

FINANCIAL ASSISTANCE
FUNDING OPPORTUNITY ANNOUNCEMENT



ADVANCED RESEARCH PROJECTS AGENCY – ENERGY (ARPA-E)
U.S. DEPARTMENT OF ENERGY

***GENerators for Small Electrical and Thermal Systems
(GENSETS) (SBIR/STTR)***

Announcement Type: Initial Announcement
Funding Opportunity No. DE-FOA-0001380
CFDA Number 81.135

FOA Issue Date:	July 16, 2015
Deadline for Questions to ARPA-E-CO@hq.doe.gov :	5 PM ET, August 10, 2015
Submission Deadline for Full Applications:	5 PM ET, August 17, 2015
Expected Date for Selection Notifications:	September 2015
Total Amount to Be Awarded	Approximately \$7 million, subject to the availability of appropriated funds.
Anticipated Awards	ARPA-E may issue one, multiple, or no awards under this FOA. Award amounts may be up to \$3.225 million.

- For eligibility criteria, see Section III.A – III.D of the FOA.
- For cost share requirements under this FOA, see Section III.E of the FOA.
- To apply to this FOA, Applicants must register with and submit application materials through ARPA-E eXCHANGE (<https://arpa-e-foa.energy.gov/Registration.aspx>). For detailed guidance on using ARPA-E eXCHANGE, see Section IV.F.1 of the FOA.
- Applicants are responsible for meeting the submission deadline. Applicants are strongly encouraged to submit their applications at least 48 hours in advance of the submission deadline.
- ARPA-E will not review or consider noncompliant or nonresponsive applications. For detailed guidance on compliance and responsiveness criteria, see Sections III.F.1 and III.F.2 of the FOA.
- Prime Recipients and Subrecipients must obtain a DUNS number and have an active registration in SAM to receive an award, and therefore should begin their DUNS/SAM registrations no later than August 17, 2015. See Section VI.B.1 of the FOA.

Questions about this FOA? Check the Frequently Asked Questions available at <http://arpa-e.energy.gov/faq>. For questions that have not already been answered, email ARPA-E-CO@hq.doe.gov (with FOA name and number in subject line); see FOA Sec. VII.A. Problems with ARPA-E eXCHANGE? Email ExchangeHelp@hq.doe.gov (with FOA name and number in subject line).

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REQUIRED DOCUMENTS CHECKLIST

For an overview of the application process, see Section IV.A of the FOA.

For guidance regarding requisite application forms, see Section IV.B of the FOA.

For guidance regarding the content and form of Full Applications, see Section IV.C of the FOA.

SUBMISSION	COMPONENTS	OPTIONAL/ MANDATORY	FOA SECTION	DEADLINE
Full Application	- Each Applicant must submit a Technical Volume in Adobe PDF format by the stated deadline. Applicants may use the Technical Volume template available on ARPA-E eXCHANGE (https://arpa-e-foa.energy.gov). The Technical Volume must include the following: - Executive Summary (1 page max.) - Sections 1-5 (30 pages max.) 1. Innovation 2. Proposed Work 3. Team Organization and Capabilities 4. Technology to Market 5. Budget - Bibliographic References (no page limit) - Personal Qualification Summaries (each PQS limited to 3 pages in length, no cumulative page limit) - The Technical Volume must be accompanied by the documents listed below (unless otherwise noted below, template documents and forms are available on ARPA-E eXCHANGE https://arpa-e-foa.energy.gov : - SF-424 (no page limit, Adobe PDF format) - SF424A (no page limit, Microsoft Excel format) - Summary Slide (1 page limit, Microsoft PowerPoint format) - SBA Company Registration Certificate generated in the SBA Company Registry (http://sbir.gov/registration) (Adobe PDF format) - If applicable, Certification for Applicants Majority-Owned by Multiple Venture Capital Operating Companies, Hedge Funds, or Private Equity Firms Applicants may use the SBIR VCOC Certification template available on ARPA-E eXCHANGE, (https://arpa-e-foa.energy.gov) (Adobe PDF format) - Completed and signed Business Assurances & Disclosures Form (no page limit, Adobe PDF format).	Mandatory	IV.C	5 PM ET, August 17, 2015

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I. FUNDING OPPORTUNITY DESCRIPTION

A. AGENCY OVERVIEW

The Advanced Research Projects Agency – Energy (ARPA-E), an organization within the Department of Energy (DOE), is chartered by Congress in the America COMPETES Act of 2007 (P.L. 110-69), as amended by the America COMPETES Reauthorization Act of 2010 (P.L. 111-358) with the following goals:

- “(A) to enhance the economic and energy security of the United States through the development of energy technologies that result in—
- (i) reductions of imports of energy from foreign sources;
 - (ii) reductions of energy-related emissions, including greenhouse gases; and
 - (iii) improvement in the energy efficiency of all economic sectors; and
- (B) to ensure that the United States maintains a technological lead in developing and deploying advanced energy technologies.”

ARPA-E funds research on and the development of high-potential, high-impact energy technologies that are too early for private-sector investment. The agency focuses on technologies that can be meaningfully advanced with a modest investment over a defined period of time in order to catalyze the translation from scientific discovery to early-stage technology. For the latest news and information about ARPA-E, its programs and the research projects currently supported, see: <http://arpa-e.energy.gov/>.

ARPA-E funds transformational research. Existing energy technologies generally progress on established “learning curves” where refinements to a technology and the economies of scale that accrue as manufacturing and distribution develop drive down the cost/performance metric in a gradual fashion. This continual improvement of a technology is important to its increased commercial deployment and is appropriately the focus of the private sector or the applied technology offices within DOE. By contrast, ARPA-E supports transformative research that has the potential to create fundamentally new learning curves. ARPA-E technology projects typically start with cost/performance estimates well above the level of an incumbent technology. Given the high risk inherent in these projects, many will fail to progress, but some may succeed in generating a new learning curve with a projected cost/performance metric that is significantly lower than that of the incumbent technology.

ARPA-E funds technology with the potential to be disruptive in the marketplace. The mere creation of a new learning curve does not ensure market penetration. Rather, the ultimate value of a technology is determined by the marketplace, and impactful technologies ultimately become disruptive – that is, they are widely adopted and displace existing technologies from the marketplace or create entirely new markets. ARPA-E understands that definitive proof of market disruption takes time, particularly for energy technologies. Therefore, ARPA-E funds the

Questions about this FOA? Check the Frequently Asked Questions available at <http://arpa-e.energy.gov/fqa>. For questions that have not already been answered, email ARPA-E-CO@hq.doe.gov (with FOA name and number in subject line); see FOA Sec. VII.A. Problems with ARPA-E eXCHANGE? Email ExchangeHelp@hq.doe.gov (with FOA name and number in subject line).

development of technologies that, if technically successful, have the clear disruptive potential, e.g., by demonstrating capability for manufacturing at competitive cost and deployment at scale.

ARPA-E funds applied research and development. The Office of Management and Budget defines “applied research” as “systematic study to gain knowledge or understanding necessary to determine the means by which a recognized and specific need may be met” and defines “development” as the “systematic application of knowledge or understanding, directed toward the production of useful materials, devices, and systems or methods, including design, development, and improvement of prototypes and new processes to meet specific requirements.”¹ Applicants interested in receiving financial assistance for basic research should contact the DOE’s Office of Science (<http://science.energy.gov/>). Similarly, projects focused on the improvement of existing technology platforms along defined roadmaps may be appropriate for support through the DOE offices such as: the Office of Energy Efficiency and Renewable Energy (<http://www.eere.energy.gov/>), the Office of Fossil Energy (<http://fossil.energy.gov/>), the Office of Nuclear Energy (<http://nuclear.energy.gov/>), and the Office of Electricity Delivery and Energy Reliability (<http://energy.gov/oe/office-electricity-delivery-and-energy-reliability>).

B. SBIR/STTR PROGRAM OVERVIEW

The Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs are Government-wide programs authorized under Section 9 of the Small Business Act (15 U.S.C. § 638). The objectives of the SBIR program are to (1) stimulate technological innovation in the private sector, (2) strengthen the role of Small Business Concerns in meeting Federal R&D needs, (3) increase private sector commercialization of innovations derived from Federal R&D activities, (4) foster and encourage participation by socially and economically disadvantaged and women-owned Small Business Concerns, and (5) improve the return on investment from Federally funded research and economic benefits to the Nation. The objective of the STTR program is to stimulate cooperative partnerships of ideas and technologies between Small Business Concerns and partnering Research Institutions through Federally funded R&D activities.²

ARPA-E administers a joint SBIR/STTR program in accordance with the Small Business Act and the SBIR and STTR Policy Directives issued by the U.S. Small Business Administration (SBA).³ ARPA-E provides SBIR/STTR funding in three phases (Phase I, Phase II, and Phase IIS).

¹ OMB Circular A-11

(http://www.whitehouse.gov/sites/default/files/omb/assets/a11_current_year/a11_2014.pdf), Section 84, p. 8.

² Research Institutions include FFRDCs, nonprofit educational institutions, and other nonprofit research organizations owned and operated exclusively for scientific purposes. Eligible Research Institutions must maintain a place of business in the United States, operate primarily in the United States, or make a significant contribution to the U.S. economy through the payment of taxes or use of American products, materials, or labor.

³ See 77 Fed. Reg. 46806 (Aug. 6, 2012); 77 Fed. Reg. 46855 (Aug. 6, 2012).

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C. TECHNICAL PROGRAM OVERVIEW

1. SUMMARY

The GENSETS Program – ***GEN*erators for *S*mall *E*lectrical and *T*hermal *S*ystems** – seeks to fund the development of potentially disruptive generator technologies that will enable widespread deployment of residential Combined Heat and Power (CHP) systems. Here, CHP is defined as the distributed generation of electricity from piped-in natural gas fuel at a residence or a commercial site complemented by use of exhaust heat for local heating and cooling. If adopted widely by U.S. residential and commercial sectors, GENSETS CHP systems could lead to annual primary energy *savings* of more than 5 quadrillion BTU (quads). GENSETS systems could also provide annual CO₂ emissions *reductions* of more than 200 million metric tons, which is roughly 10% of the CO₂ produced annually from U.S. electricity generation and 4% of total U.S. annual CO₂ emissions.

The GENSETS Program seeks transformative generators/engines with 1 kW of electrical output (kW_e) that have high efficiency (40% fuel to electricity), long life (10 years), low cost (\$3,000 per system), and low emissions. Heat engines and generators capable of achieving these targets may include internal and external combustion engines, turbines, and solid state devices such as thermophotovoltaics, thermionic emitters, and thermoelectrics. It is anticipated that the same technologies developed for 1-kW_e engines in GENSETS could be adapted to build larger engines with even higher efficiencies for various commercial sectors of the U.S.

2. BACKGROUND AND MOTIVATION

a. *OPPORTUNITY AND IMPACT OF CHP*

In 2013, U.S. central-station power plants consumed 38.2 quads of primary energy to generate 12.4 quads of electricity with an average electricity generation efficiency of 33% when aggregated over all primary energy sources, including coal, natural gas, nuclear, hydro, and wind⁴. In the process, 67% of the primary energy was wasted as heat (25.8 quads) and about 2 billion metric tons of CO₂ were emitted to the environment, which is about 38% of the total annual U.S. CO₂ emissions⁵. Distributed CHP systems are an alternative to central-station power plants. In these systems, an electrical generation system located in a residence or at a commercial site consumes natural gas to generate electricity locally and then the exhaust heat is utilized for local heating needs (in contrast to being wasted at central-stations). The combined efficiency of primary energy usage in CHP can be higher than 80%. Since about 75% of the electricity generated from all central-station power plants is consumed by the residential

⁴ https://flowcharts.llnl.gov/content/energy/energy_archive/energy_flow_2013/2013USEnergy.png

⁵ www.eia.gov

and commercial sectors, CHP in these sectors can have a huge impact on both energy savings and CO₂ emissions reduction. In addition, CHP can bring power resilience to households and commercial entities to counter weather-related outages that cause billions of dollars of losses to the U.S. economy annually.⁶

The current best-performing engines for CHP at small-scale (<2-kW_e) have a fuel-to-electricity efficiency of about 26% and a Capital Expenditure (CAPEX) of more than \$6,000 per kW_e. The combination of low efficiency and high cost has significantly limited CHP deployment in the U.S. residential sector, resulting in fewer than 1,000 total installed units⁷, or a deployment rate of less than 0.002%. In order to fundamentally change this dynamic, ARPA-E believes that an efficiency of at least 40% and a system cost of less than \$3,000 per kW_e is needed. The ARPA-E GENSETS program seeks new engine (generator) technologies to enable widespread deployment of CHP, primarily for the residential sector. However, if successful, it is anticipated that the same technologies could be readily scaled up to enable extensive CHP implementation in the commercial sector. Roughly 70 million U.S. residential homes⁵ currently have access to natural gas, critical for widespread CHP deployment. To enable residential CHP adoption, ARPA-E believes that inexpensive, efficient, small-scale generators are the key enabler.

b. THE OPTIMAL CHP SYSTEM

Optimal Size and Efficiency

A single size engine/generator will not satisfy every application in a diverse residential CHP market. However, ARPA-E's analysis, presented below, indicates that a 1-kW_e output is optimal for most residential applications.

In order to define an optimal engine/generator size that could be deployed across the entire U.S. residential sector, ARPA-E analyzed the energy consumption profile using the National Renewable Energy Laboratory (NREL) BEopt tool⁸ for twelve representative cities in the seven Building America Climate Regions⁹. For example, Figure 1 shows the hourly energy consumption/load profile for Chicago (in the cold climate zone) during representative summer and winter days. The green solid line represents the output from a theoretical 1-kW_e generator running at a steady-state all day. In both the January and July cases, a 1-kW_e system would send a small amount of electricity to the grid during the early morning hours and the household would extract electricity from the grid during evening hours to supplement their electricity needs. For most days, the electricity from the 1-kW_e system is slightly below the household needs and hence the household would need to extract a small amount of electricity from the grid.

⁶ Arghandeh et al. IEEE Power & Energy Magazine, September/October, 2014, p. 76.

⁷ http://arpa-e.energy.gov/sites/default/files/Mike%20Cocking_Marathon.pdf

⁸ <https://beopt.nrel.gov/>

⁹ <http://www.eia.gov/consumption/residential/maps.cfm>

A 1-kW_e 40% electrical efficiency system would generate 1.5 kW per hour of exhaust heat, represented by the light-blue areas enveloped by thin dashed red lines in Figure 1. For Chicago, the exhaust heat would be able to satisfy all the domestic hot water needs and also contribute to space heating requirements during the cold-weather months. Additional space heating could be provided by a natural gas fired furnace, which is likely >80% efficient. In the summer months, the exhaust heat produced from the CHP system is beyond the domestic hot water requirements. However, air conditioning energy saving opportunities could be realized through use of advanced adsorption chillers.

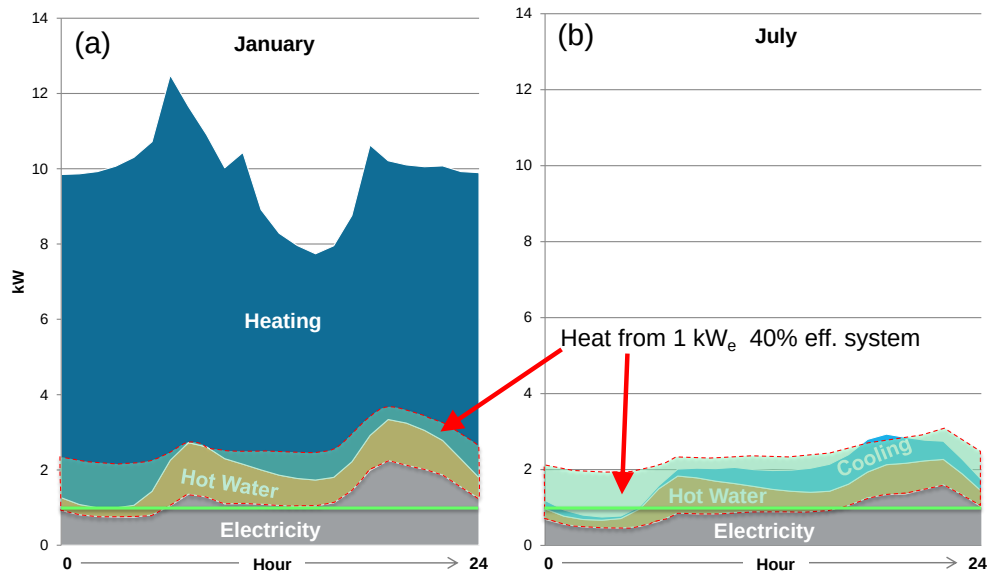


Figure 1. Hourly residential energy consumption profile for Chicago during (a) January and (b) July. The turquoise-colored areas enveloped by the red dashed lines represent the heat output from a 1-kW_e system at 40% electrical efficiency.

Larger CHP systems are unnecessary for ordinary homes in the residential sector and would lead to reduced overall efficiency. First, excess electricity generated by a larger system would need to be delivered to the grid, which may or may not pay retail or even wholesale electricity price depending on the local and the electricity utility policies. Second, systems above 1 kW_e would produce a significant amount of unused exhaust heat during the warm-weather months. This would necessitate the system to operate at a reduced load (which lowers the efficiency) or to operate only in cold weather months (which reduces the capacity factor). Similar conclusions are drawn from ARPA-E's examination of load data for the 11 other cities located across different climate zones¹⁰. Based on this analysis, ARPA-E has determined that 1-kW_e is an appropriate scale in terms of electrical and thermal output for application across the U.S. and focuses this FOA on developing a generator to provide that output with 40% electrical efficiency.

¹⁰ http://arpa-e.energy.gov/sites/default/files/JC%20Zhao_Small%20engines%20for%20CHP%20workshop%20Introduction_final.pdf

Minimum System Lifetime and Maximum Viable CAPEX

Reducing total cost of ownership will be a key enabler to CHP system adoption. This FOA focuses primarily on the CAPEX associated with the gas to electrical generation part of the system. The CAPEX defined here includes the system cost but excludes the installation and balance of plant costs. (The balance of plant includes a smart meter and heat exchangers to dissipate excess heat not being used).

ARPA-E performed a techno-economic analysis for a hypothetical residence with an hourly 1 kW electric and 1.5 kW thermal load (both assumed constant for simplicity). The 2013 national average retail price of electricity (\$0.11 per kWh) and natural gas (\$10.85 per thousand cubic feet) were used in the analysis. In this case, a customer would pay about \$1,700 a year to obtain electricity from the grid and natural gas through a pipeline, which serves as the baseline scenario. Replacing this with CHP would require the homeowner to pay the initial labor costs at installation and balance of system costs of ~\$1,400, and an Operation and Maintenance (O&M) cost of roughly \$0.005 per kWh. ARPA-E analysis shows breakeven for the homeowner in 7 years if the 40%-efficient generator system costs about \$3,000 in CAPEX. The homeowner would pay about \$1,240 per year, and would be able to use savings in electricity and natural gas costs to recover the cost of the CHP system and pay ongoing O&M costs.

More analysis was performed by varying the values of CAPEX, lifetime/durability of the system, electricity price, and capacity factor. The results clearly show that even with 40% electrical efficiency, if the system lifetime is below 10 years, it is very hard to compete with today's baseline. A lower CAPEX of \$1,000 would provide a payback period of three years, but ARPA-E recognizes that it is unlikely that a 40%-efficient generator could be produced at such low cost.

ARPA-E recognizes that installing and maintaining the electricity grid requires high fixed-cost investment in wires, transformers, etc. Currently, residential customers pay for these costs predominantly through their \$/kWh retail electricity rates. As the penetration of distributed generation continues to grow, traditional utility rate structures that recover fixed costs through variable rates can cause problems such as utility revenue inadequacy and cross-subsidization between customers. Projecting the actual cost of grid electricity into a future with widespread CHP penetration is highly uncertain, since customers who install CHP systems would continue to rely on a connection from the electrical grid and they will continue to pay a portion of the cost of grid installation and maintenance. A lower bound for comparison would be to use the current wholesale electricity price in the analysis (\$0.06 to \$0.10 per kWh), which with a 7-year payback indicates that the CAPEX would likely need to be below \$2,000 for the 40% generator.

In light of the considerations above, the GENSETS FOA sets a CAPEX target of \$3,000 and a system lifetime of 10 years. These targets provide a fair balance between payback time for the consumer in light of uncertainty in future electricity prices associated with high CHP penetration.

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Emissions and Noise Requirements

In order to be widely deployable across the country over time, ARPA-E expects CHP systems to meet the 2007 California Air Resources Board (CARB) emissions regulations for natural gas powered electrical generation technologies in distributed generation applications¹¹. The GENSETS targets for emission of nitrogen oxide (NOx), carbon monoxide (CO) and volatile organic compounds (VOCs) are 0.07, 0.10, and 0.02 lb/MW-hr, respectively.

The GENSETS Program also utilized the Environmental Protection Agency (EPA) New Source Performance Standards (NSPS) on Particulate Matter (PM) to set the limit at 0.4 g/kW-hr¹². The GENSETS Program also aims at regulating both CO₂ and CH₄ greenhouse gas (GHG) emissions using a CO₂ equivalent (CO₂eq) number that is calculated based on the 100 year global warming potential (GWP) value of 28¹³ for CH₄; and the system-out CO₂eq limit is 1100 CO₂eq lb/MW-hr. The acceptable target noise level for customers, who likely would install the CHP systems in their basement, is 55 dB (A-weighting) measured at a 3-foot distance.

C. TECHNICAL OPPORTUNITIES, CHALLENGES AND STATE-OF-THE-ART

Various systems have been commercialized or are in development for CHP applications requiring <5-kW_e, including internal combustion engines (ICEs), external combustion engines such as Stirling engines and Rankine engines, fuel-cells, micro-turbines, and solid state devices such as thermionic generators, thermoelectrics, and thermophotovoltaics (TPV)¹⁴.

Table 1 shows best-in-class electrical conversion efficiencies for small-scale CHP applications^{15,16,17}. The heat recovery efficiency is for domestic heating and hot-water. The total CHP efficiency is the sum of the electrical conversion and heat recovery efficiencies.

For a combustion engine, the final electrical efficiency η_e can be written as:

$$\eta_e = \eta_{\text{comb}} \cdot \eta_{\text{ind}} \cdot \eta_m \cdot \eta_{\text{alt}} \quad (\text{Eq. 1})$$

The combustion efficiency η_{comb} represents the portion of the fuel's energy that is converted into useful heat. The indicated cycle efficiency η_{ind} refers to the fraction of the useful heat energy that is converted into closed-cycle work after losses. The mechanical efficiency η_m is the percent of useful closed cycle work that is available at the shaft taking into account friction and parasitic losses. Finally, the alternator efficiency η_{alt} represents the portion of shaft work

¹¹ 17 CCR §94203(b) (California Code of Regulations)

¹² 40 C.F.R. § 1039.101

¹³ <http://www.ipcc.ch/report/ar5/wg1/>

¹⁴ http://www.microchap.info/micro_chp_products.htm

¹⁵ Barbieri et al., Applied Energy, V.97, 2012, pp.723-733

¹⁶ De Paepe et al., Energy Conversion and Management, V.47, 2006, pp. 3435-3446

¹⁷ <http://world.honda.com/news/2011/p110523Gas-Engine-Cogeneration/>

that is converted into useful electrical power. To reach the 40% η_e target, improvements in the contributing efficiencies in Eq. (1) are sought.

Table 1: State-of-the-art efficiencies of engines for small-scale CHP applications^{15,16,17}

Device/Parameter	ICE	Stirling engine	Micro-turbine	Thermophotovoltaic
Electrical power (kW _e)	1.0	2.0	3.0	1.5
Thermal power (kW)	2.5	8.0	15.0	9.4
Fuel Power (kW)	3.8	10.0	18.8	12.2
Electrical conv. eff. (%)	26.3	20.0	16.0	12.3
Heat recovery eff. (%)	65.7	80.0	80.0	79.8

ARPA-E recognizes there is a significant technology gap between the current state-of-the-art engine fuel to electricity efficiency (~26%) and the 40% target, especially while meeting demands on CAPEX/cost (\$3,000) and system lifetime/durability (10 years). A fundamental challenge in devising small-scale heat engines with high efficiency is minimizing heat losses. With the exception of incomplete combustion, the main losses suffered when converting one form of energy to another are attributable to heat transfer losses. The challenge is significant for 1 kW_e engines where the high surface area to volume ratio leads to increased heat transfer loss. Figure 2 shows a typical small-scale mechanical heat engine efficiency loss breakdown. This figure suggests many methods that will likely be needed to increase the engine efficiency: 1) effective recuperation of the exhaust heat using bottoming cycles; 2) reduced heat transfer through the engine wall using thermal barriers or reduced combustion temperature to reduce the gradient across the wall; 3) effective recuperation of heat transferred to the engine coolant; and 4) reduced frictional loss through better lubrication and other techniques. Additional efficiency gains could also be obtained by reducing the parasitic losses in converters and electronics. Finally, coupling a mechanical engine with a solid state device such as a thermoelectric generator may be necessary to achieve 40% electrical efficiency. Therefore, successful systems may require topping or bottoming cycles as well as potential use of emissions reduction sub-systems. Innovative approaches together with cost-effective manufacturing technologies are needed to achieve the CAPEX target.

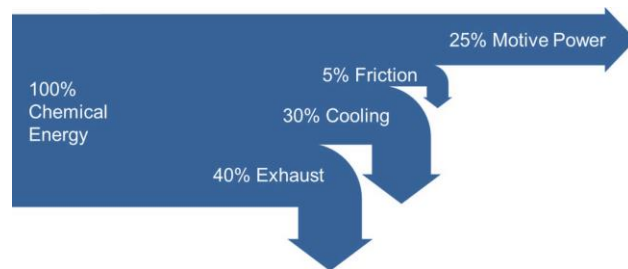


Figure 2. Typical small-scale heat engine efficiency losses.

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The subsequent technical examples are meant only to illustrate principles; they are not meant to prescribe or limit the technical approaches that might receive an award through the GENSETS Program. ARPA-E will consider making an award to any application that effectively addresses the technical challenges and leads to the development of technology that can meet or exceed the associated Technical Performance Targets specified in Section I.F. ARPA-E will make awards only to transformational solutions that go well beyond the state-of-the-art.

Internal Combustion Engines (ICEs)

For generations, ICEs have been the predominant engine for a range of applications and have also penetrated the CHP market. However, ICE efficiencies remain far below the target of this FOA. Nonetheless, there are many potential opportunities for increasing efficiency. For example, the natural gas powered ICE, noted in the second column in Table 1, achieves high efficiency by employing an over-expanded Atkinson cycle and a unique geometric design.¹⁷

Novel strategies for reducing in-cylinder heat transfer¹⁸ and friction¹⁹ and/or novel methodologies for tapping coolant and exhaust heat need to be devised for ICEs to deliver 40% electrical efficiency at the 1-kW_e size. New understanding of combustion science such as boosted homogeneous charge compression ignition (HCCI)²⁰ and novel implementation of more effective thermodynamic cycles such as Miller cycle and Humphrey cycle may also enable significantly higher efficiencies. Some of the current technologies in this direction are Miller cycle using variable valve timing (VVT)²¹, boosted HCCI, advanced Corona ignition system (ACIS)²², lean natural gas combustion²³, low temperature combustion using high exhaust gas recirculation (EGR)²³, opposed two-stroke piston engine²⁴, free piston linear generator^{25,26,27}, and employment of five-stroke cycle²⁸. It should be noted that above examples do not entail ARPA-E's endorsement of a specific technology but they are listed here to stimulate more ideas/concepts for efficiency enhancements.

Benchmarking experiments by Thomas²⁹ show that, with a three-way catalyst, a 4.7 kW_e ICE CHP system with a fuel to electricity conversion efficiency of 24.7% produces about 0.1 mg/Nm³

¹⁸ Chan and Kohr, Journal of Materials Engineering and Performance, V.9, 2000, pp.103-109

¹⁹ http://energy.gov/sites/prod/files/2014/03/f8/deer12_gangopadhyay.pdf

²⁰ Kobayashi et al., Journal of Natural Gas Science and Engineering, V.3, 2011, pp.651-656

²¹ Fontana and Galloni, Applied Energy, V.86, 2009, pp.96-105

²² Burrows, J., et al., MTZ, V.74, No. 6, 2013, pp.38-41

²³ Caton, J.A., Energy Conversion and Management, V.79, 2014, pp.146-160

²⁴ http://www.achatespower.com/pdf/light-duty_engine_study.pdf

²⁵ Kosaka, H., Akita, T., Moriya, K., Goto, S. et al. (2014) SAE Technical Paper 2014-01-1203 doi: 10.4271/2014-01-1203

²⁶ Goto, S., Moriya, K., Kosaka, H., Akita, T. et al. (2014) SAE Technical Paper 2014-01-1193 doi: 10.4271/2014-01-1193

²⁷ Van Blarigan et al. SANDIA Report SAND99-8206, 1998

²⁸ Kéromnès et al., Energy Conversion and Management, V.82, 2014, pp.259-267

²⁹ Thomas, B., Applied Thermal Engineering, V.28, 2008, pp.2049-2054

of CO and 8.4 mg/Nm³ of NOx emissions. Boosted HCCI or lean natural gas combustion can increase the electrical efficiency, but that may lead to higher CO and hydrocarbon (HC) emissions as well as higher combustion noise due to increased rates of in-cylinder peak pressure rise. Mitigation of HC and CO emissions can potentially be achieved by using a high-efficiency oxidation catalyst or a catalytic afterburner. HCCI and lean combustion can reduce system-out NOx, and additional NOx reduction can be achieved with the use of EGR, lean NOx trap (LNT), or selective catalytic reduction (SCR) to meet the emissions standards of the FOA. While the emissions challenge can be overcome, the cost of mitigation needs to be minimized to meet GENSETS targets.

Stirling Engines

Although Stirling engines may be the most mature external combustion engines that have penetrated the CHP market, considerable innovation would be needed to meet the targets of this FOA. As shown in Table 1, the current state-of-the-art small-scale Stirling engines have roughly 20% electrical efficiency.

Realizing 40% electrical efficiency will likely require significant improvements in combustion efficiency and indicated efficiency by lowering the heat losses. Significant improvements in mechanical efficiency will also be needed to achieve the FOA target. Much higher efficiency may be achieved by: 1) increasing the maximum working fluid temperature to 1000 °C or even 1100 °C using state-of-the-art high-temperature alloys^{30,31} and additive manufacturing technology³² – leading to much higher thermodynamic cycle Carnot efficiencies, 2) augmenting the recuperation effectiveness, and 3) reducing the parasitic losses in converters and electronics. ARPA-E strongly encourages innovative concepts that couple a combustion engine such a Stirling engine with a solid state device such as a thermoelectric generator and/or a thermionic emitter to achieve 40% electrical efficiency.

Thomas²⁹ also shows that a 9 kW_e Stirling engine CHP system with a fuel to electricity conversion efficiency of 26.8% produced about 191 mg/Nm³ of CO and 105 mg/Nm³ of NOx emissions. The system incorporated a flameless oxidation burner³³ and a catalyst for emissions reduction. When higher combustion temperatures are to be used to achieve higher Carnot efficiency, both HC and CO emissions can be reduced but the NOx emissions would increase and may require further exhaust after-treatment such as EGR, combustion gas recirculation (CGR)³⁴, SCR, or LNT.

³⁰ Harada, H. Proceedings of the International Gas Turbine Congress 2003 Tokyo, IGTC2003Tokyo KS-2, pp. 1-9.

³¹ Pollock, T; Tin, S. J. Prop Power, vol. 22, 2006, pp. 361-374.

³² Gibson, et al. Additive Manufacturing Technologies, Springer, 2010.

³³ Wünnig, J.G., Thermprocess Symposium, Düsseldorf, 2003 (http://www.flox.com/documents/03_TP.pdf)

³⁴ <http://www.sgc.se/ckfinder/userfiles/files/SGC144.pdf>

Micro-Turbines

Micro-turbines are essentially low-powered versions of gas-turbines used in Brayton cycle power plants. Micro-turbine technologies are more mature for applications over 20 kW_e than for the 1-kW_e regime. For applications less than 5 kW_e there are no major commercial products available; however, a prototype 3 kW_e (15 kW thermal output) system for small-scale CHP achieving 16% electrical efficiency and 80% thermal efficiency has been reported and is being commercialized.³⁵ A rig testing by Visser et al.³⁶ of another 3 kW_e micro-turbine system shows that much of the fuel energy goes into exhaust (47%), and heat, friction and parasitic losses (39.4%). Higher efficiency micro-turbines may be developed by reducing viscous losses (loss due to low Reynold's number flow) in the turbine passages, lower heat losses (loss due to high surface-to-volume ratios), and lower mechanical and parasitic losses. A suite of technologies may be required to achieve this FOA's targets such as new turbine design concepts, high efficiency intake-air recuperation, reduced heat and frictional losses, use of newer materials such as SiC and Si₃N₄^{37,38} to increase the material temperature limit to 1200 °C or higher for enabling higher thermodynamic cycle Carnot efficiencies³⁹, and incorporation of solid state devices and other topping or bottoming cycles such as organic Rankine cycle⁴⁰.

Only large-capacity turbines have demonstrated CARB 2007 distributed generation emissions compliance⁴¹. Micro-turbines may produce higher HC and CO due to inefficient combustion. Higher combustion/gas temperatures will be needed to increase the fuel to electrical conversion efficiency, which will likely result in higher NO_x emissions and thus require further exhaust after-treatment such as EGR, SCR, or LNT. Mitigation of HC and CO can potentially be achieved by using a high-efficiency oxidation catalyst or a catalytic afterburner. Other low NO_x technologies could include the flameless oxidation burner or ultra-low NO_x burner⁴².

Solid-State Devices

Several solid-state devices are applicable to power generation and CHP systems, and could be used as topping or bottoming cycles on combustion/mechanical engines. Most prominent among these are thermoelectric generators, thermionic emitters, Na/H/O ion expansion electrochemical devices, thermophotovoltaics (TPVs), and pyroelectrics. There are only a handful of demonstrated technologies in engineered systems. Data on one particular TPV system indicates an electrical efficiency of 12.3% for a 1.5 kW_e system with component

³⁵ <http://www.mtt-eu.com/applications/micro-chp>

³⁶ Visser et al., ASME Journal of Engineering for Gas Turbines and Power, V.133, 2011, pp.042301-1-042301-8

³⁷ <http://infohouse.p2ric.org/ref/20/19293.pdf>

³⁸ Singh, M. et al. DOI: 10.1002/9781118144091.ch26 (2011).

³⁹ McDonald and Rogers, Applied Thermal Engineering, V.28, 2008, pp.60-74

⁴⁰ Mago and Luck, Applied Energy, V.102, 2013, pp.1324-1333

⁴¹ <http://www.arb.ca.gov/energy/dg/eo/dg018.pdf>

⁴² <http://www.energy.ca.gov/2013publications/CEC-500-2013-043/CEC-500-2013-043.pdf>

efficiency of over 15%⁴³ as shown in Table 1. Current state-of-the-art efficiencies of solid state devices have not exceeded 20%, however they possess significant potential for achieving higher efficiencies with newer materials, architectures, and manufacturing processes^{44,45,46}. As mentioned before, they can also play a significant role in reaching high overall system efficiency by serving as either a topping or a bottoming cycle to another device/engine.

The emissions and noise challenges for solid state devices are essentially the same as the Stirling engines where natural gas combustion is used to generate heat to be converted to electricity in these devices.

D. PROGRAM OBJECTIVES

As seen in Section I.C of the FOA, all the current state-of-the-art engines for CHP suffer from low efficiency and high cost. The ARPA-E GENSETS program is seeking fundamentally disruptive technologies that can markedly improve the fuel to electricity efficiency to 40% while delivering 1 kW_e electrical power at low cost. The total system cost should not exceed \$3,000 at high volume (e.g., 1 million unit scale) (excluding \$1,400 installation and balance of plant costs). These technologies must meet the emissions requirements documented in detail in Section I.F of the FOA. The key program objectives are outlined below in detail:

Achieve 40% fuel-to-electrical power generation efficiency

The goal of the ARPA-E GENSETS program is to leverage existing technologies and encourage disruptive concepts that can realize the 40% electrical efficiency target and deliver low cost 1 kW_e systems for residential CHP applications.

Comply with emissions standards

As described above, widespread deployment of CHP systems would result in significant reduction in CO₂ emissions as compared to central-station power plants. However, significant challenges exist in reducing CO, NO_x and VOCs in natural gas powered CHP systems at the 1 kW_e size. Through the GENSETS FOA, ARPA-E is expecting generator concepts with high combustion efficiencies that produce emissions that comply with both the 2007 CARB emissions regulations on NO_x, CO and VOCs and the EPA NSPS limit on PM. A system-out GHG limit is set at 1100 CO₂eq lb/MW-hr to ensure compliance with prevailing state-level environmental standards.

⁴³ http://www.jxcrystals.com/old_TPV/RomeCHP.pdf

⁴⁴ <http://trs-new.jpl.nasa.gov/dspace/bitstream/2014/19252/1/98-0546.pdf>

⁴⁵ Caillat et al., Nuclear and Emerging Technologies for Space, 2012
(<http://www.lpi.usra.edu/meetings/nets2012/pdf/3077.pdf>)

⁴⁶ Lee et al., Applied Thermal Engineering, V.37, 2012, pp.30-37

Achieve long lifetime/durability

The target for the total system life is 10 years with a capacity factor of 99.9%, i.e., the system should have the capability of running continuously between services (e.g., oil change or cathode replacement) which should not be more than once a year, corresponding to about 8,000 running hours between service intervals. Based upon reported performance, this is a realistic goal to achieve for ICEs and Stirling engines. For example, for a 1 kW_e CHP system,¹⁷ a manufacturer reports 6,000 running hours or 3 years between service, which is close to the target set by this FOA. Also, a Stirling engine manufacturer has demonstrated maintenance-free operation for 100,000 hours (11 years) and eight other engines have more than 8,000 hours and are still running. The system lifetime target will be a challenge for new device types that are still rapidly-evolving in design such as solid state devices and micro-turbines. Accelerated testing should be used by GENSETS performers to project actual field lifetimes from shorter duration test data.

Reduce system cost to enable widespread penetration of residential CHP

The total CAPEX here includes the system cost but excludes the installation and balance of plant costs. The CAPEX target for the 1 kW_e system is no more than \$3,000.

E. TECHNICAL CATEGORIES OF INTEREST

The ARPA-E GENSETS program will fund transformational technologies that can create a paradigm shift in the residential heat and power generation process. ARPA-E expects GENSETS to open pathways for high-efficiency, low-emissions, long-life, cost-effective, 1-kW_e generators that can enable significant energy savings and CO₂ emissions reduction.

Applicants must present a well-justified, realistic proposal for the design, construction, and demonstration of a complete engine/generator system that meets all the technical performance targets. Specifically, the systems should accept natural gas at standard residential delivery pressures as their only fuel input and produce 60 Hz ac electrical output at 110 V.⁴⁷

Example technologies of interest, either as standalone solutions or in combinations, include, but are not limited to:

- Internal combustion engines
- External combustion engines such as Stirling engines and steam engines
- Any other novel engines (e.g. detonation engines, thermoacoustic engines, free-piston engines, rotary engines etc.)
- Combustion turbines such as micro-turbines

⁴⁷ The proposed systems are not required to meet all grid interconnection requirements. However, applicants should explain in the full application how low power quality output can be made compatible with grid requirements.

- Micro Rankine cycles
- Novel concepts that incorporate exhaust and coolant waste-heat recovery, reduced mechanical friction and reduced heat transfer
- Novel concepts to improve combustion efficiency and emissions reduction such as exhaust gas recirculation (EGR) or flue gas recirculation (FGR), homogeneous charge compression ignition (HCCI), spark-assisted HCCI (SA-HCCI), corona ignition, and laser ignition
- Thermophotovoltaics
- Thermionic emitters
- Thermoelectric generators
- Pyroelectrics
- Ion expansion electrochemical devices for electricity generation
- Innovative integration of topping cycles and/or bottoming cycles
- Combinations of the above devices and concepts

F. TECHNICAL PERFORMANCE TARGETS

Only technologies with potential to meet or exceed all GENSETS primary targets will be considered for funding. Program teams must propose to meet the following primary targets and will need to demonstrate these targets by the end of the award period.

Number	Property	Primary Target
1.1	Electric power generation capacity	1 kW _e
1.2	Fuel to electricity conversion efficiency	≥40%
1.3	Useful heat energy output (> 80°C)	>1 kW/kW _e
1.4	Capacity factor	≥99.9%
1.5	Complete system up front cost (not including balance of plant and installation)	≤\$3000/kW _e
1.6	Lifetime	≥10 years
1.7	Total system-out NO _x	≤0.07 lb/MW-hr
1.8	Total system-out CO	≤0.10 lb/MW-hr
1.9	Total system-out VOC	≤0.02 lb/MW-hr
1.10	Total system-out CO ₂ eq (CO ₂ + CH ₄ only)	≤1100 lb/MW-hr
1.11	Particulate matter (PM)	≤0.4 g/kW-hr
1.12	System noise	≤55 dB(A) (3-feet away)

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In addition, technologies should propose to meet the following secondary targets:

Number	Property	Secondary Target
1.13	Methane number for operation	≥ 70
1.14	Number of regular maintenance services	$\leq 1/\text{year}$
1.15	Operation and maintenance cost	$\leq \$0.005/\text{kWh}$
1.16	Time for regular maintenance	$\leq 60 \text{ minutes/service}$
1.17	System mass	$\leq 150 \text{ kg}$

Supplementary Explanations of Targets

- 1.1 The system concept should target 1-kW_e generation. However, if the efficiency target is demonstrated in a device which has < 1-kW_e power producing capacity, then a detailed scaling analysis should be presented to project efficiency at 1-kW_e. Systems larger than 1-kW_e are not of interest.
- 1.2 Natural gas fuel to ac electricity conversion efficiency is based on lower heating value (LHV) of pipeline natural gas with 983 Btu per cubic foot. Individual component efficiencies of 40% are not sufficient. A device delivering 40% electrical efficiency relative to its input heat energy is not acceptable. Solid-state devices should be treated as external combustion engines and electrical efficiency should be described as in Eq. 1 ($\eta_e = \eta_{\text{comb}} \cdot \eta_{\text{ind}} \cdot \eta_m \cdot \eta_{\text{alt}}$).
- 1.3 Residential hot-water and space heating output provided by CHP system should be > 1 kW/kW_e at > 80 °C.
- 1.4 The system is expected to run continuously between the scheduled regular maintenance and restart easily. 1.5
- 1.5 The engine/generator system, including emissions mitigation and dissipation of exhaust heat (when not fully used), must plausibly cost less than \$3,000 per kW_e in large production volumes (e.g., one million units). The \$3,000 cost of the generator system itself includes all components needed to take pipeline natural gas and produce electricity (ac, 60 Hz) and exhaust heat as outputs; the costs of installation (labor) and balance of plants (smart meters and heat exchangers for integration with other systems) of ~\$1,400 are not included. An alternator efficiency (η_{alt}) of 0.8 to 0.96 can be assumed for the purpose of FOA application if the alternator is not integral to the generator under development. The alternator cost needs to be included in the system CAPEX. The cost of commercially available alternators varies essentially linearly as the efficiency increases from 0.8 to 0.96 according to: Alternator cost [\$] = 3250* η_{alt} – 2520. Systems that do not need an alternator can exclude this cost.

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1.7-1.9 Emissions for NO_x, CO and VOCs should comply with CARB 2007 emissions limits for distributed power generation. Full applications must provide a complete discussion relative to the state-of-the-art numbers in a specific category of technology (e.g. ICE) and how improvements are made with respect to the baseline performance in the literature. Mitigation technologies are allowable as long as the cost is included in the system CAPEX.

1.10 For GHG emissions, only CO₂ and CH₄ are considered by the GENSETS Program. CO₂eq value for CH₄ must be evaluated using its 100 year GWP value of 28, i.e., 1 g of CH₄ corresponds to 28 g of CO₂eq. The total system-out CO₂eq must be less than 1100 lb/MW-hr.

1.13 The system must be able to operate at methane numbers as low as 70. Methane number is defined using the following equations⁴⁸:

$$\text{Motor octane number (MON)} = -406.14 + 508.04 \cdot (\text{H/C}) - 173.55 \cdot (\text{H/C})^2 + 20.17 \cdot (\text{H/C})^3$$

$$\text{Methane number (MN)} = 1.624 \cdot \text{MON} - 119.1. \text{ H/C is the fuel hydrogen to carbon ratio.}$$

A Wobbe index⁴⁹ of 1328 ±8% is allowed to accommodate different natural gas compositions.

G. APPLICATIONS SPECIFICALLY NOT OF INTEREST

The following types of applications will be deemed nonresponsive and will not be reviewed or considered (see Section III.F.2 of the FOA):

- Applications submitted by entities or organizations other than Small Business Concerns.
- For the STTR program, applications submitted without one Research Institution as a member of the project team.
- Applications that fall outside the technical performance targets specified in Section I.F of the FOA
- Applications for basic research aimed at discovery and fundamental knowledge generation.
- Applications for large-scale demonstration projects of existing technologies.
- Applications for proposed technologies that represent incremental improvements to existing technologies.
- Applications for proposed technologies that are not based on sound scientific principles (e.g., violates a law of thermodynamics).
- Applications for proposed technologies that are not transformational, as described in Section I.A of the FOA.

⁴⁸ <http://www.arb.ca.gov/regact/cng-lpg/appd.pdf>

⁴⁹ https://www.naesb.org/pdf2/wgq_bps100605w2.pdf

- Applications for proposed technologies that do not have the potential to become disruptive in nature, as described in Section I.A of the FOA. Technologies must be scalable such that they could be disruptive with sufficient technical progress.
- Applications that are not scientifically distinct from existing funded activities supported elsewhere, including within the Department of Energy.
- Applications that propose the following:
 - CHP systems that employ fuel cells (ARPA-E has previously solicited for innovative fuel cell technology for distributed generation applications through its REBELS FOA)
 - Internal and external combustion systems that are powered by fuels other than natural gas, e.g., gasoline and diesel engines.
 - Employment of dual-fuel combustion such as diesel/natural gas fuel blends
 - Concepts with more than 1-kW_e power generation capacity
 - Systems that only focus on converting heat to electricity and that do not consider natural gas to electricity conversion

II. AWARD INFORMATION

A. AWARD OVERVIEW

ARPA-E will accept only new applications under this FOA. Applicants may not seek renewal or supplementation of their existing awards through this FOA.

ARPA-E expects to make approximately \$7 million available for new awards under this FOA, subject to the availability of appropriated funds. ARPA-E anticipates making approximately 2 to 4 awards under this FOA. ARPA-E may issue one, multiple, or no awards.

Applicants must apply for a Combined Phase I/II/IIS Award. Combined Phase I/II/IIS Awards are intended to develop transformational technologies with disruptive commercial potential. Such commercial potential may be evidenced by (1) the likelihood of follow-on funding by private or non-SBIR/STTR sources if the project is successful, or (2) the Small Business Concern's record of successfully commercializing technologies developed under prior SBIR/STTR awards. Phase IIS awards are a "sequential" (i.e., additional) Phase II award, intended to allow the continued development of promising energy technologies. Combined Phase I/II/IIS awards may be funded up to \$3,225,000 and may have a period of performance up to 48 months (4 years).

ARPA-E reserves the right to select all or part of a proposed project (i.e. only Phase I, or only Phase I and Phase II). In the event that ARPA-E selects Phase I only or Phase I/II only, then the maximum award amount for a Phase I award is \$225,000 and the maximum amount for a Phase I/II award is \$1,725,000.

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B. ARPA-E FUNDING AGREEMENTS

ARPA-E generally uses Cooperative Agreements to provide financial and other support to Prime Recipients.⁵⁰

Cooperative Agreements involve the provision of financial or other support to accomplish a public purpose of support or stimulation authorized by Federal statute. Under Cooperative Agreements, the Government and Prime Recipients share responsibility for the direction of projects.

Phase I will be made as a fixed-amount award. Phase II and Phase IIS of Combined Phase I/II/IIS awards will be made on a cost-reimbursement basis.

ARPA-E encourages Prime Recipients to review the Model Cooperative Agreement for SBIR/STTR Awards, which is available at <http://arpa-e.energy.gov/?q=arpa-e-site-page/award-guidance-sbir-sttr>.

C. STATEMENT OF SUBSTANTIAL INVOLVEMENT

ARPA-E is substantially involved in the direction of projects from inception to completion. For the purposes of an ARPA-E project, substantial involvement means:

- Project Teams must adhere to ARPA-E's agency-specific and programmatic requirements.
- ARPA-E may intervene at any time in the conduct or performance of work under an award.
- ARPA-E does not limit its involvement to the administrative requirements of an award. Instead, ARPA-E has substantial involvement in the direction and redirection of the technical aspects of the project as a whole.
- During award negotiations, ARPA-E Program Directors and Prime Recipients mutually establish an aggressive schedule of quantitative milestones and deliverables that must be met every quarter. In addition, ARPA-E will negotiate and establish "Go/No-Go" milestones for each project. If the Prime Recipient fails to achieve any of the "Go/No-Go" milestones or technical milestones and deliverables, ARPA-E may – at its discretion - renegotiate the statement of project objectives or schedule of technical milestones and deliverables for the project. In the alternative, ARPA-E may discontinue funding, suspend or terminate the award.

⁵⁰ The Prime Recipient is the signatory to the funding agreement with ARPA-E.

- ARPA-E may provide guidance and/or assistance to the Prime Recipient to accelerate the commercial deployment of ARPA-E-funded technologies. Guidance and assistance provided by ARPA-E may include coordination with other Government agencies and nonprofits to provide mentoring and networking opportunities for Prime Recipients. ARPA-E may also organize and sponsor events to educate Prime Recipients about key barriers to the deployment of their ARPA-E-funded technologies. In addition, ARPA-E may establish collaborations with private and public entities to provide continued support for the development and deployment of ARPA-E-funded technologies.

III. ELIGIBILITY INFORMATION

A. ELIGIBLE APPLICANTS

1. SBIR ELIGIBILITY

SBA rules and guidelines govern eligibility to apply to this FOA. For information on program eligibility, please refer to SBA's "Guide to SBIR/ STTR Program Eligibility" available at http://sbir.gov/sites/default/files/elig_size_compliance_guide.pdf.

A Small Business Concern⁵¹ may apply as a Standalone Applicant⁵² or as the lead organization for a Project Team.⁵³ If applying as the lead organization, the Small Business Concern must perform at least 66.7% of the work in Phase I and at least 50% of the work in Phase II and Phase IIS, as measured by the Total Project Cost.⁵⁴

For information on eligibility as a Small Business Concern, please refer to SBA's website (<https://www.sba.gov/content/am-i-small-business-concern>).

⁵¹ A Small Business Concern is a for-profit entity that: (1) maintains a place of business located in the United States; (2) operates primarily within the United States or makes a significant contribution to the United States economy through payment of taxes or use of American products, materials or labor; (3) is an individual proprietorship, partnership, corporation, limited liability company, joint venture, association, trust, or cooperative; and (4) meets the size eligibility requirements set forth in 13 C.F.R. § 121.702. Where the entity is formed as a joint venture, there can be no more than 49% participation by foreign business entities in the joint venture.

⁵² A "Standalone Applicant" is an Applicant that applies for funding on its own, not as part of a Project Team.

⁵³ The term "Project Team" is used to mean any entity with multiple players working collaboratively and could encompass anything from an existing organization to an ad hoc teaming arrangement. A Project Team consists of the Prime Recipient, Subrecipients, and others performing or otherwise supporting work under an ARPA-E funding agreement.

⁵⁴ The Total Project Cost is the sum of the Prime Recipient share and the Federal Government share of total allowable costs. The Federal Government share generally includes costs incurred by GOGOs, FFRDCs, and GOCOs.

2. STTR ELIGIBILITY

SBA rules and guidelines govern eligibility to apply to this FOA. For information on program eligibility, please refer to SBA's "Guide to SBIR/ STTR Program Eligibility" available at http://sbir.gov/sites/default/files/elig_size_compliance_guide.pdf.

Only a Small Business Concern may apply as the lead organization for a Project Team. The Small Business Concern must perform at least 40% of the work in Phase I, Phase II, and/or Phase IIS, as measured by the Total Project Cost. A single Research Institution must perform at least 30% of the work in Phase I, Phase II, and/or Phase IIS, as measured by the Total Project Cost. Please refer to Section III.B.1 of the FOA for guidance on Research Institutions' participation in STTR projects.

For information on eligibility as a Small Business Concern, please refer to SBA's website (<https://www.sba.gov/content/am-i-small-business-concern>).

3. JOINT SBIR AND STTR ELIGIBILITY

An Applicant that meets both the SBIR and STTR eligibility criteria above may request both SBIR and STTR funding if:

- The Small Business Concern is partnered with a Research Institution
- The Small Business Concern performs at least 66.7% of the work in Phase I and at least 50% of the work in Phase II and/or Phase IIS (as applicable), as measured by the Total Project Cost
- The partnering Research Institution performs 30-33.3% of the work in Phase I and 30-50% of the work in Phase II and/or Phase IIS (as applicable), as measured by the Total Project Cost
- The Principal Investigator (PI) is employed by the Small Business Concern. If the PI is employed by the Research Institution, submissions will be considered only under the STTR program

Questions about this FOA? Check the Frequently Asked Questions available at <http://arpa-e.energy.gov/fag>. For questions that have not already been answered, email ARPA-E-CO@hq.doe.gov (with FOA name and number in subject line); see FOA Sec. VII.A. Problems with ARPA-E eXCHANGE? Email ExchangeHelp@hq.doe.gov (with FOA name and number in subject line).

B. ELIGIBLE SUBRECIPIENTS

1. RESEARCH INSTITUTIONS

A Research Institution⁵⁵ may apply only as a member of a Project Team (i.e., as a Subrecipient to a Small Business Concern). In STTR projects, a single Research Institution must perform at least 30%, but no more than 60%, of the work under the award in Phase I, Phase II, and/or Phase IIS (as applicable), as measured by the Total Project Cost.

2. OTHER PROJECT TEAM MEMBERS

The following entities are eligible to apply for SBIR/STTR funding as a member of a Project Team (i.e., as a Subrecipient to a Small Business Concern):

- For-profit entities, including Small Business Concerns
- Nonprofits other than Research Institutions⁵⁶
- Non-DOE/NNSA Government-Owned, Government Operated laboratories (GOGOs)
- State, local, and tribal government entities
- Foreign entities⁵⁷

In SBIR projects, Project Team members other than the lead organization, including but not limited to Research Institutions, may collectively perform no more than 33.3% of the work under the award in Phase I and no more than 50% of the work under the award in Phase II and/or Phase IIS. This includes efforts performed by Research Institutions.

In STTR projects, Project Team members (other than the lead organization and the partnering Research Institution) may collectively perform no more than 30% of work under the award in Phase I, Phase II, and/or Phase IIS.

⁵⁵ Research Institutions include FFRDCs, nonprofit educational institutions, and other nonprofit research organizations owned and operated exclusively for scientific purposes. Eligible Research Institutions must maintain a place of business in the United States, operate primarily in the United States, or make a significant contribution to the U.S. economy through the payment of taxes or use of American products, materials, or labor.

⁵⁶ Nonprofit organizations described in section 501(c)(4) of the Internal Revenue Code of 1986 that engaged in lobbying activities after December 31, 1995 are not eligible to apply for funding as a Subrecipient.

⁵⁷ All work by foreign entities must be performed by subsidiaries or affiliates incorporated in the United States (see Section IV.E.6 of the FOA). However, the Applicant may request a waiver of this requirement in the Business Assurances & Disclosures Form submitted with the Full Application.

DOE/NNSA GOGOs are not eligible to apply for SBIR or STTR funding.

C. ELIGIBLE PRINCIPAL INVESTIGATORS

1. SBIR

For the duration of the award, the PI for the proposed project (or, if multiple PIs, at least one PI) must be employed by, and perform at least 50% of his or her work for, the Prime Recipient. The Contracting Officer may waive this requirement or approve the substitution of the PI after consultation with the ARPA-E SBIR/STTR Program Director.

For projects with multiple PIs, at least one PI must meet the primary employment requirement. That PI will serve as the contact PI for the Project Team.

2. STTR

For the duration of the award, the PI for the proposed project (or, if multiple PIs, at least one PI) must be employed by, and perform at least 50% his or her work for, the Prime Recipient or the partnering Research Institution. The Contracting Officer may waive this requirement or approve the substitution of the PI after consultation with the ARPA-E SBIR/STTR Program Director.

For projects with multiple PIs, at least one PI must meet the primary employment requirement. That PI will serve as the contact PI for the Project Team.

D. ELIGIBILITY OF PRIOR SBIR AND STTR Awardees: SBA Benchmarks on Progress Towards Commercialization

Applicants awarded multiple prior SBIR or STTR awards must meet DOE's benchmark requirements for progress towards commercialization before ARPA-E may issue a new Phase I award. For purposes of this requirement, applicants are assessed using their prior Phase I and Phase II SBIR and STTR awards across all SBIR agencies. If an awardee fails to meet either of the benchmarks, that awardee is not eligible for an SBIR or STTR Phase I award and any Phase II award for a period of one year from the time of the determination.

ARPA-E applies two benchmark rates addressing an applicant's progress towards commercialization: (1) the DOE Phase II Transition Rate Benchmark and (2) the SBA Commercialization Rate Benchmark:

- The DOE Phase II Transition Rate Benchmark sets the minimum required number of Phase II awards the applicant must have received for a given number of Phase I awards

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received during the specified period. **This Transition Rate Benchmark applies only to Phase I applicants that have received more than 20 Phase I awards during the last five (5) year period, excluding the most recently completed fiscal year.** DOE's Phase II Transition Rate Benchmark requires that 0.25 of all Phase I awards received over the past five years transition to Phase II awards.

The SBIR/STTR Phase II transition rates and commercialization rates are calculated using the data in the SBA's TechNet database. For the purpose of these benchmark requirements, awardee firms are assessed once a year, on June 1st, using their prior SBIR and STTR awards across all agencies. SBA makes this tabulation of awardee transition rates and commercialization rates available to all federal agencies. ARPA-E uses this tabulation to determine which companies do not meet the DOE benchmark rates and are, therefore, ineligible to receive new Phase I awards.

- The Commercialization Rate Benchmark sets the minimum Phase III⁵⁸ commercialization results that an applicant must have achieved from work it performed under prior Phase II awards (i.e. this measures an applicant's progress from Phase II or Phase IIS to Phase III awards). **This benchmark requirement applies only to applicants that have received more than 15 Phase II awards during the last 10 fiscal years, excluding the two most recently completed fiscal years.**

The current Commercialization Benchmark requirement, agreed upon and established by all 11 SBIR agencies, is that the applicants must have received, to date, an average of at least \$100,000 of sales and/or investments per Phase II award received, or have received a number of patents resulting from the relevant SBIR work equal to or greater than 15% of the number of Phase II awards received during the period.

E. COST SHARING⁵⁹

Applicants are bound by the cost share proposed in their Full Applications. Specific cost-sharing requirements for this FOA are as follows:

1. PHASE I

Prime Recipients/Project Teams are not required to contribute cost share during Phase I of an SBIR/STTR award.

⁵⁸ SBIR Phase III refers to work that derives from, extends or completes an effort made under prior SBIR funding agreements, but is funded by sources other than the SBIR Program. Phase III work is typically oriented towards commercialization of SBIR research or technology. For more information please refer to the Small Business Administration's "Small Business Innovation Research (SBIR) Program Policy Directive" at https://www.sbir.gov/sites/default/files/sbir_pd_with_1-8-14_amendments_2-24-14.pdf.

⁵⁹ Please refer to Section VI.B.3-4 of the FOA for guidance on cost share payments and reporting.

2. PHASE II AND IIS COST SHARE REQUIREMENT

For Phase II and Phase IIS, Prime Recipients must contribute cost share as follows:

- Small businesses – or consortia of small businesses - will provide 0% cost share from the outset of the Phase II project through the first 12 months of Phase II (referred to as the “Cost Share Grace Period”). If the project is continued beyond the Cost Share Grace Period, then at least 10% of the Total Project Cost⁶⁰ (including the costs incurred during the Cost Share Grace Period) will be required as cost share over the remaining period of performance.
- Project Teams where a small business is the lead organization and small businesses perform greater than or equal to 80%, but less than 100%, of the total work under the funding agreement (as measured by the Total Project Cost) the Project Team are entitled to the same cost share reduction and Cost Share Grace Period as provided above to Standalone small businesses or consortia of small businesses.
- Project teams that do not meet any of the above criteria are subject to a minimum cost share requirement of 20%.

3. LEGAL RESPONSIBILITY

Although the cost share requirement applies to the Project Team as a whole, the funding agreement makes the Prime Recipient legally responsible for paying the entire cost share. The Prime Recipient’s cost share obligation is expressed in the funding agreement as a static amount in U.S. dollars (cost share amount) and as a percentage of the Total Project Cost (cost share percentage). If the funding agreement is terminated prior to the end of the project period, the Prime Recipient is required to contribute at least the cost share percentage of total expenditures incurred through the date of termination.

The Prime Recipient is solely responsible for managing cost share contributions by the Project Team and enforcing cost share obligations assumed by Project Team members in subawards or related agreements.

⁶⁰ The Total Project Cost is the sum of the Prime Recipient share and the Federal Government share of total allowable costs. The Federal Government share generally includes costs incurred by GOGOs and FFRDCs.

4. COST SHARE ALLOCATION

Each Project Team is free to determine how much each Project Team member will contribute towards the cost share requirement. The amount contributed by individual Project Team members may vary, as long as the cost share requirement for the project as a whole is met.

5. COST SHARE TYPES AND ALLOWABILITY

Every cost share contribution must be allowable under the applicable Federal cost principles, as described in Section IV.E.1 of the FOA.

Project Teams may provide cost share in the form of cash or in-kind contributions. Cash contributions may be provided by the Prime Recipient or Subrecipients. Allowable in-kind contributions include but are not limited to personnel costs, indirect costs, facilities and administrative costs, rental value of buildings or equipment, and the value of a service, other resource, or third party in-kind contribution. Project Teams may use funding or property received from state or local governments to meet the cost share requirement, so long as the funding or property was not provided to the state or local government by the Federal Government.

The Prime Recipient may not use the following sources to meet its cost share obligations:

- Revenues or royalties from the prospective operation of an activity beyond the project period
- Proceeds from the prospective sale of an asset of an activity
- Federal funding or property (e.g., Federal grants, equipment owned by the Federal Government)
- Expenditures that were reimbursed under a separate Federal program

In addition, Project Teams may not use independent research and development (IR&D) funds⁶¹ to meet their cost share obligations under cooperative agreements.

Project Teams may not use the same cash or in-kind contributions to meet cost share requirements for more than one project or program.

Cost share contributions must be specified in the project budget, verifiable from the Prime Recipient's records, and necessary and reasonable for proper and efficient accomplishment of

⁶¹ As defined in Federal Acquisition Regulation Section 31.205-18.

the project. Every cost share contribution must be reviewed and approved in advance by the Contracting Officer and incorporated into the project budget before the expenditures are incurred.

Applicants may wish to refer to 2 C.F.R. Parts 200 and 910, and 10 C.F.R Part 603 for additional guidance on cost sharing, specifically 2 C.F.R. §§ 200.306 and 910.130, and 10 C.F.R. §§ 603.525-555.

6. COST SHARE CONTRIBUTIONS BY FFRDCs AND GOGOs

Because FFRDCs are funded by the Federal Government, costs incurred by FFRDCs generally may not be used to meet the cost share requirement. FFRDCs may contribute cost share only if the contributions are paid directly from the contractor's Management Fee or a non-Federal source.

Because GOGOs/Federal Agencies are funded by the Federal Government, GOGOs/Federal Agencies may not provide cost share for the proposed project. However, the GOGO/Agency costs would be included in Total Project Costs for purposes of calculating the cost-sharing requirements of the applicant.

7. COST SHARE VERIFICATION

Upon selection for award negotiations, Applicants are required to provide information and documentation regarding their cost share contributions. Please refer to Section VI.B.3 of the FOA for guidance on the requisite cost share information and documentation.

F. OTHER

1. COMPLIANT CRITERIA

Full Applications are deemed compliant if:

- The Applicant and proposed Project Team members meet the eligibility requirements in Section III.A - III.D of the FOA
- The Full Application complies with the content and form requirements in Section IV.C of the FOA, and
- The Applicant entered all required information, successfully uploaded all required documents, and clicked the "Submit" button in ARPA-E eXCHANGE by the deadline stated in the FOA.

ARPA-E will not review or consider noncompliant Full Applications, including Full Applications submitted through other means, Full Applications submitted after the applicable deadline, and

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incomplete Full Applications. A Full Application is incomplete if it does not include required information and documents, such as Forms SF-424 and Small Business Administration Company Registration Certificate. ARPA-E will not extend the submission deadline for Applicants that fail to submit required information and documents due to server/connection congestion.

2. RESPONSIVENESS CRITERIA

ARPA-E performs a preliminary technical review of Full Applications. Any “Applications Specifically Not of Interest,” as described in Section I.G of the FOA, are deemed nonresponsive and are not reviewed or considered.

3. LIMITATION ON NUMBER OF APPLICATIONS

ARPA-E is not limiting the number of applications that may be submitted by Applicants. Applicants may submit more than one application to this FOA, provided that each application is scientifically distinct.

IV. APPLICATION AND SUBMISSION INFORMATION

A. APPLICATION PROCESS OVERVIEW

1. REGISTRATION IN SBA COMPANY REGISTRY

The first step in applying to this FOA is registering in the U.S. Small Business Administration (SBA) Company Registry (<http://sbir.gov/registration>). Upon completing registration, Applicants will receive a unique small business Control ID and Registration Certificate in Adobe PDF format, which may be used at any participating SBIR and STTR agencies. Applicants that have previously registered in the SBA Company Registry need not register again.

Applicants that are sole proprietors and do not have an Employer Identification Number may use social security numbers for purposes of registering in the SBA Company Registry. Applicants that do not possess a Dun and Bradstreet Data Universal Numbering System (DUNS) number may also use their social security number in the SBA Company Registry.

Applicants must submit their Registration Certificate in ARPA-E eXCHANGE (<https://arpa-e-foa.energy.gov>) as part of their Full Application (see Section IV.C.5 of the FOA).

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2. REGISTRATION IN ARPA-E eXCHANGE

Prior to submitting any application materials to ARPA-E, Applicants must register in ARPA-E eXCHANGE, ARPA-E's online application portal. For detailed guidance on using ARPA-E eXCHANGE, please refer to Section IV.F.1 of the FOA and the "ARPA-E eXCHANGE User Guide" (<https://arpa-e-foa.energy.gov/Manuals.aspx>).

3. FULL APPLICATIONS

Applicants must submit a Full Application by the deadline stated in the FOA. Section IV.C of the FOA provides instructions on the content and form of a Full Application.

ARPA-E performs a preliminary review of Full Applications to determine whether they are compliant and responsive, as described in Section III.F of the FOA. ARPA-E reviews only compliant and responsive Full Applications.

4. PRE-SELECTION CLARIFICATIONS AND "DOWN-SELECT" PROCESS

ARPA-E may, at the Contracting Officer's discretion, conduct a pre-selection clarification process and/or perform a "down-select" of Full Applications. Through the pre-selection clarification process or down-select process, ARPA-E may obtain additional information from select Applicants through pre-selection meetings, webinars, videoconferences, conference calls, or site visits that can be used to make a final selection determination. ARPA-E will not reimburse Applicants for travel and other expenses relating to pre-selection meetings and site visits, nor will these costs be eligible for reimbursement as pre-award costs.

ARPA-E may select applications for award negotiations and make awards without pre-selection meetings and site visits. Participation in a pre-selection meeting or site visit with ARPA-E does not signify that Applicants have been selected for award negotiations.

5. SELECTION FOR AWARD NEGOTIATIONS

ARPA-E carefully considers all of the information obtained through the application process and makes an independent assessment of each compliant and responsive Full Application based on the criteria and program policy factors in Sections V.A.1 and V.B.1 of the FOA. The Selection Official may select or not select a Full Application for award negotiations. The Selection Official may also postpone a final selection determination on one or more Full Applications until a later date, subject to availability of funds and other factors. ARPA-E will enter into award negotiations only with selected Applicants.

Applicants are promptly notified of ARPA-E's selection determination. ARPA-E may stagger its selection determinations. As a result, some Applicants may receive their notification letter in

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advance of other Applicants. Please refer to Section VI.A of the FOA for guidance on award notifications.

6. MANDATORY WEBINAR

All selected Applicants, including the Principal Investigator and the financial manager for the project, are required to participate in a webinar that is held within approximately one week of the selection notification. During the webinar, ARPA-E officials present important information on the award negotiation process, including deadlines for the completion of certain actions.

B. APPLICATION FORMS

Required forms for Full Applications are available on ARPA-E eXCHANGE (<https://arpa-e-foa.energy.gov>), including the SF-424, SF-424A, and Business Assurances & Disclosures Form. A sample response to the Business Assurances & Disclosures Form and a sample Summary Slide are also available on ARPA-E eXCHANGE. Applicants are strongly encouraged to use the templates available on ARPA-E eXCHANGE, including the template for the Technical Volume of the Full Application, and the template for the Summary Slide.

C. CONTENT AND FORM OF FULL APPLICATIONS

Full Applications must conform to the following requirements:

- Each document must be submitted in the file format prescribed below.
- All Full Applications must be written in English.
- All pages must be formatted to fit on 8-1/2 by 11 inch paper with margins not less than one inch on every side. Single space all text and use Times New Roman typeface, a black font color, and a font size of 12 point or larger (except in figures and tables).
- The ARPA-E assigned Control Number, the Lead Organization Name, and the Principal Investigator's Last Name must be prominently displayed on the upper right corner of the header of every page. Page numbers must be included in the footer of every page.

ARPA-E will not review or consider noncompliant and/or nonresponsive Full Applications (see Section III.F of the FOA).

Each Full Application should be limited to a single concept or technology. Unrelated concepts and technologies should not be consolidated in a single Full Application.

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Fillable Full Application template documents are available on ARPA-E eXCHANGE at <https://arpa-e-foa.energy.gov>.

Full Applications must conform to the content requirements described below.

Component	Required Format	Description and Information
Technical Volume	PDF	The centerpiece of the Full Application. Provides a detailed description of the proposed R&D project and Project Team. A Technical Volume template is available on ARPA-E eXCHANGE (https://arpa-e-foa.energy.gov).
SF-424	PDF	Application for Federal Assistance (https://arpa-e-foa.energy.gov). Applicants are responsible for ensuring that the proposed costs listed in eXCHANGE match those listed on forms SF-424 and SF-424A. Inconsistent submissions may impact ARPA-E's final award determination.
SF-424A	XLS	Budget Information – Non-Construction Programs (https://arpa-e-foa.energy.gov)
Summary Slide	PPT	A four-panel project slide summarizing different aspects of the proposed R&D project. A Summary Slide template is available on ARPA-E eXCHANGE (https://arpa-e-foa.energy.gov).
SBA Company Registration Certificate	PDF	Registration Certificate generated upon completion of registration in the SBA Company Registry (http://sbir.gov/registration).
Certification for Applicants Majority-Owned by Multiple Venture Capital Operating Companies, Hedge Funds, or Private Equity Firms (if applicable)	PDF	Requires SBIR Applicants that are majority-owned by multiple venture capital operating companies, hedge funds, or private equity firms to self-identify and verify registration as such in the SBA Company Registry (http://sbir.gov/registration).
Business Assurances & Disclosures Form	PDF	Requires the Applicant to acknowledge eligibility with SBIR/STTR program requirements, make responsibility disclosures, disclose potential conflicts of interest within the Project Team, and provide written assurance of its cost share commitment. Requires the Applicant to describe the additionality and risks associated with the proposed project, disclose applications for funding currently pending with Federal and non-Federal entities, and disclose funding from Federal and non-Federal entities for work in the same technology area as the proposed R&D project. Requires the Project Team to confirm if each entity has obtained a DUNS number and has an active registration in SAM. This form is available on ARPA-E eXCHANGE at https://arpa-e-foa.energy.gov . A sample response to the Business Assurances & Disclosures Form is also available on ARPA-E eXCHANGE.

Questions about this FOA? Check the Frequently Asked Questions available at <http://arpa-e.energy.gov/faq>. For questions that have not already been answered, email ARPA-E-CO@hq.doe.gov (with FOA name and number in subject line); see FOA Sec. VII.A. Problems with ARPA-E eXCHANGE? Email ExchangeHelp@hq.doe.gov (with FOA name and number in subject line).

ARPA-E provides detailed guidance on the content and form of each component below.

1. FIRST COMPONENT: TECHNICAL VOLUME

The Technical Volume must be submitted in Adobe PDF format. A Technical Volume template is available at <https://arpa-e-foa.energy.gov>. The Technical Volume must conform to the following content and form requirements, including maximum page lengths specified below. If Applicants exceed the maximum page lengths specified for each section indicated below, ARPA-E will review only the authorized number of pages and disregard any additional pages.

Applicants must provide sufficient citations and references to the primary research literature to justify the claims and approaches made in the Technical Volume. ARPA-E and reviewers may review primary research literature in order to evaluate applications. However, ARPA-E and reviewers are under no obligation to review cited sources (e.g., Internet websites).

PAGE LIMIT	SECTION	DESCRIPTION
1 page max.	EXECUTIVE SUMMARY	Summarize the objective(s) and technical approach of the proposed effort at a technical level appropriate for scientific and engineering peers. INSTRUCTIONS: (1) The Project Title should be brief and descriptive of the proposed technology. (2) Enter the estimated Total Project Cost in U.S. dollars and percentage cost share in parentheses. (3) Enter the Project Duration in months. (4) The Executive Summary shall not exceed 1 page in length. (5) The Executive Summary may contain graphics, figures, or tables as needed to summarize the technical concept.
Sections 1-5 30 pages max.	Section 1 INNOVATION	Describe how the proposed work offers an innovative approach to achieve the program objectives of the FOA. 1.1 Overall Description. • Describe the conceptual basis for the project and how the proposed technology works with minimal jargon. • Explain the objective(s) and performance characteristics of the proposed effort. • Include a descriptive schematic of the proposed innovative concept with various key components and rough dimensions of the system. • Include a fuel to electrical conversion system efficiency cascade of the entire system similar to the one prescribed in Eq. 1 ($\eta_e = \eta_{\text{comb}} \cdot \eta_{\text{ind}} \cdot \eta_m \cdot \eta_{\text{alt}}$) of the FOA, and address the pathway for

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		attaining the 40% fuel to (ac) electricity conversion efficiency target [For solid-state devices, combustion efficiency must be included in the overall efficiency equation when heat is used as input to the devices]. • Include a description of the emissions mitigation strategy for meeting the emissions targets as described in Section I.F of the FOA. The CH₄ mitigation strategy must be clearly laid out in the Full Application. 1.2 Innovativeness. • Describe how the proposed effort represents a new and innovative solution to the overall program challenge described in the FOA. • Indicate the technical goals and anticipated results, using appropriate metrics, for the project. Provide a description of how the metrics were derived, citing key previous results and/or assumptions. • Include and discuss, as appropriate, a table in which the targeted performance of the proposed technology is compared with the “Technical Performance Targets” in Section I.F of the FOA. INSTRUCTIONS: (1) The Innovation Section may include figures, tables, and graphics. (2) The suggested length of the Innovation Section is 4 pages. (3) Do not justify your project in terms of energy-savings, CO₂ reductions, and other benefits of CHP as ARPA-E is already well aware of these benefits. Full Applications must describe what innovations the project team brings to achieve the technical targets specified in Section I.F of the FOA. (4) Do not compare different technology types; compare only to the state-of-the-art within a technology type. For example, an application proposing a Stirling engine should only compare to other Stirling engines and not to internal combustion engines. (5) Use of the term "no moving parts" alone is insufficient to justify durability and long lifetime, as systems with no moving parts do not necessarily last longer than those with moving parts. Identify the failure modes of the proposed system and justify why it can attain the lifetime target.
	Section 2 PROPOSED WORK	Describe and discuss for the proposed effort the technical background and approach, the R&D tasks, and the key technical risks. This Section should justify the proposed approach as being appropriate to achieve the project’s objective(s). 2.1 Approach. • Describe the technical approach and how this approach will achieve the proposed project objective(s).

Questions about this FOA? Check the Frequently Asked Questions available at <http://arpa-e.energy.gov/faq>. For questions that have not already been answered, email ARPA-E-CO@hq.doe.gov (with FOA name and number in subject line); see FOA Sec. VII.A. Problems with ARPA-E eXCHANGE? Email ExchangeHelp@hq.doe.gov (with FOA name and number in subject line).

		- Describe the background, theory, simulation, modeling, experimental data, or other sound engineering and scientific practices or principles that support achieving the project objective(s). Provide specific examples of supporting data and/or appropriate citations to the scientific and technical literature. - A thermodynamic modeling analysis (0-D or higher) is highly recommended to obtain the analytical fuel to electrical conversion efficiency of the generator system. If the model predicted efficiency is lower than the 40% target in Section I.F of the FOA, then a technical discussion showing the pathway to overcome the efficiency deficit is necessary. - Most engine concepts can add a standard thermoelectric generator (~3% efficiency) to boost the system efficiency to the 40% target in Section I.F of the FOA. Applicants are allowed to focus on primary generator technologies only with a fuel to electricity efficiency target of 37% and a cost target of \$2,700 for the 1 kW_e system (assuming 3% efficiency gain from the thermoelectric generator at a cost of \$300). 2.2 Technical Risk. - Identify potential technical issues and risks, e.g., the approach requires a never-before-demonstrated fabrication technique or greater-than-previously-demonstrated sub-component performance, etc. - Describe appropriate mitigation techniques and plans, if any, for each identified issue and risk. - A Design Fault Mode and Effect Analysis (DFMEA) table or a Fault Tree Analysis (FTA) chart for the entire CHP system must be included. This should clearly identify failure modes and mechanisms, and propose mitigation solutions. - The system life capability of 10 years or more must be demonstrated via accelerated life testing (ALT). The procedure (thermal cycling or load cycling) for conducting such a test and appropriate references based on which the ALT procedure was selected must be provided in the Full Application. Full Applications with topping and bottoming cycles (e.g. IC engine with thermoelectric generator) must address ALT for both the technologies. In this case, each individual technology can be treated as a separate component. 2.3 Schedule. - Provide a schedule for the proposed effort by major tasks, including major milestones or Go/No-Go decision points as appropriate. (<u>A Gantt chart is recommended.</u>) - The schedule should include a milestone for the delivery of a 1-kW_e prototype at the end of the second project year which will be
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Questions about this FOA? Check the Frequently Asked Questions available at <http://arpa-e.energy.gov/faq>. For questions that have not already been answered, email ARPA-E-CO@hq.doe.gov (with FOA name and number in subject line); see FOA Sec. VII.A. Problems with ARPA-E eXCHANGE? Email ExchangeHelp@hq.doe.gov (with FOA name and number in subject line).

		subjected to independent testing. This prototype need not meet the final deliverable milestones for the project. 2.4 Task Descriptions. • Identify and provide a full technical description for each main task in the proposed effort. • Discuss the reason the identified tasks are appropriate and sufficient for the identified approach. • Describe the key technical milestones and how these define the critical path for successful completion of the task. • Indicate how completion of each task relates to reducing technological uncertainty and achieving the overall project objective(s). INSTRUCTIONS: (1) The Proposed Work Section may include figures, tables, and graphics. (2) The suggested length of the Proposed Work Section is 12 pages.
	Section 3 TEAM ORGANIZATION AND CAPABILITIES	Describe and discuss the, organization, capabilities, and management of the team and how these enable successful execution of the proposed effort. 3.1 Organization. • Indicate roles and responsibilities of the organizations on the proposed Project Team, e.g., subrecipient, consultant, subcontractor, or lead organization for each of the project tasks. Include relevant organization charts and teaming organization charts, as applicable. • Identify Key Personnel, describe how their qualifications relate to the proposed effort, and indicate their roles and responsibilities for each of the project tasks. • Identify previous collaborative efforts among team members if relevant to the proposed effort. 3.2 Capabilities, Facilities, Equipment, and Information. • Identify capabilities of the Applicant or proposed Project Team, e.g., relevant experience, previous or current R&D efforts, or related government or commercial projects, that support the proposed effort. • Identify all required facilities, equipment, and information for the proposed effort and discuss their adequacy and availability. • Indicate any key equipment that must be fabricated or purchased INSTRUCTIONS: (1) This Section may include figures, tables, and graphics. (2) The suggested length of the Team Section is 4 pages.

Questions about this FOA? Check the Frequently Asked Questions available at <http://arpa-e.energy.gov/faq>. For questions that have not already been answered, email ARPA-E-CO@hq.doe.gov (with FOA name and number in subject line); see FOA Sec. VII.A. Problems with ARPA-E eXCHANGE? Email ExchangeHelp@hq.doe.gov (with FOA name and number in subject line).

	Section 4 TECHNOLOGY TO MARKET	The significant impact sought by ARPA-E depends upon successful projects finding a path to large-scale adoption. ARPA-E projects are not required to achieve commercial deployment by the end of the project period, but the agency asks the applicant to define a reasonable path for the proposed technology toward commercial adoption. 4.1 Technology to Market Strategy. • Describe how the proposed technology is expected to transition from the lab to commercial deployment, including a description of the eventual product, potential near- and long-term market entries, likely commercialization approach (startup, license, etc.), specific organizations expected to be involved in the transition (partners, customers, etc.), and the commercialization timeline. • Discuss manufacturing, cost, and scalability risks associated with the technology. • Describe anticipated resource needs for the next phase of development following the end of the ARPA-E project. • Explain why the proposed research is not being pursued by industry today. • Discuss the anticipated roles for the proposed research team in the commercialization of the technology. 4.2 Intellectual Property. • Describe existing intellectual property, if any, that will be used to develop the new intellectual property • Discuss new intellectual property and data that is anticipated to be created as part of this effort, if any INSTRUCTIONS: (1) The Technology to Market Section may include figures, tables, and graphics. (2) The suggested length of the Technology to Market Section is 4 pages.
	Section 5 BUDGET	Indicate the budget, in US dollars, and provide a high-level budget summary, demonstrating that the budget is reasonable and appropriate for the proposed effort. 5.1 Budget Breakdown. Provide in tabular form following the template give below, a breakdown of the project budget by entity and major task in US dollars. Replace “Prime” with name of the primary (lead) entity and “Sub #n” with the name of the sub-recipient or sub-contractor entities, if applicable. Task

Questions about this FOA? Check the Frequently Asked Questions available at <http://arpa-e.energy.gov/faq>. For questions that have not already been answered, email ARPA-E-CO@hq.doe.gov (with FOA name and number in subject line); see FOA Sec. VII.A. Problems with ARPA-E eXCHANGE? Email ExchangeHelp@hq.doe.gov (with FOA name and number in subject line).

names should clearly correspond to major tasks listed in Section 2.4. Expand or contract the table as needed to add/subtract entities (columns) or tasks (rows).

Phase I

Task Name	[Prime]	[Sub #1]	[Sub #2]	[Sub #3]	[Sub #4]	Total
[Task #1]						
[Task #2]						
[Task #3]						
[Task #4]						
Total						

Phase II

Task Name	[Prime]	[Sub #1]	[Sub #2]	[Sub #3]	[Sub #4]	Total
[Task #1]						
[Task #2]						
[Task #3]						
[Task #4]						
Total						

Phase IIS

Task Name	[Prime]	[Sub #1]	[Sub #2]	[Sub #3]	[Sub #4]	Total
[Task #1]						
[Task #2]						
[Task #3]						
[Task #4]						
Total						

5.2 Budget Summary.

Provide a high-level summary for the project by major budget category, including at least these three:

- Key Personnel and technical staff to be utilized (e.g., scientists, engineers, technicians, postdocs, graduate students, etc.)
- Equipment
- Materials and Supplies

INSTRUCTIONS:

- (1) The Budget Section may include figures, tables, and graphics.
- (2) The suggested length of the Budget Section is 4 pages.

No page limit	REFERENCES	Provide a list of references appropriate to Sections 1-5. INSTRUCTIONS: (1) Only bibliographic information may be contained in the references. No additional text or commentary is allowed. (2) There is no page limit for the Bibliographic References Section, which is outside of the overall 30-page limit for Sections 1-5.
Each PQS limited to 3 pages in length, no cumulative page limit	PERSONAL QUALIFICATION SUMMARIES	A Personal Qualification Summary (PQS) is required for the PI and all other Key Personnel. Each PQS must include a description of the following only: • Education and training • Employment history • Awards and honors • A list of no more than 10 peer-reviewed publications related to the proposed project • A list of no more than 10 other peer-reviewed publications demonstrating capabilities in the broad field • A list of no more than 10 non-peer-reviewed publications and patents demonstrating capabilities in the broad field INSTRUCTIONS: (1) Each Personal Qualification Summary is limited to 3 pages in length and there is no page limit for this Section, which is outside of the 30-page limit for Sections 1-5. (2) Curriculum Vitae should not be submitted.

Questions about this FOA? Check the Frequently Asked Questions available at <http://arpa-e.energy.gov/faq>. For questions that have not already been answered, email ARPA-E-CO@hq.doe.gov (with FOA name and number in subject line); see FOA Sec. VII.A. Problems with ARPA-E eXCHANGE? Email ExchangeHelp@hq.doe.gov (with FOA name and number in subject line).

2. SECOND COMPONENT: SF-424

The SF-424 must be submitted in Adobe PDF format. This form is available on ARPA-E eXCHANGE at <https://arpa-e-foa.energy.gov>.

The SF-424 includes instructions for completing the form. Applicants are required to complete all required fields in accordance with the instructions.

Prime Recipients and Subrecipients are required to complete SF-LLL (Disclosure of Lobbying Activities), available at <http://www.whitehouse.gov/sites/default/files/omb/grants/sflllin.pdf>, if any non-Federal funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any Federal agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with your application or funding agreement. The completed SF-LLL must be appended to the SF-424.

ARPA-E provides the following supplemental guidance on completing the SF-424:

- Each Project Team should submit only one SF-424 (i.e., a Subrecipient should not submit a separate SF-424).
- Assume a project start date of January 2016, or as negotiated.
- The list of certifications and assurances in Block 21 can be found at <http://energy.gov/management/downloads/certifications-and-assurances-use-sf-424>.
- The dates and dollar amounts on the SF-424 are for the entire project period (from the project start date to the project end date), not a portion thereof.
- Applicants are responsible for ensuring that the proposed costs listed in eXCHANGE match those listed on forms SF-424 and SF-424A. Inconsistent submissions may impact ARPA-E's final award determination.

3. THIRD COMPONENT: SF-424A

Applicants are required to complete the SF-424A Excel spreadsheet. This form, with instructions included, is available on ARPA-E eXCHANGE at <https://arpa-e-foa.energy.gov>.

4. FOURTH COMPONENT: SUMMARY SLIDE

Applicants are required to provide a single PowerPoint slide summarizing the proposed project. The slide must be submitted in Microsoft PowerPoint format. This slide will be used during ARPA-E's evaluation of Full Applications. A summary slide template and a sample summary slide are available on ARPA-E eXCHANGE (<https://arpa-e-foa.energy.gov>).

Summary Slides must conform to the content requirements described below:

- A Technology Summary
 - Bullet points that describe novel aspects of the proposed technology and technology approach
- Proposed Targets
 - Including any important technical performance metrics
 - Including quantitative descriptions of the proposed targets
- Any key graphics (illustrations, charts and/or tables) summarizing technology development
- The project's key idea/takeaway
- Project title and Principal Investigator information
- Requested ARPA-E funds and proposed applicant cost share

5. FIFTH COMPONENT: SBA REGISTRATION CERTIFICATE

Applicants are required to provide a copy of the SBA Registration Certificate generated in the SBA Company Registry (<http://sbir.gov/registration>) in Adobe PDF format (see Section IV.A.1 of the FOA). Applicants that have previously registered in the SBA Company Registry may submit a copy their existing Registration Certificate.

6. SIXTH COMPONENT: CERTIFICATION FOR APPLICANTS MAJORITY-OWNED BY MULTIPLE VENTURE CAPITAL OPERATING COMPANIES, HEDGE FUNDS, AND PRIVATE EQUITY FIRMS

Only those Applicants that are majority-owned by multiple venture capital operating companies, hedge funds, or private equity firms are required to complete the Certification for Applicants Majority-Owned by Multiple Venture Capital Operating Companies, Hedge Funds, and Private Equity Funds. The certification must be submitted in Adobe PDF format. This form is available on ARPA-E eXCHANGE at <https://arpa-e-foa.energy.gov>.

In the Certification for Applicants Majority-Owned by Multiple Venture Capital Operating Companies, Hedge Funds, and Private Equity Funds, the Applicant is required to self-identify as an entity that falls into one of those categories, verify its ownership status, and verify that it has registered in the SBA Company Registry (<http://sbir.gov/registration>) as such an entity.

Applicants that are not majority-owned by multiple venture capital operating companies, hedge funds, or private equity firms are not required to complete this certification.

7. SEVENTH COMPONENT: BUSINESS ASSURANCES & DISCLOSURES FORM

Applicants are required to complete a Business Assurances & Disclosures Form. The form must be submitted in Adobe PDF format. This form is available on ARPA-E eXCHANGE at <https://arpa-e-foa.energy.gov>. A sample response to the Business Assurances & Disclosures Form is also available on ARPA-E eXCHANGE.

In the Business Assurances & Disclosures Form, the Applicant is required to:

- Acknowledge that it has reviewed SBA's eligibility requirements for the SBIR and STTR programs and that it anticipates that it will be able to certify eligibility to participate in ARPA-E's SBIR/STTR program at the time of award
- Disclose conditions bearing on responsibility, such as criminal convictions and Federal tax liability
- Disclose potential conflicts of interest within the Project Team

In addition, ARPA-E is required by statute to "accelerat[e] transformational technological advances in areas that industry is by itself not likely to undertake because of technical and financial uncertainty."⁶² In accordance with ARPA-E's statutory mandate, the Applicant is required to:

- Describe the additionality and risks associated with the proposed R&D project
- Disclose any applications for the same project or related work currently pending with any Federal or non-Federal entities
- Disclose all funding for work in the same technology area as the proposed project received from any Federal or non-Federal entity within the last 5 years
- The Applicant may use the Business Assurances & Disclosures Form to request authorization to perform some work overseas

⁶² America COMPETES Act, Pub. L. No. 110-69, § 5012 (2007), as amended (codified at 42 U.S.C. § 16538).

Each entity on a Project Team must also report the entity's DUNS number, confirmation of active registration in SAM, or the dates when the entity began or will begin the process of obtaining a DUNS number and/or register in SAM.

D. INTERGOVERNMENTAL REVIEW

This program is not subject to Executive Order 12372 (Intergovernmental Review of Federal Programs).

E. FUNDING RESTRICTIONS

1. ALLOWABLE COSTS

All expenditures must be allowable, allocable, and reasonable in accordance with the applicable Federal cost principles. ARPA-E has listed the Federal cost principles for different categories of Applicants at <http://arpa-e.energy.gov/?q=arpa-e-site-page/post-award-guidance-sbir-sttr>.

2. PRE-AWARD COSTS

ARPA-E will not reimburse pre-award costs under this FOA.

3. PATENT COSTS

For Subject Inventions disclosed to DOE under an award, ARPA-E will reimburse the Prime Recipient – in addition to allowable costs associated with Subject Invention disclosures - up to \$30,000 of expenditures for filing and prosecution of United States patent applications, including international applications ("PCT application") submitted to the USPTO.

The Prime Recipient may request a waiver of the \$30,000 cap which is subject to approval by the ARPA-E Deputy Director for Commercialization.

4. CONSTRUCTION

ARPA-E generally does not fund projects that involve major construction. Recipients are required to obtain written authorization from the Contracting Officer before incurring any major construction costs.

5. FOREIGN TRAVEL

ARPA-E generally does not fund projects that involve foreign travel. Recipients are required to obtain written authorization from the Contracting Officer before incurring any foreign travel costs and provide trip reports with their reimbursement requests.

6. PERFORMANCE OF WORK IN THE UNITED STATES

ARPA-E strongly encourages interdisciplinary and cross-sectoral collaboration spanning organizational boundaries. Such collaboration enables the achievement of scientific and technological outcomes that were previously viewed as extremely difficult, if not impossible.

ARPA-E requires all work under ARPA-E funding agreements to be performed in the United States – i.e., Prime Recipients must expend 100% of the Total Project Cost in the United States. However, Applicants may request a waiver of this requirement where their project would materially benefit from, or otherwise requires, certain work to be performed overseas.

Applicants seeking a waiver of this requirement are required to include an explicit request in the Business Assurances & Disclosures Form, which is part of the Full Application submitted to ARPA-E. Such waivers are granted where there is a demonstrated need, as determined by ARPA-E.

7. PURCHASE OF NEW EQUIPMENT

All equipment purchased under ARPA-E funding agreements must be made or manufactured in the United States, to the maximum extent practicable. This requirement does not apply to used or leased equipment. The Prime Recipients are required to notify the ARPA-E Contracting Officer reasonably in advance of purchasing any equipment that is not made or manufactured in the United States with an acquisition cost of \$25,000 or more per unit. The ARPA-E Contracting Officer will provide consent to purchase or reject within 30 calendar days of receipt of the Recipient's notification.

8. LOBBYING

Prime Recipients and Subrecipients may not use any Federal funds to influence or attempt to influence, directly or indirectly, congressional action on any legislative or appropriation matters.⁶³

Prime Recipients and Subrecipients are required to complete and submit SF-LLL, "Disclosure of Lobbying Activities" (<http://www.whitehouse.gov/sites/default/files/omb/grants/sflllin.pdf>) if any non-Federal funds have been paid or will be paid to any person for influencing or attempting to influence any of the following in connection with your application:

1. An officer or employee of any Federal agency,
2. A Member of Congress,

⁶³ 18 U.S.C. § 1913.

3. An officer or employee of Congress, or
4. An employee of a Member of Congress.

9. CONFERENCE SPENDING

Prime Recipients and Subrecipients may not use any Federal funds to:

- Defray the cost to the United States Government of a conference held by any Executive branch department, agency, board, commission, or office which is not directly and programmatically related to the purpose for which their ARPA-E award is made and for which the cost to the United States Government is more than \$20,000, or
- To circumvent the required notification by the head of any such Executive Branch department, agency, board, commission, or office to the Inspector General (or senior ethics official for any entity without an Inspector General), of the date, location, and number of employees attending such a conference.

F. OTHER SUBMISSION REQUIREMENTS

1. USE OF ARPA-E eXCHANGE

To apply to this FOA, Applicants must register with ARPA-E eXCHANGE (<https://arpa-e-foa.energy.gov/Registration.aspx>). Full Applications must be submitted through ARPA-E eXCHANGE (<https://arpa-e-foa.energy.gov/login.aspx>). **ARPA-E will not review or consider applications submitted through other means** (e.g., fax, hand delivery, email, postal mail). For detailed guidance on using ARPA-E eXCHANGE, please refer to the “ARPA-E eXCHANGE User Guide” (<https://arpa-e-foa.energy.gov/Manuals.aspx>).

Upon creating an application submission in ARPA-E eXCHANGE, Applicants will be assigned a Control Number. If the Applicant creates more than one application submission, a different Control Number will be assigned for each application.

Once logged in to ARPA-E eXCHANGE (<https://arpa-e-foa.energy.gov/login.aspx>), Applicants may access their submissions by clicking the “My Submissions” link in the navigation on the left side of the page. Every application that the Applicant has submitted to ARPA-E and the corresponding Control Number is displayed on that page. If the Applicant submits more than one application to a particular FOA, a different Control Number is shown for each application.

Applicants are responsible for meeting each submission deadline in ARPA-E eXCHANGE.

Applicants are strongly encouraged to submit their applications at least 48 hours in advance of the submission deadline. Under normal conditions (i.e., at least 48 hours in advance of the

submission deadline), Applicants should allow at least 1 hour to submit Full Application. Once the application is submitted in ARPA-E eXCHANGE, Applicants may revise or update their application until the expiration of the applicable deadline.

Applicants should not wait until the last minute to begin the submission process. During the final hours before the submission deadline, Applicants may experience server/connection congestion that prevents them from completing the necessary steps in ARPA-E eXCHANGE to submit their applications. **ARPA-E will not extend the submission deadline for Applicants that fail to submit required information and documents due to server/connection congestion.**

ARPA-E will not review or consider incomplete applications and applications received after the deadline stated in the FOA. Such applications will be deemed noncompliant (see Section III.F.1 of the FOA). The following errors could cause an application to be deemed “incomplete” and thus noncompliant:

- Failing to comply with the form and content requirements in Section IV.C of the FOA
- Failing to enter required information in ARPA-E eXCHANGE
- Failing to upload required document(s) to ARPA-E eXCHANGE
- Failing to click the “Submit” button in ARPA-E eXCHANGE by the deadline stated in the FOA
- Uploading the wrong document(s) or application(s) to ARPA-E eXCHANGE and
- Uploading the same document twice, but labeling it as different documents (In the latter scenario, the Applicant failed to submit a required document)

ARPA-E urges Applicants to carefully review their applications and to allow sufficient time for the submission of required information and documents.

V. APPLICATION REVIEW INFORMATION

A. CRITERIA

ARPA-E performs a preliminary review of Full Applications to determine whether they are compliant and responsive (see Section III.F of the FOA).

1. CRITERIA FOR FULL APPLICATIONS

Full Applications are evaluated based on the following criteria:

Questions about this FOA? Check the Frequently Asked Questions available at <http://arpa-e.energy.gov/faq>. For questions that have not already been answered, email ARPA-E-CO@hq.doe.gov (with FOA name and number in subject line); see FOA Sec. VII.A. Problems with ARPA-E eXCHANGE? Email ExchangeHelp@hq.doe.gov (with FOA name and number in subject line).

(1) *Impact of the Proposed Technology* (30%) - This criterion involves consideration of the following factors:

- The extent to which the proposed quantitative material and/or technology metrics demonstrate the potential for a transformational and disruptive (not incremental) advancement in one or more energy-related fields
- The extent to which the Applicant demonstrates a profound understanding of the current state-of-the-art and presents an innovative technical approach to significantly improve performance over the current state-of-the-art
- The extent to which the Applicant demonstrates awareness of competing commercial and emerging technologies and identifies how its proposed concept/technology provides significant improvement over these other solutions and
- The extent to which the Applicant proposes a reasonable and effective strategy for transitioning the proposed technology from the laboratory to commercial deployment

(2) *Overall Scientific and Technical Merit* (30%) - This criterion involves consideration of the following factors:

- The extent to which the proposed work is unique and innovative
- The extent to which project outcomes and deliverables are clearly defined
- The extent to which the proposed project is likely to meet or exceed the technical performance targets identified in this FOA
- The feasibility of the proposed work based upon preliminary data or other background information and sound scientific and engineering practices and principles
- The extent to which the Applicant proposes a sound technical approach, including appropriately defined technical tasks, to accomplish the proposed R&D objectives and
- The extent to which the Applicant manages risk, by identifying major technical R&D risks and clearly proposes feasible, effective mitigation strategies

(3) *Qualifications, Experience, and Capabilities of the Proposed Project Team* (30%) - This criterion involves consideration of the following factors:

- The extent to which the PI and Project Team have the skill and expertise needed to successfully execute the project plan, evidenced by prior experience that demonstrates an ability to perform R&D of similar risk and complexity, and
- The extent to which the Applicant has access to the equipment and facilities necessary to accomplish the proposed R&D effort and/or a clear plan to obtain access to necessary equipment and facilities

(4) *Soundness of Management Plan* (10%) - This criterion involves consideration of the following factors:

- The extent to which the Applicant presents a plausible plan to manage people and resources
- The extent to which the Applicant proposes allocation of appropriate levels of effort and resources to proposed tasks
- Whether the proposed project schedule, including major milestones is reasonable and
- The appropriateness of the proposed budget to accomplish the proposed project

Submissions will not be evaluated against each other since they are not submitted in accordance with a common work statement.

B. REVIEW AND SELECTION PROCESS

1. PROGRAM POLICY FACTORS

In addition to the above criteria, ARPA-E may consider the following program policy factors in determining which Full Applications to select for award negotiations:

- I. **ARPA-E Portfolio Balance.** Project balances ARPA-E portfolio in one or more of the following areas:
 - a. Technological diversity
 - b. Organizational diversity
 - c. Geographic diversity
 - d. Technical or commercialization risk
 - e. Stage of technology development

- II. **Relevance to ARPA-E Mission Advancement.** Project contributes to one or more of ARPA-E's key statutory goals:
 - a. Reduction of US dependence on foreign energy sources
 - b. Stimulation of domestic manufacturing
 - c. Reduction of energy-related emissions
 - d. Increase in U.S. energy efficiency
 - e. Enhancement of U.S. economic and energy security
 - f. Promotion of U.S. advanced energy technologies competitiveness
- III. **Synergy of Public and Private Efforts.**
 - a. Avoids duplication and overlap with other publicly or privately funded projects
 - b. Promotes increased coordination with nongovernmental entities for demonstration of technologies and research applications to facilitate technology transfer
 - c. Increases unique research collaborations
- IV. **Low likelihood of other sources of funding.** High technical and/or financial uncertainty that results in the non-availability of other public, private or internal funding or resources to support the project.
- V. **High Project Impact Relative to Project Cost.**

2. ARPA-E REVIEWERS

By submitting an application to ARPA-E, Applicants consent to ARPA-E's use of Federal employees, contractors, and experts from educational institutions, nonprofits, industry, and governmental and intergovernmental entities as reviewers. ARPA-E selects reviewers based on their knowledge and understanding of the relevant field and application, their experience and skills, and their ability to provide constructive feedback on applications.

ARPA-E requires all reviewers to complete a Conflict-of-Interest Certification and Nondisclosure Agreement through which they disclose their knowledge of any actual or apparent conflicts and agree to safeguard confidential information contained in Full Applications. In addition, ARPA-E trains its reviewers in proper evaluation techniques and procedures.

Applicants are not permitted to nominate reviewers for their applications. Applicants may contact the Contracting Officer by email (ARPA-E-CO@hq.doe.gov) if they have knowledge of a potential conflict of interest or a reasonable belief that a potential conflict exists.

3. ARPA-E SUPPORT CONTRACTOR

ARPA-E utilizes contractors to assist with the evaluation of applications and project management. To avoid actual and apparent conflicts of interest, ARPA-E prohibits its support contractors from submitting or participating in the preparation of applications to ARPA-E.

By submitting an application to ARPA-E, Applicants represent that they are not performing support contractor services for ARPA-E in any capacity and did not obtain the assistance of ARPA-E's support contractor to prepare the application. ARPA-E will not consider any applications that are submitted by or prepared with the assistance of its support contractors.

C. ANTICIPATED ANNOUNCEMENT AND AWARD DATES

ARPA-E expects to announce selections for negotiations and execute funding agreements in September 2015.

VI. AWARD ADMINISTRATION INFORMATION

A. AWARD NOTICES

1. REJECTED SUBMISSIONS

Noncompliant and nonresponsive Full Applications are rejected by the Contracting Officer and are not reviewed or considered. The Contracting Officer sends a notification letter by email to the technical and administrative points of contact designated by the Applicant in ARPA-E eXCHANGE. The notification letter states the basis upon which the Full Application was rejected.

2. FULL APPLICATION NOTIFICATIONS

ARPA-E promptly notifies Applicants of its determination. ARPA-E sends a notification letter by email to the technical and administrative points of contact designated by the Applicant in ARPA-E eXCHANGE. The notification letter may inform the Applicant that its Full Application was selected for award negotiations, or not selected. Alternatively, ARPA-E may notify one or more Applicants that a final selection determination on particular Full Applications will be made at a later date, subject to the availability of funds or other factors.

a. SUCCESSFUL APPLICANTS

ARPA-E has discretion to select all or part of a proposed project for negotiation of an award. A notification letter selecting a Full Application for award negotiations does not authorize the Applicant to commence performance of the project. **ARPA-E selects Full Applications for**

award negotiations, not for award. Applicants do not receive an award until award negotiations are complete and the Contracting Officer executes the funding agreement. ARPA-E may terminate award negotiations at any time for any reason.

Please refer to Section IV.E.2 of the FOA for guidance on pre-award costs. Please also refer to the “SBIR/STTR Applicants’ Guide to ARPA-E Award Negotiations” (<http://arpa-e.energy.gov/?q=arpa-e-site-page/pre-award-guidance-sbir-sttr>) for guidance on the award negotiation process.

b. POSTPONED SELECTION DETERMINATIONS

A notification letter postponing a final selection determination until a later date does not authorize the Applicant to commence performance of the project. ARPA-E may ultimately determine to select or not select the Full Application for award negotiations.

Please refer to Section IV.E.2 of the FOA for guidance on pre-award costs.

c. UNSUCCESSFUL APPLICANTS

By not selecting a Full Application, ARPA-E intends to convey its lack of programmatic interest in the proposed project. Such assessments do not necessarily reflect judgments on the merits of the proposed project. ARPA-E hopes that unsuccessful Applicants will submit innovative ideas and concepts for future FOAs.

B. ADMINISTRATIVE AND NATIONAL POLICY REQUIREMENTS

The following administrative and national policy requirements apply to Prime Recipients. The Prime Recipient is the responsible authority regarding the settlement and satisfaction of all contractual and administrative issues, including but not limited to disputes and claims arising out of any agreement between the Prime Recipient and a FFRDC contractor. Prime Recipients are required to flow down these requirements to their Subrecipients through subawards or related agreements.

1. DUNS NUMBER AND SAM, FSRS, AND FEDCONNECT REGISTRATIONS

Prime Recipients and Subrecipients are required to obtain a Dun and Bradstreet Data Universal Numbering System (DUNS) number at <http://fedgov.dnb.com/webform> and to register with the System for Award Management (SAM) at <https://www.sam.gov/portal/public/SAM/>. Obtaining a DUNS number and registering with SAM could take several weeks. **Prime Recipients and Subrecipients should begin their registration no later than August 17, 2015. Applicants that do not obtain a DUNS number and do not have an active registration in SAM cannot receive an award.**

Prime Recipients are also required to register with the Federal Funding Accountability and Transparency Act Subaward Reporting System (FSRS) at <https://www.fsrs.gov/>.⁶⁴ Prime Recipients are required to report to FSRS the names and total compensation of each of the Prime Recipient's five most highly compensated executives and the names and total compensation of each Subrecipient's five most highly compensated executives. Please refer to <https://www.fsrs.gov/> for guidance on reporting requirements.

ARPA-E may not execute a funding agreement with the Prime Recipient until it has obtained a DUNS number and completed its SAM and FSRS registrations. In addition, the Prime Recipient may not execute subawards with Subrecipients until they obtain a DUNS number and complete their SAM registration. Prime Recipients and Subrecipients are required to keep their SAM and FSRS data current throughout the duration of the project.

Finally, Prime Recipients are required to register with FedConnect in order to receive notification that their funding agreement has been executed by the Contracting Officer and to obtain a copy of the executed funding agreement. Please refer to <https://www.fedconnect.net/FedConnect/> for registration instructions.

2. NATIONAL POLICY ASSURANCES

Project Teams, including Prime Recipients and Subrecipients, are required to comply with the National Policy Assurances attached to their funding agreement. Please refer to ARPA-E's Model Cooperative Agreement for SBIR/STTR awards (<http://arpa-e.energy.gov/?q=arpa-e-site-page/award-guidance-sbir-sttr>) for guidance on the National Policy Assurances.

3. PROOF OF COST SHARE COMMITMENT

Upon selection for award negotiations, the Prime Recipient is required to provide cost share commitment letters from Subrecipients or third parties that are providing cost share, whether cash or in-kind. Each Subrecipient or third party that is contributing cost share must provide a letter on appropriate letterhead that is signed by an authorized corporate representative. Please refer to the "SBIR/STTR Applicants' Guide to ARPA-E Award Negotiations" (<http://arpa-e.energy.gov/?q=arpa-e-site-page/pre-award-guidance-sbir-sttr>) for guidance on the contents of cost share commitment letters. The ARPA-E Contracting Officer will determine if cost share is allowable under applicable Federal cost principles. For additional information on cost share types and allowability see Section III.E.5 of the FOA.

⁶⁴ The Federal Funding Accountability and Transparency Act, P.L. 109-282, 31 U.S.C. 6101 note.

4. COST SHARE PAYMENTS⁶⁵

All proposed cost share contributions for Phase II and Phase IIS of Combined Phase I/II/IIS awards must be reviewed in advance by the Contracting Officer and incorporated into the project budget before the expenditures are incurred.

ARPA-E requires Prime Recipients to contribute the cost share amount incrementally during the performance of work in Phase II and/or Phase IIS.⁶⁶ Specifically, every Prime Recipient is required to contribute, at a minimum, the cost share percentage of total expenditures incurred during every billing period in Phase II and/or Phase IIS (subject to any applicable Cost Share Grace Period). For example, a Prime Recipient is required to contribute at least 10% of the total expenditures incurred during every billing period in Phase II if the funding agreement states that the cost share percentage in Phase II is 10%.

Prime Recipients must submit written documentation with every reimbursement request demonstrating that it (or Project Team, as appropriate) has provided the requisite cost share during the relevant billing period.

If Prime Recipients anticipate difficulty providing the requisite cost share every billing period, they may request authorization from the Contracting Officer upon selection for award negotiations to deviate from ARPA-E's standard cost share payment schedule.

Please refer to the "SBIR/STTR Applicants' Guide to ARPA-E Award Negotiations" (<http://arpa-e.energy.gov/?q=arpa-e-site-page/pre-award-guidance-sbir-sttr>) for additional guidance on cost share payment requirements.

ARPA-E may deny reimbursement requests, in whole or in part, or modify or terminate funding agreements where Prime Recipients (or Project Teams) fail to comply with ARPA-E's cost share payment requirements.

5. ENVIRONMENTAL IMPACT QUESTIONNAIRE

By law, ARPA-E is required to evaluate the potential environmental impact of projects that it is considering for funding. In particular, ARPA-E must determine before funding a project whether the project qualifies for a categorical exclusion under 10 C.F.R. § 1021.410 or whether it requires further environmental review (i.e., an environmental assessment or an environmental impact statement).

To facilitate and expedite ARPA-E's environmental review, Prime Recipients are required to complete an Environmental Impact Questionnaire during award negotiations. This form is

⁶⁵ Please refer to Section III.E of the FOA for guidance on cost share requirements.

⁶⁶ Prime Recipients may elect to pay the entire cost share amount at the start of the project.

available on ARPA-E' website at <http://arpa-e.energy.gov/?q=arpa-e-site-page/pre-award-guidance-sbir-sttr>. The Environmental Impact Questionnaire is due within 21 calendar days of the selection announcement.

6. TECHNOLOGY-TO-MARKET PLAN

During award negotiations, Prime Recipients are required to negotiate and submit an initial Technology-to-Market Plan for Phase II and Phase IIS with the ARPA-E Program Director, and obtain the ARPA-E Program Director's approval prior to the execution of the award. During the project period, Prime Recipients are required to provide regular updates on the initial Technology-to-Market plan and report on implementation of Technology-to-Market activities. Prime Recipients may be required to perform other actions to further the commercialization of their respective technologies. Prime Recipients are not required to negotiate a Technology-to-Market Plan for Phase I only awards.

ARPA-E Deputy Director for Commercialization may waive or modify this requirement, as appropriate.

7. INTELLECTUAL PROPERTY MANAGEMENT PLAN

ARPA-E requires every Project Team to negotiate and establish an Intellectual Property Management Plan that governs the management and disposition of intellectual property arising from the project, and allocates rights to carry out any follow-on research, development, or commercialization activities. The Prime Recipient must submit a completed and signed Intellectual Property Management Plan to ARPA-E within six weeks of the effective date of the ARPA-E funding agreement. All Intellectual Property Management Plans are subject to the terms and conditions of the ARPA-E funding agreement and its intellectual property provisions, and applicable Federal laws, regulations, and policies, all of which take precedence over the terms of Intellectual Property Management Plan.

ARPA-E has developed a template for Intellectual Property Management Plan (<http://arpa-e.energy.gov/?q=arpa-e-site-page/award-guidance-sbir-sttr>) so as to facilitate and expedite negotiations between Project Team members. ARPA-E does not mandate the use of this template. ARPA-E and DOE do not make any warranty (express or implied) or assume any liability or responsibility for the accuracy, completeness, or usefulness of the template. ARPA-E and DOE strongly encourage Project Teams to consult independent legal counsel before using the template.

8. U.S. MANUFACTURING REQUIREMENT

ARPA-E requires products embodying or produced through the use of subject inventions (i.e., inventions conceived or first actually reduced to practice under ARPA-E funding agreements) to be substantially manufactured in the United States by Project Teams and their licensees, as

described below. The Applicant may request a modification or waiver of the U.S. Manufacturing Requirement.

a. SMALL BUSINESSES

Small businesses (including Small Business Concerns) that are Prime Recipients or Subrecipients under ARPA-E funding agreements are required to substantially manufacture the following products in the United States for any use or sale in the United States: (1) products embodying subject inventions and (2) products produced through the use of subject invention(s).⁶⁷ This requirement does not apply to products that are manufactured for use or sale outside the U.S.A.

Small businesses must apply the same U.S. Manufacturing requirements to their assignees, licensees, and entities acquiring a controlling interest in the small business. Small businesses must require their assignees and entities acquiring a controlling interest in the small business to apply the same U.S. Manufacturing requirements to their licensees.

b. LARGE BUSINESSES AND FOREIGN ENTITIES

Large businesses and foreign entities that are Subrecipients under ARPA-E funding agreements are required to substantially manufacture the following products in the United States: (1) products embodying subject inventions, and (2) products produced through the use of subject invention(s).⁶⁸ This requirement applies to products that are manufactured for use or sale in the United States and outside the United States.

Large businesses and foreign entities must apply the same U.S. Manufacturing requirements to their assignees, licensees, and entities acquiring a controlling interest in the large business or foreign entity. Large businesses and foreign entities must require their assignees and entities acquiring a controlling interest in the large business or foreign entity to apply the same U.S. Manufacturing requirements to their licensees.

⁶⁷ Small businesses are generally defined as domestically incorporated entities that meet the criteria established by the U.S. Small Business Administration's "Table of Small Business Size Standards Matched to North American Industry Classification System Codes" (<http://www.sba.gov/content/small-business-size-standards>). Small businesses include Small Business Concerns, as defined in Note 5.

⁶⁸ Large businesses are generally defined as domestically incorporated entities that do not meet the criteria established by the U.S. Small Business Administration's "Table of Small Business Size Standards Matched to North American Industry Classification System Codes" (<http://www.sba.gov/content/small-business-size-standards>).

c. EDUCATIONAL INSTITUTIONS AND NONPROFITS

Domestic educational institutions and nonprofits that are Subrecipients under ARPA-E funding agreements must require their exclusive licensees to substantially manufacture the following products in the United States for any use or sale in the United States: (1) articles embodying subject inventions, and (2) articles produced through the use of subject invention(s). This requirement does not apply to articles that are manufactured for use or sale overseas.

Educational institutions and nonprofits must require their assignees to apply the same U.S. Manufacturing requirements to their exclusive licensees.

These U.S. Manufacturing requirements do not apply to nonexclusive licensees.

d. FFRDCs and State and Local Government Entities

FFRDCs and state and local government entities are subject to the same U.S. Manufacturing requirements as domestic educational institutions and nonprofits.

9. CORPORATE FELONY CONVICTIONS AND FEDERAL TAX LIABILITY

In submitting an application in response to this FOA, the Applicant represents that:

- It is not a corporation that has been convicted of a felony criminal violation under any Federal law within the preceding 24 months
- It is not a corporation that has any unpaid Federal tax liability that has been assessed, for which all judicial and administrative remedies have been exhausted or have lapsed, and that is not being paid in a timely manner pursuant to an agreement with the authority responsible for collecting the tax liability.

10. APPLICANT RISK ANALYSIS

If selected for award negotiations, ARPA-E may evaluate the risks posed by the applicant using the criteria set forth at 2 CFR §200.205(c), subparagraphs (1) through (4). ARPA-E may require special award terms and conditions depending upon results of the risk analysis.

11. NONDISCLOSURE AND CONFIDENTIALITY AGREEMENTS REPRESENTATIONS

In submitting an application in response to this FOA the Applicant represents that:

- (1) **It does not and will not** require its employees or contractors to sign internal nondisclosure or confidentiality agreements or statements prohibiting or otherwise restricting its employees or contractors from lawfully reporting waste, fraud, or abuse to

a designated investigative or law enforcement representative of a Federal department or agency authorized to receive such information.

- (2) **It does not and will not** use any Federal funds to implement or enforce any nondisclosure and/or confidentiality policy, form, or agreement it uses unless it contains the following provisions:
- a. *“These provisions are consistent with and do not supersede, conflict with, or otherwise alter the employee obligations, rights, or liabilities created by existing statute or Executive order relating to (1) classified information, (2) communications to Congress, (3) the reporting to an Inspector General of a violation of any law, rule, or regulation, or mismanagement, a gross waste of funds, an abuse of authority, or a substantial and specific danger to public health or safety, or (4) any other whistleblower protection. The definitions, requirements, obligations, rights, sanctions, and liabilities created by controlling Executive orders and statutory provisions are incorporated into this agreement and are controlling.”*
 - b. The limitation above shall not contravene requirements applicable to Standard Form 312, Form 4414, or any other form issued by a Federal department or agency governing the nondisclosure of classified information.
 - c. Notwithstanding provision listed in paragraph (a), a nondisclosure or confidentiality policy form or agreement that is to be executed by a person connected with the conduct of an intelligence or intelligence-related activity, other than an employee or officer of the United States Government, may contain provisions appropriate to the particular activity for which such document is to be used. Such form or agreement shall, at a minimum, require that the person will not disclose any classified information received in the course of such activity unless specifically authorized to do so by the United States Government. Such nondisclosure or confidentiality forms shall also make it clear that they do not bar disclosure to congress, or to an authorized official of an executive agency or the Department of Justice, that are essential to reporting a substantial violation of law.

C. REPORTING

Recipients are required to submit periodic, detailed reports on technical, financial, and other aspects of the project, as described in Attachment 4 to ARPA-E's Model Cooperative Agreement for SBIR/STTR Awards (<http://arpa-e.energy.gov/?q=arpa-e-site-page/award-guidance-sbir-sttr>).

VII. AGENCY CONTACTS

A. COMMUNICATIONS WITH ARPA-E

Upon the issuance of a FOA, only the Contracting Officer may communicate with Applicants. ARPA-E personnel and our support contractors are prohibited from communicating (in writing or otherwise) with Applicants regarding the FOA. This “quiet period” remains in effect until ARPA-E’s public announcement of its project selections.

During the “quiet period,” Applicants are required to submit all questions regarding this FOA to ARPA-E-CO@hq.doe.gov. Frequently Asked Questions (FAQs) about ARPA-E and its FOAs are available at <http://arpa-e.energy.gov/faq>. For questions that have not already been answered, please send an email with the FOA name and number in the subject line to ARPA-E-CO@hq.doe.gov. Due to the volume of questions received, ARPA-E will only answer pertinent questions that have not yet been answered and posted at the above link.

- ARPA-E will post responses on a weekly basis to any questions that are received that have not already been addressed at the link above. ARPA-E may re-phrase questions or consolidate similar questions for administrative purposes.
- ARPA-E will cease to accept questions approximately 5 business days in advance of each submission deadline. Responses to questions received before the cutoff will be posted approximately one business day in advance of the submission deadline. ARPA-E may re-phrase questions or consolidate similar questions for administrative purposes.
- Responses to questions specific to this FOA are posted to the “GENSETS SBIR/STTR FOA Questions and Answers” document on ARPA-E’s website (<http://arpa-e.energy.gov/faq>).

Applicants may submit questions regarding ARPA-E eXCHANGE, ARPA-E’s online application portal, to ExchangeHelp@hq.doe.gov. ARPA-E will promptly respond to emails that raise legitimate, technical issues with ARPA-E eXCHANGE. ARPA-E will refer any questions regarding the FOA to ARPA-E-CO@hq.doe.gov.

ARPA-E will not accept or respond to communications received by other means (e.g., fax, telephone, mail, hand delivery). Emails sent to other email addresses will be disregarded.

During the “quiet period,” only the Contracting Officer may authorize communications between ARPA-E personnel and Applicants. The Contracting Officer may communicate with Applicants as necessary and appropriate. As described in Section IV.A of the FOA, the Contracting Officer may arrange pre-selection meetings and/or site visits during the “quiet period.”

Questions about this FOA? Check the Frequently Asked Questions available at <http://arpa-e.energy.gov/faq>. For questions that have not already been answered, email ARPA-E-CO@hq.doe.gov (with FOA name and number in subject line); see FOA Sec. VII.A. Problems with ARPA-E eXCHANGE? Email ExchangeHelp@hq.doe.gov (with FOA name and number in subject line).

B. DEBRIEFINGS

ARPA-E does not offer or provide debriefings.

VIII. OTHER INFORMATION

A. FOAs AND FOA MODIFICATIONS

FOAs are posted on ARPA-E eXCHANGE (<https://arpa-e-foa.energy.gov/>), Grants.gov (<http://www.grants.gov/>), and FedConnect (<https://www.fedconnect.net/FedConnect/>), and the Government-wide SBIR/STTR website (<http://www.sbir.gov>). Any modifications to the FOA are also posted to these websites. You can receive an e-mail when a modification is posted by registering with FedConnect as an interested party for this FOA. It is recommended that you register as soon as possible after release of the FOA to ensure that you receive timely notice of any modifications or other announcements. More information is available at <https://www.fedconnect.net>.

B. OBLIGATION OF PUBLIC FUNDS

The Contracting Officer is the only individual who can make awards on behalf of ARPA-E or obligate ARPA-E to the expenditure of public funds. A commitment or obligation by any individual other than the Contracting Officer, either explicit or implied, is invalid.

ARPA-E awards may not be transferred, assigned, or assumed without the prior written consent of a Contracting Officer.

C. REQUIREMENT FOR FULL AND COMPLETE DISCLOSURE

Applicants are required to make a full and complete disclosure of the information requested in the Business Assurances & Disclosures Form. Disclosure of the requested information is mandatory. Any failure to make a full and complete disclosure of the requested information may result in:

- The rejection of a Full Application
- The termination of award negotiations
- The modification, suspension, and/or termination of a funding agreement
- The initiation of debarment proceedings, debarment, and/or a declaration of ineligibility for receipt of Federal contracts, subcontracts, and financial assistance and benefits
- Civil and/or criminal penalties

Questions about this FOA? Check the Frequently Asked Questions available at <http://arpa-e.energy.gov/faq>. For questions that have not already been answered, email ARPA-E-CO@hq.doe.gov (with FOA name and number in subject line); see FOA Sec. VII.A. Problems with ARPA-E eXCHANGE? Email ExchangeHelp@hq.doe.gov (with FOA name and number in subject line).

D. RETENTION OF SUBMISSIONS

ARPA-E expects to retain copies of all Full Applications and other submissions. By applying to ARPA-E for funding, Applicants consent to ARPA-E's retention of their submissions.

E. MARKING OF CONFIDENTIAL INFORMATION

ARPA-E will use data and other information contained in Full Applications strictly for evaluation purposes.

Full Applications and other submissions containing confidential, proprietary, or privileged information must be marked as described below. Failure to comply with these marking requirements may result in the disclosure of the unmarked information under the Freedom of Information Act or otherwise. The U.S. Government is not liable for the disclosure or use of unmarked information, and may use or disclose such information for any purpose.

The cover sheet of the Full Application or other submission must be marked as follows and identify the specific pages containing confidential, proprietary, or privileged information:

Notice of Restriction on Disclosure and Use of Data:

Pages [____] of this document may contain confidential, proprietary, or privileged information that is exempt from public disclosure. Such information shall be used or disclosed only for evaluation purposes or in accordance with a financial assistance or loan agreement between the submitter and the Government. The Government may use or disclose any information that is not appropriately marked or otherwise restricted, regardless of source.

The header and footer of every page that contains confidential, proprietary, or privileged information must be marked as follows: "Contains Confidential, Proprietary, or Privileged Information Exempt from Public Disclosure." In addition, every line and paragraph containing proprietary, privileged, or trade secret information must be clearly marked with double brackets or highlighting.

F. TITLE TO SUBJECT INVENTIONS

Ownership of subject inventions is governed pursuant to the authorities listed below. Typically, either by operation of law or under the authority of a patent waiver, Prime Recipients and Subrecipients may elect to retain title to their subject inventions under ARPA-E funding agreements.

- Domestic Small Businesses, Educational Institutions, and Nonprofits: Under the Bayh-Dole Act (35 U.S.C. § 200 et seq.), domestic small businesses, educational institutions, and nonprofits may elect to retain title to their subject inventions. If they elect to retain title, they must file a patent application in a timely fashion.
- All other parties: The Federal Non Nuclear Energy Act of 1974, 42. U.S.C. 5908, provides that the Government obtains title to new inventions unless a waiver is granted (*see below*).
- Class Waiver: Under 42 U.S.C. § 5908, title to subject inventions vests in the U.S. Government and large businesses and foreign entities do not have the automatic right to elect to retain title to subject inventions. However, ARPA-E typically issues “class patent waivers” under which large businesses and foreign entities that meet certain stated requirements may elect to retain title to their subject inventions. If a large business or foreign entity elects to retain title to its subject invention, it must file a patent application in a timely fashion. If the class waiver does not apply, a party may request a waiver in accordance with 10 C.F.R. §784.

G. GOVERNMENT RIGHTS IN SUBJECT INVENTIONS

Where Prime Recipients and Subrecipients retain title to subject inventions, the U.S. Government retains certain rights.

1. GOVERNMENT USE LICENSE

The U.S. Government retains a nonexclusive, nontransferable, irrevocable, paid-up license to practice or have practiced for or on behalf of the United States any subject invention throughout the world. This license extends to contractors doing work on behalf of the Government.

2. MARCH-IN RIGHTS

The U.S. Government retains march-in rights with respect to all subject inventions. Through “march-in rights,” the Government may require a Prime Recipient or Subrecipient who has elected to retain title to a subject invention (or their assignees or exclusive licensees), to grant a license for use of the invention. In addition, the Government may grant licenses for use of the subject invention when Prime Recipients, Subrecipients, or their assignees and exclusive licensees refuse to do so.

The U.S. Government may exercise its march-in rights if it determines that such action is necessary under any of the four following conditions:

- The owner or licensee has not taken or is not expected to take effective steps to achieve practical application of the invention within a reasonable time
- The owner or licensee has not taken action to alleviate health or safety needs in a reasonably satisfactory manner
- The owner has not met public use requirements specified by Federal statutes in a reasonably satisfactory manner
- The U.S. Manufacturing requirement has not been met

H. RIGHTS IN TECHNICAL DATA

Data rights differ based on whether data is first produced under an award or instead was developed at private expense outside the award.

- Background or “Limited Rights Data”: The U.S. Government will not normally require delivery of technical data developed solely at private expense prior to issuance of an award, except as necessary to monitor technical progress and evaluate the potential of proposed technologies to reach specific technical and cost metrics.
- Generated Data: The U.S. Government normally retains very broad rights in technical data produced under Government financial assistance awards, including the right to distribute to the public. However, pursuant to special statutory authority, certain categories of data generated under ARPA-E SBIR/STTR awards may be protected from public disclosure for up to four years from delivery of the last deliverables under the agreement. Such data should be clearly marked as described in Attachment 4 to ARPA-E’s Model Cooperative Agreement for SBIR/STTR Awards (<http://arpa-e.energy.gov/?q=arpa-e-site-page/award-guidance-sbir-sttr>). In addition, invention disclosures may be protected from public disclosure for a reasonable time in order to allow for filing a patent application.

I. PROTECTED PERSONALLY IDENTIFIABLE INFORMATION

Applicants may not include any Protected Personally Identifiable Information (Protected PII) in their submissions to ARPA-E. Protected PII is defined as data that, if compromised, could cause harm to an individual such as identity theft. Listed below are examples of Protected PII that Applicants must not include in their submissions.

- Social Security Numbers in any form
- Place of Birth associated with an individual
- Date of Birth associated with an individual
- Mother’s maiden name associated with an individual

Questions about this FOA? Check the Frequently Asked Questions available at <http://arpa-e.energy.gov/faq>. For questions that have not already been answered, email ARPA-E-CO@hq.doe.gov (with FOA name and number in subject line); see FOA Sec. VII.A. Problems with ARPA-E eXCHANGE? Email ExchangeHelp@hq.doe.gov (with FOA name and number in subject line).

- Biometric record associated with an individual
- Fingerprint
- Iris scan
- DNA
- Medical history information associated with an individual
- Medical conditions, including history of disease
- Metric information, e.g. weight, height, blood pressure
- Criminal history associated with an individual
- Ratings
- Disciplinary actions
- Performance elements and standards (or work expectations) are PII when they are so intertwined with performance appraisals that their disclosure would reveal an individual's performance appraisal
- Financial information associated with an individual
- Credit card numbers
- Bank account numbers
- Security clearance history or related information (not including actual clearances held)

J. ADDITIONAL NOTICES

- This FOA is intended for informational purposes and reflects current planning. If there is any inconsistency between the information contained herein and the terms of any resulting SBIR or STTR funding agreement, the terms of the funding agreement are controlling.
- Before award of an SBIR or STTR funding agreement, ARPA-E may request the selectee to submit certain organizational, management, personnel, and financial information to assure responsibility of the Prime Recipient. In addition, selectees will be required to make certain legal commitments at the time of execution of funding agreements resulting from this FOA. ARPA-E encourages Prime Recipients to review the Model Cooperative Agreement for SBIR/STTR Awards, which is available at <http://arpa-e.energy.gov/?q=arpa-e-site-page/award-guidance-sbir-sttr>.
- ARPA-E will not pay a fee or profit on Cooperative Agreements resulting from this FOA to recipients or subrecipients.
- Actual or suspected fraud, waste, or abuse may be reported to the DOE Office of Inspector General (OIG) at 1-800-541-1625.

IX. GLOSSARY

Applicant: The Small Business Concern that submits the application to ARPA-E. In the case of a Project Team, the Applicant is the lead organization listed on the application.

Application: The entire submission received by ARPA-E .

ARPA-E: Advanced Research Projects Agency-Energy.

Cost Share: The Prime Recipient required share of the Total Project Cost.

Deliverable: A deliverable is the quantifiable goods or services that will be provided upon the successful completion of a project task or sub-task.

DOE: U.S. Department of Energy.

DOE/NNSA: U.S. Department of Energy/National Nuclear Security Administration

FFRDCs: Federally Funded Research and Development Centers.

FOA: Funding Opportunity Announcement.

GOGOs: U.S. Government Owned, Government Operated laboratories.

Key Participant: Any individual who would contribute in a substantive, measurable way to the execution of the proposed project.

Milestone: A milestone is the tangible, observable measurement that will be provided upon the successful completion of a project task or sub-task.

Prime Recipient: The signatory to the funding agreement with ARPA-E.

PI: Principal Investigator.

Project Team: A Project Team consists of the Prime Recipient, Subrecipients, and others performing or otherwise supporting work under an ARPA-E funding agreement.

R&D: Research and development.

SBA: U.S. Small Business Administration.

SBIR: Small Business Innovation Research Program.

Small Business Concern: A for-profit entity that: (1) maintains a place of business located in the United States; (2) operates primarily within the United States or makes a significant contribution to the United States economy through payment of taxes or use of American products, materials or labor; (3) is an individual proprietorship, partnership, corporation, limited liability company, joint venture, association, trust, or cooperative; and (4) meets the size eligibility requirements set forth in 13 C.F.R. § 121.702. Where the entity is formed as a joint venture, there can be no more than 49% participation by foreign business entities in the joint venture.

Standalone Applicant: An Applicant that applies for funding on its own, not as part of a Project Team.

STTR: Small Business Technology Transfer Program.

Subject Invention: Any invention conceived or first actually reduced to practice under an ARPA-E funding agreement.

Task: A task is an operation or segment of the work plan that requires both effort and resources. Each task (or sub-task) is connected to the overall objective of the project, via the achievement of a milestone or a deliverable.

Total Project Cost: The sum of the Prime Recipient share and the Federal Government share of total allowable costs. The Federal Government share generally includes costs incurred by GOGOs and FFRDCs.