incentives
- Monetizing green attributes (RECs)

Project will likely involve a combination of sources of capital

Energy Savings Performance Contract (ESPC)

An ESPC is a <u>no up-front cost</u> contracting mechanism between a site customer and an energy service company (ESCO). Energy conservation measures and on-site generation are financed and implemented by an ESCO, which is <u>repaid through energy savings</u>.

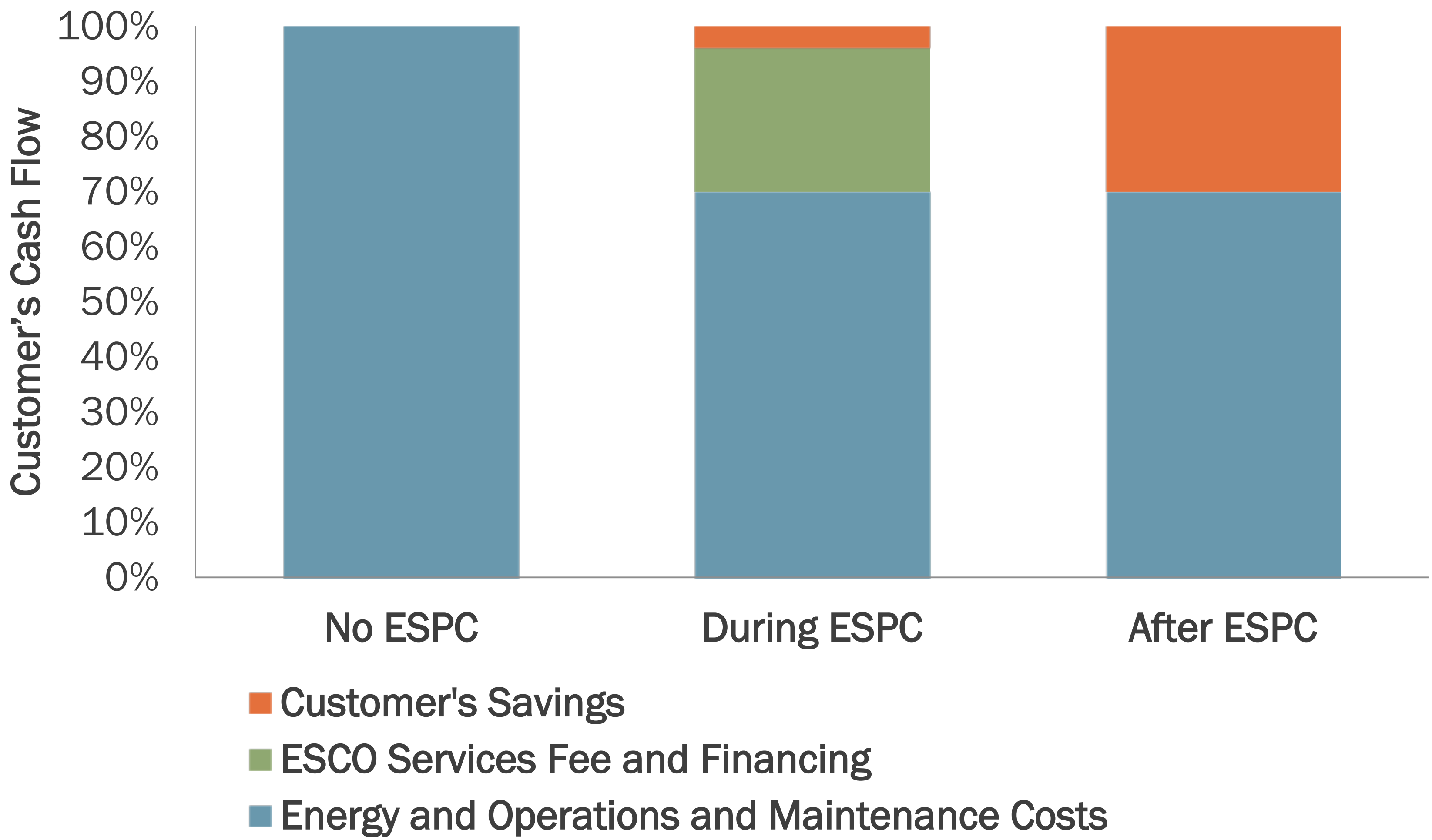
Site Customer ⟷ **ESPC Partnership** ⟷ ESCO and Financial Partner

Over 90 DOE-Qualified ESCOs, including:

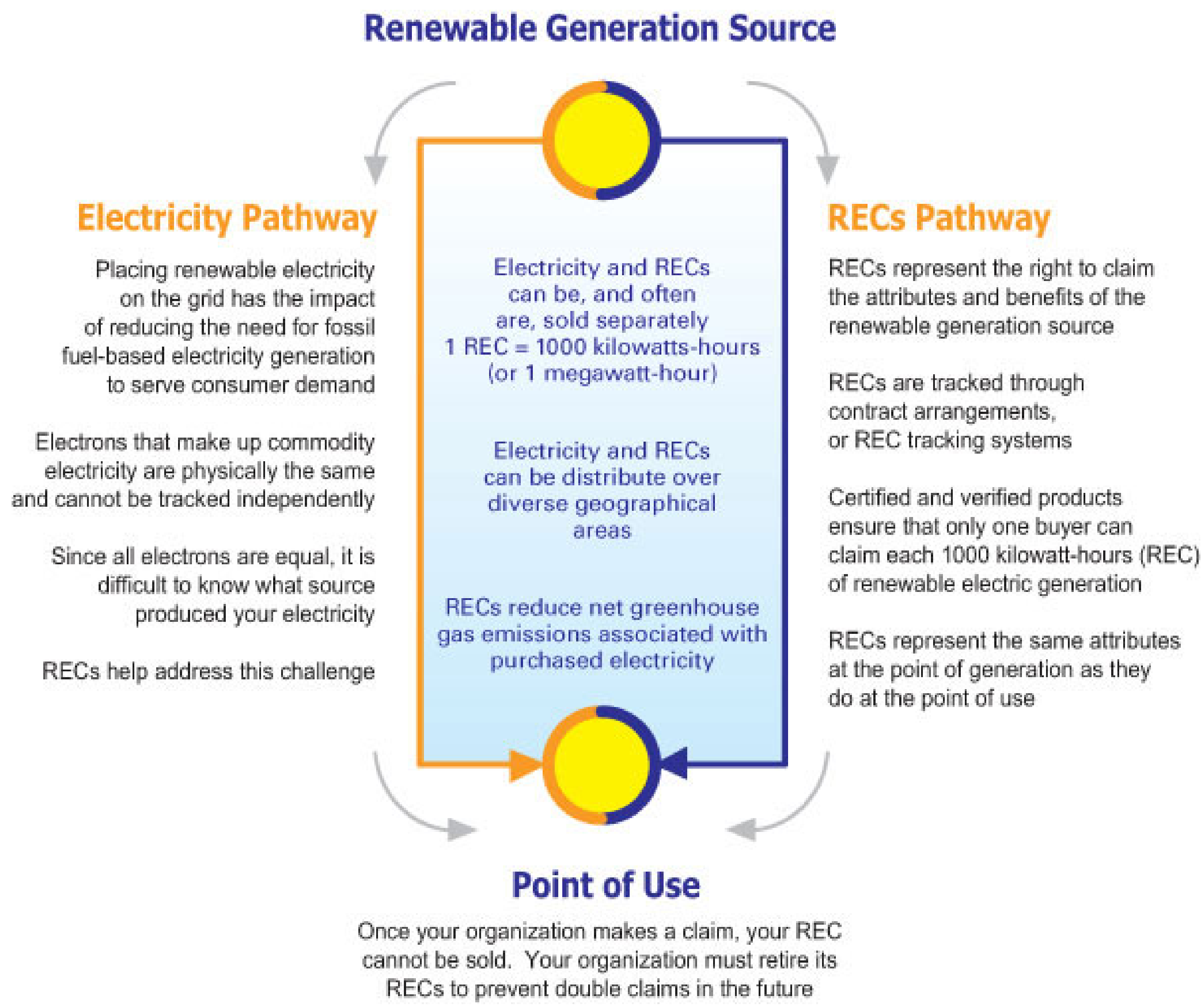
AMERESCO SOLAR — Green • Clean • Sustainable
McKinstry
Chevron — Human Energy
SIEMENS
Honeywell
TETRA TECH
Johnson Controls
TRANE

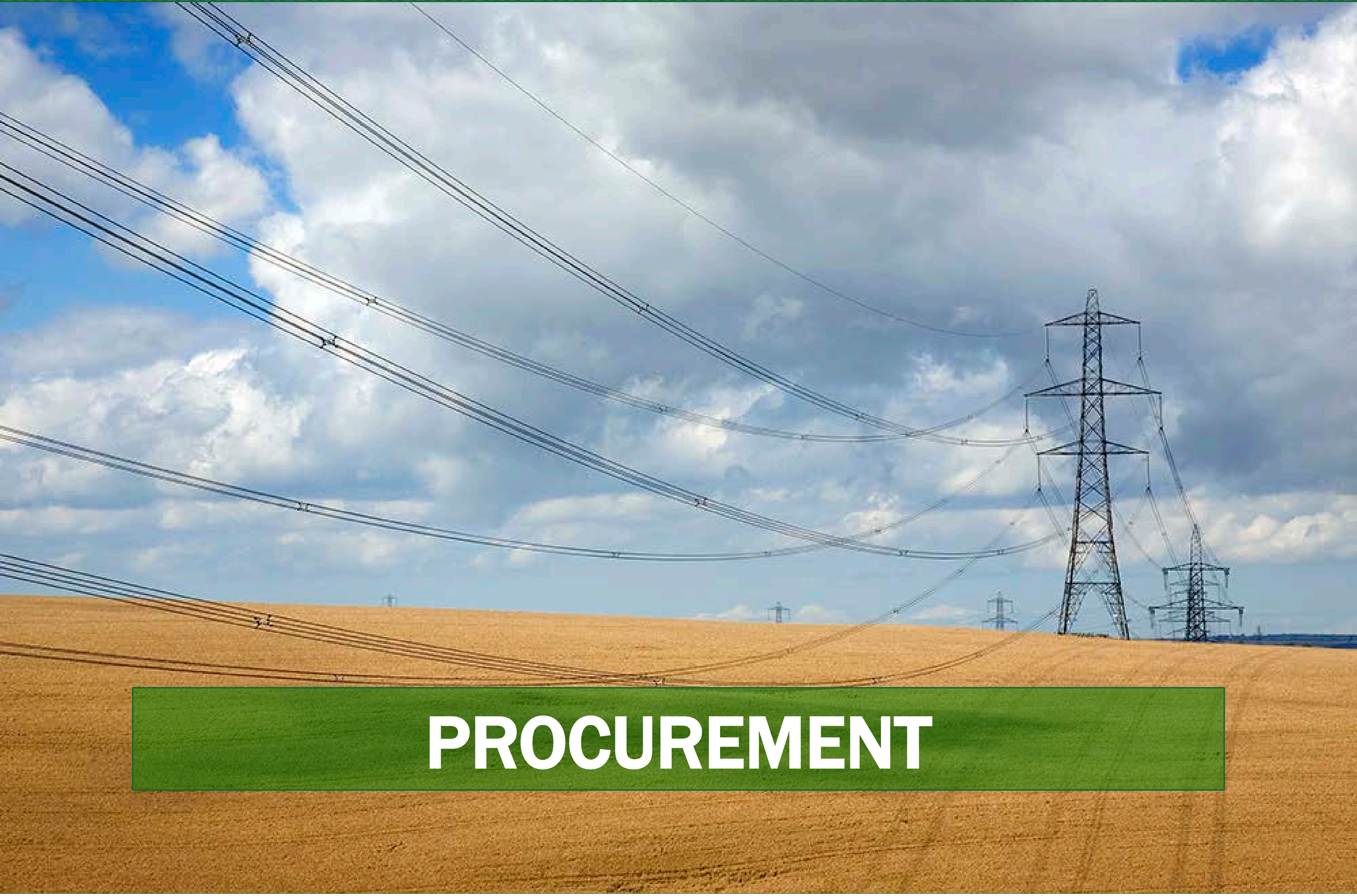
View the full DOE ESPCs list at: energy.gov/eere/femp/doe-qualified-energy-service-companies

ESPCs Reallocate Current and Future Energy Spending



Renewable Energy Certificates (REC)





PROCUREMENT

Procurement Process for Facility- and Community-Scale Projects

Step 1: Develop and Issue RFP → Step 2: Make Selection → Step 3: Negotiate Contracts

Potential Project Partners to Procure

- Consider GSA as a resource for procurement: http://www.gsa.gov/portal/category/20998
- Project developer
- Engineering, procurement, and construction (EPC) contractor
- Environmental permits contractor
  - May apply to some community projects, but not to others

Request for Proposals (RFP) Process Outline

1. **Develop RFP**
   - Timeline: 1 month to 1 year (depends on project scale and site complexity)
   - Who creates the RFP: project leader, contract officer/lawyer, site manager(s), energy manager and technology expert. RFP writers will receive input from utility, tribal leaders, and stakeholders
   - RFP content
2. **Issue RFP**

   Tribal, federal, and industry networks
3. **Administer the RFP**
   - Proposal meeting(s)
   - Site tour(s) – can be concurrent with proposal meeting
   - Q&A process – ensure all developers get same information
4. **Evaluate Criteria**
   - Should be a clear process with well defined criteria
   - Evaluation panel recommended to consist of an odd number of members (typically 3 to 7)
5. **Award Contract**

   Four approaches

4 Implementation

Step 4: Implementation

Purpose: Contract for and *build* the project

Tasks:

- Finalize pre-construction activities including project agreements—financial, contractual, and interconnection
- Start construction and equipment installation
- Interconnect project to the grid
- Start project commissioning leading to facility/community project operation

Output: Completed project (operation)

Implementation Activities

- Pre-construction
  - Financial closing (if applicable)
  - Project kickoff
  - Design and construction documents, plans/schedules, submittals
- Contract execution
  - Contract oversight/quality control
  - Change control
- Interconnection
  - Application review and approval process
  - Final building inspection
  - Paperwork submittal to utility
- Project Construction
  - Contract oversight/quality control
  - Change control
- Commissioning
  - Testing and verification
  - Interconnection verification (utility)
  - Utility permission to operate

Pre-construction: Financial Closing

The process of completing all project-related financial transactions, finalizing and closing the project financial accounts, disposing of project assets, and releasing the work site.

A few key steps:

- Establish and communicate final date for all financial transactions and account closings ***well before closing***
- Verify all items from the statement of work have been completed before disbursing final payments
- Collect all financial records and verify that all financial obligations have been satisfied
- Close all financial accounts
- Transfer or dispose of assets according to the acquisition plan.

Pre-construction: Project Kickoff and Design and Construction Documents

- Kickoff meeting
- Checklists for schedules and each activity based on contract and project documents
- Utility interconnection process and agreement
- Design (often in stages) and design approvals
- Other possible plans:
  - Utility
  - Construction
  - Management
  - Quality control
  - Commissioning
  - Environmental protection
  - Security

Project Construction

- The system has received building approval from the local permitting authority housing jurisdiction, but has not yet received final authorization for interconnection or permission to operate
- Project developer orders equipment and begins construction or installation
- Construction manager coordinates work of various trades
- Close coordination with tenants if site or building is occupied
- Frequent communication between all parties to minimize possible issues

Commissioning

- To receive final interconnection authorization from a utility, the installer must first submit verification of passed final building inspection
- Project interconnected according to utility interconnection agreement and utility process
- Commissioning
  - Physical inspection
  - Component Testing and whole system performance testing
- Upon approval of all paperwork, the utility will likely install a net meter (for net-metered systems) and finally issue a permission to operate letter.
- After permission is granted, the installer is allowed to energize the system.

Commissioning Process Example

Planning
- Determine objectives and strategies
- Assemble project team
- Compile and review documentation

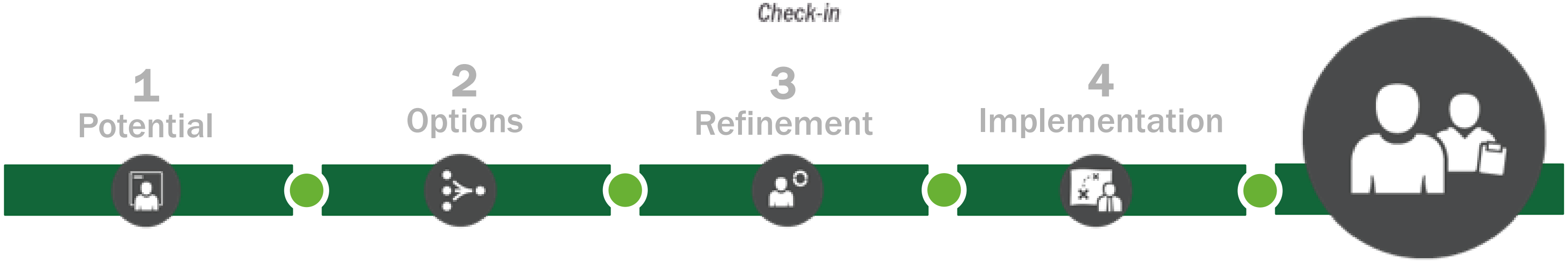
Investigation
- Conduct site assessment
- Develop functional test and monitoring plans
- Analyze test results
- Compile master list of deficiencies and recommend improvements

Implementation
- Implement accepted recommendations
- Make repairs and improvements
- Retest and remonitor
- Fine-tune

Hand-off and Integration
- Present final documentation of commissioning effort

Project Development Process

5 Operations & Maintenance



Step 5: Operations & Maintenance

Potential | Options | Refinement | Implementation | **Operations & Maintenance**

Purpose: Conduct or ensure ongoing operations and maintenance (O&M), including repair and replacement (R&R)*

Task:

- O&M agreements
- Warranties
- Monitoring system
- System performance
- Production guarantees
- Buyout Options

Outputs:

- Ensure responsible party carries out O&M/R&R*
- Measuring and tracking success
- Correlate with business plan and strategic energy plan
- Contract compliance
- Reporting of generation
- Met or exceeded energy and financial performance

**Especially if owner – role of highest O&M risk*

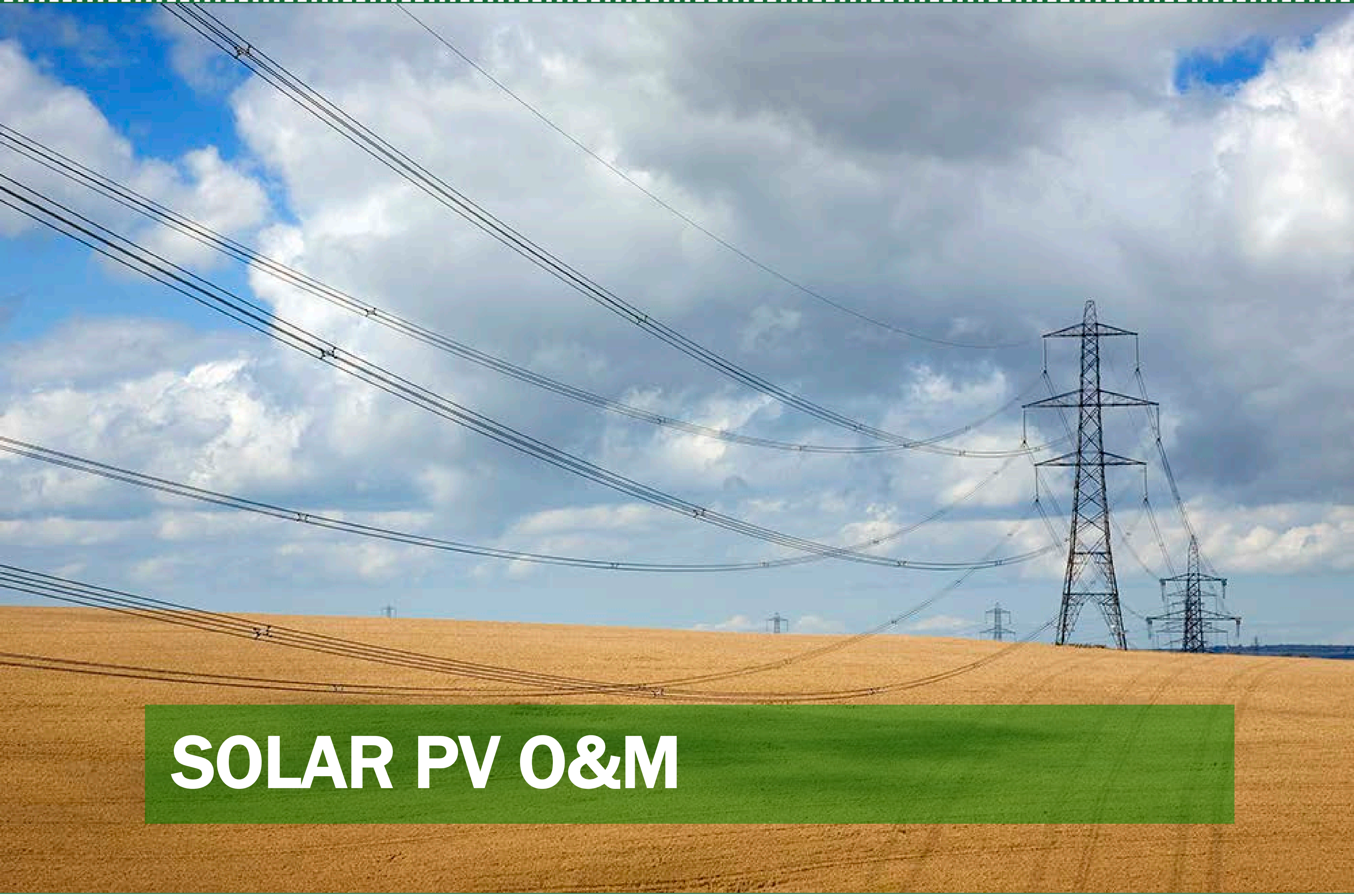
Photo by Warren Getz, NREL 00180

Post-Procurement: Project O&M

- O&M agreements
- Warranties
- Monitoring system
- System performance
- Production guarantees
- Buyout options

Drivers for Improved O&M

- Increase efficiency and energy delivery (kWh/kW)
- Decrease downtime (hours/year)
- Extend system lifetime (25–40 years)
- Reduce cost of O&M ($/kW/year)
- Ensure safety and reduce risk
- Enhance appearance and image
- Often required in financing and warranty



SOLAR PV O&M

Solar PV O&M Costs Depend On…

Location

- Remote
- Controlled access
- Restricted hours of operation

System Type

- Roof
- Ground-mount
- Tracking vs. fixed

Components

- Number of modules
- Number of combiners
- Number/type of inverters
- Number of transformers

Warranty Coverage

Environmental Conditions

- Snow
- Pollen
- Bird populations
- Sand/dust
- Humid
- Hot
- High wind
- Hail
- Salt air
- Diesel soot
- Industrial emissions
- Construction site nearby
- High insolation

O&M Activities

- **Administration**
  - Billing; accounting
  - Hiring subcontractors
  - Enforcement of warranties
  - Management of budget and reserves
- **Monitoring**
  - Metering for revenue
  - Alarms
  - Diagnostics
- **Preventive Maintenance**
  - Scheduled and planned
  - Expenditure is budgeted
- **Corrective Maintenance (repair)**
  - Unplanned or condition-based
  - Possible expenditure is kept in reserve or line-of-credit
  - Must be timely and effective

Inspection of a 67-kW PV system at Mesa Verde National Park.
Photo by Andy Walker, NREL

Solar PV O&M Maintenance Plan Example

Task	As Required	Monthly	Semiannually
Inspect modules for damage			✓
Address array shading issues	✓		
Remove debris around array	✓		✓
Inspect array mounting system			✓
Adjust array tilt	✓		
Check inverter and/or charge controller for correct settings		✓	
Inspect battery enclosure		✓	
Inspect battery terminals and connections		✓	
Equalize batteries	✓	✓	
Water batteries	✓	✓	
Measure specific gravity of each battery cell	✓	✓	
Load-test batteries			✓
Capacity-test batteries			✓
Inspect and clean all electrical equipment			✓
Monitor system for voltage and current	✓	✓	

*Adapted from Dunlop, J.P. (2010). Photovoltaic systems 2nd ed

Solar PV O&M Depends on System Size

- Small system
  - On-site inspections, operational indicators ,and procedures (e.g., shade) responsibility of the off-taker; off-taker contacts provider if there is a problem
  - Inspection of fleets on a sample rather than every system
  - Performance guarantees consider insignificant corrections that can be deferred; consider degradation rates specific to module type
- Large system
  - Emphasize automated monitoring and analytics, remote reset, push reports to stakeholders
  - Report loss of production daily; low production weekly (few false-positives)
  - Monitoring system: transparent, auditable, maintainable, backup, secure
  - On-site or remote sensing of environmental conditions (I, T) for large systems?

Warranties

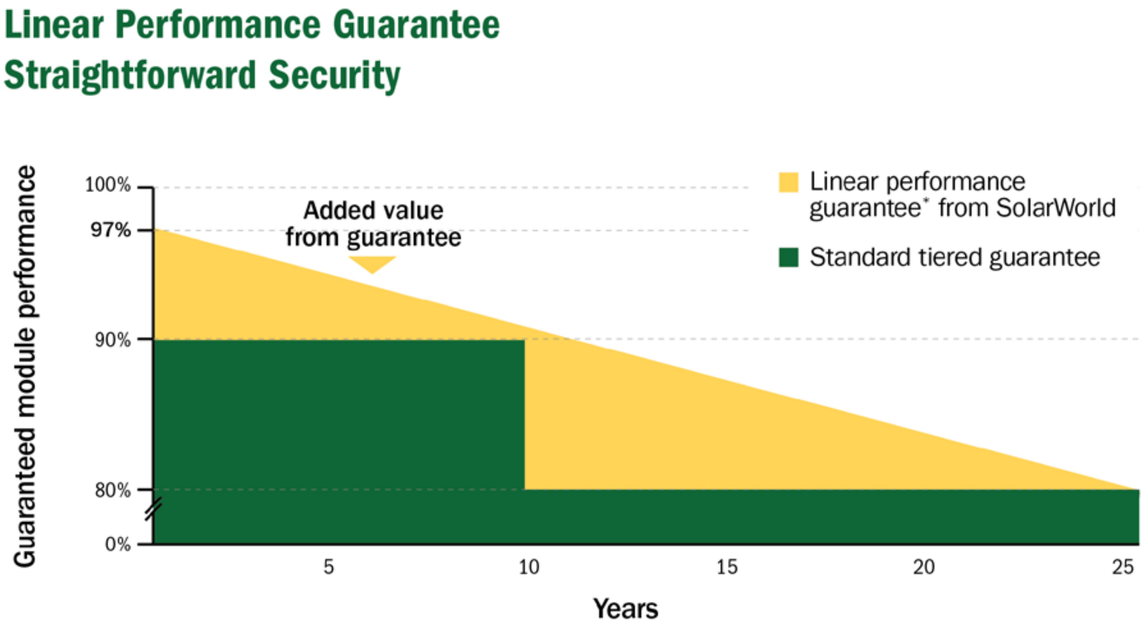
Complete systems are often warranted by the installer for one year. After the first year, the manufacturer's warranty on the PV modules (up to 25 years) and inverter (up to 10 years) as well as on any other components transfer to the owner for enforcement.

Stepped Warranty

- 90% power warranty for 12 years
- 80% power warranty for 25 years

Linear Warranty

- Starts at 97% in year one
- Maximum annual degradation rate is ~ 0.5% to 0.7%/year



Clear added value compared to standard tiered guarantees.

WIND O&M

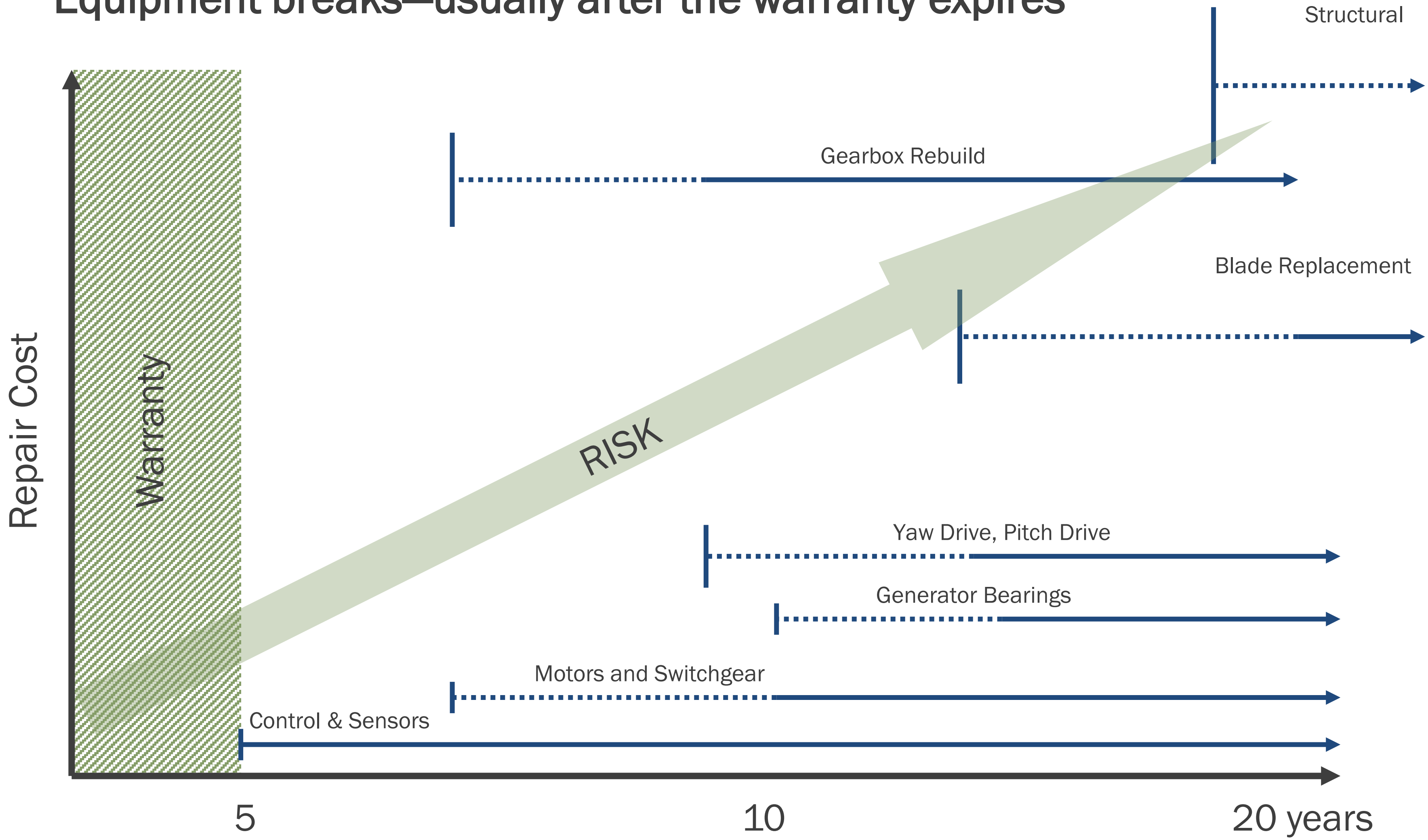
O&M Wind Energy Costs

- Generally, the annual O&M costs increase over the life of the turbine, especially in later years of 20- to 25-year useful life
- Industry-recommended practices exist for all aspects of wind turbine maintenance:
  - Towers, rotors/blades/hubs, gearboxes, generators, balance of plant, data collection/reporting, end of warranty

Members of the Navajo Tribal Utility Authority install a wind turbine. Photo by Larry Ahasteen.

Major Components at Risk

Equipment breaks—usually after the warranty expires



Source: Chris Walford: GEC (now DNV GL)

Small Wind O&M Activities

- **Follow manufacturer/installer recommendations:**
  - Schedule routine maintenance (semi-annual or annual) per manufacturer guidelines
  - If you find a good contractor, keep using the same one—experience and familiarity with a particular turbine is good

- **If you are a "do-it-yourselfer" AND you can climb a tower or have a tilt-down turbine or small bucket lifter, semi-annually or annually (follow manufacturer recommendations):**
  - Tighten screws and bolts—electrical and mechanical
  - Check for frayed wires
  - Check for insect or other debris build-up on blades and clean off (with water—no solvents)
  - Check for rust—remove using manufacturer's recommended lubricant

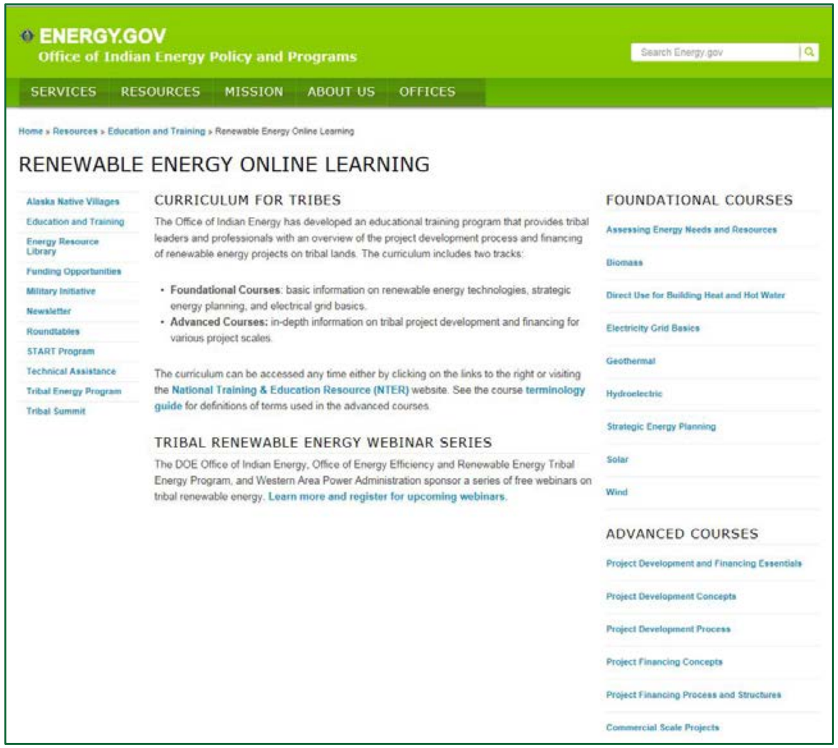
Revisit Energy Plan

- Check back in with planning document—update as necessary
- Identify next potential project from plan

Resources: On-Demand Curriculum

Access free courses anytime

- **Foundational Courses**
  Overview of specific renewable energy technologies, strategic energy planning, and grid basics
- **Leadership & Professional Courses**
  In-depth information on the components of the project development process and existing financing structures



energy.gov/indianenergy/curriculum