Version B

Living Water Solar Cooperative
Raccoon Mountain Renewable Energy Study

Living Water Solar Cooperative (LWSC) is non-profit research and development cooperative chartered in the State of Tennessee, USA.

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"He who believes in me, out of his heart will flow living water". John 7:38

SUMMARY

The Living Water Solar Cooperative, or LWSC, created the SUN WIND FIRE RAIN project . Its purpose is to determine what is required to transition Chattanooga, Tennessee from its current baseline to become 100% fossil fuel free. A companion Meetup site has been established for the project.

As shown below, the project is organized by energy type, including petroleum, coal, natural gas, and nuclear. LWSC has included nuclear power in the "fossil fuel mix". LWSC has a clear appreciation for nuclear energy but the nuclear waste problem as defied solution for decades. If a solution cannot be found renewable energy alternatives will have to be put in place as the aging nuclear power plants are decommissioned.

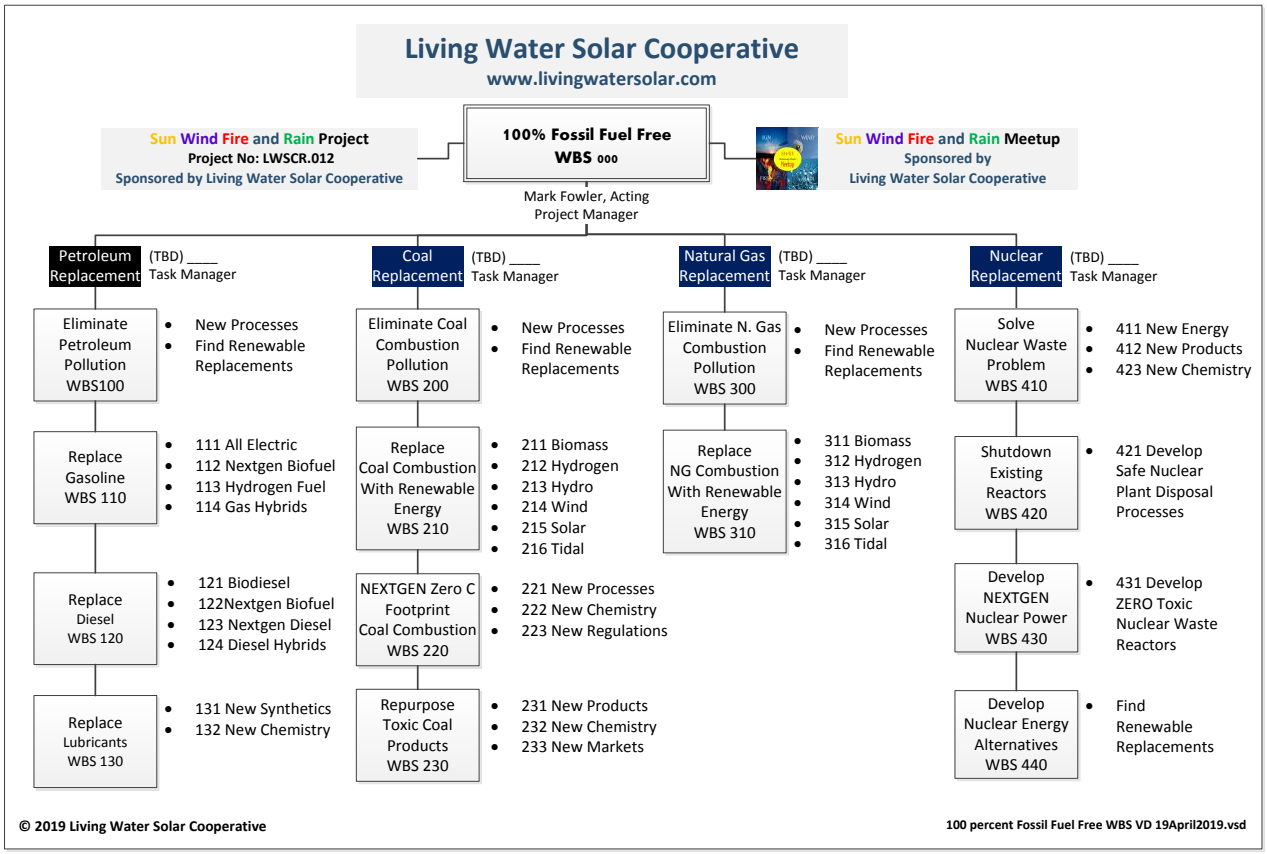


Figure 1: LWSC SUN WIND FIRE RAIN Project Organization Chart

This document addresses energy generation and storage opportunities that span across all four areas, and would expand the energy capacity of the existing electric grid. It focuses on TVA's Raccoon Mountain Pumped Storage Plant and explores four renewable energy and resource opportunities:

1. Install a floating PV solar array on the existing reservoir
2. Install wind turbines along adjoining ridges
3. Install underwater pumps in the Tennessee River driven by the river's current
4. Install large-scale electrical storage as a companion to the existing mechanical energy storage

Figure 2: Possible Additions to the TVA Raccoon Mountain Pumped Storage Plant

1. Floating Solar PV Array

This opportunity would design and install a large-scale solar PV array that would float on the surface of the existing pumped storage reservoir. As many as 500 acres (200 ha) may be available, which could provide sufficient direct area for a utility-scale array as defined by NREL. Study areas:

1.1. Power generation estimates over time, initial and life-cycle costs
1.2. Integration with existing electrical generation/grid and future on-site electrical storage (see 4.0)
1.3. Fixed versus multi-axis panel mounting cost –benefit tradeoffs
1.4. Using reservoir water to improve panel efficiency by cooling the panels in summer
1.5. Using reservoir water to melt snow and ice accumulating on the panels in winter
1.6. Using reservoir water to automatically clean the panels

2. Grindstone Ridge Wind Farm

This opportunity would design and install multiple wind generators along Grindstone Ridge which is part of the Raccoon Mountain Pumped Storage site. Analysis of this opportunity begins with aesthetic and environmental concerns. If these cannot be overcome there is no point in pursuing this option. If they can be overcome the project would study:

2.1. Power generation estimates over time, initial and life-cycle costs
2.2. Few large-scale wind generators versus many small-scale wind generators
2.3. Integration with existing electrical generation/grid and future on-site electrical storage (see 4.0)
2.4. Bird migration mitigation and noise pollution

3. "Run of the River" Power Generation

This opportunity would design and install floating or underwater turbine / pump / generators powered by the current in the Tennessee River which borders the Raccoon Mountain Pumped Storage site. The river's course provides as much as ½ mile (0.8 km) upstream and downstream of the facility's discharge that may be suitable for run-of-river installations.

As this part of the study begins it is unclear how the run-of-river units would be used. Would they generate electricity or directly pump the river water into the reservoir?

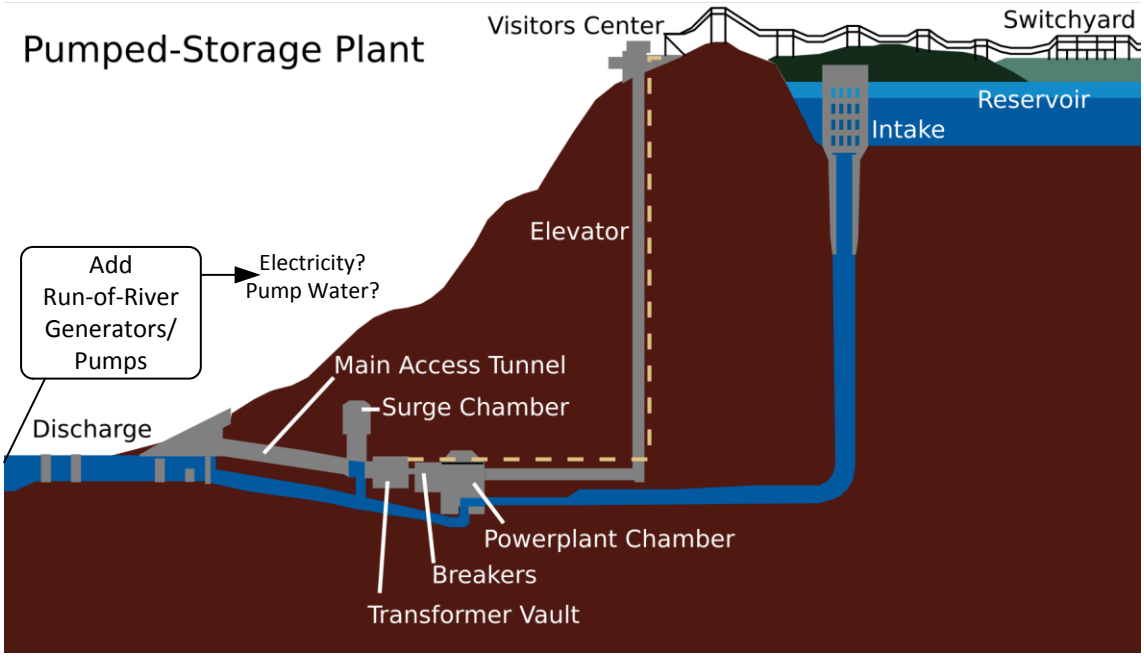


Figure 3 Raccoon Mountain Pumped Storage Plant Diagram

Obviously this opportunity would have to accommodate river traffic, high water / flood conditions and environmental considerations.

If these challenges can be overcome the project would study:

3.1. Power generation estimates over time, initial and life-cycle costs
3.2. Few large-scale “run of river” generators versus many small-scale generators
3.3. Integration with existing electrical generation/grid and future on-site electrical storage (see 4.0)
3.4. Obstruction to navigation, boater life safety

4.0 Add Large-Scale Electric Power Storage

This opportunity would design and install large-scale electric energy storage to complement the existing mechanical energy storage. This part of the study:

4.1. Analyze the viability of adding electrical storage
4.2. Evaluate integrating storage with existing and new power sources, and the grid
4.3. Determine initial and life-cycle costs
4.4. Evaluate “New” batteries versus repurposed used EV batteries, or a combination of both

5.0 Add Mystery Renewable Energy or Resource?

Research projects almost invariably discover new ideas and concepts that were hiding all along, just waiting to be discovered. Team members are highly encouraged to let their imagination and innovation explode.

PROJECT APPROACHES AND POLITICS

A key part of this project is exploring the process, not just the technology. The Raccoon Mountain Pumped Storage facility is owned and operated by TVA, a US Federal government entity. Is the political climate such that the Federal Government / TVA could partner with private enterprise and investors to create a new baseline for going forward with renewable energy and resources in a big way? Let's find out.

As the Raccoon Mountain facility began construction in 1970, America had just landed the first human on the moon the year before, we were fighting and losing the Vietnam War, Boeing's 747 made its first flight across the Atlantic, and a Greenwich Village townhouse blew up killing thee radical Weathermen. The point here is America has been capable of doing many great things at the same time, even during periods of great civil unrest. We are still capable of doing great things today and we need to rapidly rekindle that innovation spirit and fire across all aspects of American society. This project is a small part of making this happen.

We never would have made it to the moon if Americans just sat around waiting for someone to tell them what to do. Let's join together to encourage others to find the motivation and courage to move rapidly forward to a better America, just as those that went before us did to create the amazing capability at Raccoon Mountain.

Is this best accomplished by "BIG Government", "BIG Corporate", or another approach? Let's find out.

You can become part of this journey by becoming a Living Water Solar Cooperative member at the individual or corporate level. Or you can join the Meetup created for the project. Hope to hear from you!

RELATED LWSC PROJECTS

LWSCR.012 Sun Wind Fire Rain Project

This project starts in Chattanooga, Tennessee and hopefully will branch out to many cities and towns around the world. It starts with this fundamental question:

"What is needed to convert all fossil fuel users in the Chattanooga, Tennessee metropolitan area to renewable resources and energy?"

This includes, but is not limited to:

1. Residential, commercial, industrial governmental structures
2. Commercial and industrial manufacturing and related processes
3. Personal and commercial ground vehicles
4. Lighting and related life-safety functions

This project will assemble a local project team using a Meetup group sponsored by LWSC. There are three major focus areas and team members will chose the area(s) they are most interested in.

- Supply
- Demand
- Storage

Each area will be quantified to determine today's baseline and determine future projections. The members will then determine what must occur to convert each area, and each user/customer group from fossil fuels to 100% renewable energy and resources.

Timelines will be developed and cost estimates will be combined into a comprehensive plan for moving forward.

Key study areas include determining the future of nuclear electric power generation in our area. Our existing nuclear power plants are currently operating beyond their original design life and must be retired in the future.

Will we build replacement nuclear power plants, or replace the current nuclear electric generation capacity with renewable energy and resources? LWSC's current position is nuclear energy was originally proposed as "Cheap, Clean and Safe". Although Chattanooga has not experienced a nuclear disaster, others have. In order for nuclear energy to continue it must progress to an entirely new level of safety to both people and the environment. Until a successful way can be found to safely reprocess the over 70 thousand tons of existing nuclear waste LWSC does not support continuing nuclear-based electric power generation.

If nuclear electric power is going to "go away" in the Chattanooga area, which renewables are the best near-term, medium term and long term solutions to replace the electric generation?

This issue is rapidly accelerating in the Chattanooga regional area. The Sequoia Nuclear Power Plant, located in a northern Chattanooga suburb, began construction in 1970 and began operation in 1981-82 and has faithfully served our area for over thirty years. Application process and inspections are ongoing with the Nuclear Regulatory Commission to renew the licenses on both units; extending operation to 2040 and 2041, at which point the plant reactors will be over sixty years old. Key questions to be addressed by this project are:

1. How safe is a 50+ year old nuclear power plant?
2. How much additional nuclear waste will be generated over the next twenty years, and what will happen to it?
3. How much will it cost to modernize and extend the life from 30 to 70 years?
4. If the reactors are repaired and upgraded, how much will the electricity cost after the renovations?

LWSCJ.005 NEXTGEN Wind Generator Project (Joint Partners to be Determined)

This project will team with small-scale wind generator manufacturers and public sector organizations to create the NEXTGEN wind generator technology. Current wind generators focus on single unit installations. This new generation will expand the baseline to include multiple turbines interconnected in an array. Each wind turbine generator becomes a "smart" module with the addition of on-board intelligent controllers, become a node on the Intelligent Array network, and use "common rail" mounting structures that allow the generators to easily slide on and off the mount using simple hand tools.

Each generator will be continuously monitored by central controllers. Each generator will automatically report fault conditions and be capable of automatically taking themselves off line.

Seven or more generator classes will be investigated, ranging from very small (Micro) to very large (Énorme). Their sizes will be determined by a volumetric cube. The starting points:

- The Micro (100 mm^3 - ~4" ^{3})
- The Mini (500 mm^3 - ~19.6" ^{3})
- The Standard (1 m^3 - ~39.4" ^{3})
- The Standard Plus (1.5 m^3 - ~5' ^{3})
- The Double Standard (2 m^3 - ~6.5' ^{3})
- The Macro (3 m^3 - ~9.8' ^{3})
- The Énorme (5 m^3 - ~16.4' ^{3})

Both fixed and variable blade designs will be investigated. All classes will include some form of weather protection to include, but not limited to:

- Excessive Winds
    - First round of development: 100 kph or 60 mph

  - Second round of development: 200 kph or 120 mph
  - Third round of development: 300 kph or 180 mph
- Freezing Rain, Sleet and Snow
- Temperature Extremes
  - First round of development: -10°C to +50°C or 14°F to +122°F
  - Second round of development: -20°C to +65°C or -4°F to +149°F
  - Third round of development: -40°C to +85°C or -40°F to +185°F
- Humidity Extremes – 0% to 100% condensing

Every NEXTGEN wind generator will include electromechanical protection mechanisms which can operate autonomously or when commanded by the central controllers.

LWSCJ.007 NEXTGEN Energy Storage Project (Joint Partners to be Determined)

This project will create NEXTGEN energy storage technologies that have on-board intelligence and are connected to the Intelligent Array controllers via redundant network connections. This project will partner with researchers and manufacturers around the world.

This project starts with "thinking though" a unified approach to energy storage, horizontally integrating today's diverse baseline. Energy storage will include, but not limited to:

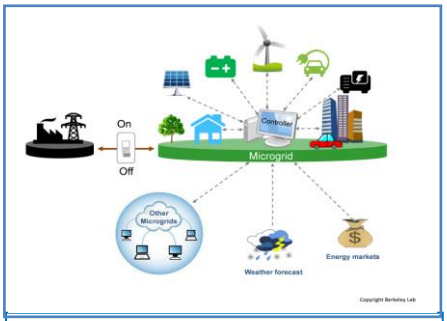
1. Electrical Energy
2. Thermal Energy
3. Mechanical Energy

A key part of this project is to develop the software to integrate multiple storage devices and types into a unified solution that is able to automatically, or manually optimize the stored energy in response to real-time supply and demand.

LWSCJ.010 NEXTGEN Power Project (Joint Partners to be Determined)

This project will explore new ways create and manage energy. The major areas of study are:

- Energy Generation
- Energy Transmission
- Energy Distribution
- Energy Consumption
- Energy Storage (See: LWSCJ Energy Store Project)



building-microgrid.lbl.gov © Berkeley

All five areas will be studied from both ends of the spectrum:

- "Top-Down" System with Highly Centralized Regulation and Control
- "Bottom-Up" Decentralized System with little or No Regulation and Centralized Control
- "Hybrid" system that is a combination of the two extremes above

This study will analyze multiple energy flows, including, but not limited to:

- Electrical Energy
- Chemical Energy, including:
    - Energy in Solid, liquid and Gas Forms
- Mechanical Energy, including:
    - Water
    - Wind

Electrical Energy

America's power grid has provided electrical energy for many years. There are reports, however, that the system is aging and in needs repair or replacement. Should America, (and in companion projects other countries) continue with an electrical energy system that is highly centralized, or should it evolve into something else?

America's recent history with electrical energy megaprojects is abysmal. We simply have to find a better way to manage this process, possibly by decoupling a very large part of the current political component. But how do you do this in a democracy? Join the project and help figure this out.

Chemical Energy

America's love affair with petroleum is embedded deep into almost all aspects of our society. But petroleum reserves are coming to an end and the petroleum industry has a gigantic system and infrastructure in place, waiting for the NEXTGEN renewable liquid and gas energy supply to replace fossil fuels. What could the NEXTGEN renewable feedstock be? Is it biological or something else? How much biodiesel can you grow in the desert, given a nearly infinite supply of fresh water created with solar, wind and tidal energy from salt water? What kind of plants could be used or created to meet the demand? Join the project and help figure it out.

Mechanical Energy

River Hydroelectric Power

America has used hydroelectric power for decades to provide a significant share of our total electrical power needs. Environmentalists have, correctly in our view, recently removed hydroelectric dams, including several almost 100 years old, which were major impediments to migratory fish and other wildlife. This project will determine if new dams can be built without creating environmental problems.

Tidal Hydroelectric Power

New forms of hydroelectric power using tidal flows have been explored but have not reached mainstream acceptance. This project will "step back" and look at tidal hydroelectric power progress to-date and determine if this area should be pursued given equal weight to long term life cycle cost and benefit, environmental concerns and local – regional electric power demand.

Large-Scale Versus Small-Scale Hydroelectric Power

This part of the project will study the relative merits of building a few very large dams or containment ponds versus an integrated system of many small hydroelectric dams that function as an integrated whole.

LWSCJ.011 Rural Microgrid Project (Joint Partners to be Determined)

Many now believe the key to a healthy, NEXTGEN power grid is focusing first on the customer as a partner. As energy providers, not just consumers.

This project will define and develop intelligent, integrated microgrid concepts and technologies that meet the needs of rural areas. Connecting point source generation locations that are separated by large distances may pose unique challenges when compared to more densely populated areas. Or it may turn out that there is a common set of standards and technologies that work well in all areas. At this point we simply do not know, and this project will find the answer to this, and other related questions.

Living Water Solar's research facility located on Amazing Grace Farm provides an excellent starting point to explore how this concept can work. Located on top of Lookout Mountain near Chattanooga, Tennessee USA, it has immediate access to a public utility power substation that adjoins the farm land.

The first project task is to develop relationships with all parties, both public and private to uncover the opportunities and obstacles that lie in the concept, system and product development paths.

The second task is to define how renewable energy generation and storage to be installed at Amazing Grace Farm can be connected to the public utility.

The third task is to find additional public utility customers located in the proposed microgrid "footprint" that have, or are planning to add renewable energy generation and storage capabilities and add them to this rural microgrid experiment.

The fourth task will document and publish the findings and begin local, regional, national and global discussions.

LWSCF.004 The Great French Broad River Race Project

This project will create a biannual international event that showcases NEXTGEN renewable resource and energy technologies operating in natural environments which range from commercial to pristine wilderness. The race will alternate years with the Australian EV race, providing an annual renewable technology race every year. It will also provide real-time live monitoring of the river's environment, uplinked via wireless links to LWSC's servers where the data will be available free on the web. Video cameras, also powered entirely by renewable energy and resources will provide live streaming views of the river and contestants, also available free to the public.

The project will use a formula similar to Australia's World Solar Challenge Race but adds the use of any renewable energy or resource for propulsion. It is anticipated that this race will also be a biannual event, held on the alternate years when the World Solar Challenge Race is not held.

Race Location

The French Broad River is an American river that flows north, starting in North Carolina and ending in Tennessee. It is 218 miles (350km) long, and the race will use approximately 2/3rd of its length, starting in Ashville, North Carolina and ending near Knoxville, Tennessee. There are initially many areas of shallow shoals and rapids as it passes through wilderness areas, followed by long stretches of "flat water" behind TVA's Douglas Dam. Contestants will choose to either pass through the lock at Douglas Dam or portage their craft around the dam, continuing down the final stage of the French Broad to where it joins the Holston River to create the headwaters of the Tennessee River in Knoxville, Tennessee.

Race Rules

The French Broad River offers contestants a wide range of technological challenges. A steering committee will be formed within the project team members to create contest rules. These rules will include, but not be limited to:

- The race will be conducted with the least possible damage to the environment while looking for ways to improve the environment. Contestants will be challenged to leave a "net positive" environmental footprint. This will be factored into determining winners.
- No fossil fuels may be used at any time by the contestants' craft or support vehicles. Competing water craft and support vehicles must be propelled entirely by renewable energy and resources. The only limitations on the type(s) of renewables are those posed by the river itself.
- Contestants are allowed to use any form of renewable energy or resource but the type and amount of additional fuel that can be taken onboard at each checkpoint is limited by the rules set by the committee.
- The committee will define race "legs" along the route. Contestants will be allowed to come ashore at these points for food, rest and support care as needed. Their craft can be reconfigured to meet the unique conditions of the next leg within the rules set by the committee.
- The committee may choose to establish multiple classes of competitors. These could range from single occupant, two person crews, four person crews and the unlimited class.

- All contestant craft will be fitted with real-time monitoring and tracking units developed by the project team. These units will simultaneously report position as well as environmental measurements (water, air, precipitation, propulsion system pollution, etc.)
- The committee will create the rules that determine the race winners.

Between each race the project will continue to look at technological developments that came from each race as well as environmental issues. For example, there are several dams along the race route, all of which have historical significance. But should they remain? Will the ecology of the river be improved by their removal? Can the ecology and local economy improve if the dams are modernized? How can the fossil-free hydroelectric power generated by the dams along the French Broad River be improved and better utilized? Will downstream flooding increase if they are removed? The Douglas Dam in Sevierville, Tennessee and the Capitola dam in Marshall, North Carolina are examples at opposite ends of the spectrum. Following each race, all contestant teams will be required to provide input to this and other challenging, multi-state / regional questions.