Infrastructure Asset Management Alberta

James R Sandercock, PhD

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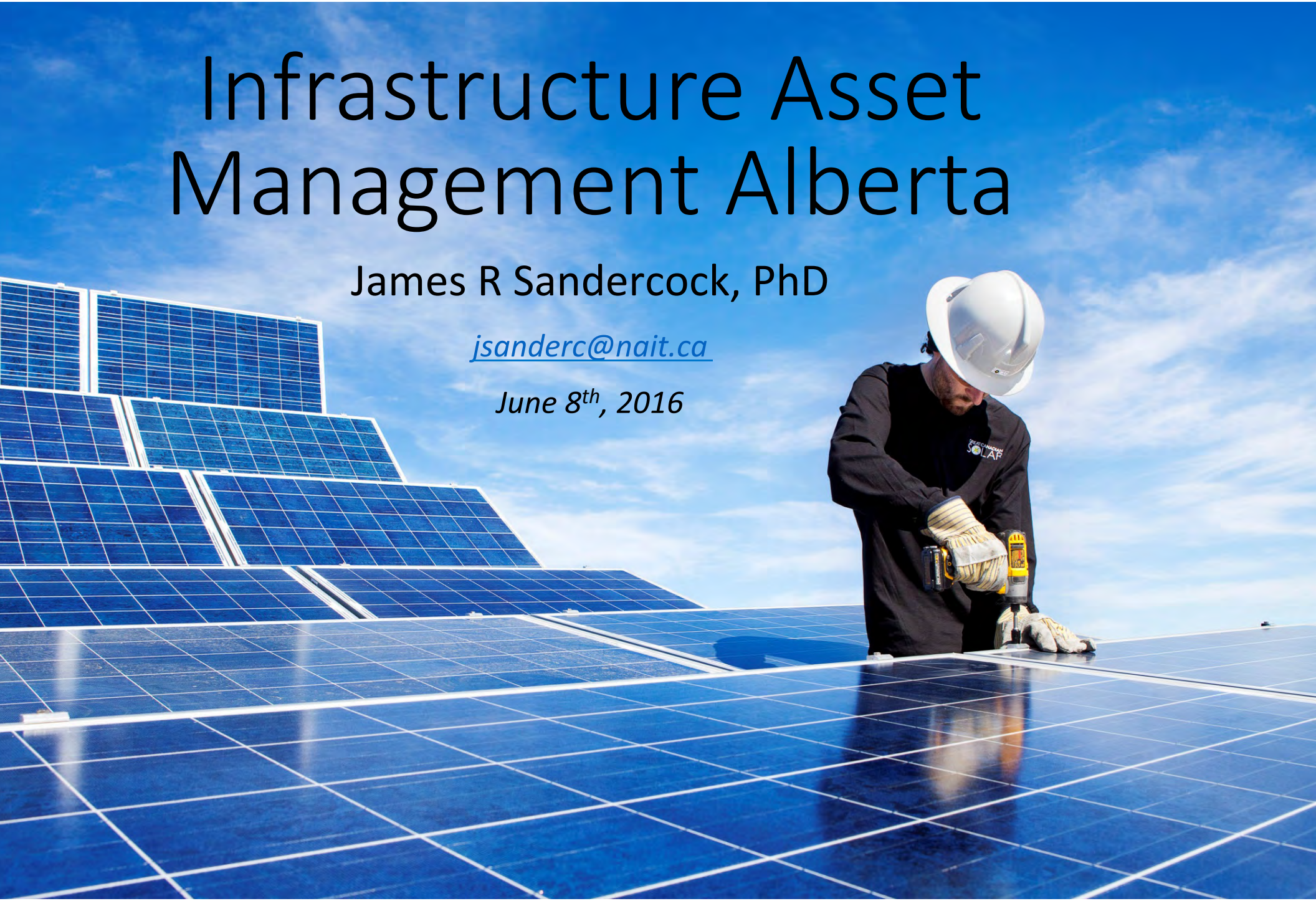
June 8th, 2016



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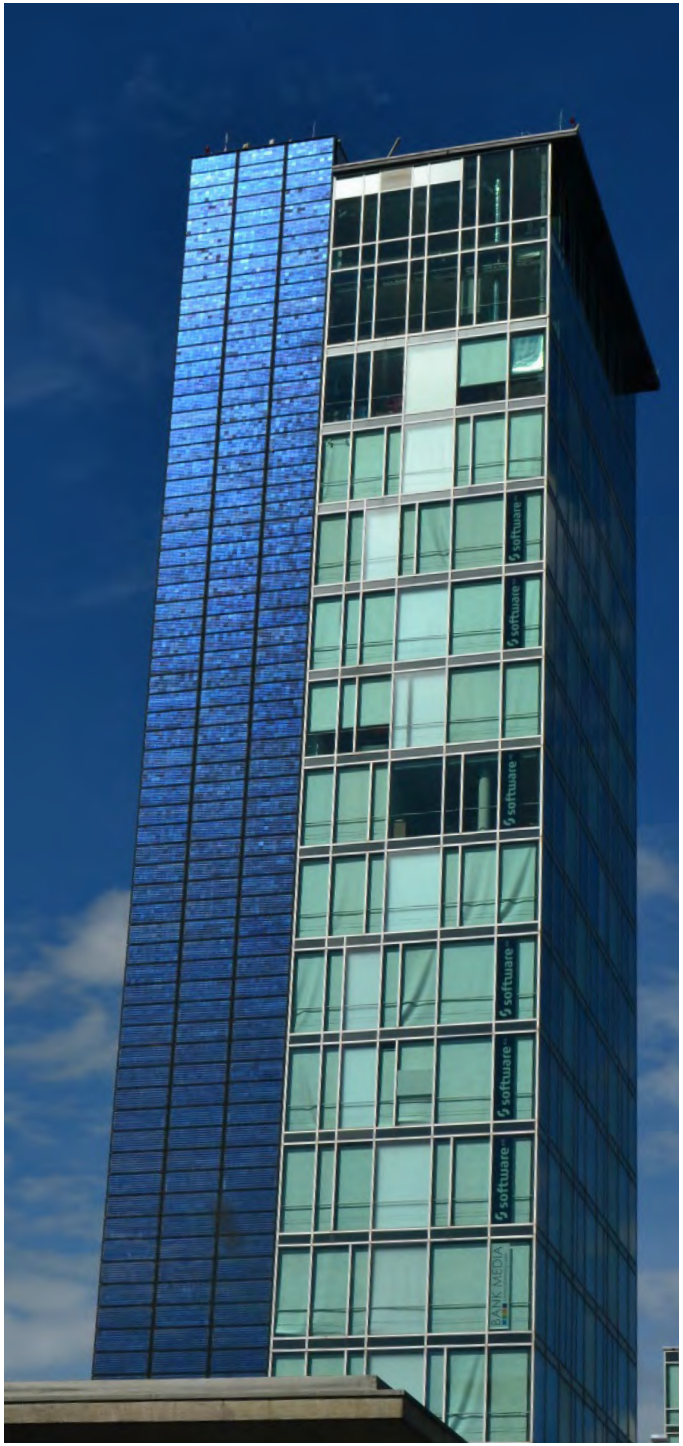

AIT's Alternative Energy Program

rgy Efficiency in the Built Environment

/3D CAD, advanced construction

eating/Cooling loads

ound & Air source heat pumps

generation, Fuel Cells

newable Power

lar, Wind, Hydro, Storage design

stem Assembly & Commissioning

ergy & Financial Modeling

brization & Feasibility

AIT's Alternative Energy Program

Sustainability in Business

- Electricity Policy & the Grid/2.0
- Project Management
- Energy Efficiency/Energy Manage
- Life Cycle Assessment

Biorefining(Biofuels, Biomass,

- Renewable Liquid Fuel productio
- Bio-based Cogeneration
- Material Handling & Processing
- QA/QC methods

e NAIT Program

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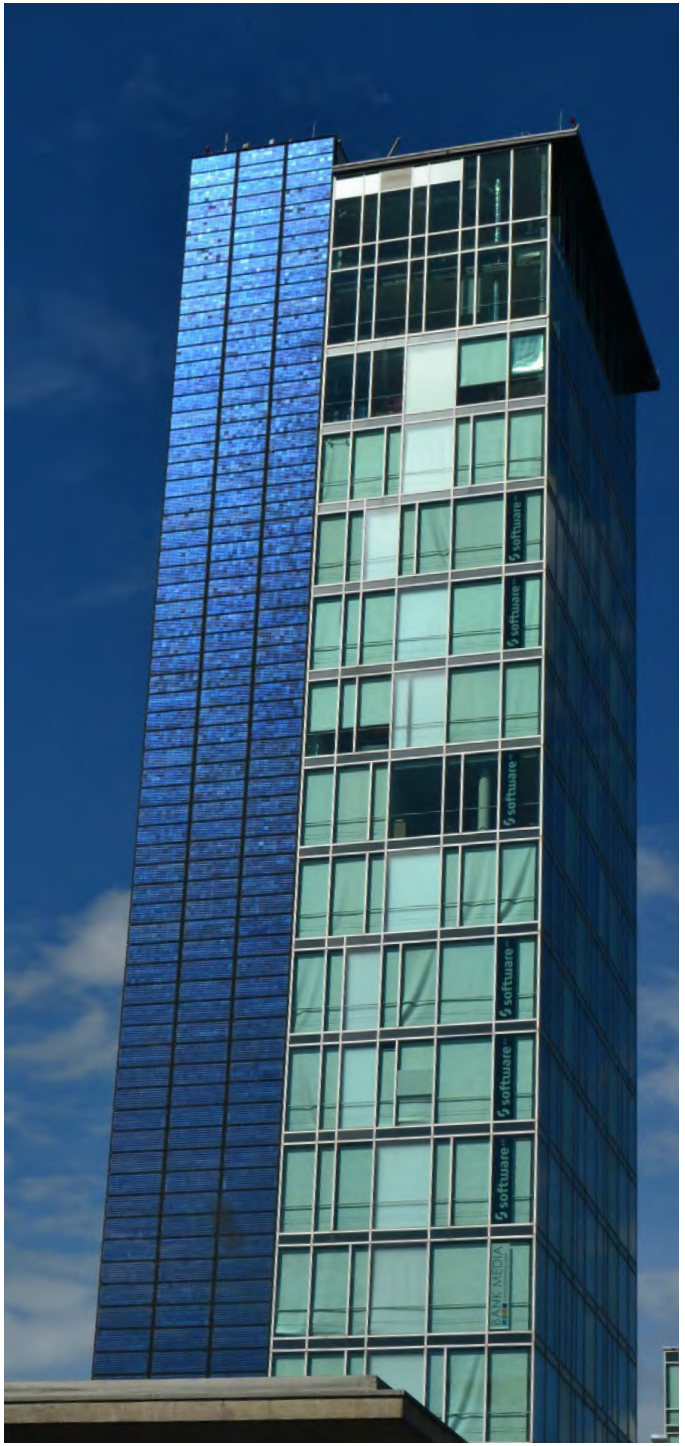
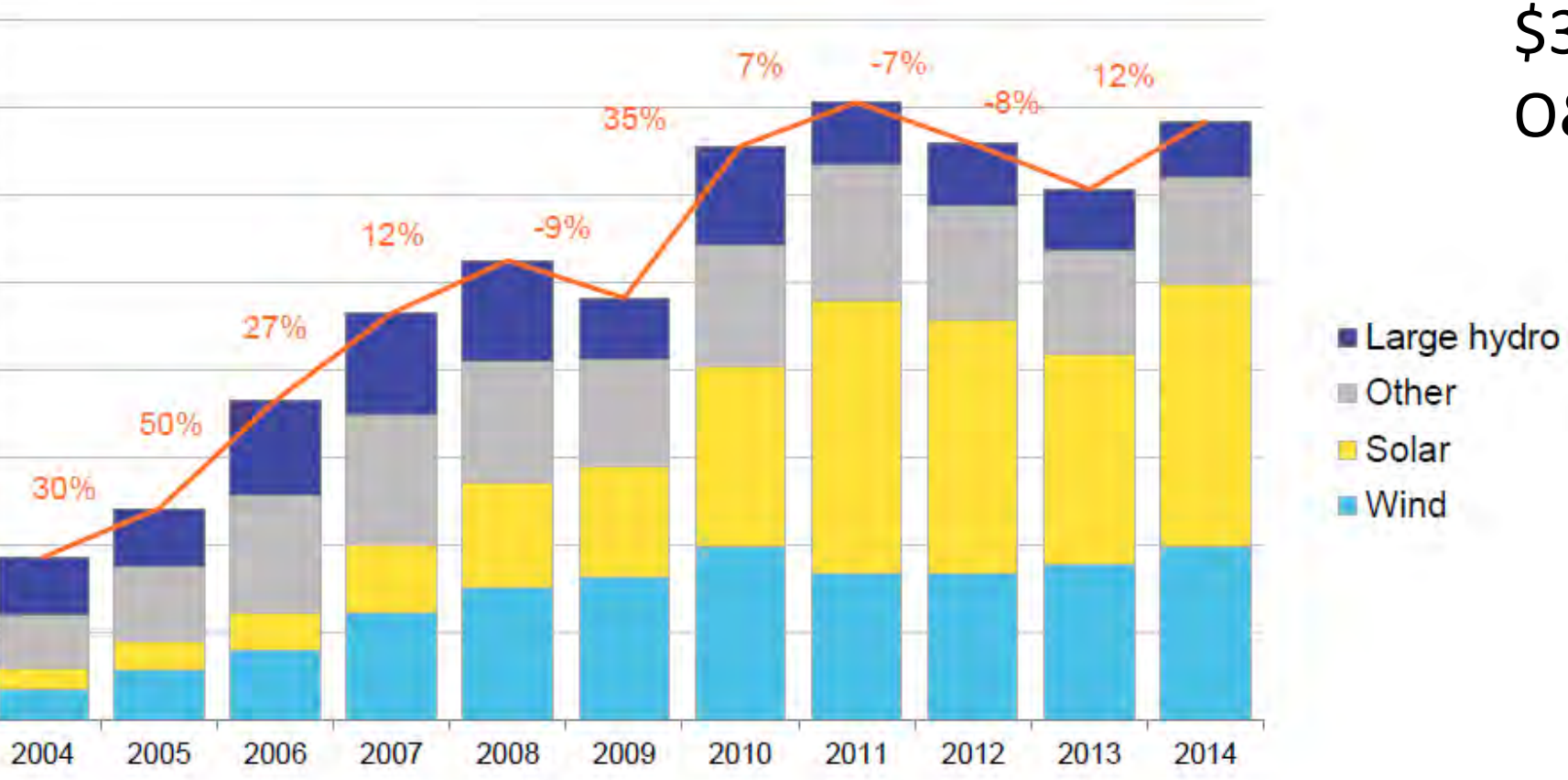


: Within an Order of Magnitude of Annual ssil Fuel Investments

2015 Cross Over
$329 b Clean En
O&G CAPEX $3

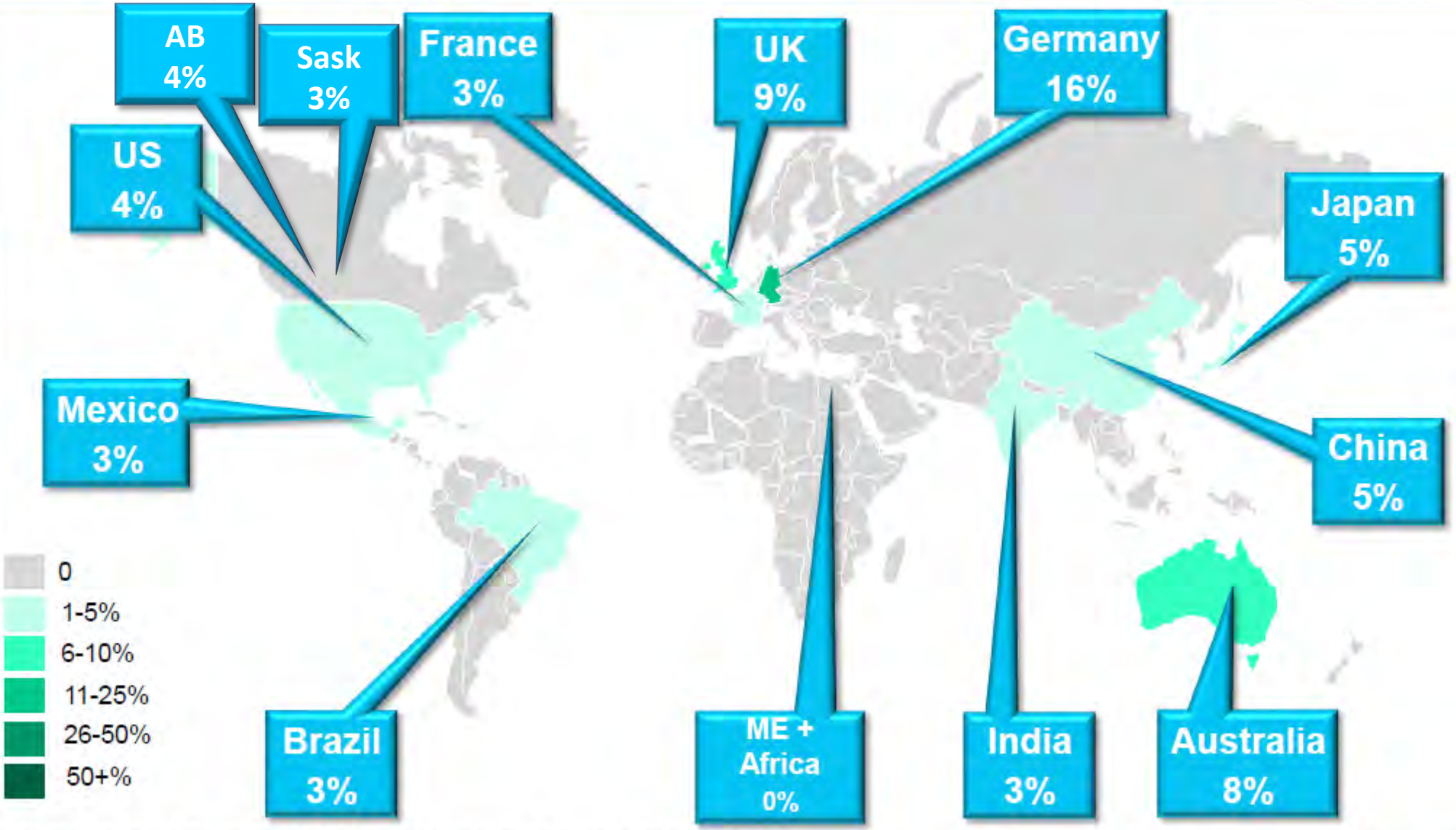


include estimates for undisclosed deals. Includes corporate and government R&D, and spending for energy storage projects (not reported in quarterly statistics), as well as a BNEF estimate for large hydro

Source: Bloomberg New Energy Finance

RENEWABLE ENERGY PROPORTION OF POWER GENERATION- INTERMITTENT ENERGY (WIND & SOLAR) , 2014 (%)

Bloomberg NEW ENERGY FINANCE

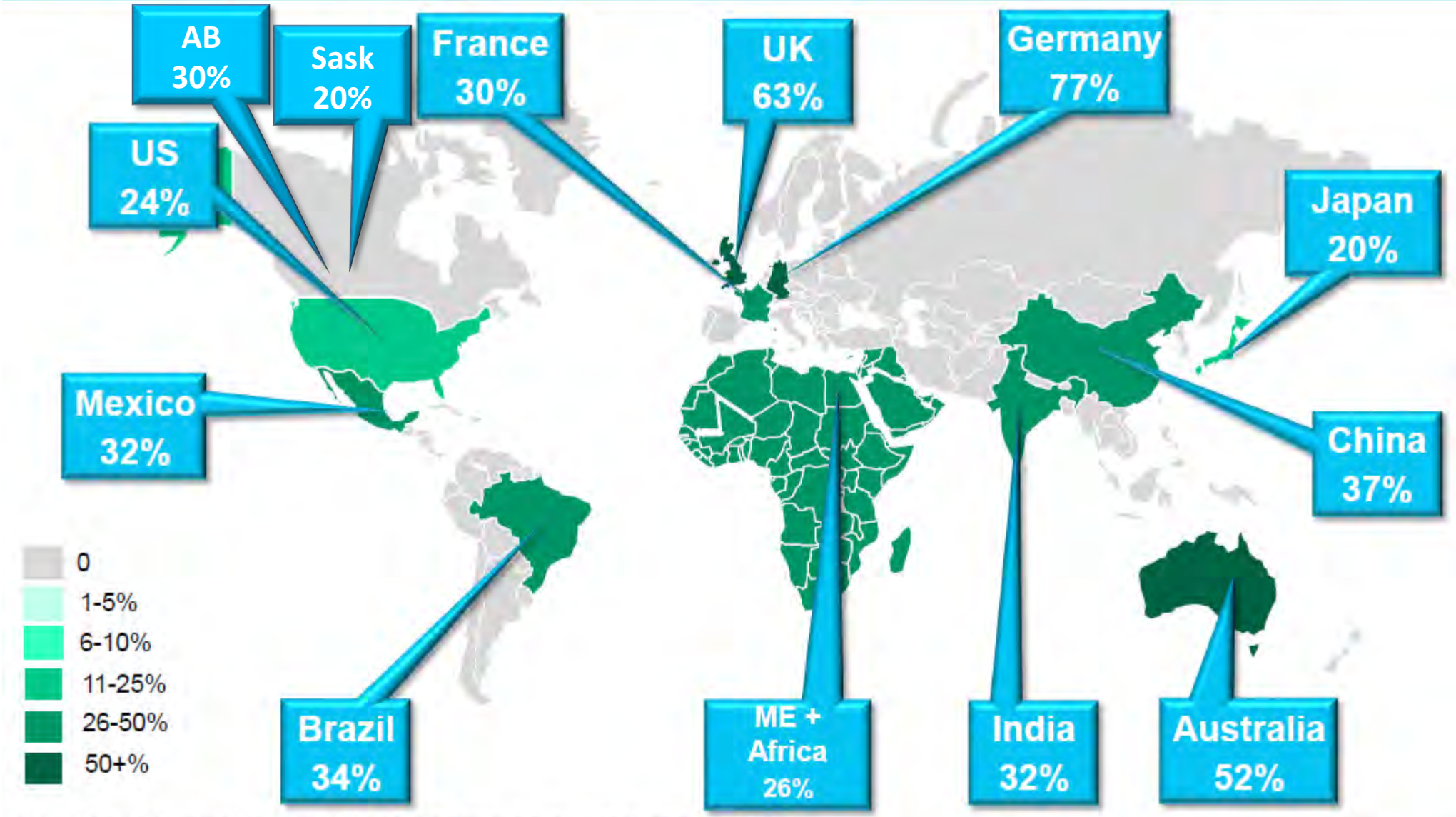


Note: This only shows the combination of wind and solar energy generation. All numbers come from BNEF's New Energy Outlook 2015

Source: Bloomberg New Energy Finance

RENEWABLE ENERGY PROPORTION OF POWER GENERATION- INTERMITTENT ENERGY (WIND & SOLAR) , 2040 (%)

Bloomberg NEW ENERGY FINANCE



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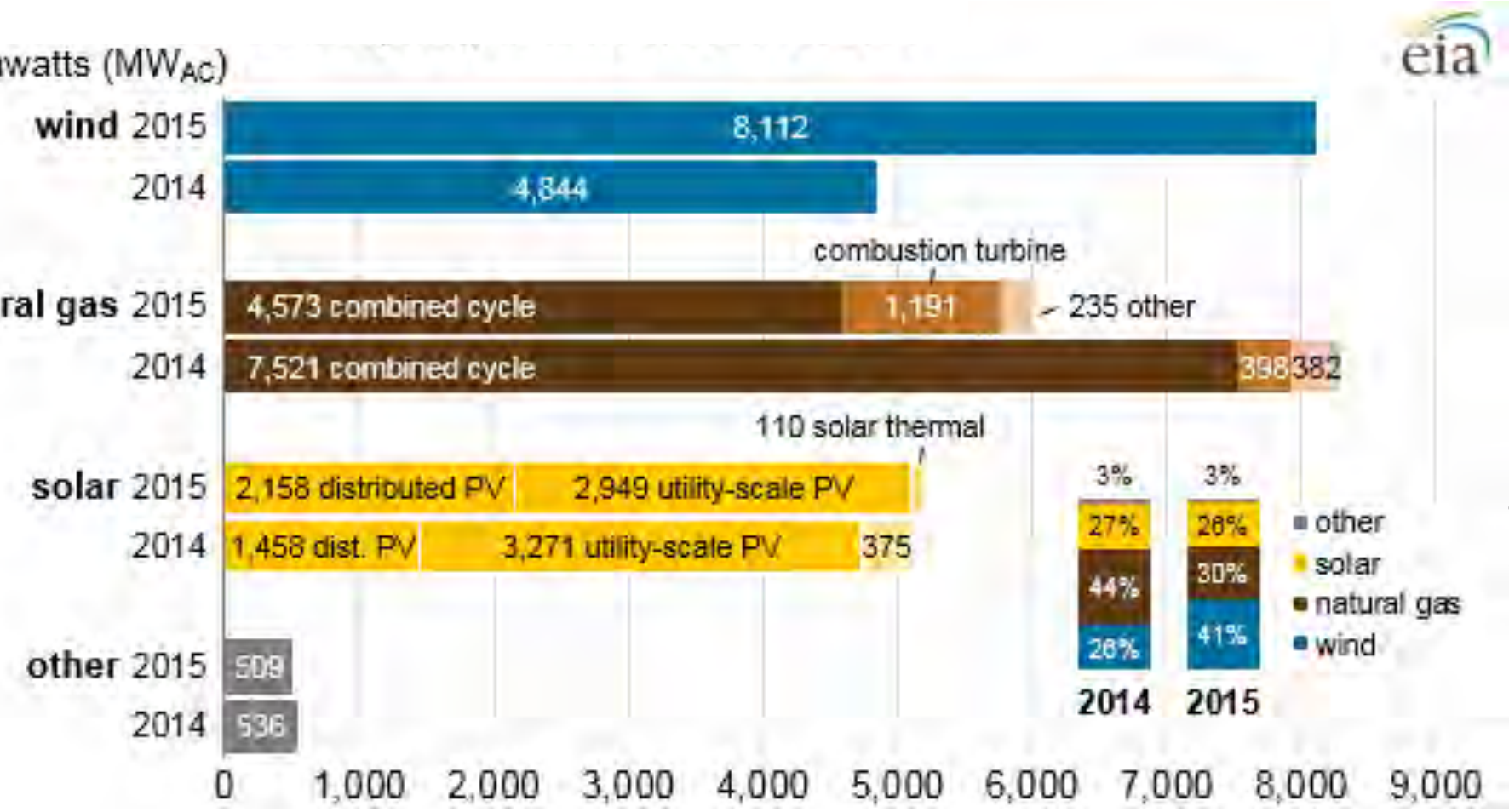
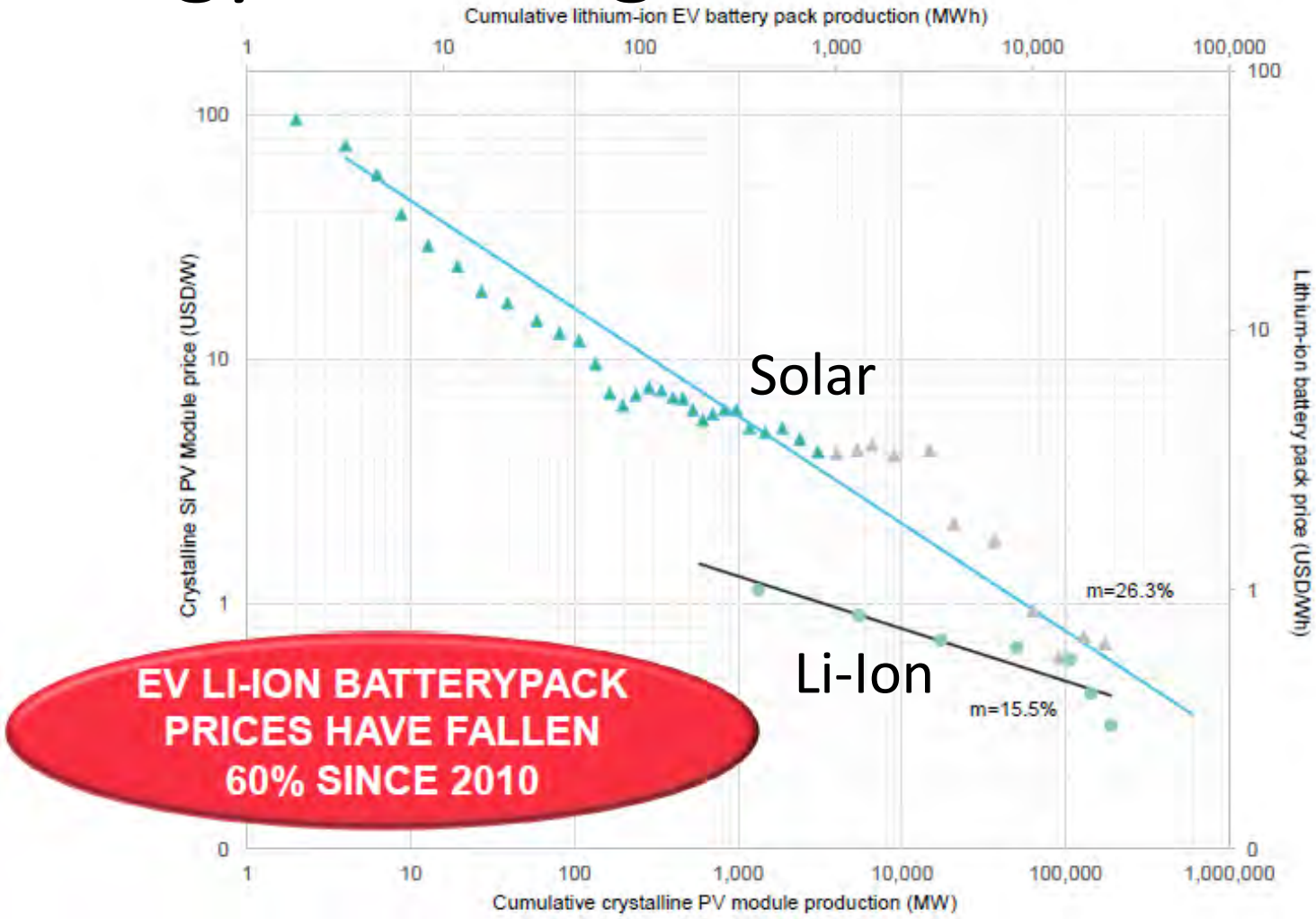
New US Electrical Capacity Additions



Renewables
of new elec
capacity, 20

42% of 201
was distribu

echnology Learning Curves



Cost Decline since 2009

Solar 53 – 7

Wind 66%

Record PPAs

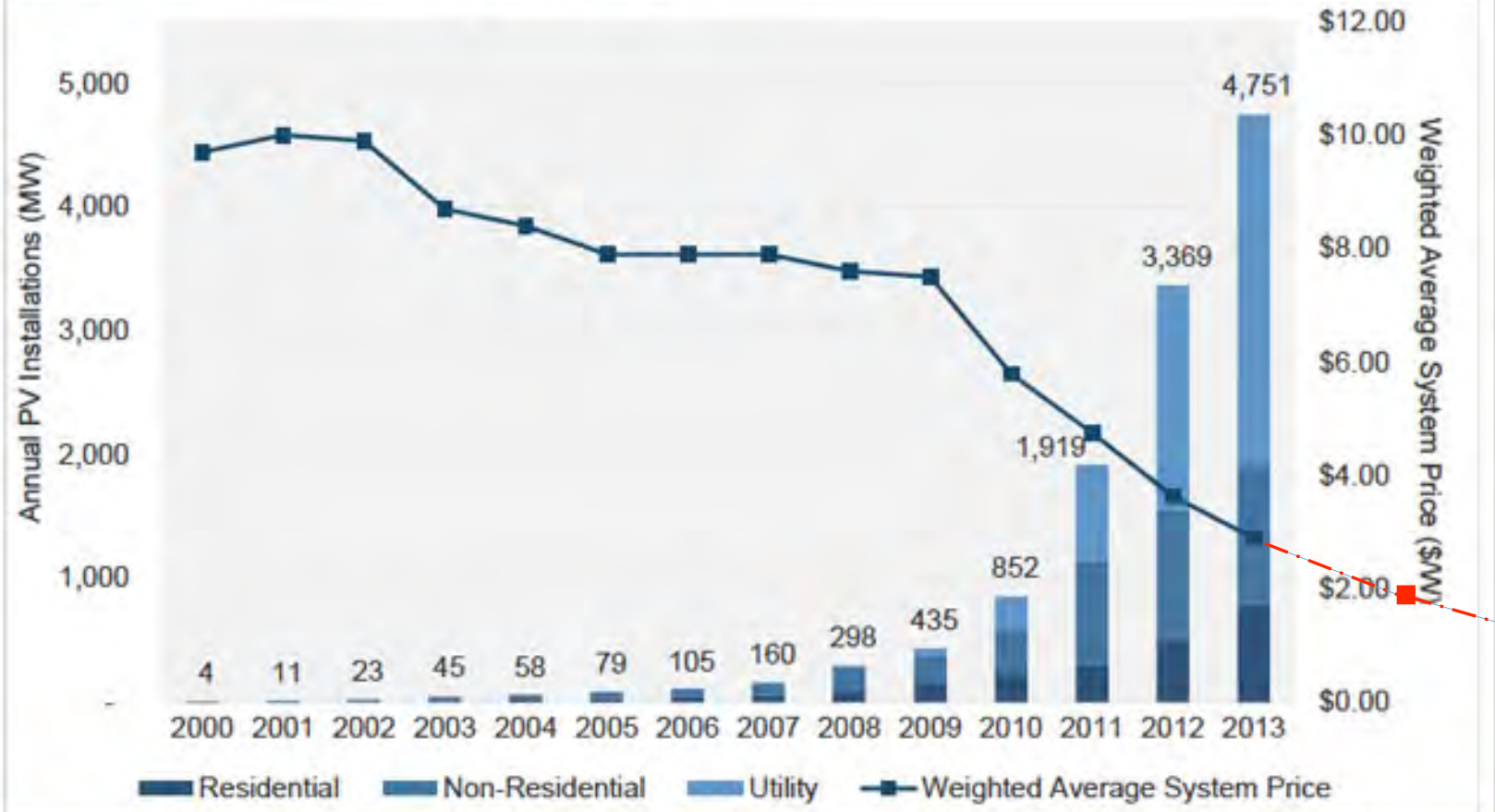
Solar $36/M

Wind $30/M

te: Values from 2010-2014 are based on BNEF's annual battery price index, *2015 based on H1 data. For more see here: ps://www.bnef.com/Insight/10299. Cumulative production is based on total EVs sold and their respective battery pack size.

Bloomberg New Energy Finance

Figure 2.1 U.S. PV Installations and Average System Price, 2000-2013



$1/W
2017

Installations (MW)	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Residential	1	5	11	15	24	27	38	58	82	164	246	304	494	792
Non-Residential	2	3	9	27	32	51	67	93	200	213	339	831	1,072	1,112
Utility	0	3	2	3	2	1	0	9	16	58	267	784	1,803	2,847
Total Installations	4	11	23	45	58	79	105	160	298	435	852	1,919	3,369	4,751

GTM RESEARCH

40 YEARS SEIA

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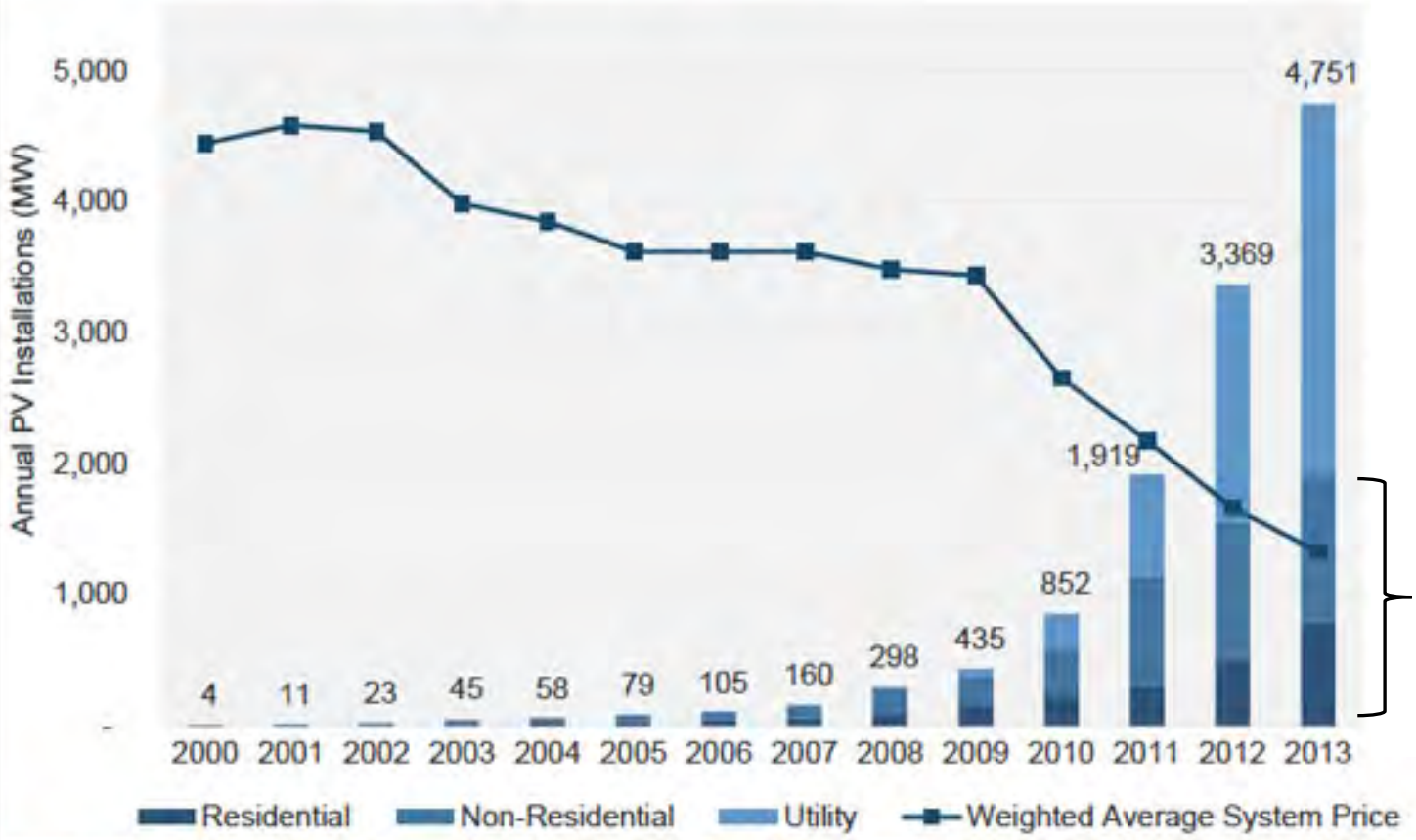

1/3 C&I, residential

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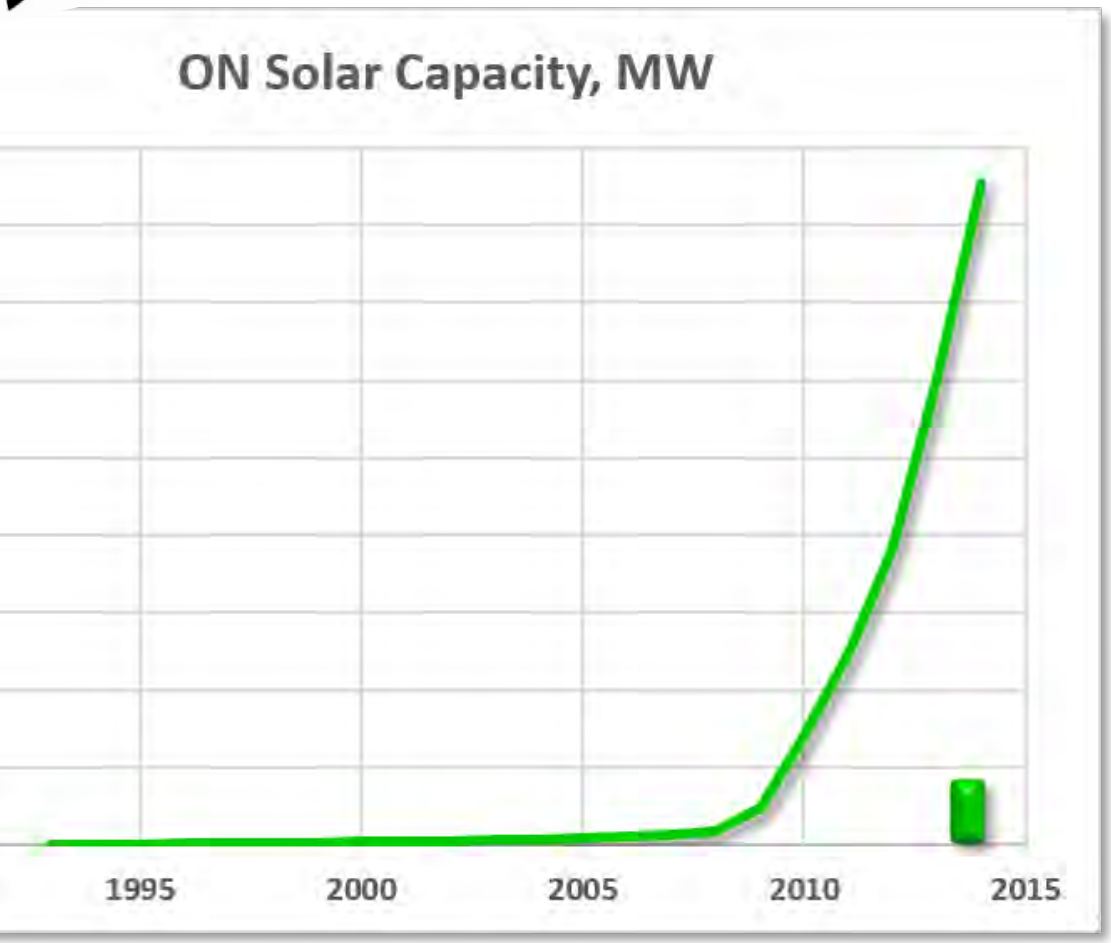
GTM RESEARCH

40 YEARS SEIA

Ontario



5 y

2014

GHG 15% below 1990

Eliminated Coal

Solar from 33 to 1,71

10% distributed

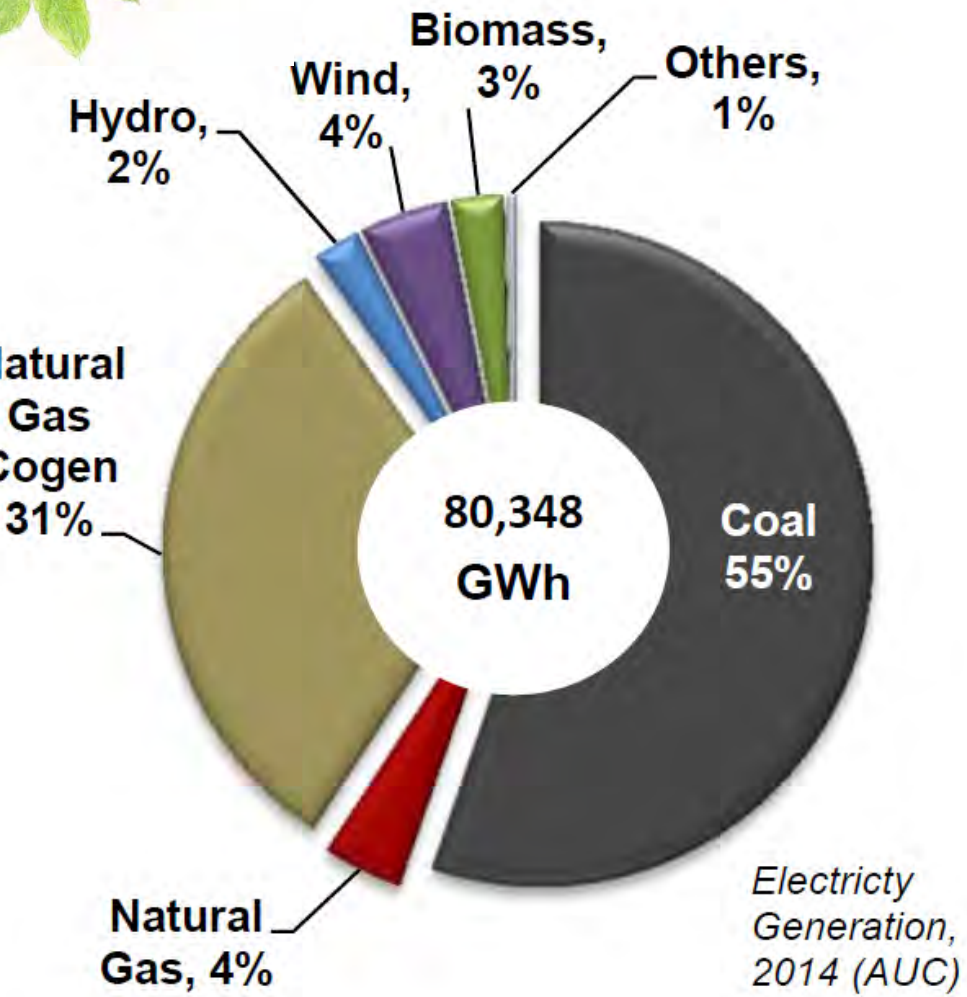
Wind 2,856 MW

New

GHG 37% below 1990

by 2030

Alberta



15 y

2016

Capacity doubled ea ye
for last three years
9.8 MW Solar PV total

2030

Eliminate Coal
30% Renewables
MCCAC (6-8 MW PV a
$3.4b for large scale F
- 240 MW PV Sunco
- 68 MW PV EdF-EN
- 39 MW PV BluEart

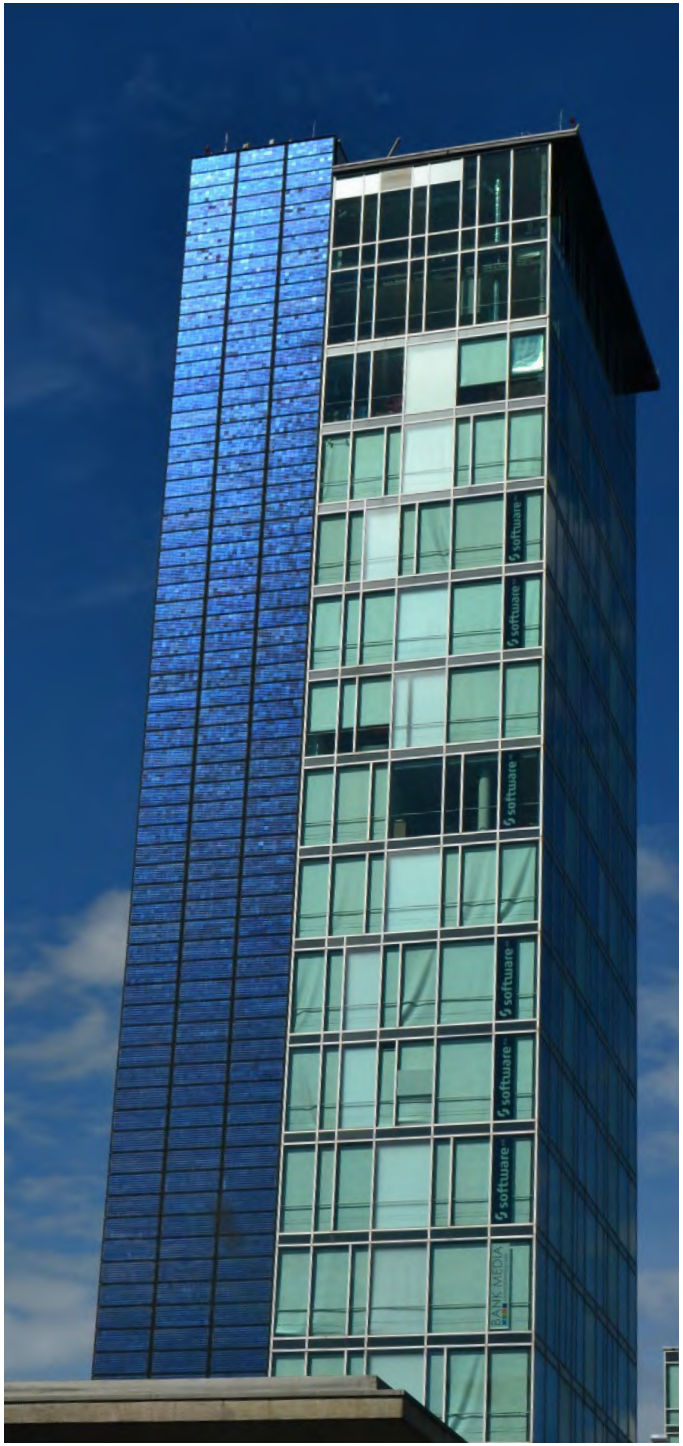
Energy Efficiency Agenc

chnologies

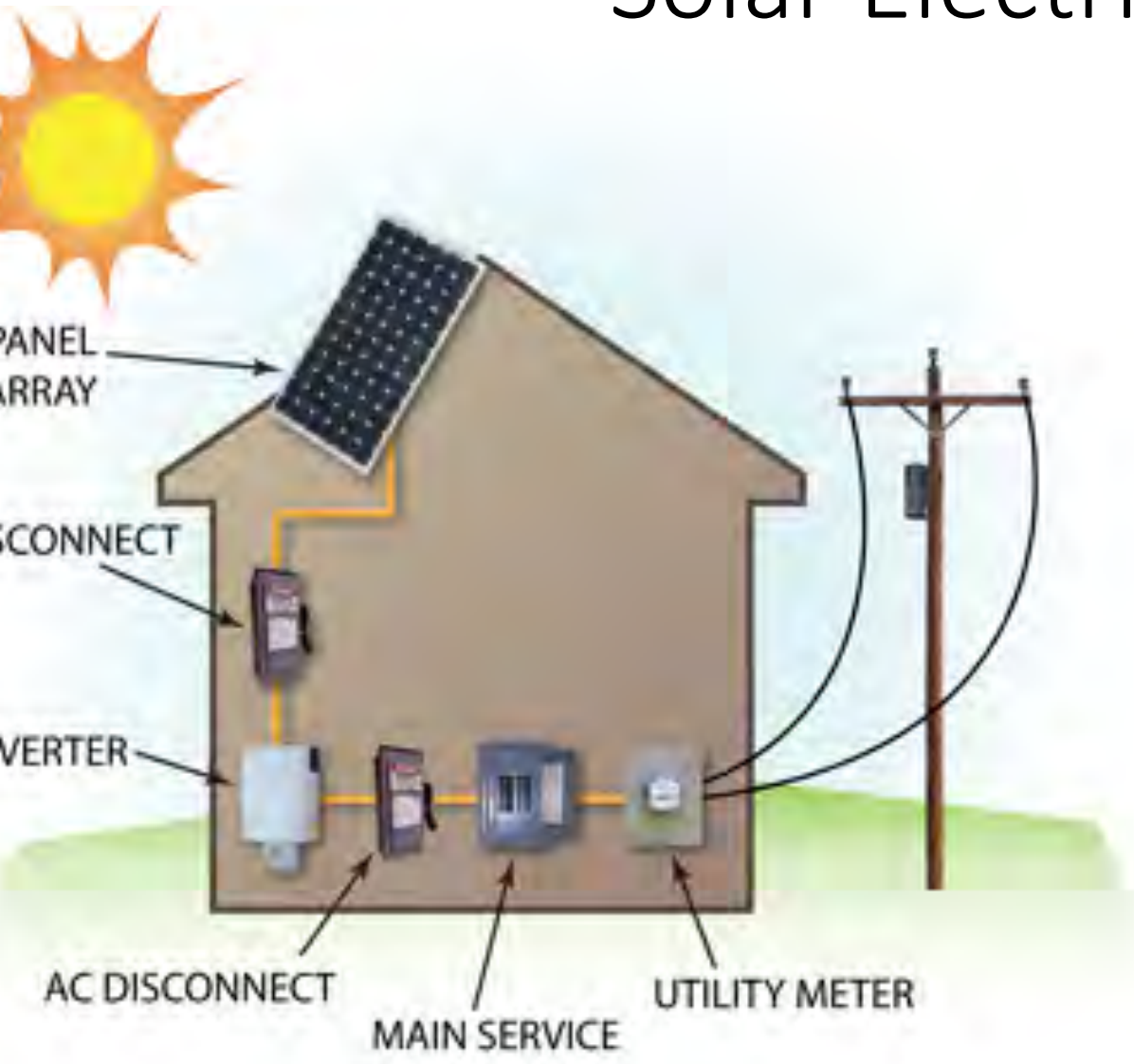
lar PV (electric)
t Zero buildings
at Pumps

conomics

et Metering/Net Billing
erformance-based savings
centives



Solar Electric (PV)



- Generates DC electricity
- Inverters convert this to AC
- AC is fed into the service p for self-consumption
- Excess electricity goes to th
  - completely legal
  - inverter anti-islanding fea
  - some financial compensa
- 95% of installations have no batteries

lar PV

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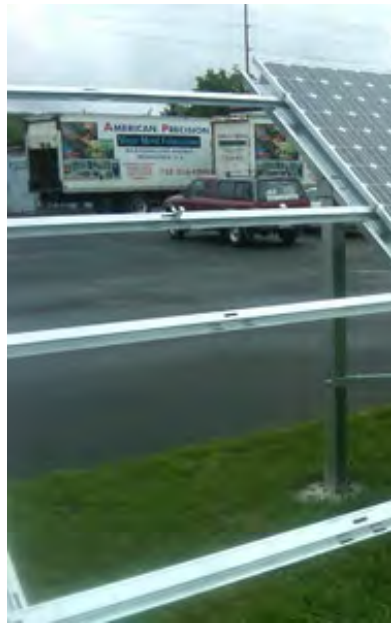
acking
rports

ush mounted
w angled on flat roofs
ilding Integrated (BIPV)



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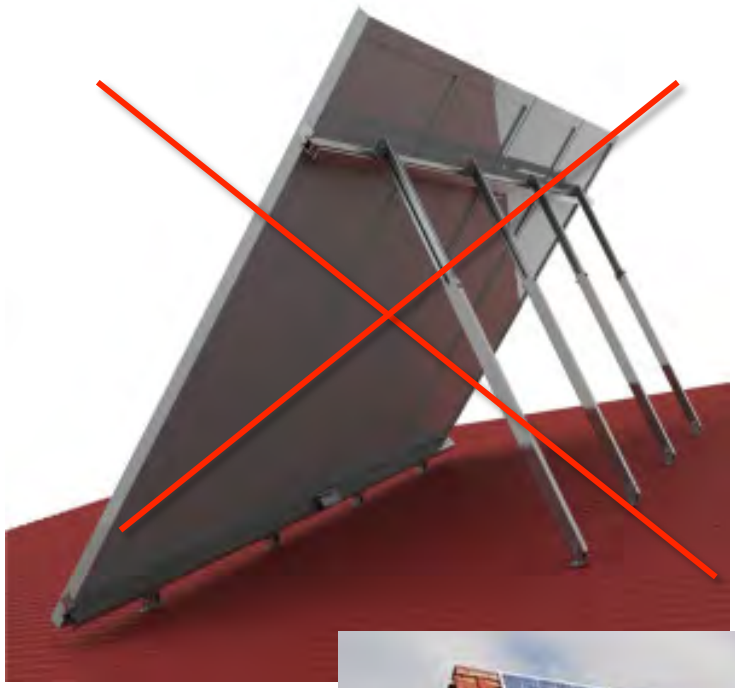

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et Zero

building that produces
much energy as it
nsumes
on an annual basis

David

Alberta's first commercial net-zero building

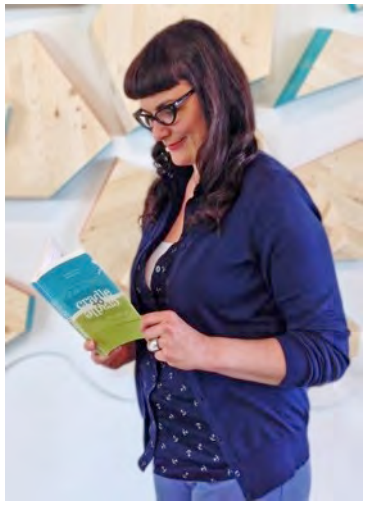
David Dodge, Green Energy

The Mosaic Centre for Conscious Community and Commerce

Solar + Geoexchange = net-zero for 30,000 sq. foot building

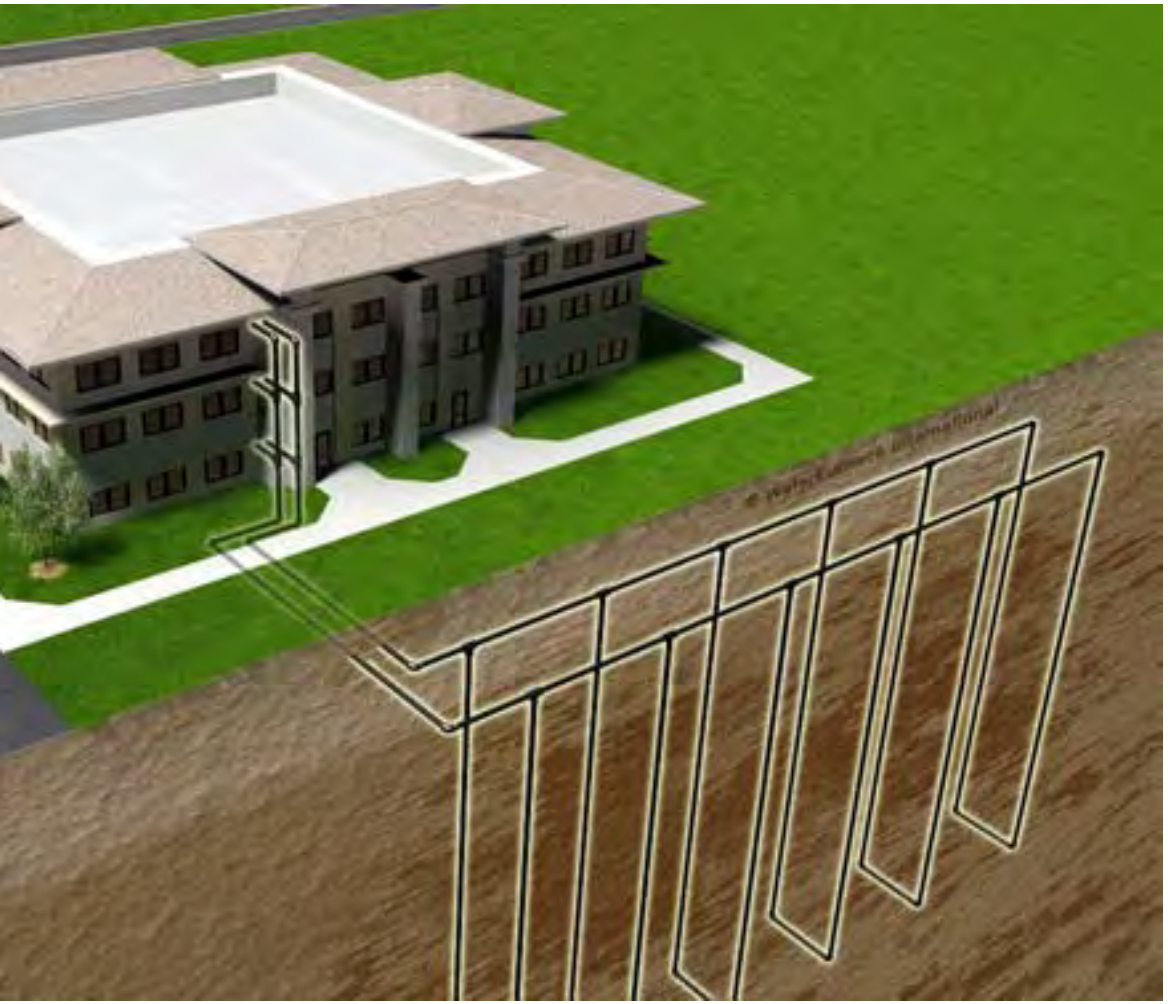
Affordable, sustainable, the future

Solar powered
Natural lighting
Energy efficient
Windows open
Beautiful
Geo heating & cooling



David Dodge, Green Energy Futures

Ground Source Heat Pumps



- High first cost
- Coefficients of Performanc
  High
- Proven performance in Alb
  climate
- Competing against all-time
  cost natural gas
  - commercial applications

Air Source Heat Pumps

- Lower first cost
- Coefficients of Performanc
  Intermediate
- Unproven performance in
  Alberta climate
- Competing against all-time
  cost natural gas

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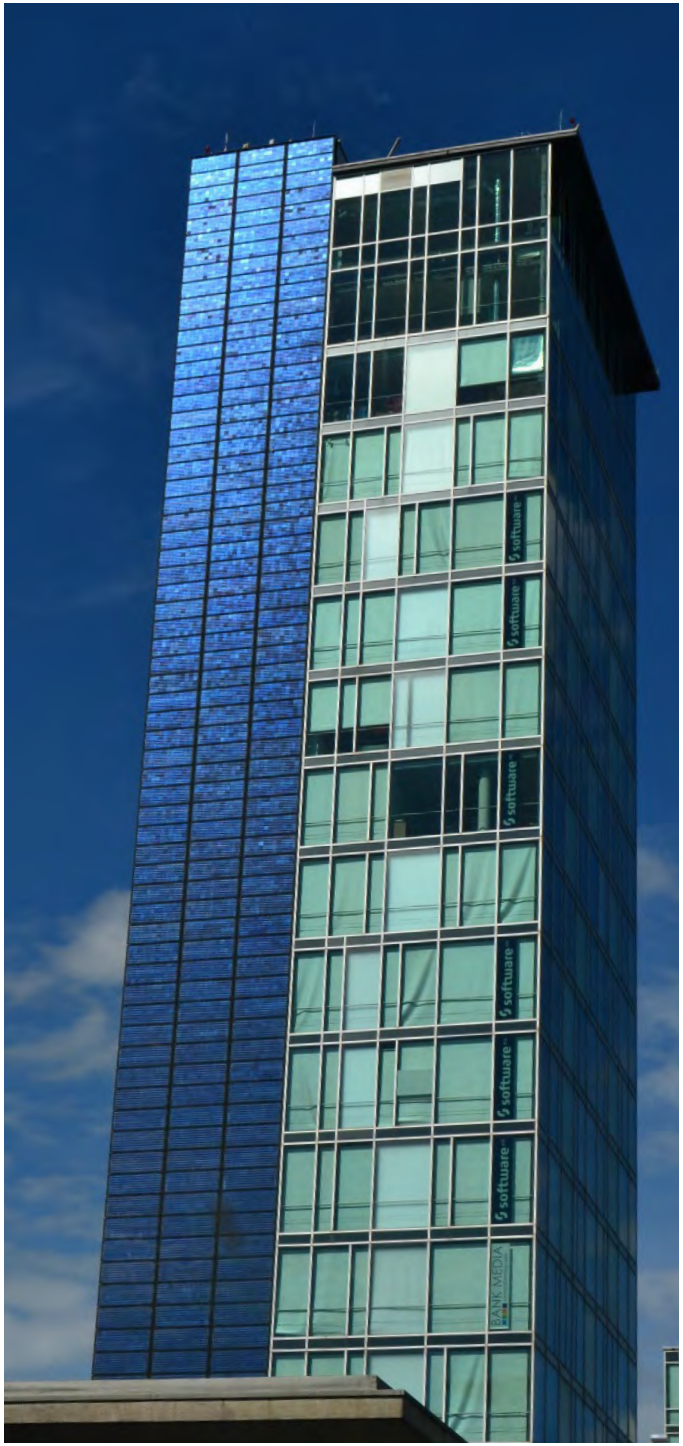
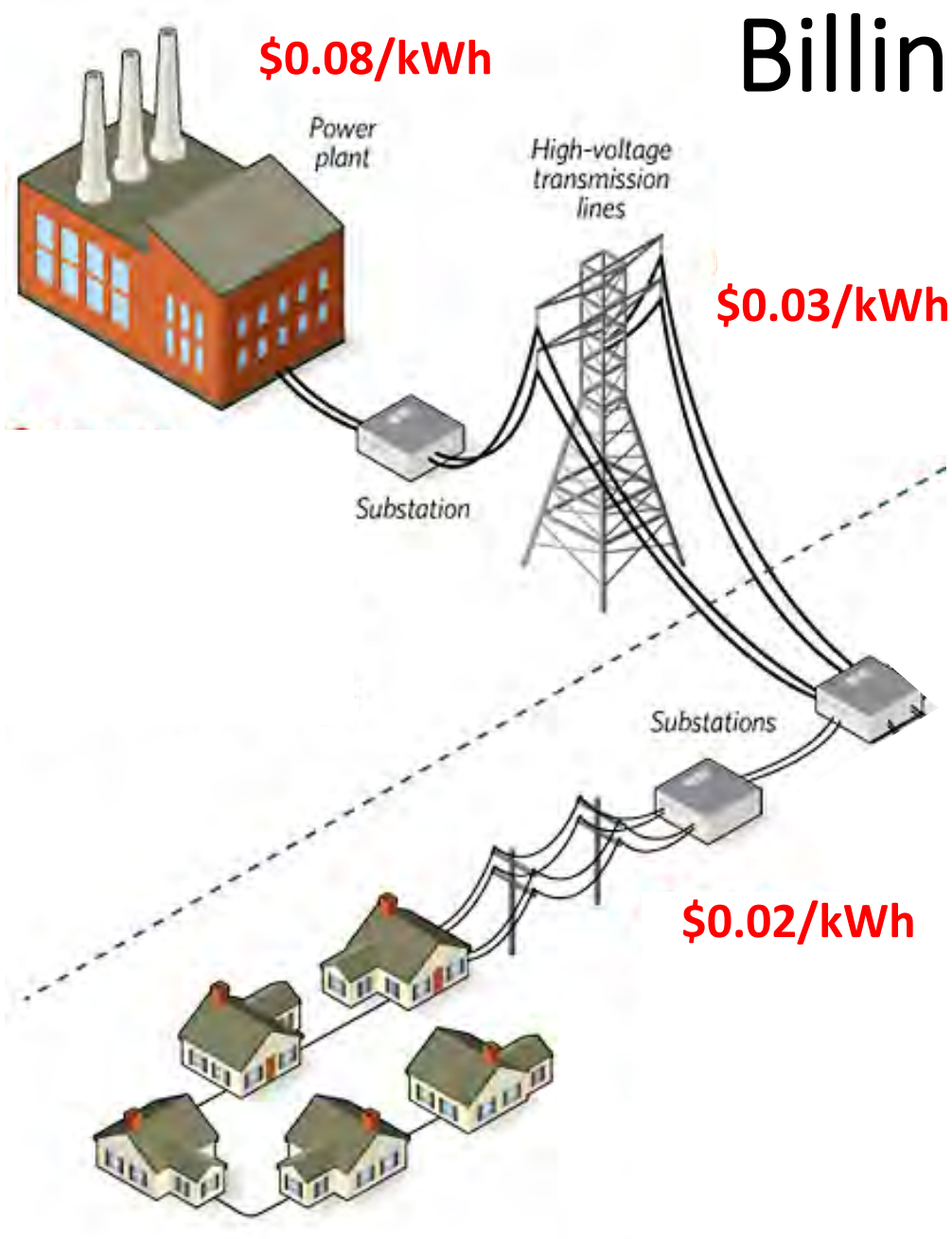


Billing



Heritage Organization, 2015

Net Metering:

Building owner is paid retail rate for excess electricity
= $0.13/kWh

T&D infrastructure is not supported

Self consumption

Net Billing:

Building owner is paid wholesale for excess
= $0.08/kWh

Neighbour *still* pays for T&D ($0.05/kWh)

Performance Based Savings

Various mechanisms exist by which long-term savings can be realized through energy efficiency and renewable generation

- Energy Savings Companies (ESCo)
  - Guaranteed Energy Savings Contracts
  - Shared Savings Contracts
- Self-funded Savings
  - U of A Envision (30,000 tonnes CO_2, $3.8 m/y)
  - Emory University ($1.5 m rolling projects)
  - Cape Breton U ($17 m “Community” wind farm)

Energy Efficiency Agency

$645 million in grants, loans, contributions & guarantees over 5 years

- Energy Efficiency & Conservation
- Community Energy Systems
  - 2017 - $45 million
  - 2018 - $90
  - 2019 - $165
  - 2020 - $170
  - 2021 - $175

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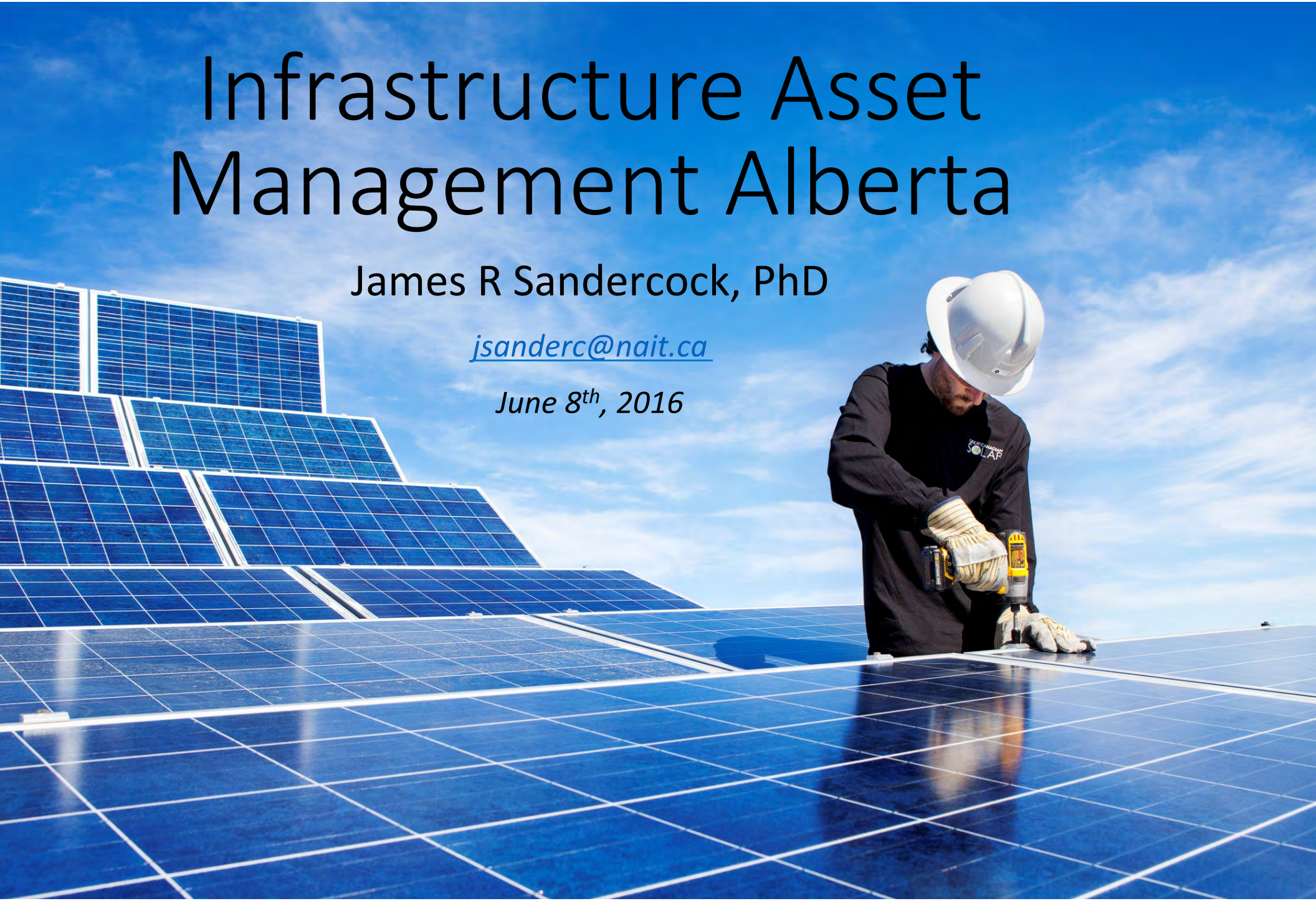
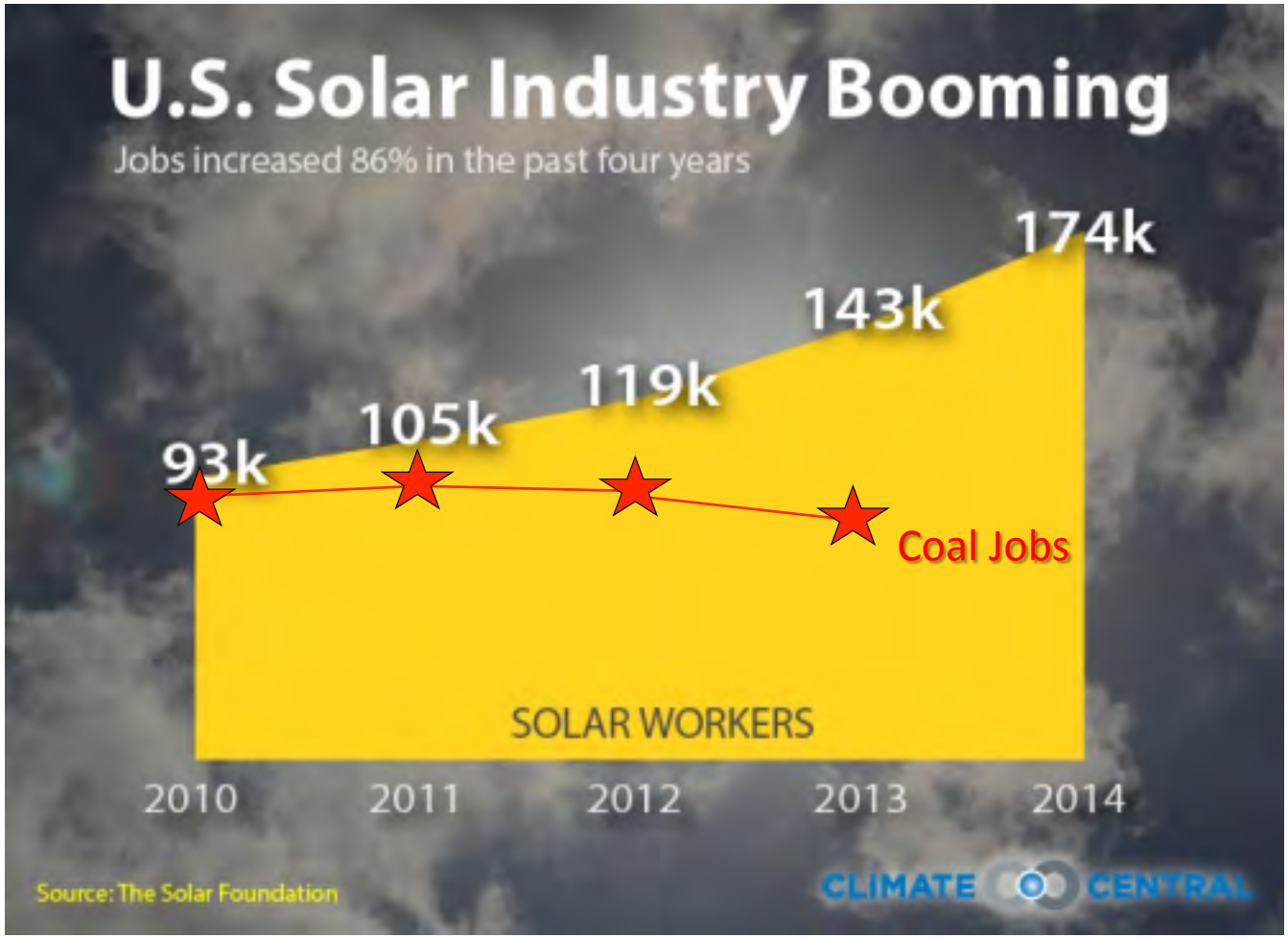


Solar Jobs


U.S. Solar Industry Booming
Jobs increased 86% in the past four years
93k
105k
119k
143k
174k
Coal Jobs
SOLAR WORKERS
2010
2011
2012
2013
2014
Source: The Solar Foundation
CLIMATE CENTRAL