Ohio | Department of Development

Final Proposal Evaluation

2011

Third Frontier Fuel Cell Program

January 2011

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This Report written by:

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PROPOSAL REVIEW TEAM

❖ TARATEC CORPORATION

- Edward Ungar, President (Quality Control)
- Paula Dunnigan, Project Leader
- Chuck Meadows
- Bill Munk
- Reed Slevin

❖ SIX (6) EXTERNAL REVIEWERS

- **Mr. Thomas J. Gross** is an energy consultant who retired from DOE after 30 years where he served as a Senior Executive and Member of the Board of Directors of Energy Efficiency and Renewable Energy (EERE) and Deputy Assistant Secretary for the Office of Transportation Technologies (annual budget of $300M). Mr. Gross held major roles in the following DOE programs: Partnership for a New Generation of Vehicles, FreedomCar Partnership, International Partnership for the Hydrogen Economy, and California Fuel Cell Partnership. His specific areas of expertise include hydrogen/fuel cells, vehicle batteries including nickel metal hydride, lithium-ion, and other types, biodiesel, and other alternative fuels.
- **Dr. Joseph M. Morabito** is a Director at Alcatel-Lucent. He was named a Bell Laboratories Fellow in 2004 for outstanding lifetime contributions to thin film surface and interface analysis and the development of new thin film systems that provide high density interconnections, thin film resistors, capacitors and cross-overs of high reliability and performance for the silicon integrated circuits (SICs) and hybrid integrated circuits (HICs) used in advanced telecommunications systems. Dr. Morabito is an expert in photovoltaic technologies and was a valuable advisor to the EPRI Solar Program for over 20 years. He has broad expertise in other distributed energy technologies and has published extensively on systems analyses linking various types of distributed energy generation with the smart grid. Dr. Morabito serves on the Board of Directors of the R&D Council of New Jersey.
- **Dr. Evan E. Hughes** is a specialist in biomass and waste as fuels for power generation via combustion, thermochemical gasification, biological gasification (e.g. anaerobic digestion, landfill gas, algae, etc.) and energy crops. He has managed technical projects involving fuel derived from municipal solid waste as well as biomass and alternate fuels (tires, plastics, paper, sawdust, other wood wastes, and energy crop fuels-both woody and herbaceous crops and crop residues). As the Manager, Biomass Energy at EPRI, he has worked with electric utilities, U.S. DOE, and the California Energy Commission. Dr. Hughes currently does project reviews and evaluations for one of the California utilities.
- **Mr. George A. Hay III** brings more than 30 years of experience with EPRI, DOE, and GRI in the areas of renewable energy and distributed generation for the electrical industry. He is a DOE proposal reviewer in the areas of biorefineries, advanced biofuels, and renewable manufacturing. Mr. Hay is currently working with the University of California and NREL on municipal/county/university applications of sustainable energy projects including solar, wind, biomass, landfill gas, energy storage, and fuel cells. He is an advisor to various committees of the New Jersey Clean Energy Program.
- **Mr. Norman D. Malcosky** has over 40 years of experience in the energy industry performing and managing research activities in fossil fuel exploration, alternative fuel vehicles, biofuels, and fuel cells. He has specialized in Liquefied Natural Gas, Compressed Natural Gas, and propane-fueled vehicles. Using his strong background in mechanical engineering, he has patented various types of industrial equipment for the natural gas industry. Mr. Malcosky retired from Battelle Memorial Institute in 2002 where he served as a Senior Research Scientist in Battelle's Transportation Group and Equipment Design and Mechanical Systems Group.
- **Dr. C. Fred Clark, Jr.** was a co-founder and co-owner of CeramPhysics (Westerville, OH) for 29 years where he combined the perspectives of a research scientist with those of a small-business entrepreneur. He was involved in all phases of contract research including proposal writing, contract administration, project management, patents, and licensing. Dr. Clark was involved in the development of a number of patented inventions involving unusual properties of ceramic materials including oxygen and NO_x sensors, SOFC electrodes, energy storage capacitors, oxygen removal technology, and improved dielectric insulation for high-temperature superconductors.

OVERVIEW OF PROPOSAL EVALUATION PROCESS

- Two-stage evaluation process

- The evaluation process is objective and robust. Its consistency has been evaluated through rescoring. Results were found to be independent of the composition of the individual review panels and consistent year-to-year.

- The objective of the **First Stage Evaluation** is to rank the proposals on the basis of which best meet the RFP requirements and then to select the highest-ranking proposals for more in-depth evaluation.
  - The cut-point is based on significant score differences and best use of evalution resources. Taratec recommends a cut-point and ODOD selects the cut-point.

- The objective of the **Second Stage Evaluation** is to rank the highest-scoring proposals from the First Stage on the basis of the quality of investment for the State of Ohio.
  - Ohio job and revenue creation/retention that is likely to occur within 3–5 years
  - Company viability and business functions that are planned in Ohio
  - Potential of the project to contribute to a cluster of related companies in an industry that Ohio is trying to build

PROPOSAL EVALUATION PROCESS

❖ FIRST STAGE EVALUATION

- Conflict of Interest evaluation for each reviewer
- Each proposal is read by 3 reviewers (internal and external)
- Proposal is scored by each reviewer using a scoring instrument (34 questions) based on the RFP criteria
- All scores from each reviewer are entered into a database
- Reviewers provide written comments on areas of concern or those requiring clarification
- A list of proposals ranked on the basis of their average scores is produced
- Taratec meets with ODOD to establish the competitive range (cut-point) for each competition
- Proposals scoring above the cut-point advance to the Second Stage Evaluation

❖ SECOND STAGE EVALUATION

- Reviewer comments are integrated into the construction of a customized set of written questions for each applicant
- Applicants have one week to submit written responses
- Face-to-face meeting (90 minutes) for reviewers and applicants to discuss issues
- Final trade secret identification by applicants
- Preparation of 2-page project write-up
- Risk-benefit scoring by the entire review team
- Scores entered into the database
- Final recommendations developed
- Preparation of materials for consideration by the Third Frontier Commission

SCORING METHODOLOGY

SUMMARY OF FIRST STAGE EVALUATIONS

	TFFCP	TFPVP	TFAEP	Total
LOIs Submitted	**25**	33	93	151
Proposals Received by ODOD	**12**	18	47	77
Proposals Evaluated by Taratec	**12**	15	43	70
Recommended for 2nd Stage	**7**	9	19	35
TFRDF Available	**$7M**	$7M	$7M	$21M
TFWCF Available	**$1M**	$1M	$1M	$3M
Cumulative TFRDF Requested	**$6.9M**	$7.5M	$16.9M	$31.3M
Cumulative TFWCF Requested	**$57K**	$163K	$3.2M	$3.4M

SCORING METHODOLOGY *(continued)*

SECOND STAGE EVALUATION FACTORS

❖ TECHNICAL RISK

- Technical Reach— (40%)
  Does the project require technology development beyond prior practice and is it practical to attain?
- Resource Limitations— (40%)
  Does the project team have sufficient resources in terms of people, facilities and funds to attain the project goals?
- Technology Protection— (20%)
  Have provisions been made to protect the technology by patent and trade secret?

❖ COMMERCIAL RISK

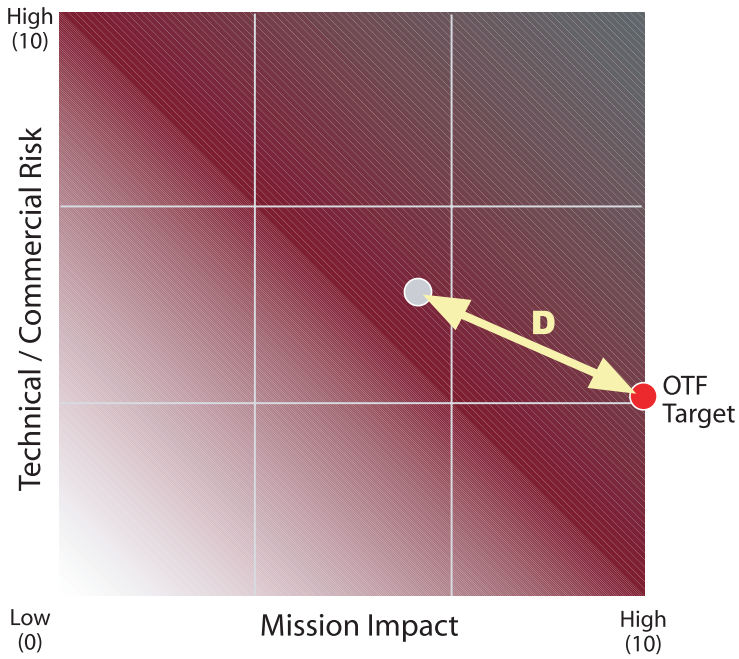
- Path to Market— (40%)
  Does the project team have a credible path to market, customer knowledge, pricing strategy, sales force, etc.?
- Corporate Stability— (40%)
  Does the project team have the financial resources available or committed to bring this product to market?
- Commercial Infrastructure— (20%)
  Does the project team have access to established distribution channels?

❖ MISSION IMPACT

- Cluster Formation— (25%)
  Does the applicant buy from, sell to, or otherwise contribute to the formation of a technology or industry cluster in Ohio?
- Ohio Economics— (50%)
  Does this project show a credible path to substantial job and revenue creation in Ohio in 3–5 years?
- Business Model— (25%)
  Is the proposed business model viable and will it lead to new business growth in Ohio?

SCORING METHODOLOGY *(continued)*

- Two 2-dimensional scoring matrices
  - One for Technical Risk
  - One for Commercialization Risk
  - Both risks are plotted against Mission Impact
- Target for Technical Risk is (10, 3.5)
- Target for Commercial Risk is (10, lowest value)
- Project's final score is based upon sum of D1 and D2



2011 TARGETS

	Technical Risk	Commercial Risk	Mission Impact
Fuel Cell	**3.50**	**2.07**	**10.00**
Photovoltaic	3.50	2.40	10.00
Advanced Energy	3.50	2.13	10.00

TARGET DEFINITION FOR OHIO'S THIRD FRONTIER CLUSTER PROGRAMS

The targets for Technical Risk, Commercial Risk, and Mission Impact have been set based on the profile of projects that are most likely to meet the intent of the Third Frontier Cluster Programs to develop new technology businesses that will produce economic development in Ohio in the 3- to 5-year timeframe. These targets were set after consultation with ODOD and the Third Frontier Commission.

Mission Impact

Ohio is seeking to fund the projects that will result in the highest economic development impacts for the dollars invested. Therefore, the target for mission impact has been set at the maximum of 10.

Technical Risk

Since economic development results are desired in a relatively short timeframe, projects selected for funding should be relatively mature, i.e., in the late Incubating or Demonstrating Stage with a functional prototype.

Projects that contain relatively little technical challenge, represent product line extensions, or are close to market are likely to score low on technical risk, i.e. 1 or 2. These types of projects would be candidates for internal funding by the applicant company, could attract investment, or would be bankable. They would not have the level of risk intended for this program.

At the other end of the spectrum, there will be projects that are still in early stages of development and have a number of significant technical and cost issues remaining to be resolved. These projects are frequently classified as Imagining or early Incubating Stage. They are likely to have technical risk scores in the range of 7–10. These projects would be candidates for federal R&D funding in the form of SBIRs or NIH grants. Only after they reach greater technical maturity would they be attractive candidates for the Third Frontier Cluster Programs.

The ideal level of technical risk for these three cluster programs has been set at 3.5. It is believed that this level of technical risk presents the optimum probability of achieving the intended economic development outcomes within the targeted timeframe.

Commercial Risk

The cluster programs are intended to serve the needs of both start-up companies and companies that have on-going business.

Existing companies frequently have well-developed distribution channels and some degree of financial stability resulting in low commercial risk scores. However, they may require assistance in new product development to reach a level of product maturity that will allow them to compete for scarce internal resources. Proposals from these companies will typically have commercial risks that score in the range of 1.5–2.5.

It was decided that these companies should not be penalized for having "too low of a commercialization risk." Therefore, for each competition, the target for commercial risk is set as the floor or at the lowest value of all proposals in the competitive range. This ensures that no proposal is penalized for having the ability to bring its product into the marketplace.

2011 TFFCP

Third Frontier Fuel Cell Program

Summaries of Proposals in Competitive Range

RECOMMENDATIONS FOR FUNDING
2011 Third Frontier Fuel Cell Program (TFFCP)

RECOMMENDED FOR FULL FUNDING

	OTF NO.	APPLICANT	OTF $ REQUESTED	OTF $ CUMULATIVE	WRIGHT $ REQUESTED	WRIGHT $ CUMULATIVE
1.	TFFCP 11-101	Rolls-Royce Fuel Cell Systems (US), Inc.	$ 999,875	$ 999,875	$0	$0
2.	TFFCP 11-103	Battelle Memorial Institute	$1,000,000	$1,999,875	$0	$0
3.	TFFCP 11-106	Lockheed Martin MS2	$1,000,000	$2,999,875	$0	$0
4.	TFFCP 11-122	American Trim, LLC	$ 994,263	$3,994,138	$0	$0
TOTAL FUNDS REQUESTED				**$3,994,138**		**$0**

2011 Third Frontier Funding Cycle Fuel Cell Program Final Round Scores

SCORE		City	County	OTFRD $ Requested	OTFRD $ Cumulative	WRIGHT $ Requested	WRIGHT $ Cumulative
Targets - Mission Impact: 10 Commercial Risk: 2.07 Technical Risk: 3.5							
86.7	**TFFCP 11-101** Rolls-Royce Fuel Cells Systems (US), Inc. Automation and Demonstration of Pilot-Scale Manufacturing for SOFCs Technical Risk: **3.53** (R: 5.00 L: 3.00 P: 1.67) Commercial Risk: **2.66** (P: 4.33 S: 1.33 I: 2.00) Mission Impact: **8.42** (C: 9.00 E: 8.33 M: 8.00)	North Canton	Stark	$999,875	**$999,875**	$0	**$0**
82.3	**TFFCP 11-103** Battelle Memorial Institute Improving the Manufacturing Readiness of a Solid Oxide Fuel Cell Military Power Generator Technical Risk: **3.13** (R: 4.00 L: 3.00 P: 1.67) Commercial Risk: **2.07** (P: 3.00 S: 1.33 I: 1.67) Mission Impact: **7.84** (C: 7.67 E: 7.00 M: 9.67)	Columbus	Franklin	$1,000,000	**$1,999,875**	$0	**$0**
79.1	**TFFCP 11-106** Lockheed Martin MS2 Military SOFC Genset Demonstration Technical Risk: **5.07** (R: 5.33 L: 5.00 P: 4.67) Commercial Risk: **3** (P: 5.33 S: 1.67 I: 1.00) Mission Impact: **7.75** (C: 7.67 E: 7.67 M: 8.00)	Akron	Summit	$1,000,000	**$2,999,875**	$0	**$0**
76.2	**TFFCP 11-122** American Trim, LLC Low-cost Manufacturing System for Fuel Cell Components Technical Risk: **3.73** (R: 4.00 L: 3.67 P: 3.33) Commercial Risk: **2.60** (P: 3.67 S: 2.00 I: 1.67) Mission Impact: **7.09** (C: 7.67 E: 5.67 M: 9.33)	Lima	Allen	$994,263	**$3,994,138**	$0	**$0**
59.4	**TFFCP 11-110** ITN Energy Systems, Inc. Commercialization of Direct Borohydride Fuel Cell Stacks utilizing Chemical Hydrogel Based Polymer Electrolyte Membranes and Catalyst Binders Technical Risk: **5.4** (R: 6.67 L: 4.33 P: 5.00) Commercial Risk: **5.8** (P: 6.33 S: 4.67 I: 7.00) Mission Impact: **5.92** (C: 5.00 E: 5.67 M: 7.33)	Littleton	NA	$1,000,000	**$4,994,138**	$0	**$0**
54.1	**TFFCP 11-107** Mound Technical Solutions, Inc. Comprehensive Fuel Cell Evaluation Products and Services Technical Risk: **6.53** (R: 6.67 L: 6.33 P: 6.67) Commercial Risk: **5.67** (P: 5.33 S: 5.00 I: 7.67) Mission Impact: **5.42** (C: 6.33 E: 5.00 M: 5.33)	Miamisburg	Montgomery	$999,271	**$5,993,409**	$0	**$0**
44.7	**TFFCP 11-112** Hocking Technical College Solid Oxide Fuel Cell Stationary Power Generation Demonstration Technical Risk: **2.4** (R: 3.00 L: 2.00 P: 2.00) Commercial Risk: **3** (P: 3.33 S: 1.67 I: 5.00) Mission Impact: **3.25** (C: 4.67 E: 3.00 M: 2.33)	Nelsonville	Athens	$943,300	**$6,936,709**	$56,700	**$56,700**

Ohio Department of Development

2011 TFFCP Evaluation Summary

Third Frontier Fuel Cell Program

Rolls-Royce Fuel Cell Systems (US), Inc. (RRFCS)

Automation and Demonstration of Pilot-scale Manufacturing for SOFCs

TFFCP 11-101	Final Score: 86.7	Rank: 1

Previous Ohio Investment

Rolls-Royce Fuel Cell Systems (US), Inc. (RRFCS) has been developing and intends to commercialize a 1-MW stationary SOFC. This system is designed to offer 55+% single-cycle efficiency at a cost of electricity that is competitive with 100+ MW conventional pulverized coal central power plants. Over $300M has been invested in the development of this technology since 2002 by the parent company and outside investors. Since 2006, the technology has received 6 OTF awards to both RRFCS and SOFCo, an Ohio company that was later purchased by RR. These awards have allowed continued development of the external fuel processor, block-scale test capability (key to obtaining a SECA award), internal steam reformer, and performance prediction capability.

The Ohio investment has been strategically important for several reasons. These grants have led to $25M of investment in Ohio and have helped to position RRFCS to win a SECA award that is potentially worth $75M over 8 years. When technical problems were encountered during the development of this technology, RRFCS was heavily reliant on OTF support to continue much of the technical development work in Ohio. RRFCS has made the decision to consolidate its fuel cell development activities in Ohio, so over $2.25M of FC prototype manufacturing equipment and $500,000 of test equipment has been moved from the UK and Singapore. These capabilities have now been made operational in Ohio where RRFCS (US) has established its headquarters and has grown to 43 employees.

Project Description

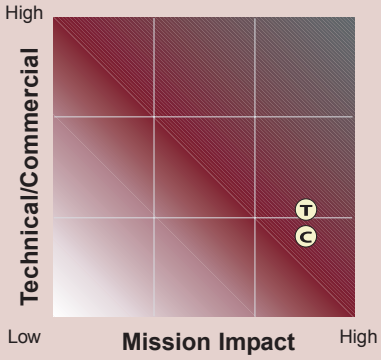
This project is focused on developing manufacturing automation and low-volume production capability in the print line. The current prototype print line is used to produce the active cells by printing various layers of material on specially designed ceramic tubes. The line, which is currently operated by 4 employees, supports production needs for development purposes. Although the printing has been automated, the evaluation of material deposition, coverage, layer alignment, and tube chipping is being done manually through visual inspection as the tubes make multiple passes through the print line.

The number of active tubes needed to support field tests over the next five years is expected to increase dramatically (15,000 tubes are needed for a 1 MW system) requiring processing of a fuel cell tube every 7.5 seconds. To increase production on the print line will require the installation of automated weighing systems, optical vision systems, and a manufacturing execution system (MES). The MES will provide a complete history of all events and process data by logging all measured data from the manufacturing line. It will also provide traceability and inventory status. Future capacity increases will require replication of the automated print line that is created in this project.

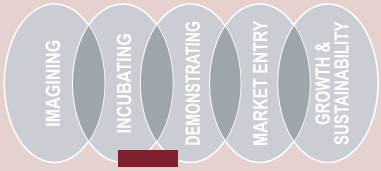
RRFCS is working with Rovisys, a company located in Aurora, Ohio that specializes in production automation systems, information management, and manufacturing execution. Rovisys will be responsible for project management, design, and implementation. Astro Manufacturing and Design, a full-service custom manufacturer located in Eastlake, OH, will develop and produce the automation hardware.

Key Issues

- Commercialization of this product will require substantial additional investment (hundreds of millions of dollars). It is unknown if this investment will come with sourcing requirements that will impact facility siting decisions.
- The projected market entry date for this fuel cell lies somewhat beyond the OTF target timeframe of 3–5 years, but the potential magnitude of product sales offers large upside potential for continuing OTF support.
- DOE reviewers touring the RRFCS operations at Stark State were reportedly highly impressed with the scope and quality of the development work and facilities that they observed and compared RRFCS's Ohio operations very favorably to other SECA teams.
- A number of incumbent technologies, such as reciprocating engine generators, will compete for this potential market. Direct fuel cell competitors are likely to include United Technologies Corporation and Mitsubishi Heavy Industries, but Siemens Fuel Cell announced plans to close by the end of 2010.



Stage of Development



County Location

Funds Requested

TFRDF Request:	$	999,875
WCF Request:	$	0
TOTAL Request:	$	999,875
Cost Share:	$	999,994

Collaborators

- RoviSys Company

Technical Risk

Overall Score = 3.53

Technical Reach

Although this is a complex technology, the tasks in this project present relatively straightforward engineering challenges. RRFCS has identified strong Ohio suppliers with relevant capabilities and experience. In this 20-month project, Rovisys will define the functional requirements, develop detailed designs, build and install the hardware (with assistance from Astro), and develop protocols and MES software. Rovisys intends to evaluate existing vision systems in similar production environments to identify the best fit with RRFCS's needs.

Resource Limitations

This is a strong technical team with adequate cash cost share to complete this project. However, an additional major fundraising effort with shareholders and investors will be required to generate the resources needed to complete development of the SOFC system in the near term. The level of funding needed is comparable to that required to commercialize turbine engines. While RRFCS has been successful in past fundraising efforts, its success with this product will depend its ability to continue meeting milestones. Access to SECA and OTF funding has been important in maintaining product development momentum.

Technology Protection

RRFCS has a robust patent portfolio with more than 25 patents and their foreign counterparts, and the company is pursuing almost the same number of patent applications. RRFCS has taken steps in all of its development agreements to make sure that it either retains title to the IP or that it has a license to practice the technology. Careful IP management and the time and expense associated with development of a technically complex product such as the RRFCS SOFC are expected to provide a competitive advantage.

Commercialization Risk

Overall Score = 2.66

Path to Market

RR has a leading position in the world-wide gas turbine market for stationary power generation. Originally, its plan was to establish a partnership with AEP, a potential first utility customer, to test and demonstrate the initial commercial prototype SOFC system. This system was intended to operate continuously as a base load power generator. That agreement was terminated in 2008 because of the delay in RRFCS's technology development schedule. While all equipment has been removed from AEP's site, the strategic relationship between RRFCS and AEP continues, and AEP remains seriously interested in the technology.

Corporate Stability

RR has a U.S. investment exceeding $1B with more than 8,000 U.S. employees. Although the company has many resources, RRFCS must compete for them. The proposed work will contribute to the decision by RR on whether this manufacturing process is robust enough to produce the large quantity of high quality fuel cell components necessary to do a large-scale demonstration.

Commercial Infrastructure

RR has a well-developed commercial infrastructure that serves its current power generation product line. Much of this expertise will be available to RRFCS. The company continues to believe that the U.S. will represent nearly 50% of the potential market for this product. Its investment in sales and marketing capabilities will increase as the product moves closer to commercial introduction.

Mission Impact

Overall Score = 8.42

Cluster Formation

RRFCS has been working with a number of Ohio suppliers during the development and testing of this complex system, and business with them is likely to increase with the planned scale-up activities. RRFCS will make make-or-buy decisions on the manufacture and assembly of subassemblies, system integration and packaging. In addition, the company has established a strong relationship with Stark State and employs student interns. Several have been hired after graduation.

Ohio Economics

The company has located its headquarters in North Canton and currently has 43 employees. As this product approaches market entry, RRFCS has requested that market entry dates, sales, and employment projections remain confidential, but the proposal has been scored on the basis of those projections. During the 3–5 year OTF commercialization target timeframe, it appears that the largest benefit to Ohio will come from both internal and external investment and SECA funding. If RRFCS is successful in winning a Phase II SECA award for its demonstration project (progress review by DOE appears positive), up to $30 M could come from DOE to support this effort. The company anticipates continuation of its current employment growth pattern and intends to hire within Ohio to support the manufacturing, assembly, packaging, and testing that will be required.

Business Model

RRFCS intends to produce the active fuel cell tubes by printing the active layers on the bare ceramic tubes purchased from a ceramics supplier. These active tubes will be assembled into stacks, the stacks will be combined into a generator module, and four generator modules will be assembled into a full fuel cell system and tested by RRFCS. An intermediate production facility will be required to meet early production demands. The siting decision for this production facility will be made by 2013, followed by a decision on a full-scale manufacturing facility.

Prior Ohio Investments

- Reliability of FCs for Megawatt Scale Power Systems, 2010 $999,770
- Low Cost Steam Reformer for 1MW SOFC Electric Power System, 2009, $600,000
- Development of a High-Pressure Stack Block Test System for a Fuel Cell Power Module Overhaul Facility, 2008, $1,000,000
- 250KW Fuel Processing Subsystem, 2007, $999,870
- Advanced Components for Commercially Competitive Solid Oxide Fuel Cells, 2006, $999,841
- 1MW Solid Oxide Fuel Cell System Package Development, Integration & Prototyping (collaborator to OnPower), 2006
- Sulfur-Tolerant SOFC Power Systems Operating on Distillate Fuels (as SOFCo), 2003, $775,286

Ohio Department of Development

2011 TFFCP Evaluation Summary

Third Frontier Fuel Cell Program

Battelle Memorial Institute

Improving the Manufacturing Readiness of a Solid Oxide Fuel Cell Military Power Generator

TFFCP 11-103 Final Score: 82.3 Rank: 2

Previous Ohio Investment

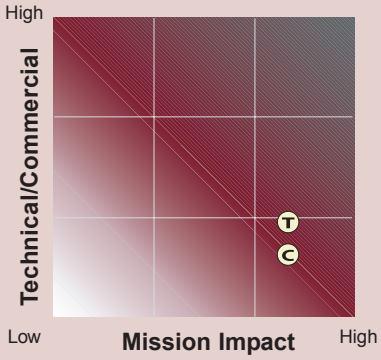
Under a 2009 TFFCP award, Battelle successfully created a new version of its Advanced Power Generator (APG) that integrates NexTech's SOFC stack with Battelle's proprietary desulfurization, fuel processing and balance-of-plant (BOP) subsystems. A factory acceptance test of a 2kW stack and a system shakedown and demonstration are scheduled for completion by the end of 2010. Near-term revenues and jobs (from USDoD contracts and early demonstration unit sales) have fallen well short of projections and are now scheduled for 2013/2014 rather than 2011. The longer-term projections have been delayed only by one year.

Project Description

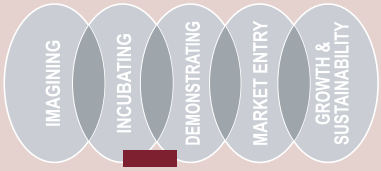
In this 2-year project, Battelle proposes to improve the manufacturing readiness and Technology Readiness Level (TRL) from 4 to 6 for its pallet-mounted, Advanced Power Generator (APG) system, a replacement for internal combustion power generators used by the military. The SOFC-based products proposed (2kW to 15kW) will operate on JP-8 fuel. The project involves a rigorous SOFC stack testing effort and, in parallel, a field test of the packaged system with a PEMFC will be conducted. While the PEMFC does not adequately meet the JP-8 fueling requirement, the test will demonstrate the manufacturing readiness of the desulfurization system and BOP. Collaborator Energy Technologies, will improve the controls, reliability, and packaging, and reduce the manufacturing costs. After the testing by the Air Force Research Laboratory (AFRL) using labor provided by UES, the system will be demonstrated to attract military funding for an engineering design contract leading to a production contract for Energy Technology.

Key Issues

- The Battelle/Energy Technology/AFRL/NexTech team features very strong Ohio technical and manufacturing capabilities and a business management team that has access to and experience in the targeted market.
- While the military has placed a priority on fuel reduction and has targeted power generation for advanced technology, the timing of volume purchases of equipment is subject to strategic and budget drivers that the technology providers cannot control. This creates a risk in the project's meeting its economic development projections.



Stage of Development



County Location

Funds Requested

TFRDF Request:	$1,000,000
WCF Request:	$ 0
TOTAL Request:	$1,000,000
Cost Share:	$1,000,000

Collaborators

- Air Force Research Laboratory (AFRL), Wright Patterson AFB
- Energy Technologies, Inc.
- UES

Technical Risk

Overall Score = 3.13

Technical Reach

Battelle has designed and built a prototype power generator based on NexTech's SOFC technology that meets a number of the military's requirements, including the ability to use JP-8 fuel. Thus, many of the BOP design issues have been resolved, but field demonstration is required to validate the manufacturing readiness. The SOFC stack has proven to be more tolerant of sulfur-containing fuels, but it requires packaging and controls upgrades and additional testing by the Air Force to demonstrate TRL-6 achievement.

Resource Limitations

Battelle has excellent technical capabilities related to fuel cell development. NexTech's "FlexCell" SOFC has demonstrated improved performance characteristics compared to other SOFC suppliers. Energy Technologies currently manufactures and sells ruggedized power systems to the U.S. military and major defense contractors. AFRL, with its facilities, equipment, and fuel cell experience, is uniquely qualified to conduct a vigorous stack performance verification program. Battelle has already invested $10M in project, plus the OTF funds. Energy Technology will need $5M to $10M in 2013 and 2014 to prepare the manufacturing facility to begin production and product entry of 500 units in 2015.

Technology Protection

Battelle has many patents protecting the sulfur removal, hydrogen reformer, and BOP component technologies. The SOFC fuel cell for this APG will be purchased from NexTech. Battelle and NexTech both have independent, unique intellectual property programs that will differentiate the APG product from competing products. The Battelle APG design considers the fuel cell system to be a purchased component. The appropriate IP will be licensed to Energy Technologies, Inc. who will manufacture the APG's in Mansfield, Ohio, for military customers.

Commercialization Risk

Overall Score = 2.07

Path to Market

The U.S. military is seeking ways to reduce the fuel requirement for forward-based operations and has identified the increased efficiency of fuel cells for power generation as technology to be pursued. AFRL, the research and development arm of the U.S. Air Force, is actively participating in the project and its determination that the Battelle APG has reached TRL 6 will influence implementation activity not only by the Air Force, but also by the other Armed Services. Energy Technologies currently has an established sales channel for military power generation systems. The Battelle/Energy Technologies team will bid on military procurements for APGs.

Corporate Stability

Battelle, a well-known, financially stable R&D organization, has experience in setting up business ventures such as that proposed with Energy Technologies. Energy Technologies is an economically sound, well-established military supplier.

Commercial Infrastructure

Battelle is a world-class R&D organization with experience in setting up spin-off companies and licensing technologies. It does not typically manufacture and sell products directly, but will team with Energy Technologies that has both the manufacturing capability and the sales channel for military customers. Energy Technology will manufacture the Battelle APG in Mansfield, Ohio.

Mission Impact

Overall Score = 7.84

Cluster Formation

The key system component, the SOFC stack, will be sourced from NexTech, and will be assembled by Energy Technologies, both Ohio companies. Other BOP components will be purchased from Ohio companies such as Catacel and others in the Ohio fuel cell supply chain.

Ohio Economics

The project team expects to build 100 pre-production prototypes in 2014, and begin commercial production with 500 units in 2015. Forecasted sales are $4M in 2014, $25M in 2015, $50M in 2016, $75M in 2017, and $100M in 2018. Forecasted cumulative jobs at Energy Technologies are 16 in 2014, 80 in 2015, 160 in 2016, 240 in 2017, and 320 in 2018. It is expected that additional job creation will occur at other Ohio supply chain companies such as NexTech and Catacel.

Business Model

Energy Technologies has both the manufacturing capability and the sales channel for military customers, and will manufacture the Battelle military power generator in Mansfield, Ohio. Battelle will license the appropriate technology to Energy Technology and will obtain royalties from Energy Technology on APGs sold. The Battelle/Energy Technologies will team to bid on early military procurement of APUs.

Prior Ohio Investments

- Solid Oxide Fuel Cell Generator Prototype, 2009, $1,000,000

Ohio Department of Development

2011 TFFCP Evaluation Summary

Third Frontier Fuel Cell Program

Lockheed Martin MS2

Military SOFC Genset Demonstration

TFFCP 11-106 Final Score: 79.1 Rank: 3

Previous Ohio Investment

Lockheed Martin MS2 has received two previous awards totaling $2M to develop an SOFC system, including balance-of-plant (BOP), that can meet military performance requirements for mobile generator sets (gensets). In its most recent award, MS2 completed shock and vibration testing of BOP components without failures, improved the power density of the hot stage assembly (HSA), began fabrication of a new thermal jacket for the HSA, and completed successful shock/vibration testing of the HSA isolation mechanism. MS2 and Technology Management, Inc. (TMI) have completed 2,400 hours of testing of the stack with the longest test lasting 150 hours. Issues related to stack sealing and coking or carbon deposition appear to have been addressed. These two grants have created 14 new jobs and 2 vacancies exist. Both will end in early 2011.

MS2 also recently received a $1.65M award from the U.S. Army/CERDEC to design, build, and conduct initial functional testing of a 1-kW SOFC genset with JP-8 containing 500 ppm sulfur. This award represents the first tangible sign of military support for this technology. MS2 expects to create 10 additional jobs with its CERDEC award which will keep the company on track to create a total of at least 20 jobs during the TRL 5 development stage.

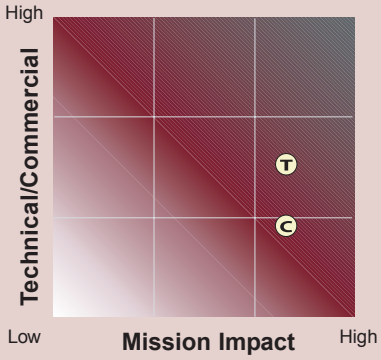
Project Description

In the CERDEC program, MS2 will create a new system design more suitable for Army genset applications, build it, and conduct initial functional testing by QE3 2011. This demo unit will then be used in the proposed OTF program for initial environmental testing in Lockheed's environmental chamber (TRL 5 demo). To reach TRL5 will require 1-button stand alone startup within 1 hour, shock and vibration testing of the integrated system, establishment of the temperature and humidity operational range with water neutrality, and demonstration of fuel efficiency at various power levels.

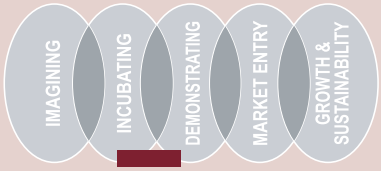
In the OTF program, improved components and subsystems will be developed in collaboration with five participating Ohio suppliers. They include Gorman-Rupp (water and fuel pumps), Catacel (exhaust condensers), Refractory Specialties (insulation), Energy Technologies (rugged UPS/inverter) and Core Technologies (DC/DC converters). Most of these suppliers have received previous OTF support for fuel cell component development, and MS2 is focused on building an Ohio-centric supply chain for its SOFC genset. MS2 will also work with Edison Welding Institute (EWI) to improve the manufacturability of the HSA. During 2012, the improved system will be taken to Camp Ravenna for a field demonstration (partial requirements for TRL 6).

Key Issues

- The military genset opportunity has been identified as best point of entry for SOFC fuel cell technology. At the present time, there is great interest in reducing genset fuel consumption on the front lines by one-third. However, financial support for this technology by the military remains limited.
- MS2 received previous OTF funding to improve the energy density of this system. While the energy density has been improved, it has not attained required levels. MS2 believes that it has another approach that will achieve the goals, but this remains to be proven.
- MS2 is relying on a first-to-market strategy, and it is unclear whether this is a viable approach without knowledge of the technical positions of its competitors. Competitors are likely to include Acumentrics (MA) and Delphi (MI). Compatibility with untreated JP-8, system durability, and time to market are expected to be the key product differentiators.



Stage of Development



County Location

Funds Requested

TFRDF Request:	$1,000,000
WCF Request:	$ 0
TOTAL Request:	$1,000,000
Cost Share:	$1,200,104

Collaborators

- Technology Management, Inc. (TMI)
- Catacel Corporation
- Energy Technologies, Inc.
- Gorman-Rupp Industries
- Refractory Specialities, Inc.
- Core Technology, Inc.

Technical Risk

Overall Score = 5.07

Technical Reach

Major issues were encountered with BOP component operation and reliability, thermal management, electronics and controls, and packaging. These problems limited the ability to operate the system for extended periods of time, but none were judged to be "show stoppers." MS2 and its collaborators appear to have the expertise in component development, systems engineering and testing to address these issues, but the ability of the system to function continuously for 1,000 hours remains to be demonstrated.

Resource Limitations

Although this is a strong technical team, MS2 is supporting fuel cell development through its internal R&D (IRAD) funds which are limited. DOD data suggests that $5M will be required to bring this technology to the TRL 5 level and an additional $8M to reach the TRL 6 level. Additional funding of $20–30M likely will be required for manufacturing development and scale-up. Lockheed Martin Corporation spent $1.7M in 2010 and has already committed $1M in 2011 IRAD funds to fuel cells with additional amounts under consideration.

Technology Protection

The core fuel cell IP is held by TMI through a combination of U.S. and international patents, trade secrets, and know-how. The age and coverage of the relevant TMI patents has not been specifically identified, and most of the IP appears to be held in the form of trade secrets. Lockheed adds intangible IP in the form of know-how and trade secrets related to ruggedization of products and system integration. The parties have negotiated a licensing agreement covering rights to IP developed under programs on which they are jointly working.

Commercialization Risk

Overall Score = 3.00

Path to Market

Lockheed has contacts with all of the military agencies and is directly working with several that have expressed interest in fuel cell gensets. The Program Manager for Mobile Electric Power has indicated that successful completion of the CERDEC grant and this OTF work plan would bring the fuel cell to a point where it is likely to qualify to for insertion into a specific military program which would provide development funding from the military.

Corporate Stability

MS2 has been located in Akron for over 80 years and has multiple military R&D and production programs. MS2 has grown from 550 employees in Akron in 2005 to 700 employees in 2009. Manufacturing employment at the Akron facility has increased from 69 to 116 over this same period and includes machining, assembly, cable manufacturing, welding and finishing. MS2 expects the its commitment of IRAD funds to position future manufacturing for the fuel cell genset in Akron, but this ultimately will be a business decision.

Commercial Infrastructure

Lockheed is an established and qualified DOD supplier/contractor. In 2009, LM invested $750K to support marketing and proposal efforts in pursuit of military SOFC opportunities. During 2010, MS2 has already conducted 30-40 briefings and tours of its Advanced Fuel Cell Lab for Lockheed senior management, military personnel, elected officials, and DOE staff. MS2 is actively pursuing additional CRAD funding with multiple branches of the military and has an ongoing fuel cell program at DOE in Golden, CO.

Mission Impact

Overall Score = 7.75

Cluster Formation

MS2 is developing and intends to commercialize cell and reformer technology developed by TMI, an Ohio company. MS2 currently purchases approximately $500M (1/08–5/09) in materials from Ohio suppliers. There are five Ohio subcontractors whose products will be incorporated into this fuel cell as part of this project. Testing is planned at Stark State College, and EWI is assisting with joining issues.

Ohio Economics

MS2 projects reaching TRL 5 by August 2011 and TRL 6 by early 2013. Military program funding could become available to MS2 as early as late 2011 for a specific end-use application. By 2014, MS2 projects that it will create or retain 40 jobs. MS2 estimates that 700 Ohio jobs would be directly created or retained in manufacturing, engineering, and support fields at MS2 and its suppliers as soon as full production is reached.

Business Model

While precise market projections are proprietary, the size of the market for military tactical gensets appears to be considerable ($200–700 million). Other end uses such as ground vehicle APUs and FEMA needs would further expand the application of this technology. The target market entry date appears to be in the 2014–2017 time period (exact date proprietary), but the operational cost of fuel and military requirements may accelerate this time line. Current plans are for 70% of the value to come from Ohio suppliers, further strengthening the case of Ohio production at MS2.

Prior Ohio Investments

- Miltary SOFC Ruggedization, 2010, $1,000,000
- Military SOFC Genset Project, 2009, $998,393

Ohio Department of Development

2011 TFFCP Evaluation Summary

Third Frontier Fuel Cell Program

American Trim, LLC (AmTrim)

Low-cost Manufacturing System for Fuel Cell Components

TFFCP 11-122	Final Score: 76.2	Rank: 4

Previous Ohio Investment

OTF has made two previous awards to American Trim, LLC (AmTrim) to develop its high speed electromagnetic forming (EMF) and laser welding technologies. These technologies were intended to form and join bipolar plates for General Motors (GM) to use in PEMFCs for automobile propulsion. Their potential to be scaled at 10% of the cost of other processes made them attractive to AmTrim and GM. Both of these projects achieved their technical goals and demonstrated that high velocity metal forming could be used to form bipolar plates using 1% of the energy of traditional forming. There are currently 8 employees working on the technology development team and in 2011 there will be 2 funded production jobs and 8 commercial jobs.

AmTrim's business for EMF and joining has developed more slowly than projected. GM has made a policy shift away from hydrogen fuel cells in favor of battery technology for electric vehicle applications. Although the GM fuel cell team continues to function, its goals have been pushed out from 2012 to the 2017–2020 timeframe, and it now appears likely that GM will not require bipolar plates from American Trim until 2013–14. AmTrim does not have a binding agreement with GM and has been approached by many major manufacturers who are interested in these new manufacturing technologies, particularly for crimping applications. AmTrim has invested heavily in the development of this technology for the purposes of axisymetric crimping.

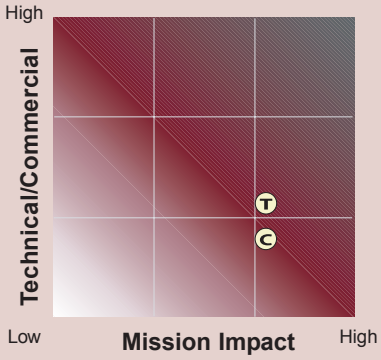
Project Description

In this project, AmTrim will work with Modine to produce the more effective plates for heat exchangers that are used in Modine's SOFC balance-of-plant (BOP) and new emerging Rankine cycle heat exchangers for heat recovery units on Class 8 trucks. The total volume projected is 5M plates for a market of $5–6M annually. Because the volume is low, conventional tooling does not warrant the investment in product improvements, but EMF at 10% of the cost of conventional tooling makes these improvements viable. Modine also intends to work with AmTrim in the area of laser welding. Using lasers to replace existing vacuum brazing methods will be investigated to allow downgauging of the flow fields. Modine feels that this combination of manufacturing technologies could revolutionize current heat exchanger manufacturing methods.

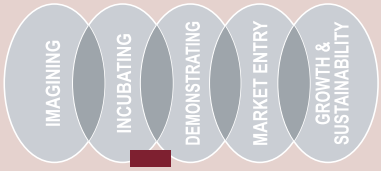
In this project, AmTrim will enhance the capabilities of the current prototype manufacturing equipment by doubling the power of the capacitor bank to over 60 kJ, designing parallel switches to increase switch life for millions of discharges, developing a durable compliant layer, and integrating the forming and laser cutting/piercing process into a continuous production line with appropriate monitoring capabilities. Initial simulation modeling by LS-DYNA will be done by OSU prior to the construction of both alpha and beta machines. ONU will analyze the flow properties within the fuel cell using computational fluid dynamics (CFD). AmTrim will privately fund a production line for the Modine part and produce runs of approximately 1,000 for evaluation as the manufacturing process becomes more robust.

Key Issues

- At this point, cost savings in energy consumption, tooling, and capital equipment are projections based upon early stage prototypes. It remains to be proven if these savings can be sustained in a production environment.
- The slower than projected growth of the fuel cell market has greatly increased the economic pressure on the developing fuel cell supply chain. This trend has been exacerbated by the recent economic downturn. AmTrim's project with GM has been affected, and initial market pull for automotive propulsion is not expected to occur until 2013–14.
- Earlier TF awards have raised the profile of these new manufacturing technologies and attracted the attention of other manufacturing companies (Parker Hannifin, Crown, Moen, Modine, and others) who have contacted AmTrim. A viable commercial production line has the potential to transform these inquiries into new business opportunities for AmTrim in many industries beyond fuel cells.



Stage of Development



County Location

Funds Requested

TFRDF Request:	$	994,263
WCF Request:	$	0
TOTAL Request:	$	994,263
Cost Share:	$	994,454

Collaborators

- Ohio Northern University
- The Ohio State University (OSU), Department of Materials Science
- Edison Materials Technology Center

Technical Risk

Overall Score = 3.73

Technical Reach

AmTrim already has capability in place for metal forming, piercing, and shape corrections via EMF. The company has built a three stage in-line alpha EMF machine and is completing a beta forming machine to produce full-scale bipolar plates. The proposed equipment enhancements for this project will involve engineering know-how but should lie within AmTrim's capabilities. The Ohio State University (OSU) will assist by developing forming parameters for the Modine heat exchanger plates using a simulation based on LS-DYNA modeling, and ONU will use computational fluid dynamics to analyze flow properties in the fuel cell.

Resource Limitations

Because the fuel cell market has developed more slowly than anticipated, AmTrim has limited resources available to support new product development in this area. This project shows good creativity by combining a fuel cell application (BOP heat exchanger for SOFCs) with a truck application to create a project of sufficient mass to be economically viable. OTF support and AmTrim cost share should be sufficient to demonstrate the economic advantages of these new manufacturing technologies in a commercial application, and both AmTrim and Modine will have incentive to expand their relationship.

Technology Protection

Although this technology was originally developed and patented at OSU, AmTrim has a strategy that includes maintaining control over all aspects of the IP. AmTrim and all collaborators have formal IP agreements. These agreements contain provisions for dispute resolution related to IP ownership but they provide that no injunction may be obtained that precludes the use of the disputed IP from this program.

Commercialization Risk

Overall Score = 2.60

Path to Market

AmTrim has an annual commitment from Modine to purchase $6M of Heat Recovery Plates for a fluid channel distribution system for an SOFC BOP system and a truck application if certain cost and performance targets are met. If this effort is successful, many additional end-use applications at Modine would be candidates for this manufacturing technology.

Corporate Stability

AmTrim, a privately held company headquartered in Lima, Ohio, was founded in 1951 and specializes in metal coating, decorating, and forming. It has annual sales of approximately $150M and employs 700–800 Ohioans. The company has operations in the Midwest, Southeast, and Mexico, but approximately 70–80% of its total employment is in Ohio. AmTrim produces up to 750,000 parts per day and has long-standing supplier relationships with industry leaders such as Whirlpool and International Truck. Modine is a global leader in innovative thermal technologies with over $1.6B in annual revenue.

Commercial Infrastructure

AmTrim has an existing sales and marketing staff that serves the transportation, appliance, architectural, and arts and leisure industries. It is able to service its products with its field support staff. In addition, AmTrim has a strong product design team to assist the customer in optimizing product design for manufacturing efficiency. Its production capabilities include stamping, assembly, coating, screen printing on metal, anodizing, and roll forming.

Mission Impact

Overall Score = 7.09

Cluster Formation

This project will allow AmTrim to build a stronger relationship with this global fuel cell component leader. Beyond fuel cells, lower cost forming and joining have the potential to position AmTrim as a key supplier to other Ohio manufacturing companies. If the projected cost savings are confirmed, high speed forming and joining could enable many Ohio companies to become more cost competitive in their respective industries.

Ohio Economics

Successful completion of this project could result revenues of $1M and 26 jobs by Year 3 for AmTrim. Modine sales are expected to grow to $6M by Year 5 and to maintain the 26 jobs. While this impact is relatively small, the companies have been discussing the wider application of these two manufacturing processes and have identified opportunities within Modine's product line that could lead to $100M annually in new revenues for AmTrim.

Business Model

AmTrim envisions a phased approach that will allow the company to create the equipment to move from production of single parts to millions of parts. This work will take place at the Lima facility and will involve multiple generations of equipment for high speed forming and joining that will be configured in increasingly complex production lines. It is estimated that 3–5+ years will be required to fully mature the production process.

Prior Ohio Investments

- Agile Hybrid Joining of Fuel Cell Bipolar Plates, 2008, $1,000,000
- Agile Low-Cost Manufacture of Fuel Cell Plates via EMF, 2007, $1,000,000

Ohio Department of Development

2011 TFFCP Evaluation Summary

Third Frontier Fuel Cell Program

ITN Energy Systems, Inc.

Commercialization of Direct Borohydride Fuel Cell Stacks Utilizing Chemical Hydrogel-based Polymer Electrolyte Membranes and Catalyst Binders

TFFCP 11-110	Final Score: 59.4	Rank: 5

Previous Ohio Investment

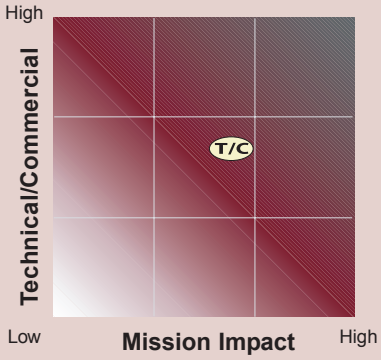
ITN Energy Systems, Inc. has not received a prior OTF award, but the project proposed is a direct extension of a 2009 TFFCP award to The Ohio State University (OSU) on which ITN is a collaborator and commercializing entity. The 2009 project is nearing completion and has led to the successful development of a biopolymer-based DBFC electrolyte membrane, an electrode catalyst binder, and a Ni-based composite anode catalyst that have demonstrated a 60% improvement in the DBFC power density. Plans for ITN establishing a new fuel cell production company in 2011 have been delayed until 2013, although in 2011 two ITN employees will be relocated to Ohio creating ITN-Ohio.

Project Description

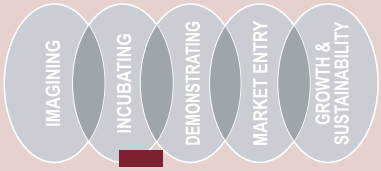
The goal of the project is optimize, manufacture and commercialize Direct Borohydride Fuel Cells (DBFCs) in Ohio that are targeted at portable and mobile fuel cell applications. DBFCs can operate on liquid sodium borohydride, a safe, non-toxic feedstock. OSU developed the DBFC membrane and catalyst binder materials from chitin, an inexpensive natural biopolymer made from shrimp and lobster shells. These materials cost less than 10% of the currently used membrane material, Nafion®. ITN plans to start a polymer membrane and catalyst manufacturing facility in Ohio at the beginning of the project that will be expanded to an assembly facility for producing DBFCs for performance characterization and field testing, and ultimately, commercial product. This 2-year project will include laboratory-scale optimization of the membrane preparation and assembly of complete DBFC stacks, followed by pilot plant production and assembly of DBFC stacks for long-term testing.

Key Issues

- The establishment of an Ohio fuel cell manufacturing facility is a compelling advantage of the proposal, and ITN has proven experience and capability in creating successful technology-based spin-off companies.
- The economic impact schedule is very aggressive based on the current stage of DBFC development. Demonstrations of the prototype DBFCs applied to specific applications are likely to be required before commercial product sales will be achieved.
- There are no customers or strategic marketing partners directly involved in the project that support a market pull for the DBFC proposed. Interest by Boeing is for a product line that does not appear to be within the initial ITN target market.



Stage of Development



County Location

★ Located outside of Ohio

Funds Requested

TFRDF Request:	$1,000,000
WCF Request:	$ 0
TOTAL Request:	$1,000,000
Cost Share:	$1,000,000

Collaborators

- The Ohio State University (OSU)

Technical Risk

Overall Score = 5.40

Technical Reach

The chitosan membrane electrolytes and binders have been demonstrated at the laboratory scale and have shown a 60% performance improvement over Nafion® equivalents. Long-term (~5000 hours) chemical, thermal and mechanical stability need to be characterized and optimized. In addition, the ability to cast the membrane at the pilot-scale needs to be verified, system integration of the entire stack must be demonstrated, and cost reduction of the balance-of-plant remains to be achieved. The end-of-project deliverable will be demonstration of a full-sized (1 kW) DBFC stack.

Resource Limitations

ITN's management team has successfully spun off four companies, two producing CIGS PV products, one producing micro-energy storage devices, and one producing spacecraft subsystems. Each of these companies is producing annual revenues at multi-million dollar levels. The proposed project funds appear sufficient to accomplish the project goals, but the next stage of commercialization will require $10M that will be sought from investors and federal grants. "Soft" commitments for this level of funding have been obtained.

Technology Protection

OSU has submitted provisional and full patent applications that cover the catalyst binder technology and also has IP covering the chitosan membrane technology and nickel alloy anode catalyst. ITN and OSU have a technology transfer arrangement in place and ITN has been granted exclusive corporate licensing rights.

Commercialization Risk

Overall Score = 5.80

Path to Market

ITN has targeted the portable power application for its initial product line. Kirloskar Integrated Technologies, the largest diesel generator set manufacturer in India, and Boeing have both expressed interest in the DBFC technology and a willingness to work with ITN if the technology goals are successfully met. However, there is no active customer involvement in the TFAEP project. Strategic partnerships, yet to be developed, will likely be needed to reach the intended markets.

Corporate Stability

ITN is a 15-year old R&D company based in Littleton, CO that introduces its technologies through new company spin-outs. It employs between 25 to 100 people depending on the status of a new spin-out. Its major source of revenue is contract research and it currently has $9M in government (~75%) and industrial projects ongoing.

Commercial Infrastructure

ITN technologies are commercialized through stand-alone, spin-out companies. The plan for the DBFC technology will follow that approach with the new Ohio company created as part of this project. ITN has had discussions with the companies mentioned earlier, and they present potential avenues to markets through their existing infrastructures. However, these discussions appear to be still at an early stage.

Mission Impact

Overall Score = 5.92

Cluster Formation

The DBFC technology proposed has its roots at OSU, and OSU continues to support its optimization. ITN will establish a DBFC production operation in Ohio, and has identified several Ohio companies in the Ohio fuel cell supply chain/cluster that could supply DBFC materials and balance-of-plant components. While ITN will seek Ohio suppliers, none of these are active in the proposed project. At the current stage of commercial and business development, it is too early to establish firm supplier relationships.

Ohio Economics

ITN's new Ohio company will initially lease space, potentially at Tech Columbus, and consist of 2 employees in 2011 growing to 6 by the end of the project in 2012. Membrane Electrode Assembly (MEA) production will begin during the project period, and in 2013 a capital raise of $10M will be sought. With that capital raise, a commercial-scale manufacturing facility for DBFCs will be established and employee count will be 10. Revenues will begin in 2014 in the range of $2M to $4M growing to $8M in 2016. Employee count in 2014 an 2016 will be 15 and 30 respectively. Full production employment in 2020 is projected to be 150.

Business Model

ITN plans to create an Ohio entity to manufacture, market, and distribute DBFCs for a variety of markets. Its initial products are expected to focus on portable power applications such as lift trucks, construction tools, scooters, and military generators. ITN will partner with larger companies with established market access for specific applications and will support product development to adapt the technology for additional markets.

Prior Ohio Investments

- Development of a Cost Effective Membrane Electrolyte Assembly and a Direct Borohydride Fuel Cell, 2009, $350,000 (Lead Applicant—OSU)

Ohio Department of Development

2011 TFFCP Evaluation Summary

Third Frontier Fuel Cell Program

Mound Technical Solutions, Inc. (MTS)

Comprehensive Fuel Cell Evaluation Products and Services

TFFCP 11-107	Final Score: 54.1	Rank: 6

Previous Ohio Investment

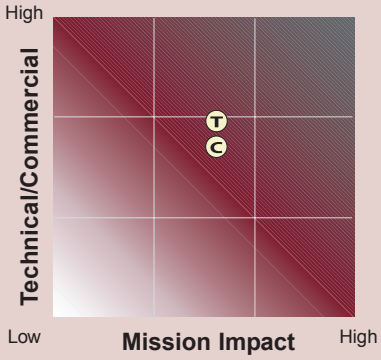
Mound Technical Solutions, Inc. (MTS) received a 2005 TFFCP award to develop an alpha-level comprehensive fuel cell test system prototype and a 2007 TFFCP award to upgrade the prototype to a commercial product and add additional capabilities including enhancing test fixtures for PEMFCs and SOFCs. The result of these earlier projects is that MTS has produced the leading fuel tester on the market; however, economic impact estimates by MTS have fallen well short of projections. MTS employment has grown to 10 staff, about 25% of that projected. Likewise total fuel cell tester sales are below projections and currently stand at 13, generating slightly over $1M.

Project Description

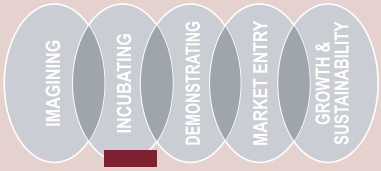
MTS proposes creating a "one-stop" fuel cell testing service business to serve fuel cell developers, manufacturers and end users. Currently a complete, standardized set of "mil-spec" tests for fuel cell technologies and equipment does not exist, so fuel cells are tested to more generalized "mil-specs" that are in place. Based on MTS' experience with its fuel cell tester product and from feedback from end-users such as the Air Force and FBI, it will tailor and/or develop "mil-specs" for fuel cells in such areas as electromagnetic compatibility, durability, heat generation, emissions, fuel compatibility and many others. The "one-stop" testing business will incorporate the use of MTS' in-house equipment and those at the facilities of other Ohio fuel cell cluster companies such as University of Dayton Research Institute (UDRI), Air Force Research Laboratory (AFRL), Stark State, L3 Communications–Nova, etc. The Air Force will supply a variety of "personal power" fuel cells (~50 watts) it is evaluating to use in the test development.

Key Issues

- The need for fuel cell testing services and standards development proposed might be premature based on the status of the fuel cell utilization. Interest from smaller system developers and the military is evident, but this does not appear to support the business growth projected.
- While MTS and its team have the technical capabilities to design and perform the testing, the creation of the proposed service business presents challenges for the team. The resources that will be required in terms of personnel and financing appear to be underestimated and likely will rely heavily on Air Force support.
- Organizing and setting up the business arrangements for an Ohio network of testing capability presents additional unaddressed challenges. Identification of the capabilities required to create the "one stop" shop to date appear to be defined by individual customer request rather than industry consensus of need.



Stage of Development



County Location

Funds Requested

TFRDF Request:	$ 999,271
WCF Request:	$ 0
TOTAL Request:	$ 999,271
Cost Share:	$1,003,656

Collaborators

- University of Dayton Research Institute (UDRI)
- Air Force Research Laboratory (AFRL), Wright Patterson AFB
- ENrG Inc. (Buffalo, NY)
- Heraeus, Inc. (W. Conshohocken, PA)

Technical Risk

Overall Score = 6.53

Technical Reach

MTS and UDRI have established testing and analytical equipment in place that will serve as the core for testing service proposed, but relationships with other Ohio testing providers will need to be formalized. The ability for MTS to establish industry-accepted standards is not completely clear, although the participation by the Air Force adds a level of creditability. The current dynamic nature of fuel cell technology results in new materials and configurations being introduced making selection/identification of the testing equipment that will be needed uncertain.

Resource Limitations

The technical capabilities at MTS, UDRI and AFRL create a strong base for services proposed, but the ability to consolidate these resources, form them into a marketable business, and financially support the business development aspects related to the service is less clear. Future capital requirements and business development costs by early customer usage are expected to support the business as well as investor and additional federal/military funding. Initial discussion with angel investors is underway.

Technology Protection

The intellectual property involved in the project is the expertise and experience residing within the project team. MTS has gained critical knowledge of fuel cell systems and customer needs in the area of fuel testing from its current fuel cell tester business. By being the organization that establishes the test procedures and protocols, MTS believes it will be positioned to be the premier provider of the test services proposed.

Commercialization Risk

Overall Score = 5.67

Path to Market

MTS will initially focus on personal power fuel cell testing services with the Air Force as its target customer, but plans to be capable of testing all fuel cell platforms in sizes from watts to several kilowatts. ENrG and Heraeus, fuel cell component manufactures/suppliers, are collaborators in the project and have indicated interest in and plans for using the testing services proposed. The FBI has visited MTS and indicated its strong interest in having a testing service such as that proposed by MTS.

Corporate Stability

MTS was founded in 1996 and is located in the Mound Advanced Technology Center in Miamisburg, OH. It currently has 10 full-time employees. Its revenues are from fuel cell tester and specialty instrumentation (tritium testers) sales and contract R&D, and have been steady at slightly under $1M annually. It is debt-free and profitable. New staff, some supported by the proposed project, will be hired to support development and marketing of the testing service.

Commercial Infrastructure

MTS has a worldwide sales and service organization for its tritium testers, a niche product providing a steady business. The fuel cell tester is sold directly and through instrumentation distributors. The marketing of the new testing service will require development directed by the new marketing personnel being hired under this project.

Mission Impact

Overall Score = 5.42

Cluster Formation

MTS proposes utilizing existing analytical capabilities and equipment in the Ohio fuel cell cluster to provide the entire array of testing services it will offer. It is already partnered with UDRI and AFRL and has worked with Stark State for customer requested testing services provided to date. MTS believes that the being the first to offer comprehensive fuel cell testing services will make it the "go to" source for evaluating products both by fuel cell developers and end users.

Ohio Economics

MTS projects that its testing service business will generate $4.5M in revenues and 16 jobs by 2013 and $6M and a total of 25 jobs by 2015. These estimates are based on market research projections for fuel cell sales growth. Unfortunately, these forecasts have proven to have been optimistic as shown by the slower than anticipated growth of MTS' fuel cell tester sales and resultant jobs. While customer demand appears promising, firm estimates of usage have not been established.

Business Model

MTS has sufficient space at the Mound Technical Center to expand and accommodate the proposed testing service business. The marketing plan is not yet fully developed and initially it will rely on word-of-mouth communication and collaborator recommendations. Developing the business model and arrangements for accessing the Ohio testing capabilities will be a challenge yet to be fully addressed.

Prior Ohio Investments

- Development, Maintenance and Commercialization of a Comprehensive Fuel Cell Test System, 2005, $600,000
- Enhancement of Comprehensive Fuel Cell Test System Products, 2007, $494,040

Ohio Department of Development

2011 TFFCP Evaluation Summary

Third Frontier Fuel Cell Program

Hocking Technical College

Solid Oxide Fuel Cell Stationary Power Generation Demonstration

TFFCP 11-112	Final Score: 44.7	Rank: 7

Previous Ohio Investment

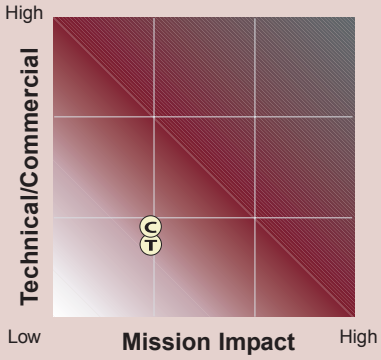
Hocking Technical College has not received any prior OTF awards as a lead applicant. However, Hocking is a major collaborator on a 2010 TFFCP award to NexTech Materials. In that project, Hocking's role is to install and operate equipment for the manufacture of green electrolyte tape for NexTech's large-area FlexCell product. The project is claimed to be on schedule with initial tape production to begin in mid-2011.

Project Description

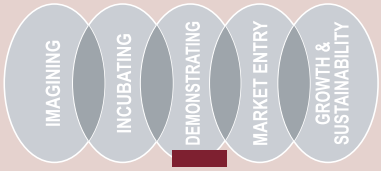
In this 2-year project, Delphi will install two 5kW, fixed position, natural gas powered, solid oxide fuel cell (SOFC) power generators at Hocking Technical College. These fuel cells will demonstrate the durability and efficiency of SOFC systems as they power a public, medium-sized building (12,500 square feet). The two SOFC units will run 24 hours a day for about 11 months. The efficiencies of the systems will be evaluated and compared to the efficiencies and emissions of typical coal-fired power generating plants. After 11 months, one unit will be dismantled, and its physical integrity will be evaluated. The other system will continue to provide power at the Hocking site. This project will provide Delphi with valuable data on the long-term, continuous operation of its system. It will provide Ohio with a demonstration project of a stationary fuel cell being used for power generation, and it will give Hocking the opportunity to expand its student training program in alternative energy systems.

Key Issues

- The project will create an Ohio demonstration site showcasing a continuously operating stationary SOFC power generation system. The system will provide Hocking College Energy Institute with a valuable asset and resource for its advanced energy and fuel cell related curricula and student training.
- The economic impact for Ohio is minimal unless Delphi selects an Ohio location for its fuel cell manufacturing operations. This decision will not occur until after project completion, and it is not clear that Ohio has a strong advantage that will leverage that decision in its favor.



Stage of Development



County Location

Funds Requested

TFRDF Request:	$ 943,300
WCF Request:	$ 56,700
TOTAL Request:	$1,000,000
Cost Share:	$1,103,765

Collaborators

- Delphi Corporation (Auburn Hills, MI)

Technical Risk

Overall Score = 2.40

Technical Reach

Delphi has demonstrated SOFC stack durability of over 9,500 hours with over 200 thermal cycles. Delphi is ready to take the latest version of its fuel cell-based auxiliary power unit (APU) out of the laboratory and into real world applications. Delphi's initial interest is for the truck APU market (diesel fuel powered). However, though the proposed SOFC systems at Hocking are stationary and use natural gas as their fuel source, the wear data and information related to the stack after long-term, continuous use is claimed to be directly applicable to the diesel-fueled truck APU product as well as other SOFC products for other markets.

Resource Limitations

Over the last decade Delphi has committed and leveraged significant technical and financial resources into the development of portable power SOFCs, and it is a partner with United Technologies Corporation in the USDOE sponsored coal-based fuel cell development program. Delphi has the technical and financial capabilities to continue development efforts to commercialize the APU product and to enter the various other SOFC markets such as stationary power.

Technology Protection

Delphi has intellectual property related to the innovations it has made improving the durability and performance of SOFC technology. However, it also is working with other fuel cell end-users to assure its final design/product meets their cost and performance objectives. Delphi has experience in the management and handling of both internally generated and licensed IP.

Commercialization Risk

Overall Score = 3.00

Path to Market

While no end-user is directly involved in this project, Delphi has existing business ties to the target truck market and has based its APU product on input from those truck manufacturers. Delphi has also worked with the DOE on funded projects for stationary power systems, has contacts with other system integrators for commercial stationary power systems, and is working with the Naval Research Lab on funded projects to provide SOFC-based power systems for unmanned underwater vehicles (UUV).

Corporate Stability

Hocking College was established in 1968, and the Advanced Energy Institute was opened in 2003. Delphi is a large, major USA corporation supplying components and systems to the auto and truck industries.

Commercial Infrastructure

Components and systems for the Delphi fuel cell systems have been made internally and were produced at Delphi R&D facilities in Michigan and New York. Full-scale production will not occur at those locations, so Delphi plans to locate and convert an existing under-utilized facility to produce the fuel cells and ancillary systems. The current plan is to identify the location of the future fuel cell manufacturing plant sometime in 2012.

Mission Impact

Overall Score = 3.25

Cluster Formation

Several Ohio companies have collaborated with, and supplied various services and product to Delphi. The Ohio material content of the proposed two systems is estimated to be approximately 5%, but the potential content of the commercial systems could be about 20% and even greater if an Ohio manufacturing location were to be selected. Therefore, the major impact to the Ohio fuel cell cluster would occur from Delphi locating its SOFC manufacturing plant in Ohio. The project would provide Ohio with an in-service fuel cell demonstration for showcasing fuel cell operation.

Ohio Economics

Hocking indicates one or two new employees at Hocking will result from this project. There will be no direct sales revenues or jobs created or claimed in Ohio by 2013 as a result of this project, except for those at Ohio suppliers for the 2 demonstration units. Significant job potential is associated with the manufacturing operation, but the timing for and location of that facility are uncertain.

Business Model

The proposed project will provide the Delphi R&D group with important performance information on its SOFC stack, fuel reformer, and overall system. This project is one step in the overall SOFC development project by Delphi. Delphi plans to be a SOFC system manufacturer of APUs to the truck market, a SOFC component supplier to the stationary power market, and a SOFC component or SOFC system supplier to the military market.

Prior Ohio Investments

- Improving the Manufacturing Readiness of Nextech's SOFC Stack Technology, 2010, $1,490,000 ($551,000 to Hocking)