HOW TO SAVE A DRAFT OF YOUR RESPONSE

AFTER you click "submit" on the final application screen, another screen will come up that provides the following instructions: "Your response has been recorded, you can edit your response until the due date."

"TO BE ABLE TO EDIT YOUR RESPONSE:
Click on the 'Edit Response' link and then save the unique URL that is generated (e.g., copy and paste into an e-mail or notepad). Using this unique URL, you will be able to come back and edit the link until February 21 at 6 pm Pacific.
Edit your response
Submit another response"

COMPANY INFORMATION

This section provides basic information about your startup or cleantech project.
FAQs
Please confirm that you have carefully reviewed C2M’s FAQs for startups at [https://haas.berkeley.edu/c2m/startups/](https://haas.berkeley.edu/c2m/startups/).

- Yes, we have reviewed them.

<table>
<thead>
<tr>
<th>COMPANY NAME (or project title if not yet incorporated)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Icarus RT, Inc.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>WEBSITE (if any)</th>
</tr>
</thead>
<tbody>
<tr>
<td><a href="http://www.icarusrt.com">www.icarusrt.com</a></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>APPLICANT(s) NAME(s) &amp; JOB TITLE(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mark G. Anderson, PE Founder and CEO</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PHONE(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>760-889-1327</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>EMAIL(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td><a href="mailto:Manderson@icarusrt.com">Manderson@icarusrt.com</a></td>
</tr>
</tbody>
</table>
AFFILIATION(s)

Please check all that apply—whether current or prior—and name any others (including universities) in "other" section

- ARPA-E
- DARPA
- OTHER DOE
- CALSEED
- CALCEF
- OTHER CEC
- CYCLOTRON ROAD
- CLEANTECH OPEN
- LOS ANGELES CLEANTECH INCUBATOR (LACI)
- FLOW
- I-CORPS
- BLUETECH VALLEY
- NSF
- UC BERKELEY
- STANFORD
- CALTECH

Other: Cleantech San Diego, Shell NREL Gamechanger
COMPANY or PROJECT STATUS
Please check all that apply.

- [x] Company or LLC formed
- [ ] Founder(s) only
- [ ] Founder(s) plus 1-2 full-time equivalent employees
- [x] Founder(s) plus >2 full-time equivalent employees
- [ ] Other:

PARTNER(s)
In addition to the affiliations listed above, please list and explain the nature of any other key partner relationship(s), e.g., accelerators, incubators, and strategic partnerships (for materials, testing, trials, etc.).

Jacobs School of Engineering/University of California San Diego; San Diego State University, College of Engineering, Combustion and Solar Lab; Imperial Valley Proof of Concept Center, San Diego State University; The Center for Sustainable Energy, San Diego, CA; The Chemours Company, Wilmington, DE; Interphase Materials, Pittsburg, PA; Cleantech San Diego.

FUNDING
Please summarize all funding received to date, including all debt, equity and/or grant amounts.

Icarus RT, Inc. was founded in October 2016 and has raised $235,000 in private funds through a private placement offering (PPO) plus $20k in exchange for equity from Canopy San Diego (an accelerator program) plus the $150,000 CalSEED award to date. The PPO round is open, and we have soft commitments for additional funds to close the round and to be used for installation and testing of a Beta Prototype and facilitate third party validation. Our recent selection into the Shell-NREL GameChanger Program provides $250k in non-dilutive funds over the next 18 months to be applied towards technical assistance at NREL.

TECHNOLOGY
This section provides key information about your technology.
TECHNOLOGY

Icarus RT, Inc. is an award-winning firm developing a patent-pending hybrid solar photovoltaic/thermal (PV/T) technology to extract waste heat from PV panels in commercial and utility scale arrays, collect and store heat, and convert heat energy to power using Organic Rankine Cycle (ORC).

The hybrid solar PV/T system is co-located with commercial and utility scale PV arrays. Heat extractors snap on to the back of PV panels and allow pumped fluid to flow through a closed loop. The fluid cools the panels by absorbing heat which is stored and then converted to additional power via ORC thus improving energy production and efficiency. Icarus’ technology aims to increase PV power generation and provide energy storage.

The combination of heat extraction and ORC generation results in a 25% or greater increase in power output and allows consumers to utilize stored energy during peak demand times, reducing energy costs and improving grid reliability.

Simulations show that the system with storage increases overall power output at least 25% by cooling the panels and generating additional power from recovered heat. A 100-kW array is converted into a 125-kW in real time during solar production, while charging the thermal battery. The combined production lowers levelized cost of energy from $0.078/kWh to $0.034/kWh when compared to panels alone.

Icarus has a 2.2 kW alpha prototype at the Englekirk Facility of UCSD used to confirm the feasibility and usefulness of the heat extraction and cooling technology through this proof of concept and continue to develop the storage system. The robust monitoring system and weather station measures and reports panel and fluid temperature and pressure.
RISKS

Describe any known or expected technology risks, explain their potential impact, and discuss any current or pending plans to mitigate or resolve them.

There are key technical challenges Icarus faces. The top concern is effectively converting the extracted/stored low-grade waste heat into electricity. This is due to the low-grade temperature of the fluid stored. Icarus is concerned about developing a cost-effective manufacturing process for the heat exchanger as the component has never been fabricated before. Finally, there are concerns about the design optimization and technical challenges the team will encounter during beta testing.

We have demonstrated the ability to extract, collect and store the waste heat in both simulations and in-situ testing. We are using new materials not available five years ago to improve the heat transfer (nanosurface treatment, extract and transport the heat and convert the heat into power (organic fluid with scroll turbo expander or turbine-generator). Engineering analysis, simulations and projections show that we can capture and convert at least 16%, and up to 30% of the insolation otherwise lost or rejected into power. We have already demonstrated in testing the ability to improve the power performance of solar panels through cooling, by another 9%.

These feasibility and technical risks are scaled starting with small, simple prototypes and increasing size and complexity, such as the 2.2 kW array prototype. These challenges are the focus and will continue to be overcome through design optimization, fabrication and testing. Icarus is approved to build a 25-kW beta prototype with storage at SDSU Imperial Valley Proof of Concept Center in 2020 which will be used to test the work of this SBIR study and to provide third party validation of performance.

Technology risk is being overcome through deeper effort and outreach including interviews of prospective end users to understand needs and reduce risks. Affordability risk is managed by cost control. Feasibility risk is scaled by starting with small, simple prototypes and increasing size and complexity. We are also working with Marsh McLennan and Chubb Insurance for financial risk management and risk engineering services, and Knobbe Martens to manage risk through contractual language, patent infringement searching and protection, and trade secrets and copyright.
WHAT'S NEXT?

Describe (a) what you’re working on now and (b) key activities/milestones expected over the remainder of 2020, with specific emphasis on August–December (which is when C2M students would be conducting market research for you).

Currently, a 2.2 kW alpha prototype is installed at the University of California, San Diego Englekirk Facility. The 14-panel array provided nominal proof of concept testing of heat extraction, panel cooling, and fluid heat up.

Icarus RT, working with engineers from UCSD, is developing a proprietary monitoring and control system for use with our products. The system measures performance of the heat extraction, storage and energy generation sub-systems as well as PV panel performance. These measurements are synthesized with customer guidelines and utility rate structures to make buy/sell/store decisions and to automate the actions necessary to carry out these decisions.

Icarus and SDSU engineers are collaborating to develop optimal designs for the heat exchanger and storage system. The proposed design schedule for fabrication and testing in Q2-2020 is predicted to cool panels by as much as 20 °C.

Icarus will continue to conduct performance testing and data collection at the Englekirk Facility in Scripps Ranch, CA. We expect to verify the performance of our control panel performance to ensure measurements are accurate. Our testing will involve panels with and without pairing with the Icarus heat extractor under various conditions. Data we will collect will be power generated, panel temperature, cooling fluid temperature, turbine generator power output, amount of energy stored, and power generated from stored energy.

Next Icarus is approved to install a 25kw scale system at the Imperial Valley Proof of Concept center for third party validation by SDSU.

Commercial beta testing is scheduled to begin later in 2020. Icarus is in mid-level discussion with the National Director of Energy and Utilities at Kaiser Permanente (who has provided Letters of Support) finalizing plans for a beta test at one of their California or Hawaii overhead parking canopy PV installations. Kaiser is currently arranging a meeting between Kaiser, Icarus and Kaiser’s EPC Contractor, Ameresco to discuss required details. A partnership with Kaiser, the largest healthcare provider in California, provides Icarus the opportunity to secure the reliability of their 60,000 MWh of solar energy resources against outages, cloud transients and lack of solar production at night.
INTELLECTUAL PROPERTY
Provide description/status of any patents or other IP, including patent or tech transfer numbers, if any. If your IP is licensed, please identify the licensor and explain the details of the license.

Thorough patent searching, literature reviews and competitor assessments showed no similar systems that extract panel heat using fluid to cool solar panels that collects and stores the heat and uses Organic Rankine Cycle to convert the collected/stored heat into electricity. Icarus has significant first mover advantage.

Icarus Founder/CEO Mark Anderson et al filed a US provisional patent in February 2017, which was updated and filed as utility patent, PCT/US18/18030, SYSTEM AND METHOD FOR COOLING SOLAR PANEL AND RECOVERING ENERGY THEREFROM, 13FEB2018.

Anderson et al filed a US provisional patent in August 2018, which was updated and filed as utility patent, PCT/US19/44932, SYSTEM AND METHOD FOR SOLAR PANEL HEAT ENERGY RECOVERY, HEAT ENERGY STORAGE AND GENERATION FROM THE STORED HEAT ENERGY, 02AUG2019.

An additional patent related to the control system, and licensing agreements for sale and installation of the technology are planned in 2020.

All intellectual property is properly assigned to and owned solely by Icarus RT, Inc.
TECHNOLOGY READINESS LEVEL (TRL)

- TRL 2 - TECHNOLOGY FORMULATION: Technology concept or application formulated.
- TRL 3 - APPLIED RESEARCH: Early lab tests completed; proof of concept.
- TRL 4 - LAB PROTOTYPE: Component testing in a laboratory environment.
- TRL 5 - FIELD PROTOTYPE: Component testing in the intended field environment.
- TRL 6 - SYSTEM PROTOTYPE: More complete system demonstrated in intended field environment with close to expected performance.
- TRL 7 - DEMONSTRATION SYSTEM: System prototype demonstration in an operational environment at pre-commercial scale.
- TRL 8 - INITIAL COMMERCIAL SYSTEM: Actual system completed & demonstrated, manufacturing issues solved.

COMMERCIAL OUTLOOK

This section is for you to provide any information YOU may have on the commercial outlook for your technology. If your company/technology is selected for the C2M program, YOUR C2M TEAM will conduct 15 weeks of market research (using a minimum of 80 sources) to provide you with a 100-page report comprising a detailed technology-assessment and market-based information and related recommendations.

ESTIMATED TIME TO MARKET

Estimated time to initial paying customer(s)

- Within the next 12 months
- 1 - 3 Years
- 3 - 5 Years
- More than 5 years
TIME TO MARKET BACKGROUND
Please explain reasoning/support for time to market estimate above.

Icarus has two planned beta tests for 2020. The first is with Kaiser Permanente for a commercial beta test at a facility in California or Hawaii. The second test will be conducted at the Imperial Valley Proof of Concept Center for third party validation by SDSU. The goal is to test throughout Q3 2020. Product finalization would occur during Q4-2020 with fabrication starting Q2-2021. With fabrication completed, installation would conclude just in time for solar energy savings in Q3-2021.

Throughout commercialization we will work to insure we meet price, specification, performance and quality requirements. Within three years of commercialization, we plan to work closely with PV panel manufacturers in the US to integrate Icarus technology during manufacturing.

Icarus will make a significant impact on the solar industry within 10 years by providing clean, low-cost energy storage and improved value in solar generation, creating rewarding jobs and increasing the deployment of solar power.

IMPACT
Describe market opportunities and customer pain points that your technology may address.

The target markets for Icarus are: 1) solar energy storage, set to grow from $400 million to over $4 billion by 2024, 2) commercial and utility scale PV, including through PV panel manufacturers, and 3) EV Charging stations. The PV market shares in the United States are $2.8 billion for commercial installations and $8.3 billion for utility installations. The Serviceable Addressable Market is $11.1 Billion, and the US Obtainable Market is $96 million. Globally, the Total Addressable Market of solar panel manufacturers is $30.8 billion. The International Energy Agency (IEA) states over 500,000 solar panels were installed daily since 2016 (globally), while "the US energy storage market will grow from $400 million to over $4 billion ($1.5 billion in utility scale) by 2024" (Kelly Pickerel, Solar Power World, 10/2018).

Icarus is primed for high density housing, community buildings, and small businesses in emerging economies. The system will be deployed at 44% or less of the cost of comparable solar PV systems with traditional battery storage systems. Lower cost renewable power will increase deployment and usability of solar power in emerging economies where the cost prohibits access to clean energy with storage.

Community solar projects are projected to be a larger part of the energy landscape, facilitated in part by grant funding in low-income areas, and/or where the air quality is poor. State and federal grants provide funding for "green certified" developments, improving the ROI for real estate development in low income areas. All of this provides job opportunities in local communities in a high growth sector, which may encourage training in these skills for additional opportunities in the industry.
Increased deployment and usability of solar power due to lower installation costs, lower ongoing power costs, lower levelized cost of electricity (LCOE) and improved return on investment, results in less reliance on fossil fuels for power generation. We anticipate and strive to influence measurable reduction of ongoing monthly energy costs that will in turn allow for use of available income on other vital needs such as healthcare and transportation. We further anticipate that an overall reduction of a community's reliance on fossil fuels will contribute to less air pollution and improved air quality. Our recent estimates, presented in a CalSEED Ratepayer Benefit Framework, show that installing Icarus on a 100-kW system would remove 6.34 MT of CO2 annually from the environment. Installing Icarus in just 1% of the California's 25,000 GWh PV resources would remove 112,000 MT of CO2 in one year. Ideally, enhancements in the quality of the air breathed and reduction of stress relative to saved expenses can lead to better general health. All these benefits may be correlated with better job access, productivity, and state of mind.

Icarus is designed to be co-located with PV arrays to generate power from storage fully compatible with medium-low voltage, variable generation output characteristics of typical solar PV inverters. Icarus improves real time production performance and stores energy for use on demand without consuming PV power. This will allow for an increase in solar PV integration, operation flexibility, and provide power when needed most and rates are highest.

The social and environmental impacts of the Icarus system are many. By lowering the cost of PV installations, more jobs will be created due to increased demand. Lower costs will also allow for larger deployment in low income housing projects. By increasing solar energy resources there will be less demand on fossil fuel plants and the air quality will improve. Increased use of thermal energy storage reduces lithium mining which is difficult to recycle. Cooling solar panels will allow improve electrical production, prolong lifetime and improve return of investment. Improved production also reduces the number of panels necessary to generate electricity and reduces solar panel waste.

There may be further possibilities to explore, work with and contribute to the major objectives of the Center for Sustainable Energy, California Strategic Growth Council (SGC), California Transformative Climate Communities (TCC) Program, and California Climate Investments (cap-and-trade) initiative. We understand the goal of the TCC Program as being to “accelerate catalytic, transformational change in some of the state’s most disadvantaged and polluted communities to achieve large-scale, holistic impacts in areas of high need”. As Icarus RT progresses with its commercialization efforts, we look forward to collaborating with pertinent public agencies, community groups, foundations, businesses, financial institutions and nongovernmental organizations, in the planning and integration of clean technologies throughout the state.
**ADVANTAGES**

Describe the expected and/or potential advantages your technology has over existing alternatives and emerging competitors.

Previous hybrid PV/T systems have failed. Some technologies cool solar panels to improve efficiency (Solar Energy Booster) and others produce domestic hot water (Sun Water Solar). However, none collect waste heat from PV panels and store it to generate on-demand power via organic Rankine cycle (ORC) while improving PV performance.

Icarus mission is to increase the adoption of solar power by overcoming inefficiencies and lowering the overall cost per kWh. Icarus will provide future commercial and utility scale PV plants an innovative, cost effective, environmentally responsible energy storage solution that will reduce dependence on natural gas to meet demand after sundown.

A 100-kW array panel at 21% efficiency results in $412,000 lost to waste heat, at the rated temperature, 77 °F (25 °C). Panels often reach temperatures of 150–170 °F and performance drops by 0.28%/°F increase causing efficiency to drop from 21% to 16% or lower, resulting in additional loss.

Traditional batteries use PV output to charge, resulting in further loss. Icarus has a huge advantage: cooling PV panels and using waste heat to charge the thermal battery. Icarus expects to provide additional power with storage at a lower cost than traditional PV plus battery storage systems (from $0.078/kWh to $0.034/kWh). The increased power output decreases the payback period on new and existing solar installations, encouraging new investment in our target utility and commercial markets.

**BARRIERS**

Describe expected barriers to commercialization and potential mitigation strategies.

The most significant market risk is a major drop in PV or Lithium-ion battery cost (lead acid batteries are price stable) before Icarus is introduced into the market. Icarus engineers believe improvements and design optimization will increase the value of Icarus over time, but it is important to launch with the predicted four hours of storage at array capacity with 25% power output increase in 2021. The pricing forecast for commercial solar production in 2030 is $0.04/kWh not including storage. The target launch pricing for Icarus is expected to be $0.031/kWh. The price includes four hours of thermal energy storage and is highly attractive for 2021. The price will remain competitive until 2030. Finally, note that improvements in battery technology will not impact the proposed technology applied to heat storage for later thermal uses, since batteries are not used for thermal storage.
SCALING

Describe the opportunities and issues you see with scaling this technology.

Icarus does not plan to become a major manufacturer or installer but plans to contract with major commercial installers such as Baker Electric Solar, Helix Electric, REC Solar, and Sunpower during the first two years of installation. Components will be manufactured by others per Icarus’ customers specifications and supplied to installers. The next move would be toward commercial and utility scale projects. Currently, Kaiser has a strong interest in a pilot program in which the Icarus system would be employed in a commercial beta test. Kaiser has 35 MW of solar PV installed and another 30 MW in the pipeline. The ultimate goal is to contract with PV panel manufacturers to integrate Icarus technology in the panel manufacturing process. Icarus plans to spec production to manufacturers capable of scaling with demand. Licensing the technology in multiple markets with strategic, well-established partners will allow Icarus to avoid capital-intensive investments, resulting in lower cost of sales. Partners benefit with a clear edge over competitors by offering enhanced performance with a 2.7-year ROI.

FEEDBACK

Summarize any feedback you have received so far from industry, entrepreneurs or potential investors.

Initial customer discovery surveys of commercial and utility scale installers indicate keen interest in energy storage, lower projected cost, and improved ROI. We are furthering customer discovery currently through the Small Business Development Center Lean Essentials Program, and NSF iCorps Zap and Launch programs which will allow us to pursue the NSF I-Cops Team Grant to talk to more potential customer and gain a still better understanding of the market and how Icarus address energy storage and array performance in the solar market.
Icarus RT, initially started out with the goal to cool PV solar panels and improve their efficiency. Initial experiments demonstrated that panels could be cooled, and the byproduct was useful, low grade energy. The discovery led CEO, Mark Anderson, to consider using the low-grade energy for a secondary process, an Organic Rankine Cycle. The ORC effectively made use of the waste energy and generated additional power. After additional market discovery, Mr. Anderson and CTO Ron Pitt realized there is untapped potential in thermal energy storage. At that point Icarus pivoted to focus on thermal energy storage as a potential critically important solution to the California demand vs production challenge, known as the Duck Curve. Today, Icarus is working to cool solar panels, store the heat removed from the panels, and focused on using the stored heat to provide additional energy during peak charge times. It is important to note, that during customer discovery, customer interest in storage was notably greater than merely in increased production. The pivot has worked well for Icarus.

OBJECTIVES & QUESTIONS

Please describe why you would like to be selected for the C2M program and ask any questions you may have.

OBJECTIVES

What do you most hope to get out of your participation in the C2M program?

We seek to obtain qualified market research and a marketing plan, an improved business plan and to expand our fundraising capabilities (private and through non-dilutive grant programs). In addition, we hope to expand our contact network and develop relationships with key industry and utility personnel. Finally, we hope to be able to answer additional questions, including those we have not yet considered.

QUESTIONS

What questions (if any) do you have about the C2M program?

Currently abstain.

SUPPORTING MATERIALS
Please upload the following to inform C2M's selection process (selection committees & graduate student teams).

**DETAILED TECHNOLOGY DESCRIPTION**
Please upload up to three (3) pages of detailed supporting materials to further explain your technology.

Three Page Tech...

**SUMMARY POWER POINT SLIDE**
Please upload one (1) summary Power Point (.pptx) slide to serve as an overview of your company/project.

Summary Slide 1...

**90-SECOND PITCH VIDEO**
Please upload one (1) 90-second video to serve as a virtual "elevator pitch." This is meant to be easy and informal, i.e., feel free to use any existing materials you may have an/or create a new video on your smartphone.

90 Second Video...

This form was created inside of UC Berkeley.

Google Forms