



41 m²
 7 kW
 solar electricity
 Calgary

700 m²
 100 kW
 solar electricity
 Switzerland



Can Alberta's Solar Resource Meet Its Energy Demands?

-- Solar Electricity --

university of alberta
energyclub

2010 January 19

300 m²
 43 kW
 Calgary

78,000 m²
 11,000 kW
 solar electricity
 Germany



Gordon Howell, P.Eng.

hm howell-mayhew
 engineering, inc.

Edmonton

Photo Credit:
 Conergy Inc.

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Intro: My Presentation...

- Solar electricity in Alberta
- What is it doing now?
- What is its future here?
- “Should” it meet all of Alberta’s electrical energy needs?

6,000 kW
30,000 solar PV-electric modules



20 m²
3 kW
solar PV electricity on each house
Premier Gardens, California



Intro: Me...

- We are solar electric system project developers
 - working with solar energy since 1977 and with solar electricity since 1984
- We manage, design, supply and commission solar electric systems
- We participate in provincial, national and international standards writing committees
- We have no vested interests in any one solar electric technology

my own house

20 m²

2.3 kW

1995, Edmonton

100% solar electricity



My Obligations as a Professional Engineer...

- Professional engineers are required by law to present to you the truth.

We are overseen by APEGGA, which is governed by statutes of Alberta and implemented by engineers as a self-regulating association.

- We are legally obligated to NOT:
 - over-promote any technology
 - neglect to bring to your attention any pertinent matter.
- If we fail, we can be brought to a tribunal of APEGGA to face disciplinary action, fines, our name published and dismissal.
- I seek and welcome any questions, comments, suggestions, challenges and criticism of anything I present here.
This is a work in progress.

Gordon Howell. P.Eng.
is APEGGA member # 28241



Howell-Mayhew Engineering, Inc.
holds APEGGA permit # 4284

Solar Energy

– where can it be used –



Photo Credit:
Gordon Howell

Okotoks swimming pool
solar heating



Photo Credit:
SPS Energy

Cochrane High School
solar electricity

- Anything that needs **electricity**
- Anything that needs **heat**
 - Space **heating**
 - Water **heating** – for domestic water, pools
 - Industrial and commercial process **heating**
 - **Cooking**
- Anything that needs **illumination**
 - in the daytime

Best Western Hotel
Kelowna



Photo Credit:
Swiss Solar
Tech

Red Deer's
net zero
electricity home



Photo Credit:
Gordon Howell

Solar Energy Technologies...

- There are many technologies that use the energy in solar radiation to provide energy services for mankind.
- Most of these technologies can be widely scale from tiny to gigantic.
 - **Solar photovoltaic electricity**
 - flat plate, cylindrical, concentrating ...
 - mono-crystalline Si, multi-crystalline Si, amorphous Si, CIS, CIGS, GaAs, CdTe, dye sensitised +++...
 - **Solar thermal electricity**
 - solar power towers, parabolic troughs, convection towers ...
 - **Passive solar heating**
 - mass, glass, direct gain, sunspaces, greenhouses ...
 - **Active solar heating**
 - water/glycol/air, flat-plate/evacuated tube, concentrating ...
 - **Daylighting**
 - light shelves, direct gain windows, clerestory windows ...

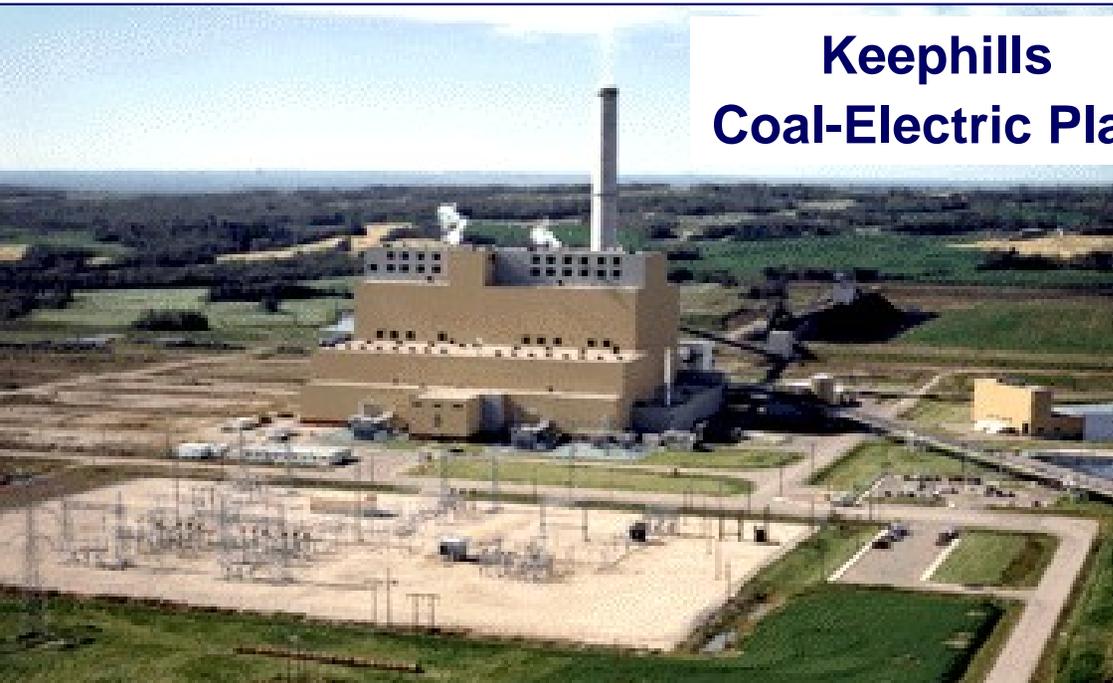
Alberta's Energy Needs

- Total energy consumption: ~2.2 EJ per year
- Heating: space, water, processes
- Transportation
- Electricity (as of 2006) (0.20 EJ/year)
 - Farm 3%
 - Domestic 16%
 - Commercial 25%
 - Industrial 56%
 - Unaccounted for losses ~3%?
 - Transmission line losses ~8%?
 - Distribution line losses ~8%?

Sources of Alberta's Electrical Energy

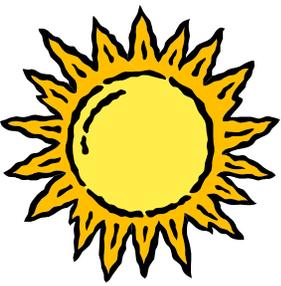
- 72% coal (baseload)
- 17% natural gas (some baseload, some load following)
- 4% hydro (mostly load following)
- 3% wind (cannot be controlled)
- 4% imports from BC and SK

Reported on Page 43 of the 2008 AESO annual report
(see reports at www.hme.ca/reports)



Question:

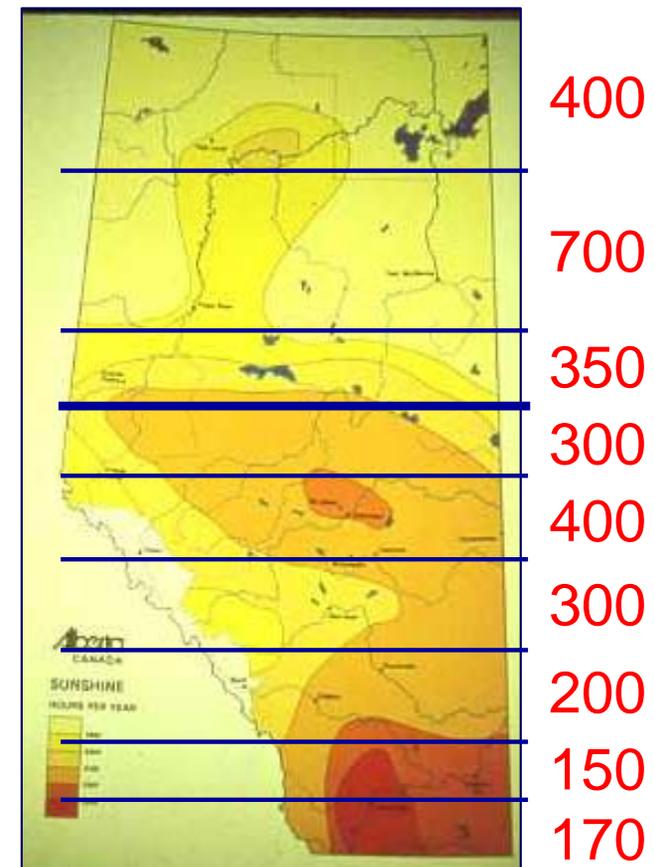
What is Alberta's most abundant energy resource?



Alberta: The Solar Province

– Our Most Abundant Energy Resource

- 18 hours of sunshine
= all our fossil energy resources in 2007!
- Alberta's solar radiation is 240 times more than our total annual fossil fuel energy production.

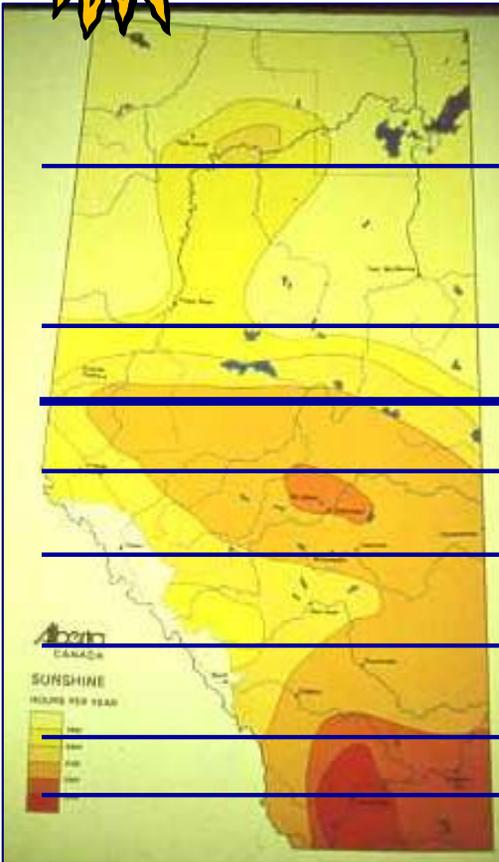


====
solar = 3000
EJ/year

fossil fuels = ~12.2
EJ/year
in 2007



Alberta: The Solar Province



400

700

350

300

400

300

200

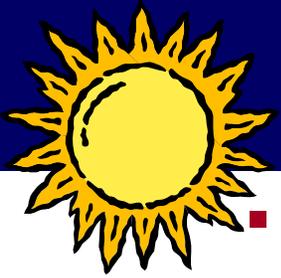
150

170

=====

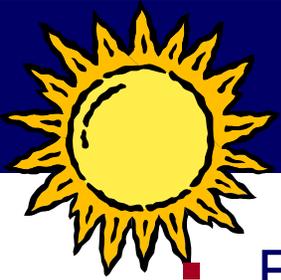
solar = 3000
EJ/year
total land area

- Minus mountains, lakes, rivers, cities, farms, roads
= leaves **32%** of land available for solar systems
= **1000 EJ/year**
- If generated by solar PV-electric technologies (at 25% coverage, properly tilted, 12% system efficiency, 80% storage efficiency, 10% system losses)
= **26 EJ/year** of energy services



Alberta: The Solar Energy Province

- Fossil fuels produced in 2007 (coal, oil, tar sands, natural gas) **~12.2 EJ/year** in fuel
- Fossil fuels used in Alberta **~4.7 EJ/year** in fuel (the rest is exported)
- Energy services used in Alberta **~2.2 EJ/year** (the rest is wasted)
- Solar PV potential = **26 EJ/year** of energy services
- How much land will be needed if we produce all our energy with solar PV? **7000 sections** (18,000 km²) (= 3% of Alberta's land = twice as much coverage as roads)
- What would it cost to do? At PV prices in 2015, likely **\$1.8 trillion.**
- Could we do this?
Yes, but other technologies need to be developed first.
- Would we do this?
No, because we firstly need to be **energy efficient** and then we need to have a **diverse mix** of renewable energy sources.



Alberta: The Solar Electricity Province

- Electrical energy generated in Alberta
 - **0.23 EJ/year** (56% = industrial, 25% = commercial, 16% = residential)
- Electrical energy services used in Alberta
 - **0.20 EJ/year** (the rest is wasted)
- How much land will be needed if we generated it with PV?
 - **1000 km²** all properly spaced out
 - **400 sections**
 - an area of **33 x 33 km**
- What would it cost to do?
 - At PV prices in 2015, likely **\$130 billion**
- Could we do this? **Yes.**
- Would we do this?
No, because we firstly need to be **energy efficient** and then we need to have a **diverse mix** of renewable energy sources.

Challenges with Solar Energy...

At this time:

- **Purchase costs are very high...**
 - though typically decreasing by 10% per year
- **Not a lot of broad-based experience in Canada**
 - supply and installation chain is very small though growing rapidly in its experience and depth
 - much training needed for design professionals, financiers, and installers
- **Has to compete with highly subsidized coal- and natural gas-fired utility electricity**
 - fossil fuel industries know how to lobby the government to obtain favourable policies and many types of incentives
- **Previously little interest by Canada's and Alberta's governments in developing policies to facilitate solar**

Development of Alberta's Solar Resource

- Alberta's solar energy resource today is similar to the tar sands of several decades ago:
 - rich resource
 - currently expensive
 - not a lot of experience in Alberta
 - many barriers to utilization
 - many opportunities to develop jobs, products and markets for the world
- What was needed to develop the tar sands?
 - government incentives and policies

Alberta's Policies and Response to our Huge Solar Resource

Alberta

Policies that facilitate	New microgeneration grid-connection regulations as of 2009 January 01
Policies that subsidise	None
Development programmes and policies – industrial capacity, infrastructure, standards, issues resolution, incentives	None
Taxation policies	Solar PV is considered an industrial generator. Industrial taxes are 4x the value of the electricity generated.
Policies that subsidize competing energy sources	<ul style="list-style-type: none">– Natural gas rebates in the winter– Low oil, gas, and coal royalty rates– Tax holidays for the tar sands– Low environmental standards– No environmental royalties– Lots of research and development

How do we want to organise ourselves?

- How do we change policies of governments and corporations so that solar energy can take its **right-full place** in society's **mix** of fuel production and electricity generation?
- Policies are answers to questions about organisation...
The changes to achieve this relate to how we want to organise ourselves as a society, ...they are not technical.
- How do we want to organise ourselves as a society?
 - Do we want to continue to **subsidise fossil fuels** with our health care budgets?
 - Do we want to **value the environment**, and thus put a money value on it?
 - Do we want to **encourage** small local distributed electricity generation? (...the 10 km energy diet)

How do we want to organise ourselves?

- **Socialism** collapsed because it did not allow the market to tell the **economic** truth.
- **Capitalism** is heading in the direction of collapsing because it does not allow the market to tell the **ecological** truth.

Quote Øystein Dahle
former VP, Exxon Norway

Is this the outcome we want
just because the market forces are not allowed to tell the truth?

Key Issues for Alberta's Solar Electricity

- How to **store** energy?
 - from day to night, from summer to winter
 - to provide firm “dispatchable” electrical power (not electrical energy)
 - Society needs massive energy storage technologies already regardless of solar and wind energy (to shave the peaks and fill in the troughs, to avoid brownouts, blackouts, vast new transmission lines and large additional generating plants)
- How to obtain the equivalent **public subsidies** as do fossil fuels?

Key Issues for Alberta's Solar Electricity

- Will the boiler-based electric generators (coal, nuclear and natural gas, which is called “base load”) be **flexible** enough to permit the very large generation of solar and wind onto the grid?
 - Alberta now has ~8200 MW of wind under development (with 4000 MW more to come)
 - What happens when on a **windy** day Alberta’s wind generators produce **all** of our electricity?
 - Will the baseload generators **turn off**?
 - ...apparently **not**!!! Because they need to keep running at about ½ rated-capacity levels in order to maintain operating temperatures and pressures...
 - So are we going to continue to operate dirty coal plants when we have clean wind and solar?

Industrial-Scale “Solar Power Tower”



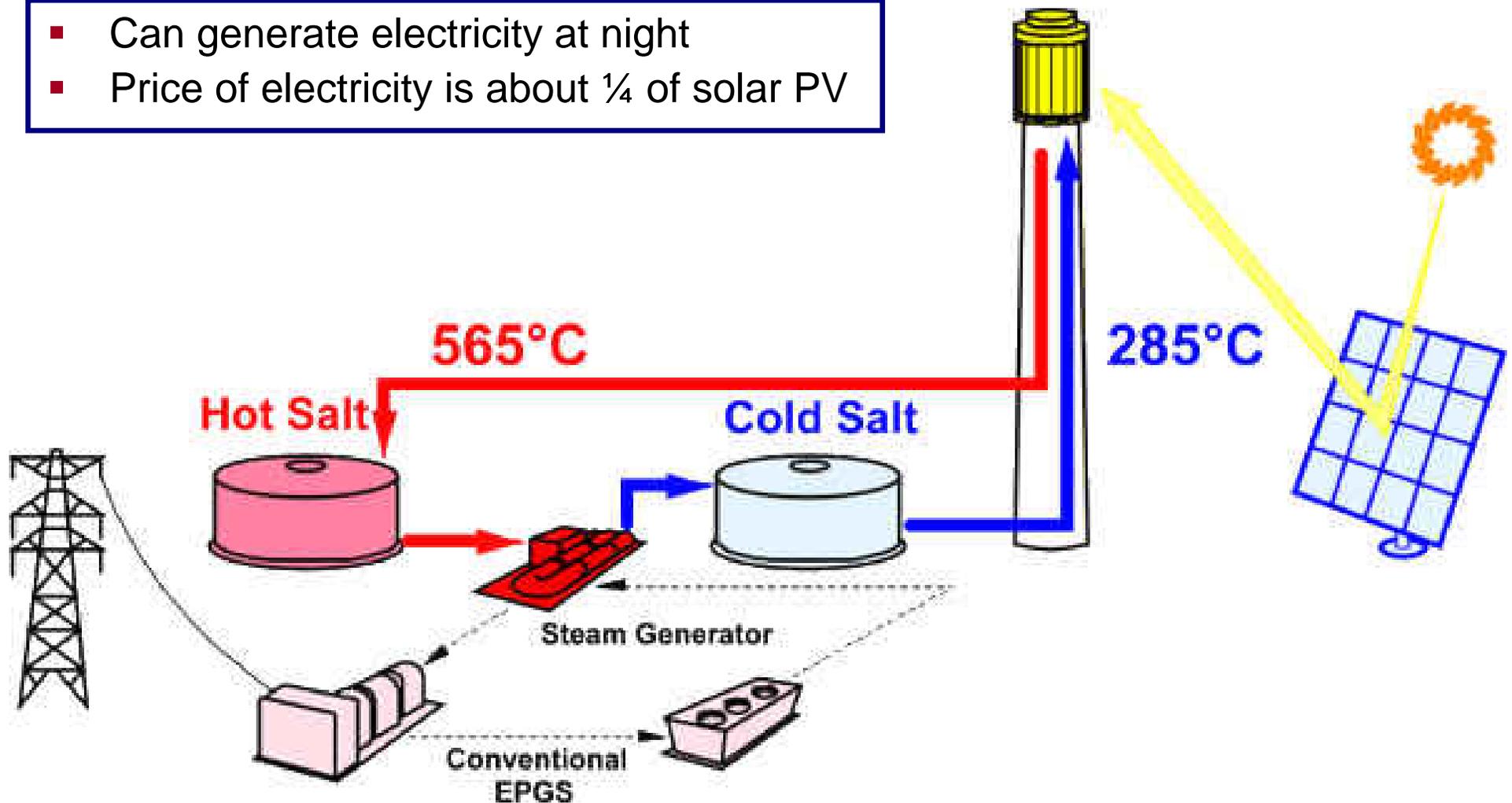
Mojave Desert, California
~20 years old

- Some 1300 heliostats
- Turns the black central receiver white hot
- 10 000 kW



Solar Power Tower – Operating Diagram

- Can generate electricity at night
- Price of electricity is about $\frac{1}{4}$ of solar PV



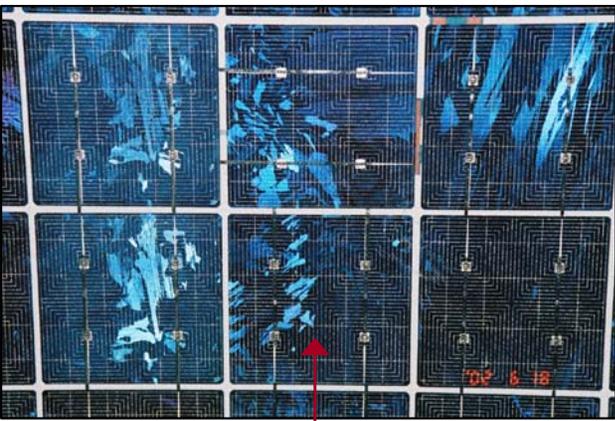
Industrial-Scale Parabolic Troughs



1008 troughs
168 parallel loops
550 000 m²
200 ha of land

AndaSol
50 000 kW
Spain





Solar PV Cell

Solar PV Electricity

The technology is called "photovoltaics", but we only call it "PV".



Solar PV Module

PV can generate any amount of electricity.
Large PV systems = more PV modules.



Solar PV Array

5,000 modules
1000 kW



30,000 modules, 6000 kW

170,000 modules (200 W ea.)
34,000 kW PV array





2.9 kW, Alberta
Legislature



120 kW, Berlin

Placed on Roof-Tops



85 kW, Germany



1300 kW, Netherlands

Building-Integrated PV (BIPV)

- BIPV is an architectural feature, which draws interest.
- BIPV is a building cladding and is sold on an area price basis ($\$/m^2$) rather than energy price basis ($\text{¢}/kWh$).
- Gives structure, environmental protection, PR, image, and emission reductions... as well as electrical energy.





30 kW,
Netherlands



45 kW (340 m²), Netherlands.
©Saint-Gobain Glass Solar.

Integrated into Glazing for Natural Lighting

UofC Child Development Centre



Photo Credit:
Conergy Inc



Photo Credit:
Anton Driesse

Queens University, Kingston

Integrated into Shading Structures

Railway station Canopy,
Switzerland. © EPEL-LESO



15 kW sunshades, America.
© Kawneer Company Inc.



Integrated into Roofing Materials



With
concrete
roof tiles



With metal roofs

As shingles



With slate tiles



Buildings are becoming Solar Electric Plants!



1000 kW, Munich



**Aachen,
Germany**



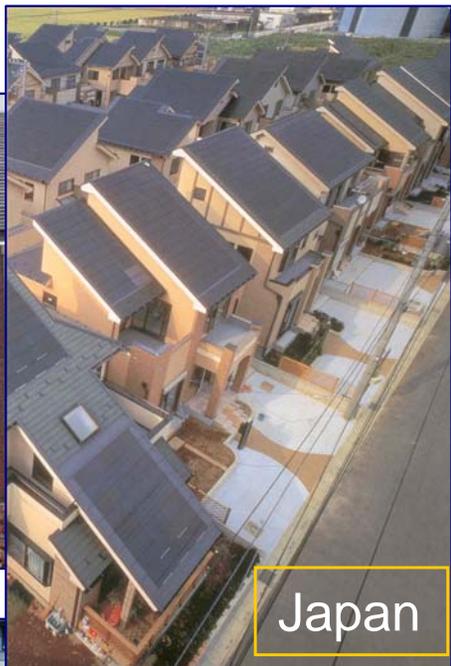
8 kW, Red Deer



6 000 kW, Germany

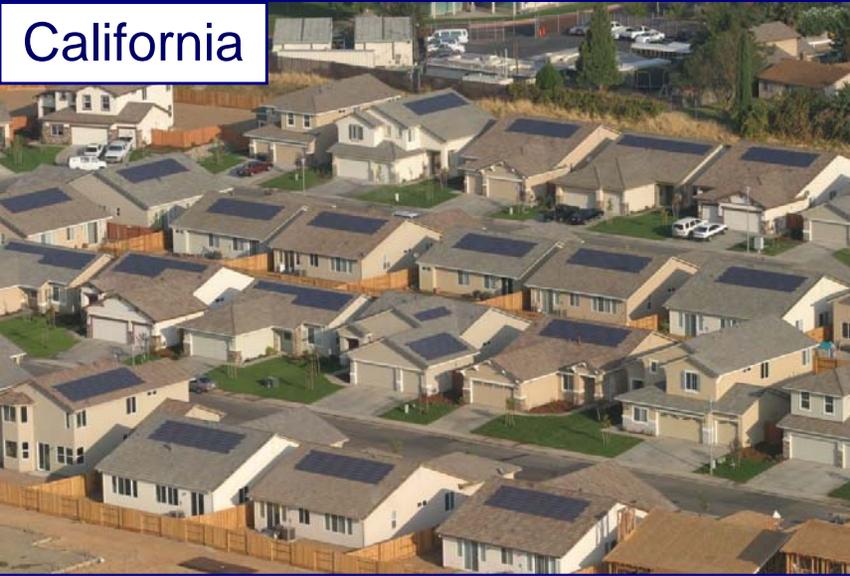
Neighbourhoods are becoming Solar Electric Plants!

1000 kW community PV project on 500 houses in the Netherlands



Japan

California



Cities are becoming Solar Electric Plants

Ota City, Japan

2200 kW, 500 homes





**340 kW
California**

Parking lots are becoming Solar Electric Plants

Fields are becoming Solar Electric Plants

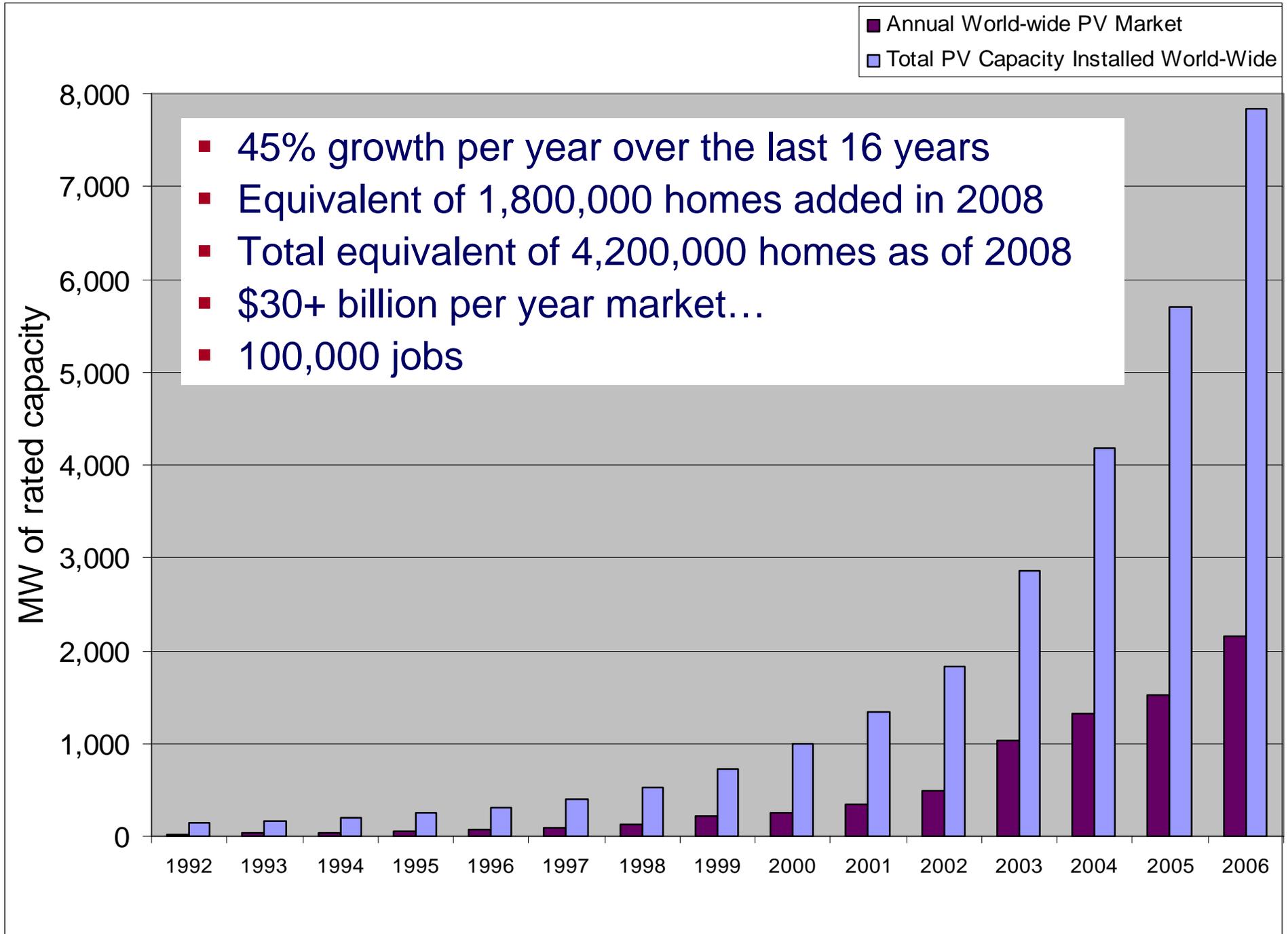


**Geiseltalsee Solarpark
Germany**

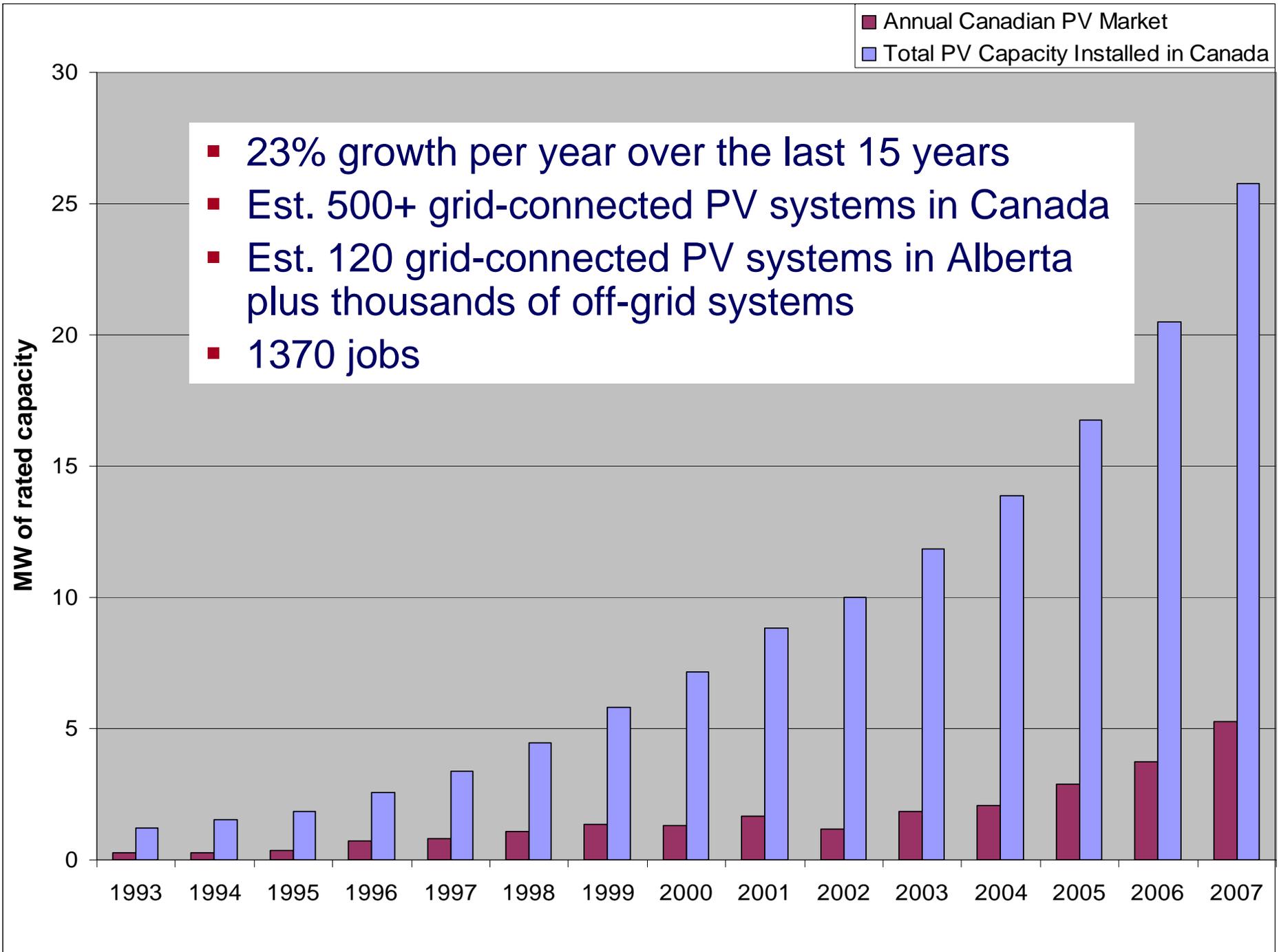
**4000 kW,
24 864 PV modules**

**Over 1000 systems greater than
1000 kW around the world now,
biggest being planned are 2- and
3-million kW in China and India**

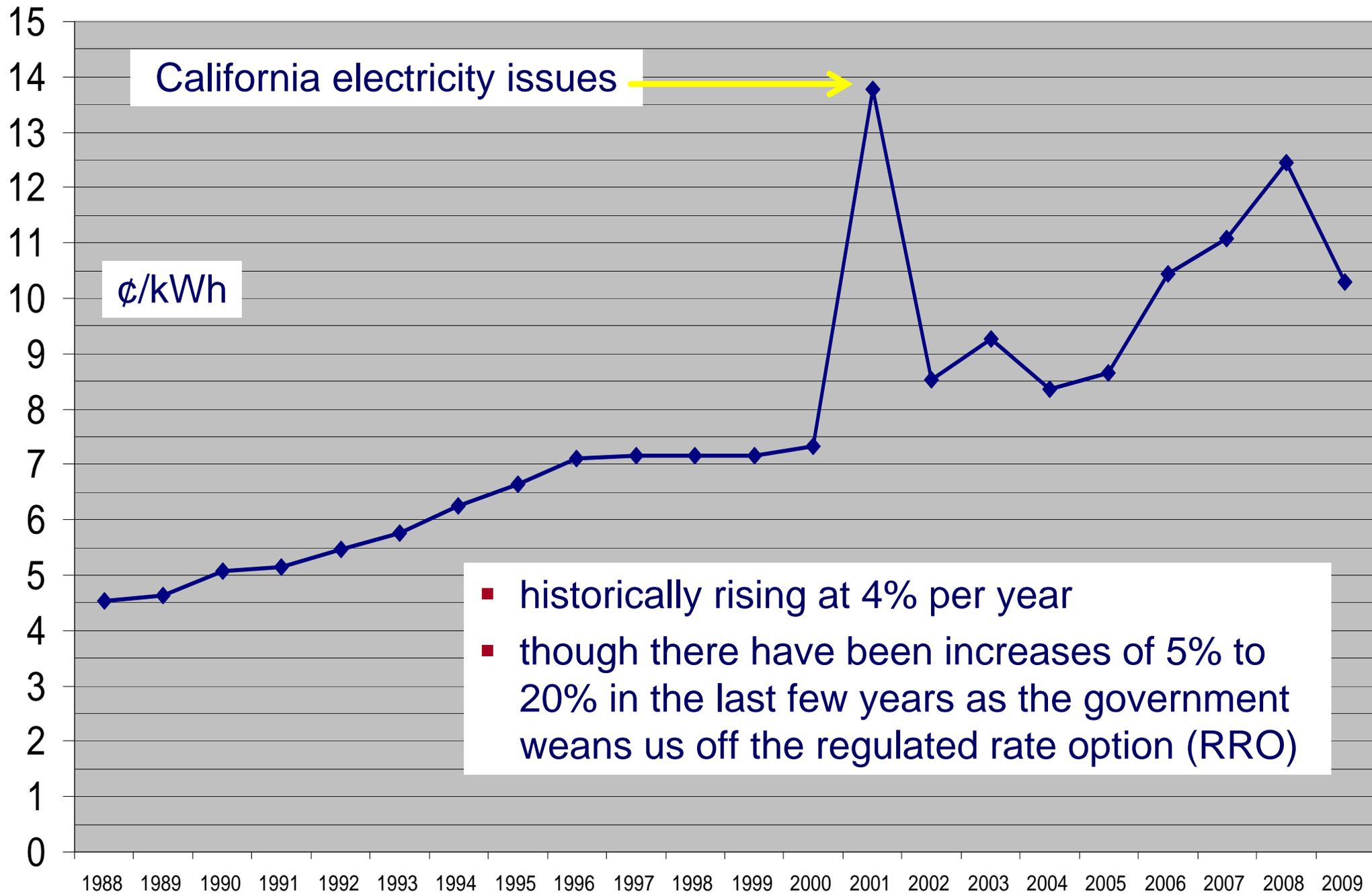
Context: World Grid-Connected Solar PV-Electric Market



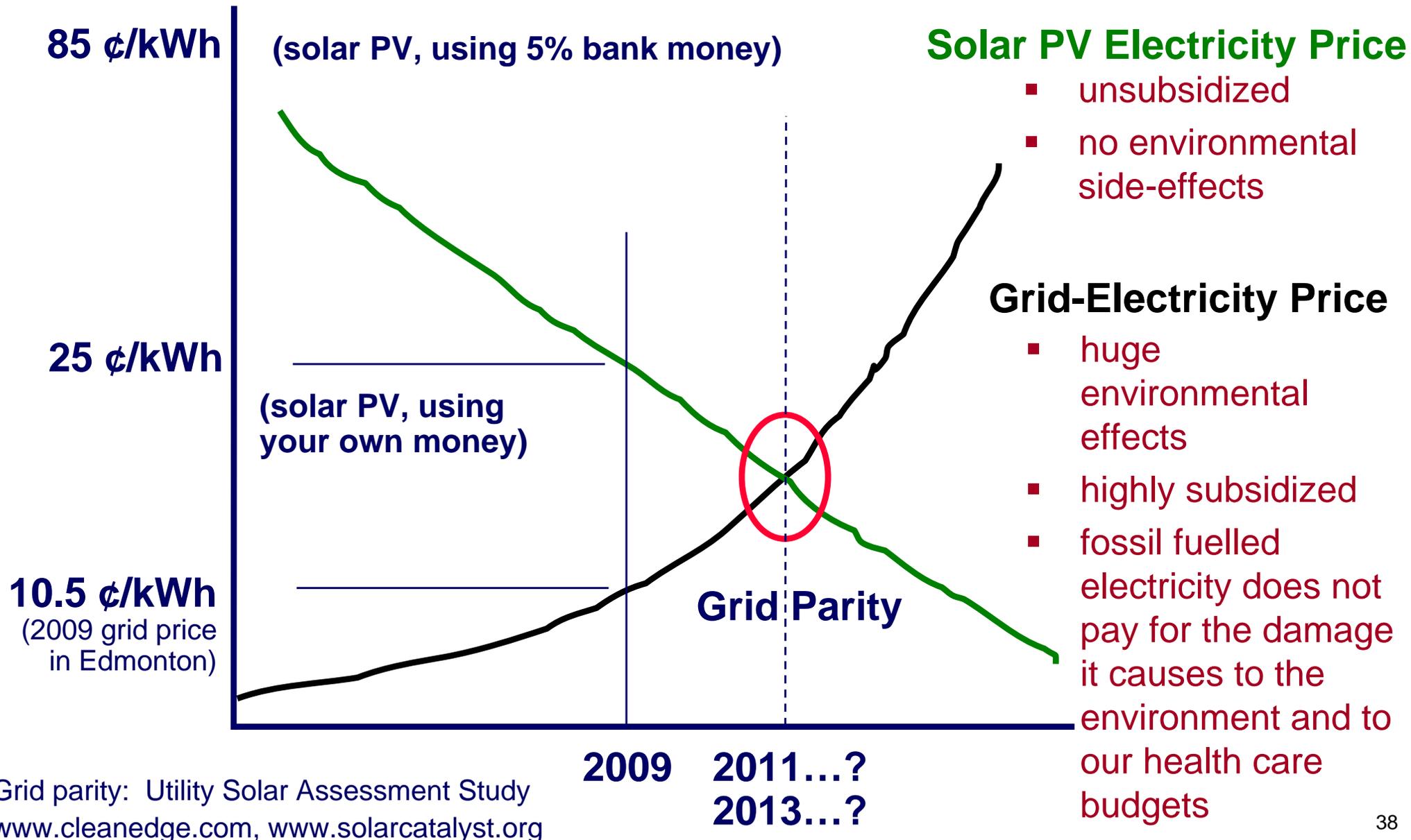
Context: Canadian Solar PV Market



Consumer Price of Electricity – EPCOR RRO



Declining Solar PV Prices, Increasing Grid Prices



...we hold the future in our hands

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We welcome any feedback, questions, suggestions,
comments and challenges to anything we present.