

January 31, 2012

Prepared at the request of the U.S. Environmental Protection Agency (EPA) OSC Green Response Team

Access to sufficient fuel for powering initial response and cleanup operations at hazardous waste sites can be costly, particularly at remote sites or other areas without connection to grid electricity. In addition, transport and burning of petroleum fuel typically used in electricity generators during response and cleanup results in emission of air pollutants such as greenhouse gases and particulate matter. Renewable energy-based alternatives to petroleum-fuel fired generators and grid electricity are increasingly available to power equipment used in the field or housed in trailers. On-scene coordinators (OSCs) and other emergency response team members recognize a particular need for renewable power systems that can be rapidly transported and deployed in various settings.

*Manufacturers of mobile power systems estimate that **petroleum fuel may cost \$14-20 per gallon** when used at remote U.S. sites and factoring in ground transportation.*

To help OSCs, remedial project managers (RPMs,) and other response or remedial decision-makers, EPA's Office of Superfund Remediation and Technology Innovation (OSRTI) compiled and offers on following pages a list of commercial products meeting these needs. The products are categorized under:

Section 1: **Mobile turnkey systems integrating solar with wind resources** to produce electricity for general site operations. These systems offer a range of electricity power, from less than 1 kW to over 20 kW. Most include or offer optional back-up generators powered by diesel or propane fuel. Mobility is provided by features such as collapsible platforms, fold-up photovoltaic (PV) panels, and telescoping wind turbine towers. Most are self-contained on a flatbed trailer that can be towed by a pick-up truck or in some cases an ATV, while others are designed for packing in rugged containers that can be moved by forklift or inside an SUV.

Section 2: **Mobile turnkey systems relying primarily on PV components** to produce electricity for general site operations.

Section 3: **Portable renewable power systems for dedicated small purposes** such as recharging telephones, radios, laptops, and other small electronic devices, purifying water for onsite use, or powering appliances such as ventilation fans and refrigeration units. While some systems are hand held, portability of larger systems can be provided by mobile mounting systems such as metal frames or skids that can be easily hauled. Equipment connection to these portable power sources is relatively simple, involving procedures comparable to fuel-fired generators.

Section 4 highlights removal and remedial actions in which **stand-alone solar or wind systems have been deployed to power selected cleanup equipment** such as submersible pumps and exhaust fans on a dedicated short- or long-term basis. Some of these systems are fully portable while others involve small units such as PV panels that can be easily disassembled, transported, and reassembled on lightly fixed mountings to power a range of equipment in multiple areas. Lastly, Section 5 mentions **innovative methods for recovering other sources of renewable energy** at some sites, such as micro hydropower or liquid pressure differentials. EPA and other federal agencies anticipate future field tests to evaluate performance and deployment ease of these methods.

Developing an Overall Power Budget and Strategy

Anecdotal information from OSCs suggests that emergency response units with a "heavy" electricity demand have traditionally been met by one or more diesel-fueled generators with a combined electrical capacity of 15-20 kW. Due to weather-related infeasibility of using solar or wind resources to exclusively meet this demand, and the need to remain within project budgets, vendors encourage decision-makers to develop strategies that allow these systems to incrementally reduce (rather than immediately eliminate) the load on petroleum fuel-fired generators. One strategy, for example, may involve procuring sufficient renewable power capacity to initially substitute 50% of a response unit's fuel-fired power system. Strategies also can plan productive use of mobile systems when not deployed for emergencies, such as supplementing grid electricity for an administrative building or research laboratory or powering cleanup equipment at selected sites on a short-term basis.

*Develop a renewable energy portfolio involving **multiple and diverse inputs**.*

A turnkey system for producing power from renewable sources of energy typically includes a DC/AC inverter, charge controller, power packs containing industrial deep-cycle storage batteries, and a programmable user interface. When procuring a mobile renewable power system, vendors recommend that users consider:

- A scale that accounts for the power distribution mode as well as the anticipated power budget
- An adaptable architecture that can handle various DC inputs, energy storage components, and applications on a modular basis

- Hybrid systems using renewable, conventional, and other inputs such as DC fuel cells
- Durability of the system's trailer or shipping container(s), and
- Energy efficiency of the equipment being powered and replacement of outdated equipment with energy-efficient models.

Minimize the energy load through energy efficiency.

Managing the Onsite Energy Budget

Readily available tools that can help OSCs, RPMs, and other cleanup decision-makers screen the potential contribution of renewable energy resources and manage energy loads at a particular site include:

- Dynamic maps, geographic information system data, and analytical tools developed by the National Renewable Energy Laboratory (NREL) for wind and solar resources (http://www.nrel.gov/renewable_resources/)
- State-specific renewable energy maps developed by EPA in partnership with NREL (http://www.epa.gov/oswer/ocpa/maps_incentives.htm)
- PV Watts, an online NREL calculator to determine energy production and cost savings of adding grid-connected PV systems (<http://www.nrel.gov/rredc/pvwatts/>)
- Devices such as radiometers and sun trackers for precise measurement of solar radiation, and
- Nearby meteorological towers operated by other organizations.

Procuring Mobile Systems

Whether through purchase or rental agreement, OSCs and RPMs can expect the procurement process for a renewable power system to follow the same channels used to procure equipment such as fuel-fired generators. Some vendors or retailers offer General Service Administration (GSA) discounts and a few offer additional incentives; for example, one manufacturer of turnkey solar/wind integrated products offers a 3% "bulk" discount for GSA purchases exceeding \$100,000. Other incentives such as federal or state credits/rebates may be available to non-government organizations. To date, few vendors offer leasing arrangements for these systems although most are exploring commercial partnerships for leasing capability. Many manufacturers and retailers offer turnkey services to help users meet energy goals and assure proper interface among equipment while exploring capital cost financing.

Federal users may explore procurement through government-wide agency contracts (GWACs) operated by other agencies. The U.S. Department of Defense's National Defense Center for Energy and Environment (NDCEE), for example, maintains a GWAC to help agencies reduce total ownership costs while fulfilling environmental, safety, occupational health, and energy requirements related to agency missions (<http://www.ndcee.ctc.com/index.html>); agencies may access the NDCEE through an interagency agreement (IAG) or a military interdepartmental purchase request (MIPR) to demonstrate and transition emerging and existing technologies involving energy, water, and waste. More GWAC opportunities may be available from the U.S. Department of Interior National Business Center's "other transaction authority" (OTA) with the Consortium for Energy, Environment, and Demilitarization (CEED).

About the Product List

The following list is not intended to be exhaustive but instead illustrates the range of options for using mobile or portable renewable power systems to power response and remediation actions. Pricing details, model specifications, and other descriptors in the list reflect readily available online information or general verbal quotes from manufacturers and are subject to vendor/retailer verification or update at the time of procurement. Primary points of contact for manufacturers of turnkey systems are provided to streamline follow-up communications among potential users. Additional information about performance and safety of turnkey systems may be available from the Army Test Center at Aberdeen Proving Ground (PG), MD.

Mention of specific products or vendors does not constitute EPA endorsement.

Suggestions for additional products or detail demonstrating use of these products at particular sites or within organizations may be forwarded to Carlos Pachon (OSRTI) at: parchon.carlos@epa.gov. Updates to the product list may be forwarded to: sandra.novotny@novaee.us.

Appreciation is extended to the many OSCs and RPMs contributing site-specific examples or suggestions summarized in the product list.

Product	Manufacturer	Rated Power or Sample Output (model name where applicable)	Other Specifications	Vendor or Retailer Website (point of contact)	Purchase Cost (sample or starting range)	User or Referral [to be developed per user input]	Illustration
Section 1: Mobile Turnkey Systems Integrating Solar with Wind Resources							
Solar Generator	Mobile Solar	-MS-100: 3.5 kW -MS-200: 3.5-7 kW -MS 300: 7 kW	-3' by 5' towable platform -5' by 9' to 5 by 16" light trailer -5' by 16' or 6' by 20' heavy trailer -Custom trailers (e.g. with integrated wind turbine) available -Grid connectivity	http://www.mobilesolarpower.net/ (Travis Semmes)	-\$17,900 -\$25,860 -\$43,620 Pending inclusion in GSA schedule Leasing available through dealers; contact Semmes		
SkyTrailer®	SkyBuilt Power	10.92 kW (including 4.92 kW PV "blankets," 6 kW diesel generator)	-Solar and wind systems on a ruggedized trailer -Deployable in 2 man-hours -Total weight of 4,200 lbs -Optional quick-deploy wind turbine -Optional grid connectivity	http://www.skybuilt.com/products/products_skytrailer.htm (Michael Gayle)	\$210,000 GWAC available Leasing available		
SkyStation®	SkyBuilt Power	20.64 kW (including 5.64 kW PV array, 15 kW diesel generator)	-20' by 8' container providing deployed shelter -Deployable in 12 man-hours -Total weight of 25,000 lbs -Optional quick-deploy wind turbine -Optional grid connectivity	http://www.skybuilt.com/products/products_skystation.htm (Michael Gayle)	\$205,000 GWAC available Leasing available		
SkySkid®	SkyBuilt Power	9.76 kW (including 3.76 kW PV array, 6 kW diesel generator)	-Skid-based container for forklift or helicopter lift -66" by 72" by 30" cabinet -Total weight of 2,500 lbs -Optional grid connectivity (PV blankets with/without power pack also available in smaller SkyCase (\$24,000) or SkyPak (\$3,100) products)	http://www.skybuilt.com/products/products_skyskid.htm (Michael Gayle)	\$70,000 GWAC available Leasing available		
Solar Stik™ 360 Breeze	Solar Stik	3-4 kWh average daily output	- Plug & play deployment - Capable of daisy-chain expansion for increased output - Packs in 2 cases (Tested at Aberdeen PG)	http://www.solarsolutions.com/products-generation/solar-stikm-360-breeze (Al Zaccor)	\$32,000 (GSA discount)		

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Tactical Wind Turbine®	Energy Technologies, Inc.	600-3,500 watts	<ul style="list-style-type: none"> -50 pounds -Quick assembly -Stand-alone or integrated with companion <i>Tactical Solar®</i> PV panels 	http://tacticalsheltersystems.com/windpower.php (Todd Reffey)	To be determined		
Titan	White Door	2-5 kW (600 watt wind generator, combined 1,280 watt PV panels, optional 1 kW hydrogen fuel cell)	<ul style="list-style-type: none"> -48' telescoping turbine tower -8 160-watt PV panels -Integrated with diesel/gas generator or propane system -80 cft tank for fuel cell -Grid connectivity -16' or 20' platform on 8-wheel trailer 	http://www.criticalsolutions.net/products/titan (Jeff Siriani)	\$110,000 Pending inclusion in GSA schedule		
Mojo	White Door	1.12 kW (600 watt wind generator, combined 520 watt PV panels)	<ul style="list-style-type: none"> -28' telescoping aluminum tower -4 130-watt PV panels -Grid connectivity -2-wheel ruggedized trailer 	http://www.criticalsolutions.net/products/mojo (Jeff Siriani)	\$65,000 Pending inclusion in GSA schedule		
Mobile Trailer	Mobile Gen	22 kW (6 kW wind, 12kW PV)	<ul style="list-style-type: none"> -48' turbines (2 Skystream units) -6 PV panels -Standby propane generator (80 hrs) -Water treatment unit -Fits into 40' container -Operational within 1 hour -Grid connectivity <i>(Depicted at Gulf of Mexico oil spill)</i> 	http://www.mobilegen.com/product.html (James Ethchechury)	\$90,000 Bulk discount available Financing available Pending inclusion in GSA schedule		
GSW 7000	Strategic Services International	12 kW (2,400 watt wind generator (at 29 mph) and combined 4,600 watt PV panels)	<ul style="list-style-type: none"> -Telescoping 106' tower for wind turbine and telecommunications -16 PV panels -Optional reverse osmosis water purifier -Deployable in 30 minutes -Trailer mounted 	http://providentetrade.com/mobile-solar-and-wind-powered-energy-water-and-communications-system/	\$175,000		

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Mobile Renewable Power Station	Arista	1.3 kW (if equipped with WindTamer 4.5 ^{GT}) plus selected PV bundle)	-Rotor system using wind/vacuum -Includes PV inputs -Extended life cycle, high capacity energy storage bank -38' height and 2 m/s cut-in speed (with WindTamer 4.5) -Trailer mounted (Under testing at Aberdeen PG)	http://aristapower.com/micro-grid/portable-power/	To be determined		
T-REX (Trans-portable Renewable Energy eXchange)	Ameresco (purchaser of technology developed by Live Oak Solar)	5.5 kW (including 2.24 kW PV array, 400 watt wind turbine)	- Equipped with propane storage tank - Trailer mounted - Designed for rugged conditions - Deployable by one person within 30 minutes (Tested at Nellis AFB; depicted at Seymour Johnson AFB demo)	http://www.ameresco.com/solution/renewable-energy (John Oliveri)	To be determined		
Section 2: Mobile Turnkey Systems Relying Primarily on Solar Resources							
Mobile Solar Power Systems™	Pure Power Distribution	- R5: 4.5 kW - R10: 6 kW - Super 10: 18 kW - Hybrid S10: 18 kW - S48T: 72 kW	-Mounted on 12- to 48-foot positioning platform for towing -Hybrid S10 includes 35 hp Tier 4 generator operating on diesel (up to B20) or propane	www.PurePowerD.com	To be determined	Will Duncan (EPA Region 9) duncan.wil@epa.gov	
Green Tow Trailer	Green Tow	-GT916: 3.6- 6.8 kW -GT1932: 3.6-10..8 kW -GT3049: 3.6-10.8 kW	-5' by 9' trailer, 12 panels, 4-8 batteries -6' by 19' trailer, 24 panels, 8-16 batteries -6' by 30'trailer, 36 panels, 8-16 batteries	http://greentow.com/models/	-\$46,900 -\$74,900 -\$97,900 Buy-back policy		
Mobile Max®	WorldWater & Solar Technologies	1.7 kW	-18' by 7' trailer -Includes 9 PV panels -Includes 2-hp submersible water pump with average capacity of 200 gpm during daylight -Also available as Mobile MaxPower with embedded 10-hour battery -Also available as Mobile MaxPure with built-in 30,000 gal/day water purification system	http://www.worldwatersolar.com/2-mobilemax.html (David York)	-\$25,000 -\$115,000		

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Section 3: Portable Renewable Power Systems for Dedicated Small Purposes							
DG Portable Solar	DynGlobal	- Panels: 14, 16, 18, and 300+ watt (up to 10 kW) - Power station: 500 watt, 1,000 watt, 1,500 watt, and 5 kW	<i>Blanket generator</i> - Light-weight foldable panels including built-in USB port - Power station includes inverter, charge controller, and back-up battery	http://dynglobal.com/solar-energy/	-\$2,500 (600 watt) panel -\$2,990 (1,000 watt) panel		
PowerMods	FTL Solar	-300 watts (1,125 Whr average daily output at 5 hrs/sun per day) -500 watts (1,875 Whr) -1,000 watts (3,750 Whr)	<i>Fully or partially enclosed shelter</i> -14' by 46', 27 lbs -36' by 95' fold-in, 80 lbs -35' by 95' fold-in, 105 lbs	http://www.ftlsolar.com/product/powermod-300-1000/	-\$5,400 -\$9,000 -\$18,1000		
Rover	Onsite Guardian	-170 watt -260 watt	<i>Remote surveillance, communications, & weather station</i>	http://www.onsiteguardian.com/	-\$27,000 -\$29,000 One- to four-year leasing available		
SolMan®	Sol Solutions	1,200 watts	<i>Portable power station</i> - Includes 1 PV panel, 3 100 amp/hour deep cycle sealed batteries, charge controller, watt meter, 1,500 watt inverter/charger, external AC/DC plugs - Contained on 2-wheel cart	http://www.sol-solutions.com/products-services/solman-portable-solar-solutions.html	\$3,950		
Portable Power & Charging System	Energy Masters	200 watts	<i>Portable power station</i> -Includes telescoping legs and connectors for rapid deployment -Foldable PV array fits in a vehicle trunk -Includes charge controller and inverter	http://www.sunshinetworks.com/solar-panels-emergency-use.htm	\$950		
Solar Stik™	Solar Stik	-100 Lite: average daily output of 1.0 kWh -100 Nano Pro: 100 watts (average 1.0 kWh/day) -160 Terra: 160 watts (average 1.5 kWh/day)	<i>Portable dual-axis PV station</i> -60 lbs -70 lbs	http://www.solarstik.com/products-solutions/power-generation	-\$3,600 -\$8,300 -\$12,600		

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Tactical Solar Panels	Energy Technologies, Inc.	-5-300 watts -5-20 watts	<i>Portable tie-down generator</i> -Foldable panel of briefcase size -Rollable panel of backpack size	http://www.tacticalsolar.com/rugged_solar_panels.php	To be determined		
Personal Solar Pack	Energy Technologies, Inc.	10 watts	<i>Electronics charger</i> -Includes USB adapter -Briefcase size	http://www.personalpowerstore.com/index.php?route=product/product&product_id=72	\$200		
UltraCell XX55™	UltraCell	50-85 watts	<i>Portable fuel cell power</i> - Operates on methanol and water mixture -Sample of power time: 5-gal configuration yields 75 watts for 180 hours, 220 watts for 60 hours	http://www.ultracellpower.com/assets/XX55_Data_Sheet_02-15-2011.pdf	To be determined		

Section 4: Stand-Alone Solar or Wind Systems Dedicated to Selected Cleanup Equipment

<i>N/A; multiple components selected and integrated</i>	<i>Multiple PV units purchased from Industrial Solar & BP Solar</i> <i>Telemetry offered by: Hach/Hydro-lab, YSI, Measurement Specialist Inc., & Netronix</i>	20-40 watts	<i>Remote monitoring</i> -PV charges 12V/26Ahr sealed battery -Uses a multiprobe sonde to measure 11 water quality parameters of stream impacted by acid mine drainage -Uses satellite telemetry for hourly data collection and transmission to EPA Region 9 offices <i>(4 systems also deployed at Leviathan Mine, CA)</i>	Custom built by EPA Region 9 laboratory staff http://www.svtucs.com/IndustrialSolar.html http://www.bpsolar.us/solar-products	-\$300 PV panel and battery -\$5,000 satellite telemetry hardware -\$3,500 cellular telemetry hardware -\$230/month sat/cell/web fees	Greg Nagle (Region 9) nagle.greg@epa.gov	 New Idria Mercury Mine, CA
Solar Sipper	GeoTech	65 watts	<i>-Pressure/vacuum pump for hydrocarbon recovery (skimming)</i> -Offers 12 volt battery, trailer, recovery tank, and other parts for a stand-alone system	http://www.geotechenv.com/rental-remediation-equipment.html	\$6,000 (skimmer assembly and PV panel)	Clint Sperry (Region 7) sperry.clint@epa.gov	 Lake City Army Ammunition Plant, MO
<i>Detail unavailable</i>	<i>Detail unavailable</i>	<i>Detail unavailable</i>	<i>Oil recovery</i> -Deployed for short-term recovery of large amounts of free product (> 1-foot thickness) from wells on 76,800-acre site -Requires moderate wind conditions	N/A; custom built	<i>Detail unavailable</i>	Guy Warren (Alaska DEC) guy_warren1@alaska.gov	 Former Adak Naval Air Facility, AK

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SQ Flex	Grundfos	11 SQF-2: 200 watts	<i>Groundwater recirculation</i> -PV system enables automatic pump shutdown when solar energy is insufficient (to avoid overheating) -Submersible pump maintains an average 2.5 gpm flow through subsurface bioreactor -Adaptable to 1 kW <i>Whisper 100</i> wind turbine	http://net.grundfos.com/doc/webnet/sq_flex/int/download.html	\$2,300	J. Seb Gillette (AFCEE) john.gillette.1@us.af.mil [http://www.clu-in.org/greenremediation/subtab_d1.cfm]	 Altus Air Force Base, OK
<i>Detail unavailable</i>	<i>Detail unavailable</i>	<i>Detail unavailable</i>	<i>Dewater below caps</i> -Pumps perched water for forced evaporation treatment in brine concentrators	<i>Detail unavailable</i>	<i>Detail unavailable</i>	Andria Benner (Region 9) Benner.andria@epa.gov [http://www.clu-in.org/greenremediation/subtab_d16.cfm]	 Apache Nitrogen Products, Benson, AZ
Kyocera 135 Universal Track Rack UTR-064™ PPT 48-20A	Kyocera Zomeworks Solar Converters, Inc.	135 watts N/A: passive solar tracker N/A: linear current booster	<i>Groundwater pumping</i> - Multi-axis solar tracking array of 4 135-watt panels - Extracts 100-160 gal/day of groundwater for ex situ treatment - Steel pipe foundation tied to existing concrete pad	http://www.kyocerasolar.com/products/ksimodule.html http://zomeworks.com/products/pv-trackers http://www.solarconverters.com/product_frame.html	PV: \$350 Tracker: \$1,620 Booster: \$400	Vicky Kugler (Missouri DNR) vicky.kugler@dnr.mo.gov Curt Elmore (MO S & T) elmoreac@mst.edu [http://www.clu-in.org/greenremediation/subtab_d33.cfm]	 Busy Bee Laundry, Rolla, MO
<i>Detail unavailable</i>	<i>Detail unavailable</i>	10 watts	<i>Vapor intrusion mitigation</i> -Uses single 36"by 36" PV panel to drive 65-watt 200-cfm radon fan -45-minute installation time -Relatively maintenance-free -Battery life of 5-7 years	http://www.ecovantageenergy.com/catalog/subcat54.htm	\$250 (including PV panel, fan, and battery)	Greg Fife (Region 6) fife.greg@epa.gov [http://www.clu-in.org/greenremediation/subtab_d30.cfm]	 Delfasco Forge, Grand Prairie, TX

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<i>Detail unavailable</i>	<i>Detail unavailable</i>	390 watts	<i>Irrigation</i> -Array of 3 130-watt 12-volt PV panels -Array mounted on 4-inch diameter, 12 foot-long metal pipe inserted directly into ground -Powered a surface water pump used to collect spring-source water and transfer it to an upgradient holding tank, which supplied drip-feed irrigation water for phytoremediation	<i>Detail unavailable</i>	\$3,000 (including pump designed for solar applications and connecting hardware)	Myles Bartos (EPA Region 3) bartos.myles@epa.gov [http://www.clu-in.org/greenremediation/subtab_d19.cfm]	 Crozet Orchard, Crozet, VA
Vantage Pro2	Davis Instruments, Inc.	N/A	<i>Weather station</i> -Collects data on 2-hr basis and stores it for up to 6 months -Includes lithium battery for power storage -Includes solar and UV sensors -Compatible with <i>Weatherlink</i> software and data logger	http://www.davis.com/catalog/product_view.asp?sku=8640311	\$900	Jeff Field (EPA Region 7) field.jeff@epa.gov	 Murdock Groundwater Cleanup, NE
Section 5: Innovative Methods for Recovering Other Sources of Renewable Energy							
Micro-hydro power submersible turbine	DLLD Co., Ltd.	- 550 watts - 2 kW	-Provides mechanical energy or drives an electricity generator -Propeller design reaction turbine -Required head of 1.5-3.2 m -Flow capacity of 0.025-0.055 m ³ /s	http://www.exmork.com/micro-hydropower.htm	-\$1,800 -\$5,000		
<i>General: "reverse" submersible pumps as micro-hydro generators</i>	<i>To be determined</i>	<i>To be determined</i>	<i>To be determined</i> ; US ACE investigating potential for reverse operation of pumps in settings with low (e.g. 50- to 100-ft) water head and seeking partners for a low-cost demonstration at a Superfund site	<i>To be determined</i>	<i>To be determined</i>		
<i>General: energy recovery at pressure reduction stations</i>	<i>To be determined</i>	<i>To be determined</i>	<i>To be determined</i> ; US ACE considering potential in natural gas lines; California utility examining potential in water lines associated with the JPL Superfund site	<i>To be determined</i>	<i>To be determined</i>		