Meeting the Worlds Energy Demands More Effectively and Efficiently
ThermoPhotoVoltaics (TPV)

Combustion
- Gas
- Oil
- Coal

NUCLEAR

WASTE HEAT

SOLAR

Micron-gap ThermoPhotoVoltaics (MTPV)

Combustion
- Gas
- Oil
- Coal

NUCLEAR

WASTE HEAT

SOLAR

HOT

BLACKBODY RADIATIVE SURFACE

MACROSCALE GAP

PHOTOVOLTAIC

PLANK'S LAW = \( \sigma T^4 \)
INDEPENDENT OF GAP DIMENSION

POWER TRANSFER

MICROSCALE GAP

PHOTOVOLTAIC

EVANESCENT COUPLING REGIME
DEPENDENT OF GAP DIMENSION

GAP (microns)

0.5

1.0

POWER

1x

2.5x

5x

7.5x

10x

MTPV confidential material for intended audience only
High Power & High Efficiency

*estimated based on past performance and scientific models
## Opportunities for Growth

### Automotive
- All Electric Drive Hybrid Primary Power
- Stand-alone Alternator
- Waste heat recovery
- Heavy equipment industry

### Solar
- Distributed, Modular CSP
- 24/7, Dispatchable, Cogen Solar
- Solar Storage
- Low beam uniformity req’d

### Industrial
- On-site CoGen
- Glass industry
- Steel industry
- Cement industry

### Portable Power
- Fuel to electricity
- Power tools
- Portable electronics
- Mobile power
MTPV Square Meter Panel (~10 KW)
The Challenge

Science / Invention / Idea

\[ I = -e \int d\varepsilon_b \int d\varepsilon_1 \int d\varepsilon_a \int d\varepsilon_3 \rho_b(\varepsilon_b) \rho_1(\varepsilon_1) \rho_a(\varepsilon_a) \rho_3(\varepsilon_3) \]
\[ \times \frac{2\pi}{\hbar} |\langle r_a, r_3 | U_{\text{eff}}(\varepsilon_1 + \varepsilon_b) | r_b, r_1 \rangle|^2 \delta(\varepsilon_b + \varepsilon_1 - \varepsilon_a - \varepsilon_3) \]
\[ \times \{p_b(\varepsilon_b)p_1(\varepsilon_1)[1 - p_a(\varepsilon_a)][1 - p_3(\varepsilon_3)] - p_a(\varepsilon_a)p_3(\varepsilon_3) \]
\[ \times [1 - p_b(\varepsilon_b)][1 - p_1(\varepsilon_1)] \}. \]

How Do You Fund The Journey?

Saleable Product
The Idea

\[ l = -e \int d\epsilon_b \int d\epsilon_1 \int d\epsilon_a \int d\epsilon_3 \rho_b(\epsilon_b) \rho_1(\epsilon_1) \rho_a(\epsilon_a) \rho_3(\epsilon_3) \]
\[ \times \frac{2\pi}{\hbar} | \langle r_a, r_3 | U_{\text{eff}}(\epsilon_1 + \epsilon_b)| r_b, r_1 \rangle |^2 \delta(\epsilon_b + \epsilon_1 - \epsilon_a - \epsilon_3) \]
\[ \times \{ p_b(\epsilon_b) p_1(\epsilon_1) [1 - p_a(\epsilon_a)][1 - p_3(\epsilon_3)] - p_a(\epsilon_a) p_3(\epsilon_3) \}
\[ \times [1 - p_b(\epsilon_b)][1 - p_1(\epsilon_1)]. \]
$100K University Self Funded → IDEA → Journey
Can you prove it?

Friends/Family
Government
Angels

Experiment / Proof

Basement
Garage
Universities
National Labs
Strategic Corp.
Customers
$100K University Self Funded

$500k -$1M Draper Lab Grants

Journey

IDEA

Prove It
Can you build one?

**Initial Prototype**

- Angels Groups
- Grants
- Early Stage VC

**Next Steps**

- Incubators
- Universities
- National Labs
- Strategic Partners
- Machine shops
- Design shops
$100K University Self Funded

$500k - $1M Draper Lab Grants

$5M Draper Grants

Make One

Prove It

IDEA

Journey
Scalability
(Can You Build One of Commercial Size)

- Initial Prototype
- Plant/Property
- Incubators
- Universities
- National Labs
- Strategic Partners

- Angels/Grants
- Family Firms
- Early Stage VC
Manufacturability (Can You Build Many)

- Angels
- Government
- Mainstream VC

Manufacturability

- Integrated
- Disaggregated
- Outsourced
- Hybrid
$100K University Self Funded

$500k - $1M Draper Lab Grants

$5M Draper Grants

$4M Incubator Angel Private

$5M Disaggregated Strategic

Journey

IDEA

Prove It

Make One

Scale

Make Many
Commercialization
Can You Sell One / Can You Sell Many

Direct Sales
• VARs
• Dealers
• Distributors
Licensing
Sale of Company
Sale of IP

Indirect Sales

Government
VC
Debt / PE
Value Chain (Sample flow)

Sub Assembly
- Chips
  - Applied Materials
  - SVTC
- Cold housing
  - Scientific Machine & Welding
- Hot housing
  - Saint-Gobain
- Balance of System
  - GE
  - Johnson Controls
  - McMaster-Carr

Contract Manufacturer
- Celestica

System Installation
- Engineering Firms/Manufacturers
  - Aura Engineering, LLC
  - TECO
  - RAVEN RIDGE RESOURCES
  - JW Technologies, LLC
- Value added Resellers (TDB)
- MTPV Authorized Installers (TDB)
Value Chain Cont’d (Sample flow)

System Installation

- Engineering Firm/Manufacturers
  - Raven Ridge Resources
  - Aura Engineering, LLC
  - JW Technologies, LLC

- Value added Resellers (TDB)

- MTPV Authorized Installers (TDB)

MTPV components integrated into a larger solution

Lower Margin/ Lower SG&A
Larger Market Reach

Siemens as an example

Capital Equipment
Or
Electricity

Capital Equipment
Or
Electricity

Higher Margin & Higher SG&A

Customers

Peabody
LBC
Chevron
Human Energy

Siemens as an example

Capital Equipment
Or
Electricity

PPG
Saint-Gobain
Cardinal
Glass Industries

Higher Margin & Higher SG&A
Thank you