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Solar Energy

Airports Going Green
Aimee Fenlon



DENVER INTERNATIONAL AIRPORT
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Renewable vs. Non-Renewable Electrical Generation

Renewables:

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Source	Advantages	Disadvantages
Solar PV	No CO ₂ ; Needs no Fuel	Intermittent – no power at night, cloudy day, covered by snow. Need large area, high front cost
Wind	No CO ₂ Needs no Fuel	
Hydro Power (#1 renewable)	No CO ₂ ; Need no Fuel Available 24/7	
Geothermal	No CO ₂ , No Fuel, 24/7	
GS HP	Winter use heat from ground; Summer add heat.	
Biomass	Carbon “neutral”; 24/7	

Continued...

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Energy Conservation – “Renewable”

- Watt saved does not need to be generated
- Conservation often cheaper
- DIA Energy Conservation Initiatives: Escalators; Lighting; HVAC Controls

3

Electrical Terms

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- **Power** is how fast you spend Energy or do Work.
 - Electrical **Power** is measured in watts (W)
 - 1 kilowatt (kW) = 1,000 W
 - 1 megawatt (MW) = 1,000 kW = 1,000,000 W
 - Electrical **Energy** is measured in watt-hours (Wh)
 - 1 watt-hour is 1 watt of power over a time of one hour
 - 1 kilowatt-hour (kWh) = 1,000 Wh
 - 1 megawatt-hour = 1,000 kWh = 1,000,000 Wh
- Direct Current (DC) = Like a battery produces
- Alternating Current (AC) = Like typical home uses



Average home in Colorado uses about **832** kWh AC Electrical **Energy** per month. (Xcel Energy)

4

Solar PV Basics

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- All Photovoltaic (PV) cells produce DC
- Cells; Modules & Panels
- Panels joined in “Strings”; Strings → Array
- Then what do you do with the DC power?
 - Either charge a battery,
 - Use DC directly, or
 - Use an “Inverter” to convert the DC to AC.
- Sometimes a combination of these.
- Most large PV systems convert DC to AC; like all systems at DIA.
- Then you can either use the electrical energy “on-site” or sell it to the electrical “grid”. (Electric Grid is AC)
- PV is different than Solar “Thermal” where the sun heats a fluid to run a generator.

5

PV Design Considerations

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- How big? - Solar PV is sized in MW DC – “nominal power rating”; STC = 25 C, 1000 W/m²
- Types of Solar PV Panels:
 - Mono (1)-crystalline – Most efficient – most expensive
 - Poly (many)-crystalline – Less efficient – less expensive
 - Non-crystalline (thin film) – Least efficient – least expensive, and more flexible.
 - New generation – multijunction; exotic compounds.
- Tracking System vs. Fixed Tilt System
 - Tracking – follows the sun east to west
 - Tracking is more expensive but more efficient
 - Tracking Systems: Single Axis or Dual Axis.
- Also how much does land cost?
- Other design factors: weight of snow and wind forces, soil conditions, geometry or glare.

6

Solar Rays

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DIA PV Installations

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- All poly-crystalline panels
- Combined, DIA Solar I, II and II produce 13 million kWh per year;
 - This is about 6% of electricity used by DIA in a year
 - Also equivalent to about 1,300 typical homes
- All DIA Solar Arrays are owned by private companies
 - Public-Private Partnership
 - DIA has Ground Lease Agreement and Power Purchase Agreement with Owner
- DIA is "site host":
 - Owner Sells Electricity to DIA
 - DIA use some Electricity on site, and sells excess Electricity to Xcel Energy at current Energy prices

8

DIA PV Installations

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- Owners of the DIA Solar Arrays receive:
 - Payments for Electrical Energy from DIA
 - Federal tax benefits
 - Renewable Energy Certificates (REC) and Rebate Payments from Xcel Energy
- Without Tax Benefits and Xcel Payments, these DIA Solar Installations would probably not have been built;
 - would not be financially attractive to Owners
- We all helped to pay for building these Solar Arrays:
 - Through Federal taxes
 - Through Xcel Electric Bills
 - Colorado Renewable Energy Standard - Increased to 30% by voters in 2010

9

DIA I – Pena Boulevard

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- Facility Owner – Sun Edison
- Developer - World Water & Solar Technologies (now Entech Solar)
- Prime Construction Contractor - Intermountain Electric (IME)
- Total construction cost approximately \$14 million
- Leased Area 8.8 Acres of Land
- Commissioned September 2008

10

DIA I

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- Nominal Rating is 2 MW DC.
- Annual production is approximately 3.5 million kWh
- 9254 panels at 216 watts each
- Strings of 14 panels.
- Flat single axis tracking system
- Tracking is hydraulically operated
- For Trackers had to build support-expensive
- 8 Arrays served by 8 Inverters
- Installation Cost: \$7 per watt

11

DIA II

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- Serves DIAs Fuel Storage & Distribution Facility (Fuel Farm)
- Owner - Airport Solar One LLP
- Developer - Oak Leaf Energy Partners
- Contractor – Intermountain Electric
- Leased Area 9.4 Acres
- Commissioned February 2010.

12

DIA II

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- Nominal Rating is 1.6 MW DC
- 7392 Panels at 216 watts per panel
 - Also Strings of 14 panels
- Fixed Tilt at 25 degrees South
- 25 degree fixed tilt 17% less efficient per panel than the flat tracker...but far less costly to construct
- Produces 2.5 million kWh per year
- Cost about \$7 million
- Output matches well to the overall electrical usage of the Fuel Farm
- Cost \$4.38 per watt

13

DIA III

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- Connects to Sewer pump station far north end of DIA
- Owner: Denver Airport Solar, LLC (Constellation Energy)
- Developer: Oakleaf Energy Partners
- Construction Contractor: Intermountain Electric
- Built on 26 Acres of Land
- Commissioned in July 2011.

DIA III

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- Nominal Rating is 4.46 MW DC
- 18,980 panels at 235W each
 - Strings of 13 panels
- Fixed Tilt at 25 degree South
- Produces about 7 million kWh per year
- Cost about \$14 million.
- \$3.14 per watt

15

Renewable vs. Non-Renewable

-ALL Energy Sources have Advantages and Disadvantages

-To allow Solar and Wind to replace Coal, Natural Gas and Nuclear, need to develop better ways to store the Energy.

- Batteries
- Hydrogen
- Other

-Price is coming down for Renewable Energy

-For many years, will need to use Coal, Gas, and Nuclear.



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