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Accelerating the Clean Energy Revolution

Mapping the Clean Energy Innovation Investment Ecosystem

Initial global scan of key players financing clean energy innovation

June 2017

This analysis was commissioned by Natural Resources Canada, and performed by the Cleantech Group.
It does not necessarily represent the views of the Government of Canada.

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Executive Summary

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Objectives

- Establish an initial knowledge base of the investment ecosystem for clean energy innovation , beginning with three Innovation Challenges (ICs): **Off-Grid Access to Electricity**, **Sustainable Biofuels**, and **Clean Energy Materials**
- Establish a methodology for developing private sector engagement strategies in these three ICs

Activities

- Identify investors, businesses, incubators/accelerators, government initiatives, labs, universities, and industry associations that align with the specific scope of each IC
- Analyze investment flows and key trends in each IC to support development of initial hypotheses regarding key participants to engage and types of challenges to resolve to attract and encourage investment in emerging technologies

Key Findings

- The three ICs vary in technological and business model maturity
  - Each IC ecosystem has a unique balance of private and public sector participants
  - Investor engagement will align with IC maturity (from seed to growth capital)
- Engagement strategy will be IC-specific, requiring close alignment with technical teams

Next Steps

- Further develop engagement strategy by interviewing key ecosystem participants
- Align with IC technical teams to identify critical areas of input for private sector participants

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Key Findings

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Each IC targets technologies and business models at different levels of maturity, resulting in varied targeted ecosystem participants across ICs

	Off-Grid Access	Sustainable Biofuels	Clean Energy Materials
Maturity	• Solar PV technology is readily available for off-grid use; however, adaptable appliance technologies are currently at lower TRLs • Business models, such as pay-as-you-go, are rapidly maturing	• Commercially available second-generation biofuels exist and have been used by major corporations • Business models and potential supply chain structures are well-known	• Innovation in the material discovery and development process is in early stages of development with limited private sector adoption, but is gaining momentum • Initial business models have been developed, but are not yet proven
Target Ecosystem	• Startups developing off-grid business models • Incubators and investors supporting the startups • Public sector banks and nonprofits providing grant financing for electrification efforts • Corporates in energy equipment supply and financial firms who may assist in credit history development	• Corporates in aviation, shipping, equipment manufacturing and fueling • Multinational and industry organizations in aviation and shipping • Investors active in biofuels • Startups developing advanced biofuels from innovative feedstocks	• Universities and labs that are leading material discovery innovation and the application of robotics • Startups that are applying material discovery innovation • Investors financing the startups • Corporations that are implementing material discovery and robotics-assisted material development

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Snapshot – Off-Grid Access to Electricity

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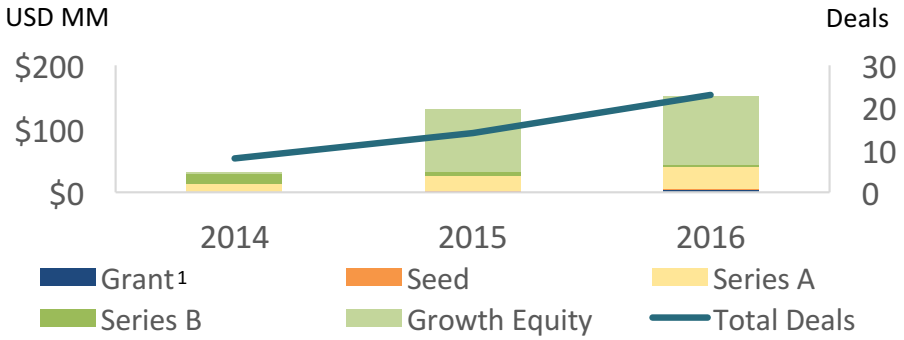
Challenge Definition and Scope

- Manufacture, financing, delivery, and provision of services for standalone renewable power generation systems, with a focus upon isolated rural households and communities
- Excludes power generation over 100kw
- Power generation type primarily solar PV, but also includes wind, tidal, storage and other forms of off-grid generation

Investment Flows



Source: CTG i3 database, CTG research and analysis
[1]Includes grants made to for-profit entities

Private Sector Challenges

A. Credit risk and geographic unfamiliarity concerns limit early-stage private investment
B. Geographic fragmentation of off-grid market requires geographic, technological, and culturally specific solutions, which in turn present issues in developing scalable business models
C. Appliance innovation is in earlier stages than energy access innovation

Initial Engagement Hypotheses

- **Challenge A**: Share information on geopolitical/ macroeconomic environments and geography-specific best practices with private sector businesses and investors to de-risk perception of early-stage investment.
- **Challenge B**: Facilitate interaction across regional participants and technology providers to identify potential synergies and opportunities for developing scale
- **Challenge C**: Evaluate opportunities to build appliance-focused business models off of energy access progress

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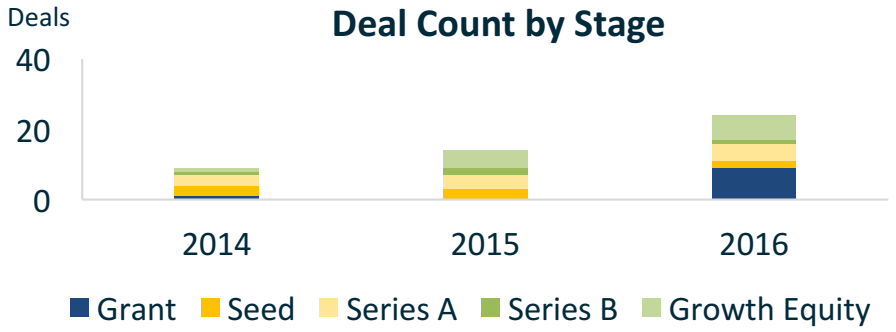
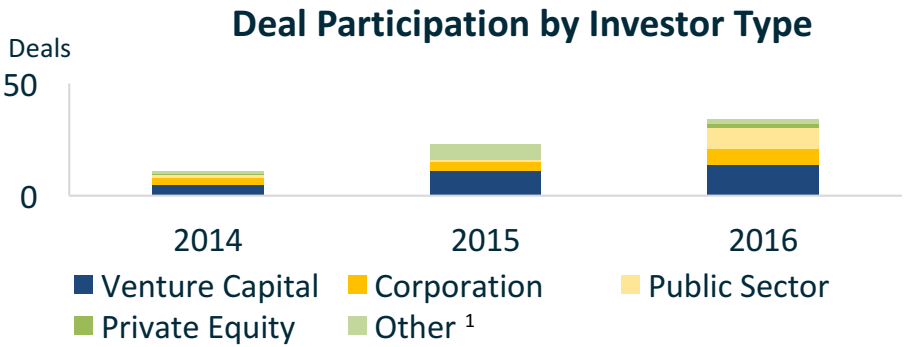
Investment Flows – Off-Grid Access to Electricity

2014-2016 Investment Overview





Source: CTG i3 database, CTG analysis
[1]Includes angel investors, individuals, crowdfunding, and other sources

Observations

- Total deal count has increased since 2014, representing both increased public and private participation
- Public sector grant funding has increased since 2014, representing an increase in general awareness and public sector activity, driven by factors such as the Paris Agreement in 2015
- Growth equity investment in particular has been buoyed by major private investments in 2016, in Lumos Global ($90MM) and Off Grid Electric ($58MM), indicating private sector demand for established off-grid companies
- However, early-stage funding has been scarce, as the majority of investors are in North America and Europe. As such, many are unfamiliar with investment in sub-Saharan Africa and India and the path to large-scale business models is unclear to investors concerned about geographic fragmentation, resulting in a higher perceptions of risk

Private Sector Engagement – Off-Grid Access to Electricity (1 of 2)

- Early-stage private sector investment in off-grid startups is limited, especially in seed round funding.
  - Though investors are aware of the vast potential market, unfamiliarity with developing world investment ecosystem(s) increases risk perceptions. Country-level risk briefs from public organizations would help reduce risk perceptions
  - Integration of advancements in credit evaluation, potentially from fintech, big data and/or IoT, may unlock further early-stage private investment. Energy payment patterns can also help establish credit history to consumer financiers
- Public sector grants and charitable funds have been critical in enabling early off-grid success, but more diverse mechanisms are required for early-stage startup funding.
  - Growing startups such as d.Light and BBOXX, among others, have received early funding from public sector grant programs such as USAID Scaling Off-Grid Energy Grand Challenge Enterprise and the Africa Enterprise Challenge Fund (AECF).
  - Off-grid startups have argued that equity capital is preferable to debt (whether from public sector such as AfDB Facility for Energy Inclusion or private sector), suggesting that debt financing is too expensive in its existing form

Private Sector Engagement – Off-Grid Access to Electricity (2 of 2)

- Accelerators are playing an important role in the development of off-grid startups
  - InnoEnergy, Climate KIC, and PowerHouse have 20 off-grid companies in their portfolios, primarily focused on the technology portions of the value chain
  - Selco Incubation Centre, located in Bangalore, supports local entrepreneurs addressing electricity access challenges
    - Incubation support for local entrepreneurs developing sales/customer solutions business models rather than off-grid technology packages
    - Supported by Small Scale Infrastructure Development Fund, with investors including socially-focused organizations E+Co, The Lemelson Foundation, and The Good Energies Foundation
- Innovation in energy-efficient appliances compatible with renewable generation is in very early stages
  - Customer relationships, brand reputation, and channel access from energy access providers may provide opportunities to shortcut business model development for appliance providers

Snapshot – Sustainable Biofuels

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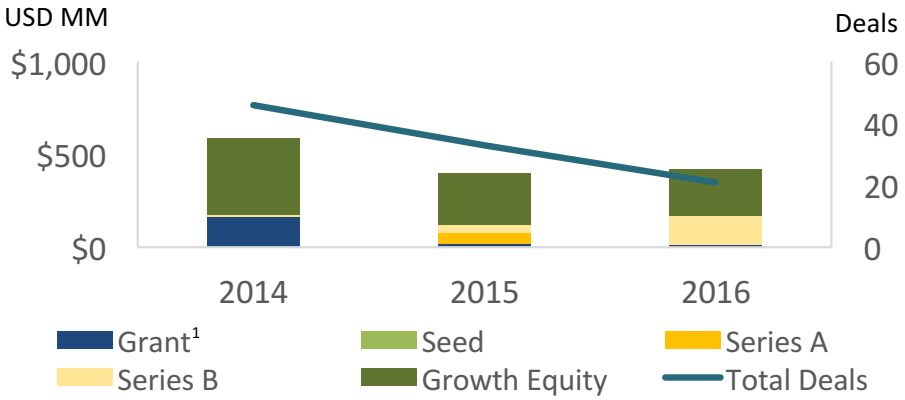
Challenge Definition and Scope

- To develop ways to produce, at scale, widely affordable, advanced biofuels for transportation and industrial applications
- Excludes first generation (food-based) solutions
- Transportation applications focus on aviation and shipping industries, rather than personal vehicles

Investment Flows



Source: CTG i3 database, CTG research and analysis
[1]Includes grants made to for-profit entities

Private Sector Challenges

A. While the aviation industry has been active in piloting and adopting biofuels, shipping/ marine has made less progress
B. Feedstock scalability potential is uncertain
C. Investment in early-stage (seed-Series B) startups has been low, suggesting shrinking future pipeline of biofuels companies

Initial Engagement Hypotheses

- **Challenge A**: Engage with biofuels users through industry-specific multinational organizations such as ICAO and SAFUG (aviation) and IMO and the Sustainable Shipping Initiative (shipping) to target specific needs per use case
- **Challenge B**: In conjunction with Advanced Materials IC, investigate potential for materials discovery platforms to accelerate biofuel adoption through feedstock innovation
- **Challenge C**: Facilitate discussions with investors to identify specific concerns and potential mitigation/ support structure options

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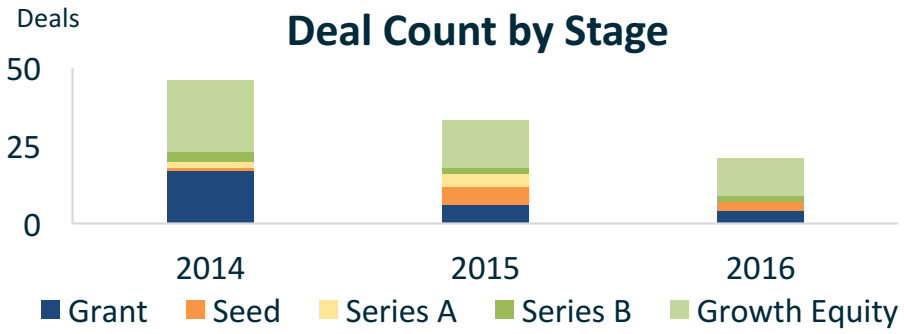
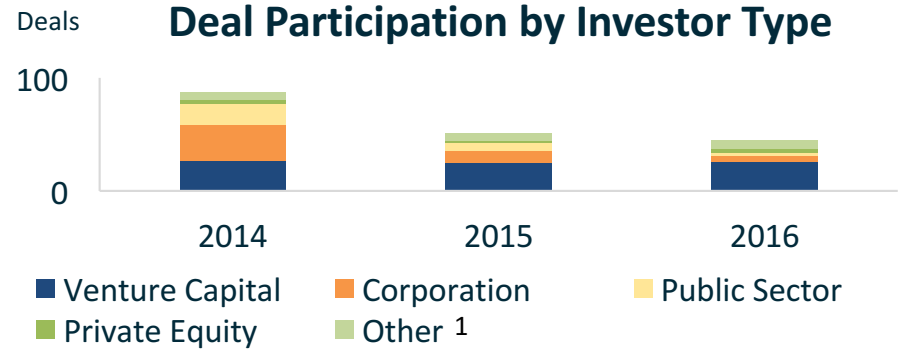
Investment Flows – Sustainable Biofuels

2014-2016 Investment Overview





Source: CTG i3 database, CTG analysis
[1]Includes angel investors, individuals, crowdfunding, and other sources

Observations

- Total deal counts have dropped off significantly since 2014, with corporate and public sector investment accounting for much of the decline
- Venture capital participation has remained steady, but is largely participating in growth equity rounds rather than earlier stages
- Earlier stage (seed, Series A, and Series B) financing has been scarce, with only 23 total deals over 2014-16 in comparison to 50 growth equity financings
  - The decline in early stage financings indicates a capacity issue for further investigation
- Ginkgo Bioworks and Zymergen are strain improvement/ discovery platforms leveraging advanced computational techniques and have raised over $300MM in combined financing, indicating strong interest from investors in the potential of such technologies and business models

Private Sector Engagement – Sustainable Biofuels (1 of 2)

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- Corporates across the value chain from engines/turbines to fuel end users have been active participants across the innovation spectrum, from technology development partnerships to investment in startups to biofuel demonstration and offtake agreements.
- The aviation industry provides case studies for biofuel adoption and development:
  - The Sustainable Aviation Fuel Users Group (SAFUG) includes 28 airlines and major manufacturers Boeing, Airbus, and Embraer
  - SAFUG members United Airlines and Cathay Pacific have invested in biofuels startups and others such as KLM, Lufthansa, Scandinavian Airlines, Southwest, and JetBlue have signed offtake agreements
  - Offtake agreements include participation from major fuel suppliers such as Neste, Air BP, and Total; startups such as Fulcrum Bioenergy, AltAir Fuels, Amyris, Gevo, and SkyNRG; and aviation services company World Fuel Services
  - Scalability of feedstocks for airline use specifications remains a key concern

Private Sector Engagement – Sustainable Biofuels (2 of 2)

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- Though the shipping industry has been less active, notable developments include:
  - Formation of the Sustainable Shipping Initiative, which includes ship owner/operators Maersk, U-Ming Marine, IMC, Cargill, and Bunge; engine manufacturer Wartsila; and NGOs Forum for the Future and World Wildlife Foundation
  - Royal Boskalis Westminster, Wartsila, and GoodFuels partnering for a 2-year development program for drop-in biofuels
  - MAN B&W delivering its dual-fuel tankers, capable of running on methanol, to operator Waterfront Shipping Co.
  - Shipping has focused on methanol, while aviation has focused on fuels based on jatropha or waste vegetable oil
- Investors of note include North Bridge Venture Partners, Data Collective, Draper Fisher Jurvetson, and Braemar Energy Ventures, who have all participated in 3 or more venture financings over 2014-16
- European accelerators Innoenergy and Climate KIC have a combined 14 biofuels companies in their portfolios; Elemental Excelerator is the only North American program with multiple biofuels companies

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Snapshot – Clean Energy Materials

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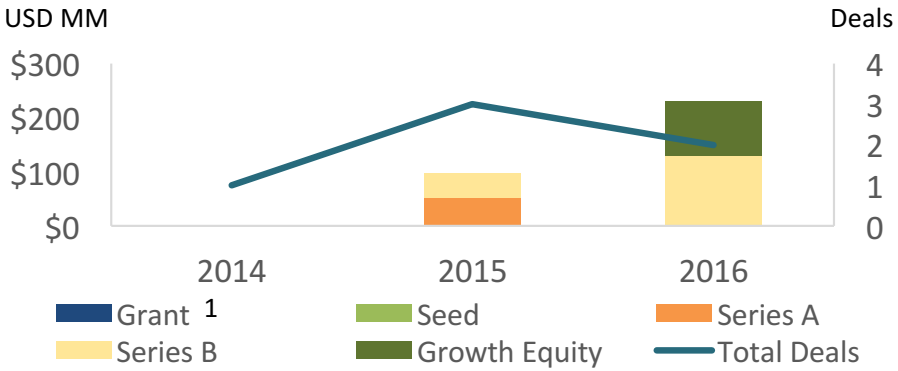
Challenge Definition and Scope

- To accelerate by 10x the innovation process for the exploration, discovery, and use of new, high-performance, low-cost clean energy materials.
- Directed towards developing a fully integrated, end-to-end platform that will accelerate materials discovery along the whole process from low to high technology readiness levels (TRLs).

Investment Flows



Source: CTG i3 database, CTG research and analysis
[1]Includes grants made to for-profit entities

Private Sector Challenges

A. Innovation in materials synthesis and testing has shown limited public sector piloting and has not yet shown private sector adoption

B. Uncertainty about whether development of public sector open data initiatives will overlap/compete with current private sector business models

Initial Engagement Hypotheses

- **Challenge A**: Explore opportunities for public sector efforts to complement private sector interests and limitations, particularly with the potential use of robotics for materials development and testing
- **Challenge B**: Engage startups and investors in materials discovery to develop a clear understanding of business and revenue models, particularly with regard to legal/IP

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Investment Flows – Clean Energy Materials

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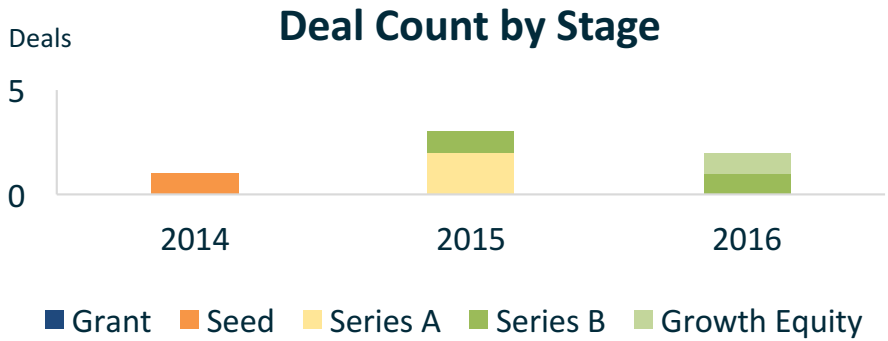
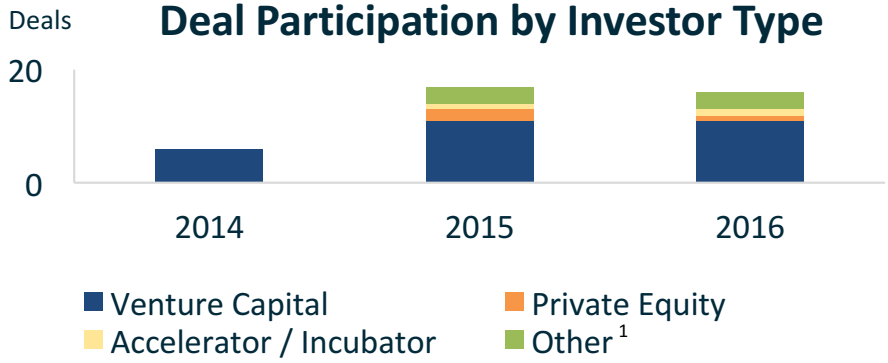
2014-2016 Investment Overview





Source: CTG i3 database, CTG analysis
[1]Includes angel investors, individuals, crowdfunding, and other sources

Observations

- Financing of private sector startups in advanced material discovery techniques has been limited in count, but large Series B and growth equity financings in 2016 suggest rapid momentum gains
- Four investors have participated in financing of multiple companies in this sector, with biology companies Zymergen and Ginkgo Bioworks featuring prominently
  - AME Cloud Ventures
  - Data Collective
  - Innovation Endeavors
  - Prelude Ventures
- While investors have shown interest in material discovery through advanced computation, synthesis and testing companies without discovery capability have not gained traction with investors
  - With uncertainty regarding business and revenue models, this may be a key area for public sector participation

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Private Sector Engagement – Clean Energy Materials (1 of 2)

- Organizations and initiatives applying advanced computational techniques to materials discovery include:
  - Public sector initiatives such as the Materials Genome Initiative, Novel Materials Discovery (NOMAD), the Energy Materials Network
  - Startup companies in advanced materials/chemicals (Citrine Informatics, Exabyte.io) and biology (Zymergen and Ginkgo Bioworks)
  - Corporates such as BASF, Dow Chemical, and Schrodinger
  - Nonprofit laboratories such as Battelle Memorial Institute, Southwest Research Institute, Toyota Research Institute, and SRI International
  - Academic institutions such as the University of Liverpool and University College London
- Dow Chemical has also developed automated techniques leveraging robotics for high-throughput synthesis in industrial coatings

Private Sector Engagement – Clean Energy Materials (2 of 2)

- Materials discovery and testing companies focusing on battery chemistries such as Wildcat Discovery Technologies, Polaris Battery Labs, and Ilika have also received venture financing
  - The business models and approach to IP these companies use may provide examples for private sector development
- Investors AME Cloud Ventures, Innovation Endeavors, and Prelude Ventures stand out for their financing of both Citrine Informatics and Zymergen; Data Collective Venture Capital has financed Zymergen and Ginkgo Bioworks
- Pharmaceuticals are a potential source of synergies, as a number of startups are applying machine learning for drug discovery

Summary of Initial Engagement Hypotheses

	Off-Grid Access	Sustainable Biofuels	Clean Energy Materials
Participants	• Facilitate interaction across regional participants and technology providers to identify potential synergies and opportunities for developing scale	• Engage with biofuels users through industry organizations such as IMO and ICAO to target specific needs per use case • Facilitate discussions with investors to identify specific concerns and potential mitigation/support structure options	• Engage startups and investors in materials discovery to develop a clear understanding of business and revenue models, particularly with regard to legal/IP
Topics	• Share information on geopolitical/ macroeconomic environments, and geography-specific best practices with private sector businesses and investors to de-risk perception of early-stage investment. • Evaluate opportunities to build appliance-focused business models off of energy access progress	• In conjunction with Advanced Materials IC, investigate potential for materials discovery platforms to accelerate biofuel adoption through feedstock innovation	• Explore opportunities for public sector efforts to complement private sector interests and limitations, particularly with the potential use of robotics for materials development and testing

Next Steps

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- Share findings with IC technical groups and collect feedback
- Further develop private sector engagement hypotheses by interviewing specifically selected ecosystem participants for each IC
  - Off-Grid Access to Electricity
    - Interview venture funds who have backed early-stage startups about their investment evaluation methods in off-grid access to determine key aspects of startups who have been successful in raising funds
    - Interview startups who seek a wider range of financing options and structures, and procure startup perspectives on potential for appliances adapted to off-grid use cases
  - Sustainable Biofuels
    - Assess investor perspective on decline in early-stage financings and past challenges in growing companies
    - Identify synergies with industry associations for biofuels and how MI resources can be best leveraged
  - Clean Energy Materials
    - Interview startups to develop understanding of revenue and business models and handling of IP
    - Establish investor perspective on key uncertainties and areas for public sector involvement in materials synthesis and testing

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GLOSSARY

Ecosystem Participant Definitions

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- **Fund**: Private sector vehicles investing directly into startups and/or startup projects via equity, venture debt, or project financing mechanisms.
- **Corporate (investor)**: Publicly traded (or otherwise mature and established) companies investing directly into startups and/or startup projects.
- **Corporate (non-investor)**: Publicly traded companies engaging with innovation without investing (joint development, technology partner, licensee, etc). Excludes corporate-owned incubators/accelerators.
- **Government**: State-owned entities enabling innovation, including investment. Can include investment arms, research organizations/labs, one-off initiatives.
- **Incubator/Accelerator**: Organizations providing startups developmental and operational support. Can include financial support and investment. Includes stand-alone, corporate, and government-supported incubators and accelerators.

Stage Definitions

- **Grant**: Non-repayable funds, consisting of cash and potentially other types of support, for specific use purposes.
- **Seed**: The first stage of venture capital financing, often for the early development of a new product or service. Commonly used for product development, market research, building a management team and developing a business plan.
- **Series A**: The first round of financing, often when external investors are given company ownership for the first time. Commonly raised for gaining product traction.
- **Series B**: Second round the financing, commonly raised for scaling product with existing traction.
- **Growth Equity**: Series C, D, etc., raised by growing companies for ongoing scaling of the business

Relationship Definitions

- **Channel Partner**: A partnership where one company provides another with a sales avenue in which to sell its product.
- **Customer**: Customers are those that buy the company's end product, as well as those companies whose products it buys (i.e. suppliers).
- **Development Partner**: When 2 or more companies work together to develop a product or project, but not integrate their technologies together. Examples might include a company allowing another to use its facilities to pilot/test its product or a utility putting out an RFP to vendors for their smart meter deployment. It might include a manufacturing partnerships where companies may build a factory together or expand into a new region. It may include companies working on a particular project together.
- **Joint Venture**: Two or more companies setting up and jointly investing in a new company set up for a specific purpose in order to leverage their different skill sets.
- **Licensee**: The customer (licensee) instead of outright buying the licensers end product, pays the licenser a fee to use its technology and IP in its own product.
- **Project Development**: A partnership whereby two or more companies work together to build a particular plant together.
- **Technology Partner**: When 2 (or more) companies integrate their technologies with one another