

Developments in Advanced LPG Distributed Generation Systems

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Electricity Generation

- **Electricity is generated in central plants with non-renewable fuels**
- **Electric transmission systems are:**
 - **vulnerable**
 - **expensive**
 - **very unsightly**
 - **energy inefficient**
- **U.S. centralized power 31.4% efficient**

Distributed Generation (DG)



- PERC has been working on DG (on-site power) since 2000
- Advances in DG technology:
 - enable LPG systems to generate electricity reliably
 - recover usable heat
 - operating at higher efficiencies than previously possible
- DG electrical power not restricted to a grid

DG Applications



Off-Grid (rural or remote locations)

- residential sites
- small industrial sites (businesses)
- telecommunications (mobile phone towers)
- radar
- military sites

On-grid

- peak shaving
- critical back-up

Current DG Systems



Large systems >150kW are heavy-duty already

But smaller systems are not robust:

- **based on light-duty gasoline engines**
- **not for sustained operation**
- **typically back-up capability only**
- **require very frequent maintenance**
- **often only have a 2 – 3 yr life span**

Advanced DG Systems



Very Durable

- **5,000 – 40,000 operating hours = 10+ year life (comparable to gas appliances)**

Low Maintenance

- **600 – 4,000 hrs maintenance interval (target is once per year)**

Higher efficiency = comparable to a grid (same amount of LPG produces more power)

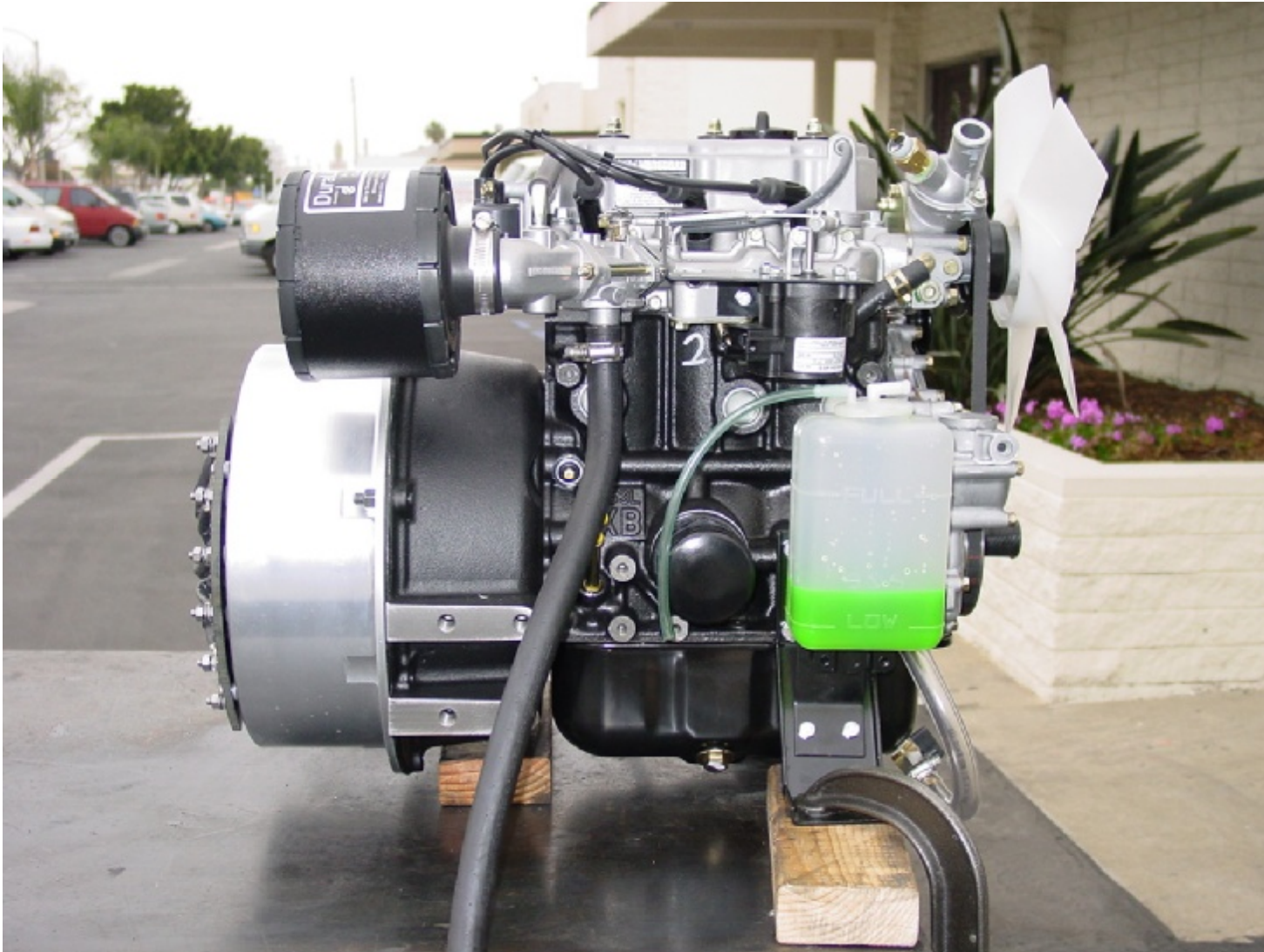
Advanced DG Systems

Improvements made possible by . . .

- advanced materials
- heavy-duty engine cases
- liquid-cooled engines
- larger oil & air filters
- increased oil storage capacity
- lower engine speed (RPMs ~1800)
- high efficiency, heavy-duty alternator / generator heads

Heavy-duty Engine Platforms

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Optimized Components

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Extended-life Premium Air Filters

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Increased Lube Oil Sump Capacity

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Large Oil Filter Capacity

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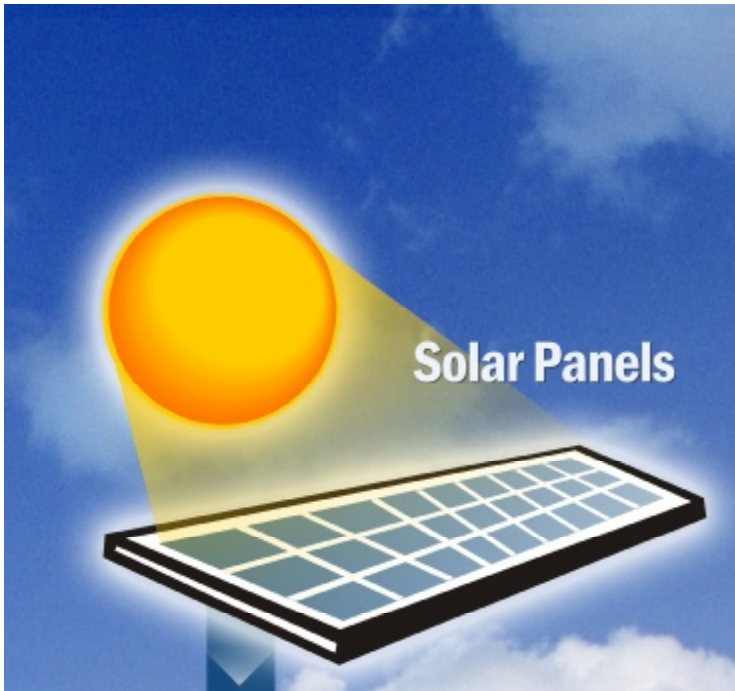
Hybrid Concept

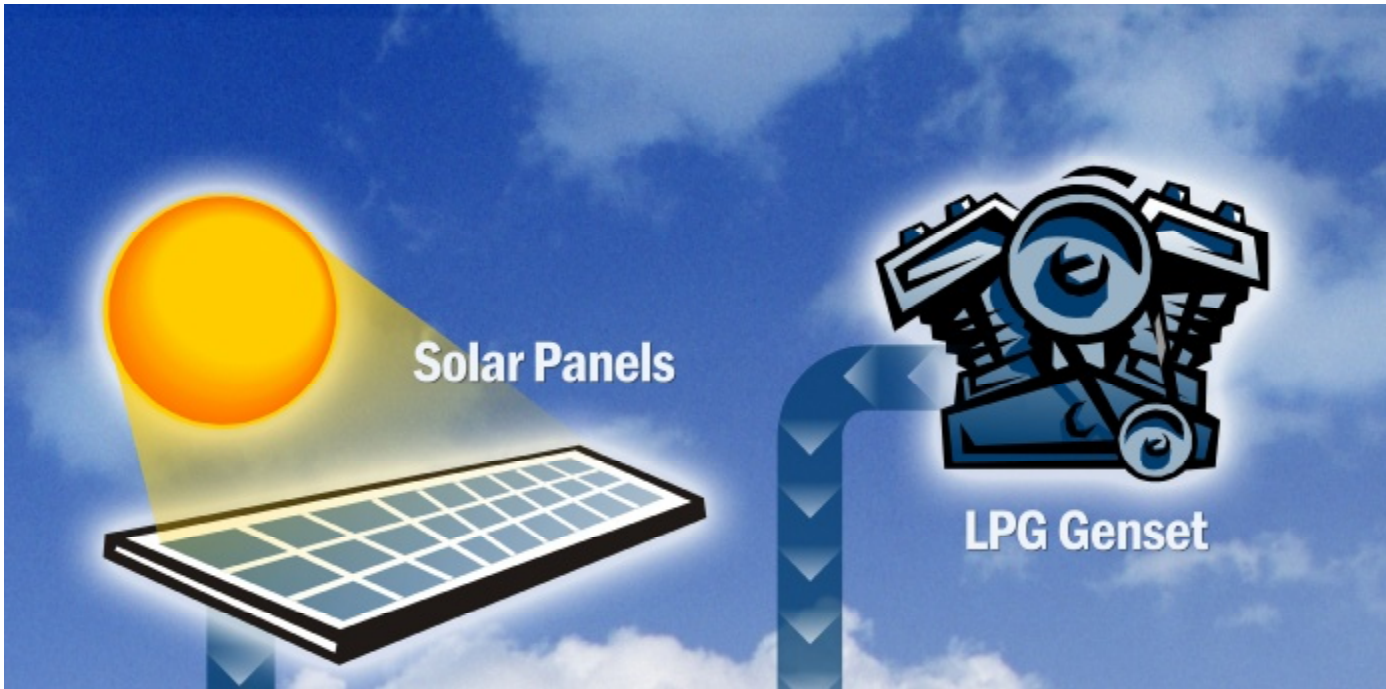
Large-scale renewables have limitations

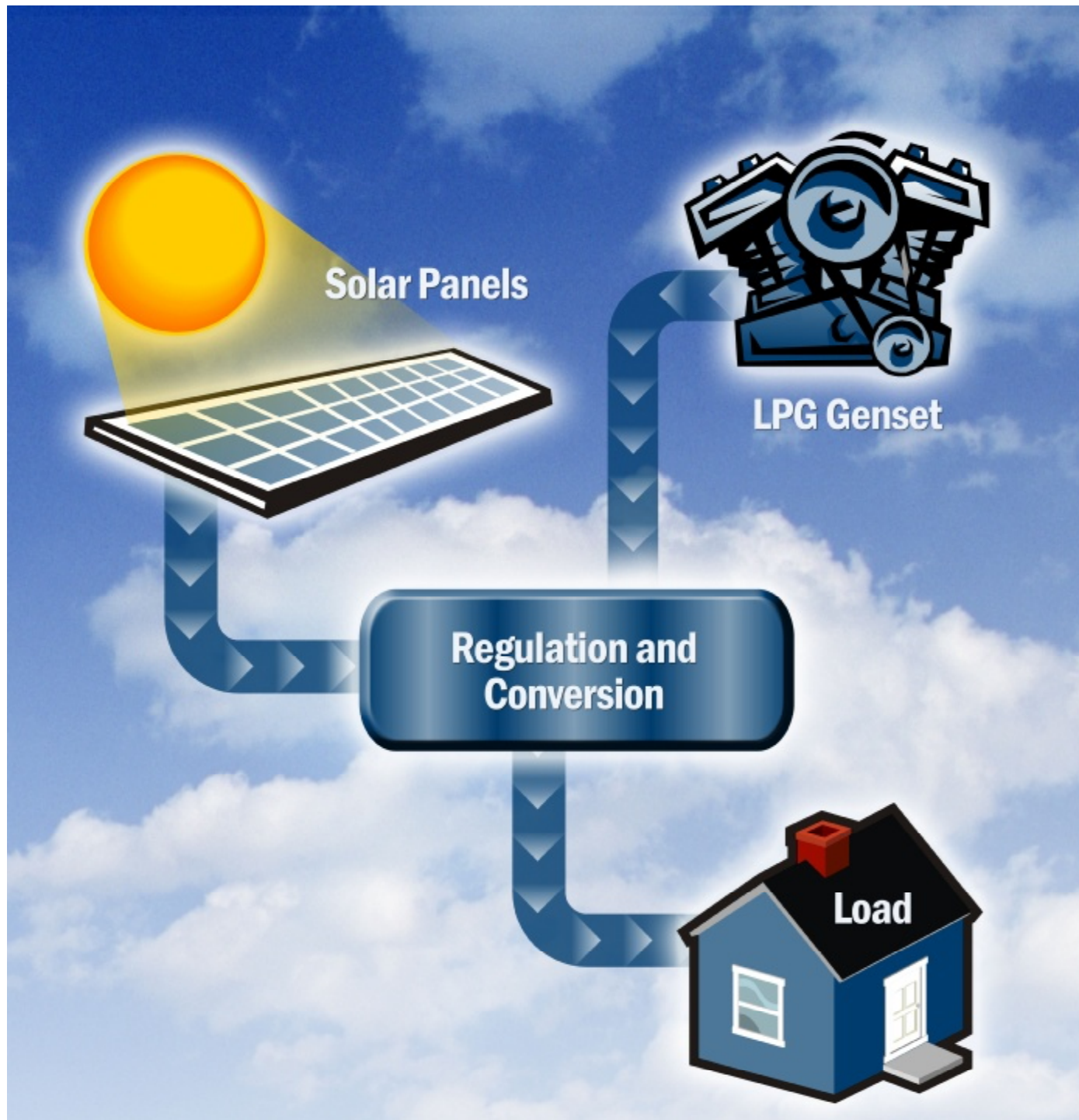
- rely on transmission system (power lines)
- over-sized
- intermittent resources
- high capital costs

Small-scale renewables utilized on site

- wind
- solar







DG & Hybrid Demonstration



Goal of full commercialization

Nationwide DG demo program

Partners

- **manufacturers**
- **government agencies**
- **universities**
- **U.S. propane industry**

DG Hybrid Demonstration



Hydronic Micro-CHP System

- **Climate Energy**
- **Honda engine**
- **1.2 kW power**
- **residential system**

DG Hybrid Demonstration



Propane Distributed Generation Demonstration Program for Rural Alaska

- Energy Alternatives
- Yanmar micro-cogen
- 5 kW power / 10 kW thermal output
- rural Alaska
- U.S. Department of Energy (DOE)
- University of Alaska's Arctic Energy Technology Development Laboratory

DG Hybrid Demonstration



Replace Kennecott Power Generation System with Battery-and-Propane Hybrid at Wrangell- Saint Elias National Park and Preserve

- National Park Service
- replace diesel generator
- 20 kW micro-grid

DG Hybrid Demonstration



Solar-Augmented Propane Combined Heat and Power Demonstration Project

- North Carolina Solar Center
- photovoltaic's + solar thermal + co-gen
- marketer facility
- North Carolina State University

Other DG Demonstrations



Yanmar CHP Performance Testing and Field Evaluation

- **Gas Technology Institute**
- **5 kW micro-CHP**
- **GTI's Distributed Energy Technology Center**

Conversion and Demonstration of Ecopower Micro-CHP to U.S. Utility Grid Configuration

- **Marathon Engine Systems**
- **4.7 kW ecopower**

Distributed & Hybrid Generation



Distributed generation systems powered by clean, efficient, and reliable LPG hold great potential for the growth of the LPG industry worldwide

Key Steps

- **development**
- **demonstration**
- **validation**
- **commercialization**