

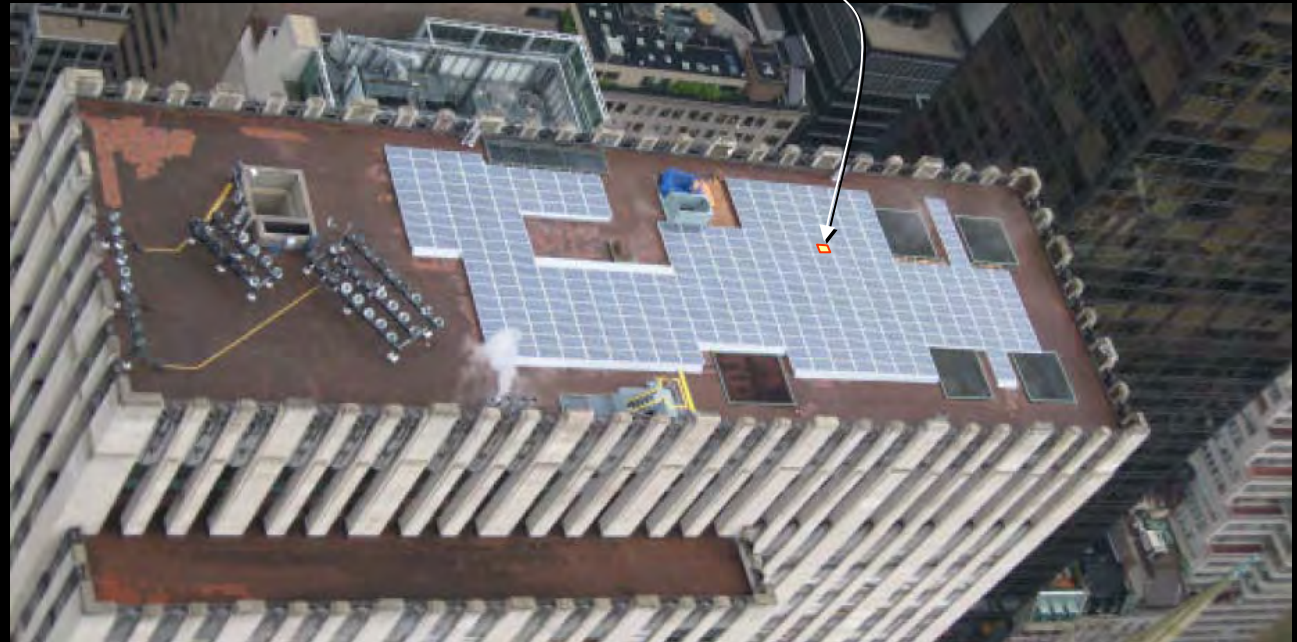
# **OUR SOLAR FUTURE**

**too expensive ..  
..or a bargain?**

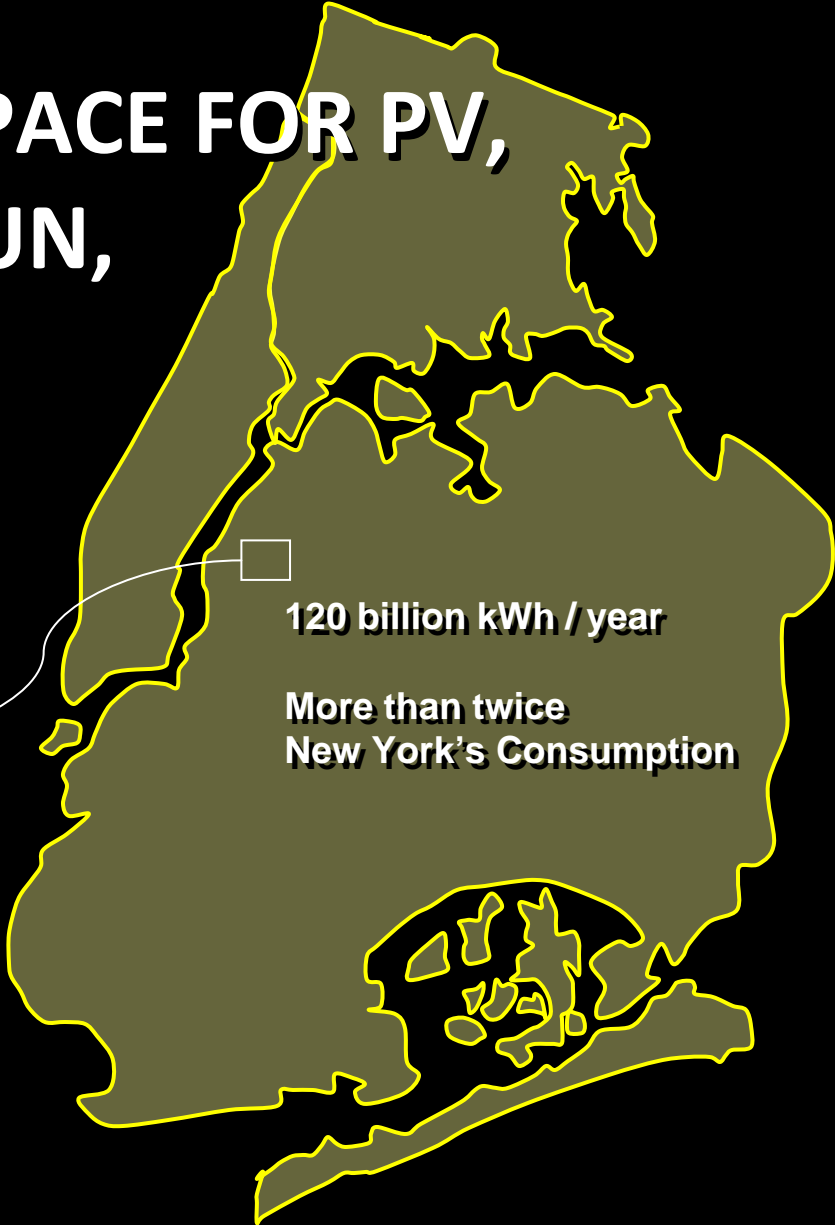
***RICHARD PEREZ, U. Albany, State University of New York  
with contribution from TOM HOFF, Clean Power Research***

# NOT ENOUGH SPACE FOR SOLAR, NOT ENOUGH SUN,

Each square foot in New York can generate 20 kWh of photovoltaic electricity per year



# NOT ENOUGH SPACE FOR PV, NOT ENOUGH SUN,



**120 billion kWh / year**

**More than twice  
New York's Consumption**





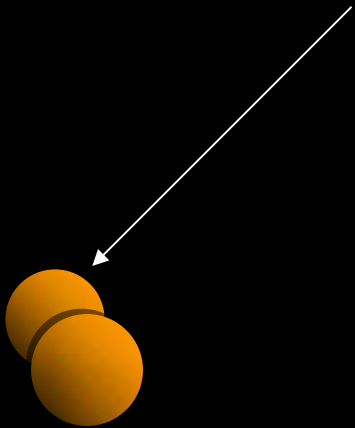
9 MW

10 kW

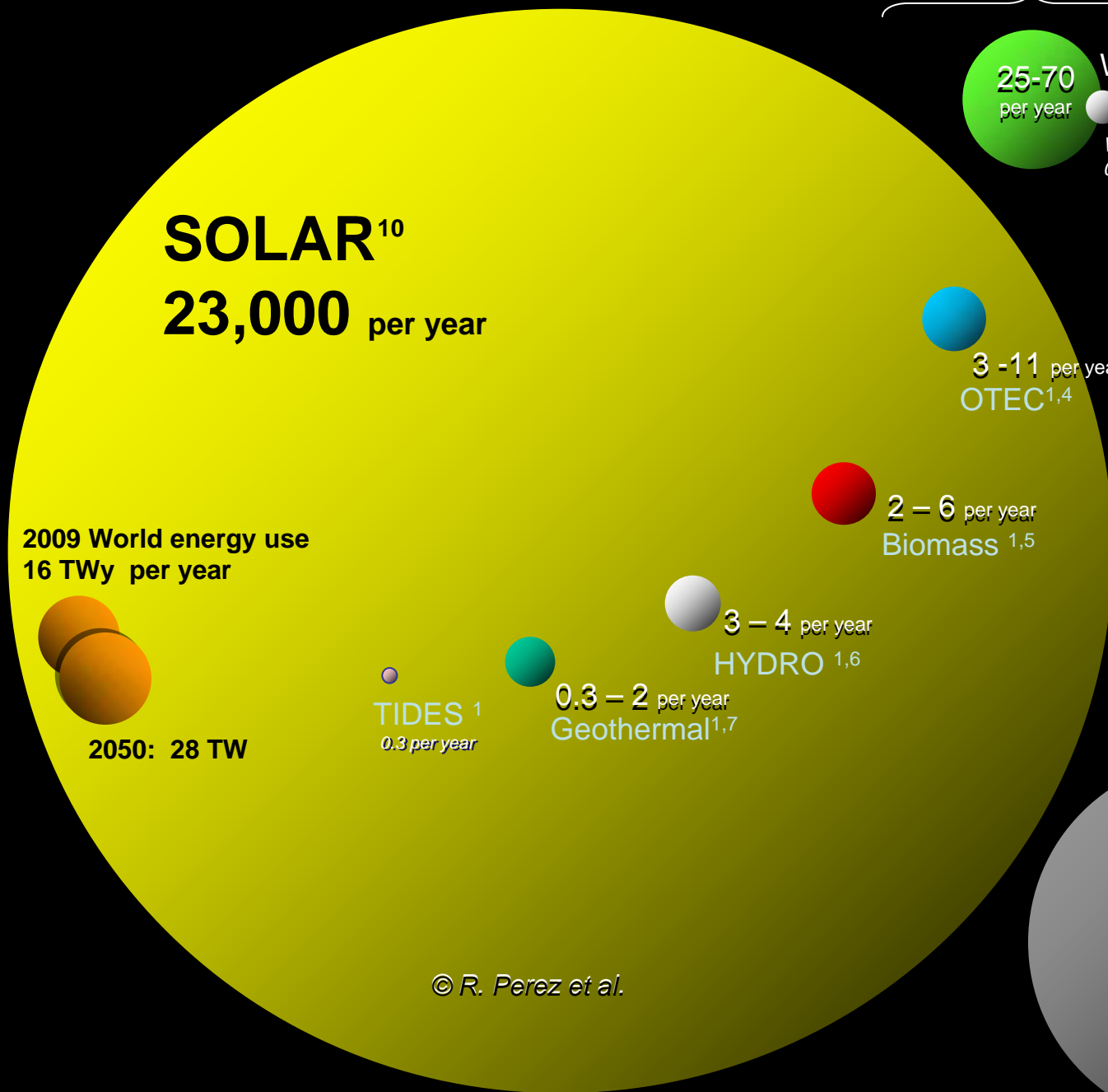
Richard Perez, et al.

**1500 MW all roofs/parkings in viewing area alone**

**2009 World energy use:  
16 TW-year per year**



**2050: 28 TW**

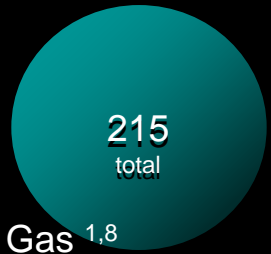


renewable                      finite



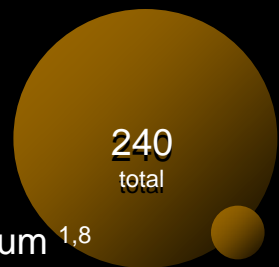
WIND<sup>1,2</sup>

Waves<sup>1,3</sup>  
 0.2-2



215  
 total

Natural Gas<sup>1,8</sup>



240  
 total

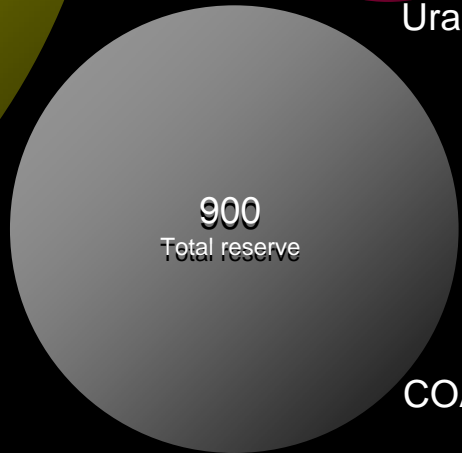
Petroleum<sup>1,8</sup>

ANWR



90-300  
 Total

Uranium<sup>1,9</sup>



900  
 Total reserve

COAL<sup>1,8</sup>

© R. Perez et al.

**ENOUGH SPACE,  
ENOUGH SUN,  
...TOO EXPENSIVE...**

Ralph Izzo, Chairman, PSEG:

*“We’ve got to stop pretending solar power will lower the cost of energy.*

*It’s going to increase the cost and people have got to understand why it is worth more”*

# Solar delivers value

	PV OWNER	UTILITY	CONSTITUENTS
EQUIPMENT	COST	BENEFIT	BENEFIT
INCENTIVES	BENEFIT		COST
UTILITY BILLS	BENEFIT	COST	
TAX EFFECTS	BENEFIT		COST

## TRANSMISSION LEVEL

Energy

Capacity

## DISTRIBUTION LEVEL

Capacity

LOSS SAVINGS

GRID SECURITY

ENVIRONMENTAL COMPLIANCE

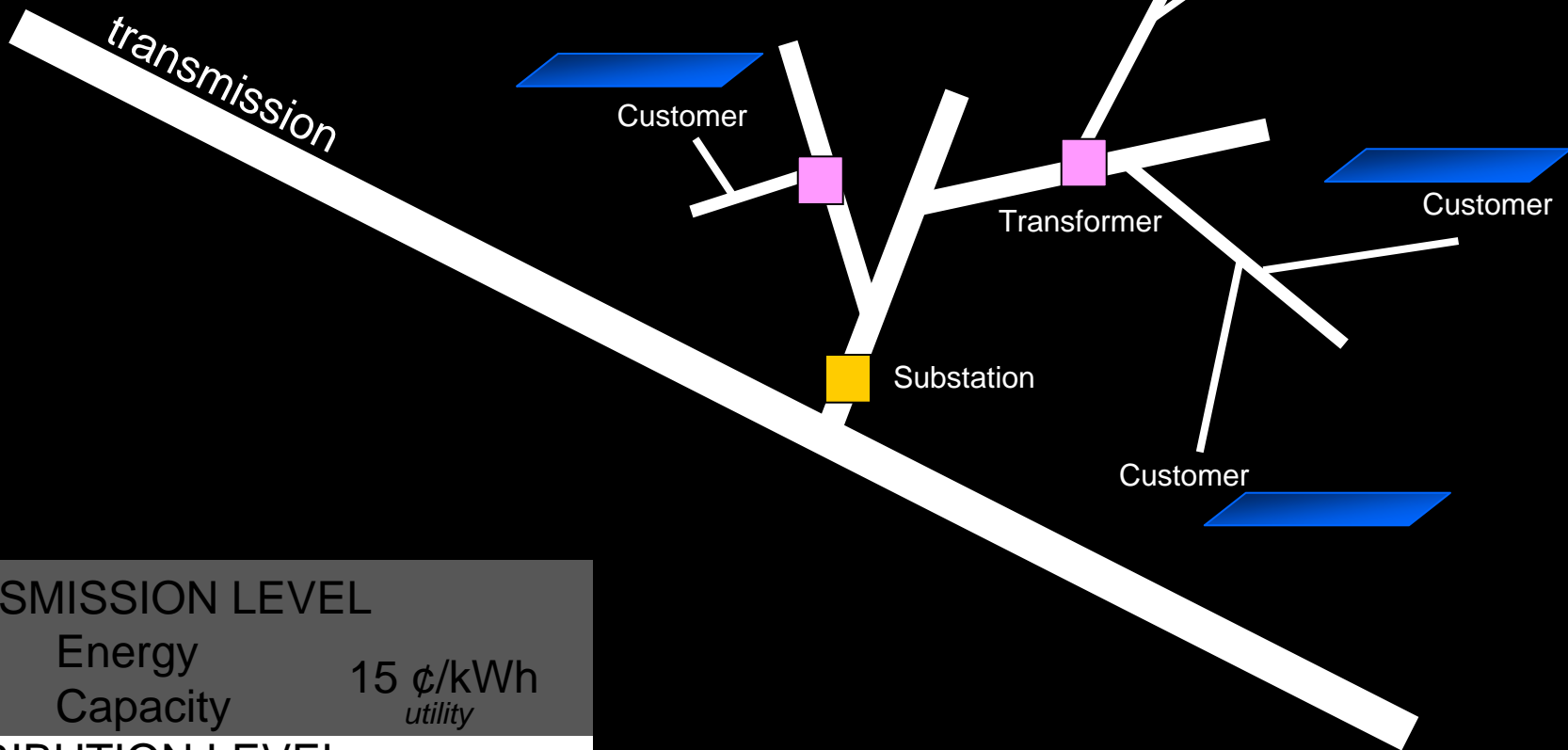
FUEL PRICE RISK MITIGATION

ECONOMIC GROWTH





# Distribution System



## TRANSMISSION LEVEL

Energy  
Capacity 15 ¢/kWh  
*utility*

## DISTRIBUTION LEVEL

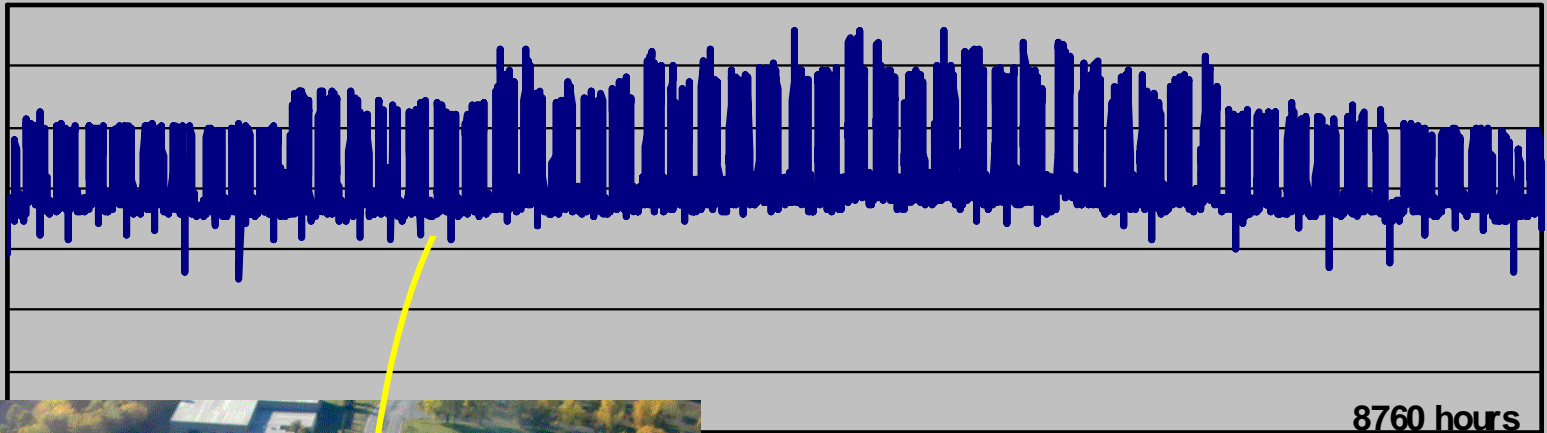
Capacity  
Loss savings 1-6 ¢/kWh  
*utility*

Power flow



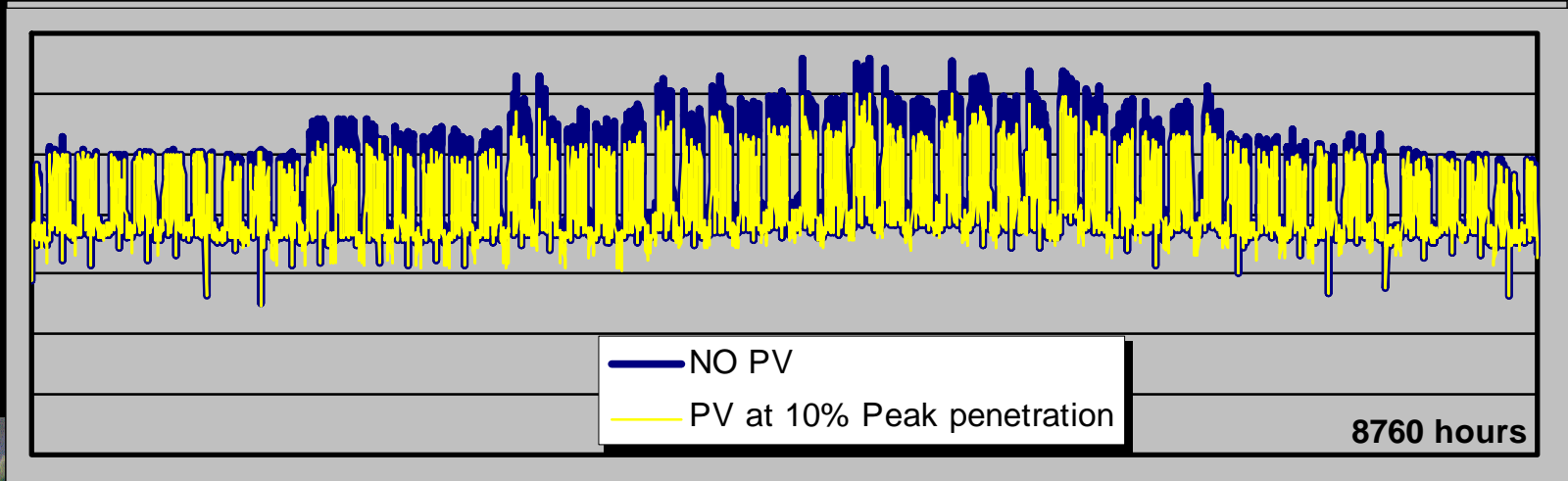
© Richard Perez, et al.

# ELECTRICAL DEMAND THROUGHOUT ONE YEAR



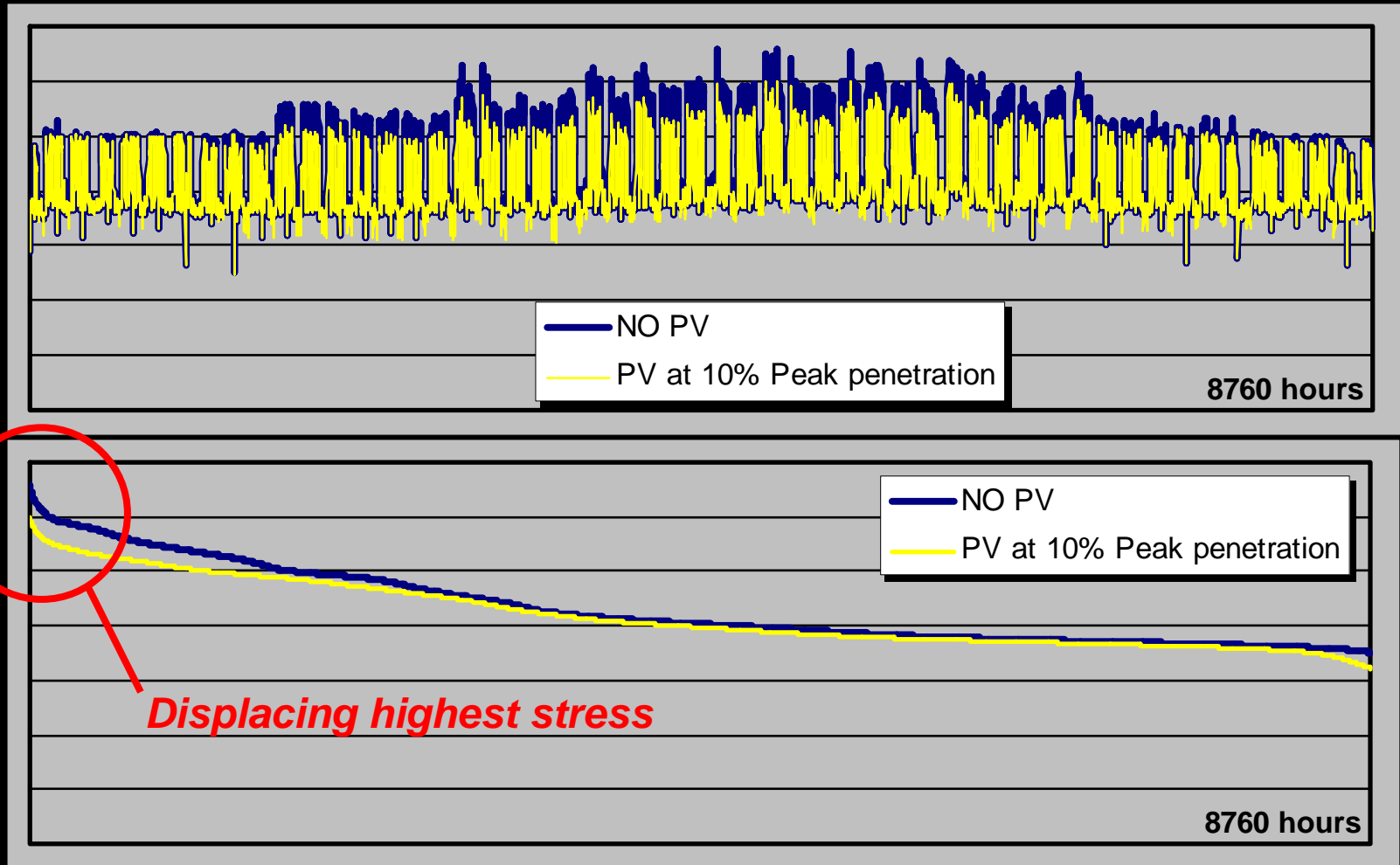


# ELECTRICAL DEMAND THROUGHOUT ONE YEAR





# PV IMPACT AT 10% CAPACITY PENETRATION





US-Wide cost of outages:  
\$100-200 billion per year\*

20% mitigated by PV at  
15% capacity penetration

TRANSMISSION LEVEL

Energy  
Capacity 15 ¢/kWh  
*utility*

DISTRIBUTION LEVEL

Capacity  
Loss savings 1-6 ¢/kWh  
*utility*

GRID SECURITY 3-7 ¢/kWh

*Constituent*

*\*Gellings, C. W., and K. Yeager, (2004):  
Transforming the electric infrastructure.  
Physics Today, Dec. 2004.*

# CO<sub>2</sub>

## TRANSMISSION LEVEL

Energy 15 ¢/kWh  
Capacity *utility*

## DISTRIBUTION LEVEL

Capacity 1-6 ¢/kWh  
Loss savings *utility*

GRID SECURITY 3-7 ¢/kWh

ENVIRONMENTAL COMPLIANCE

Preventing Global warming → 1.5% GDP

PV = 10% of solution

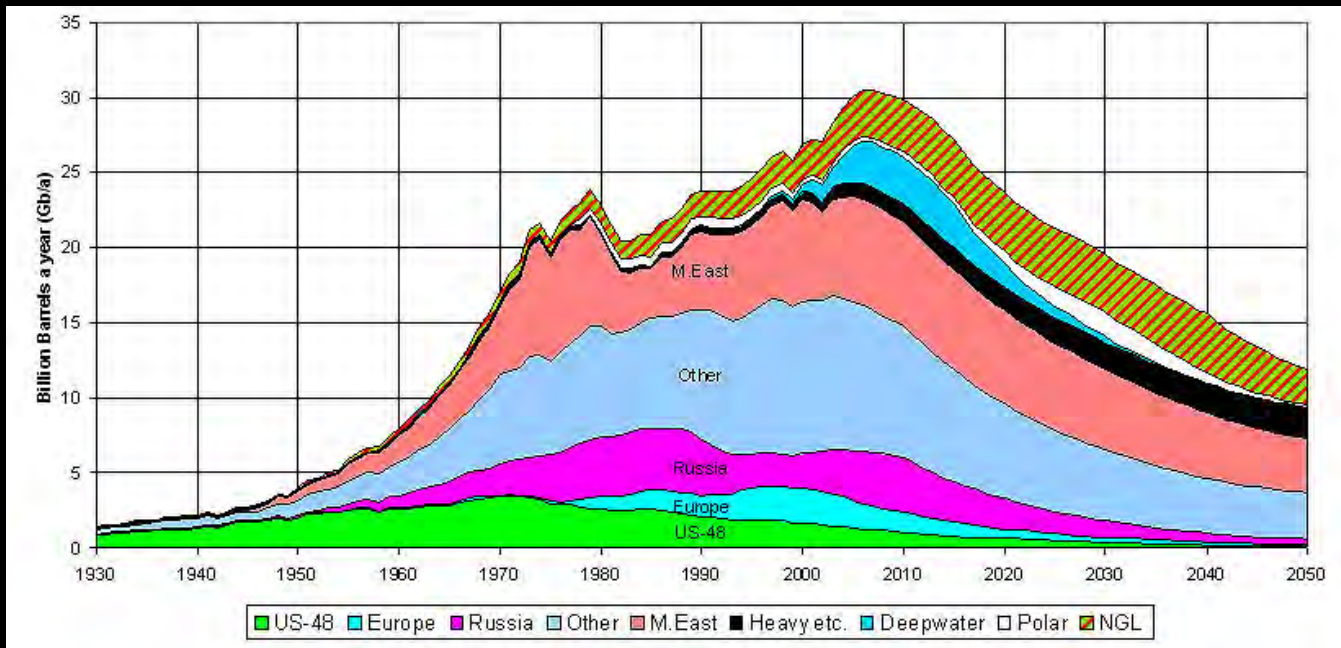
250 cents per kWh\*\*

Constituent

2 cents per kWh est, @ \$40/metric ton CO<sub>2</sub>\*

\* Based upon current NYS generation mix

\*\* based upon 2010 PV industry size



## TRANSMISSION LEVEL

Energy  
Capacity 15 ¢/kWh  
utility

## DISTRIBUTION LEVEL

Capacity 1-6 ¢/kWh  
Loss savings utility

GRID SECURITY 3-7 ¢/kWh

ENVIRONMENTAL COMPLIANCE

FUEL PRICE RISK MITIGATION

**Hedging \$500/bbl oil in 2040:**

**NPV = 25 cents per kWh est.**

Constituent

2-100+ ¢/kWh Constituent

5-25+ ¢/kWh Constituent

Each megawatt (MW) of photovoltaic (PV) panels **manufactured** in the US employs 14 people.

Each MW of PV **installed on homes** in the US employs 14.3 people.

Each MW of PV **installed on commercial buildings** employs 9 people.

Each MW of PV **maintained** employs .3 people.

TRANSMISSION LEVEL

Energy Capacity 15 ¢/kWh  
*utility*

DISTRIBUTION LEVEL

Capacity Loss savings 1-6 ¢/kWh  
*utility*

GRID SECURITY 3-7 ¢/kWh

ENVIRONMENTAL COMPLIANCE 2-100+ ¢/kWh *Constituent*

FUEL PRICE RISK MITIGATION 5-25+ ¢/kWh *Constituent*

ECONOMIC GROWTH 2-3+ ¢/kWh *Constituent*



PV VALUE: 30–100's ¢/kWh

PV COST W/O INCENTIVES TODAY:  
30-45 ¢/kWh

TRANSMISSION LEVEL

Energy  
Capacity 15 ¢/kWh  
*utility*

DISTRIBUTION LEVEL

Capacity  
Loss savings 2-6 ¢/kWh  
*utility*

GRID SECURITY 3-7 ¢/kWh

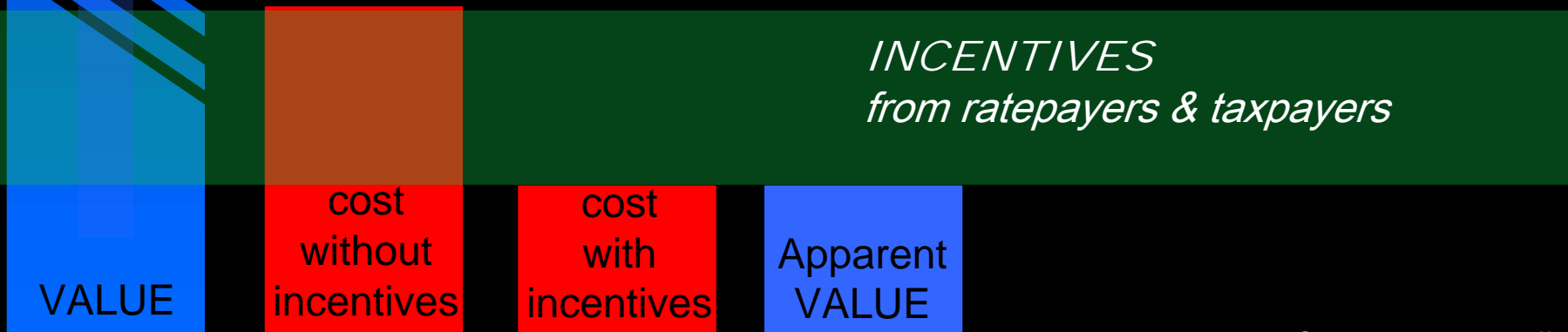
ENVIRONMENTAL COMPLIANCE 2–100+ ¢/kWh *Constituent*

FUEL PRICE RISK MITIGATION 5-25+ ¢/kWh *Constituent*

ECONOMIC GROWTH 2-3+ ¢/kWh *Constituent*

PV VALUE: 30–100's ¢/kWh

PV COST W/O INCENTIVES TODAY:  
30-45 ¢/kWh



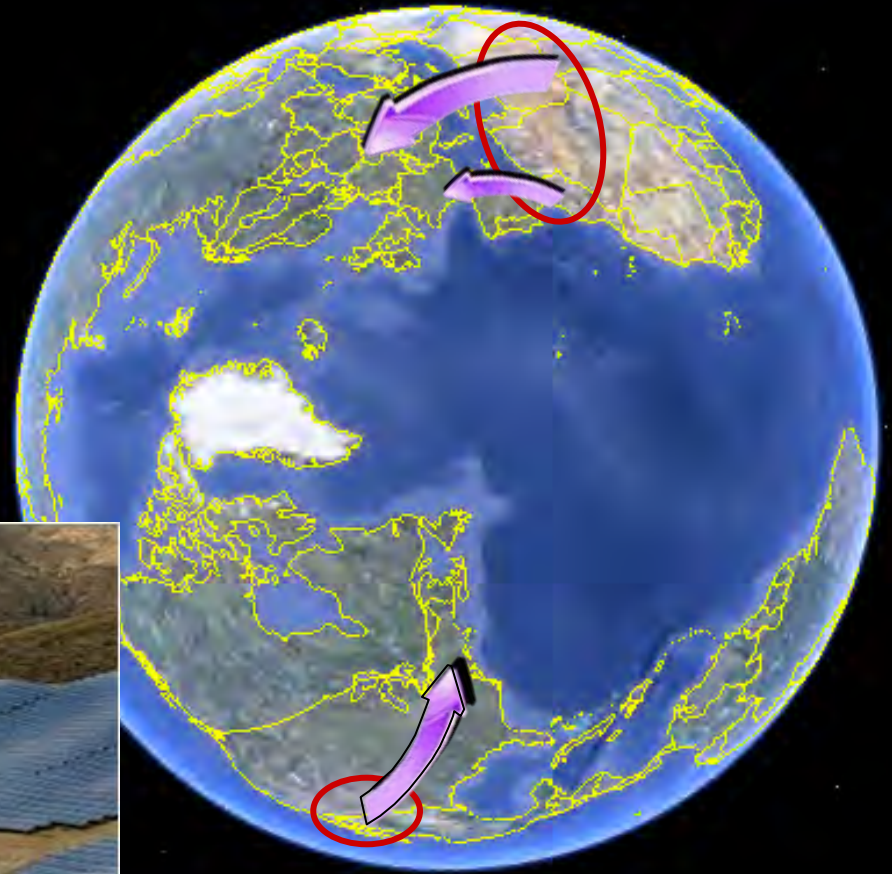
**ENOUGH SPACE,  
ENOUGH SUN,  
NOT TOO EXPENSIVE**

# Local Deployment Model





# Continental Deployment Model





# Solar Resource is large enough to accommodate either model

**SOLAR**<sup>10</sup>  
**23,000** per year

2009 World energy use  
16 TWy per year

2050: 28 TW

25-70  
per year

WIND<sup>1,2</sup>

Waves<sup>1,3</sup>  
0.2-2

215  
total

Natural Gas<sup>1,8</sup>

3-11  
per year  
OTEC<sup>1,4</sup>

240  
total

Petroleum<sup>1,8</sup>

ANWR

2-6  
per year  
Biomass<sup>1,5</sup>

90-300  
Total

Uranium<sup>1,9</sup>

3-4  
per year  
HYDRO<sup>1,6</sup>

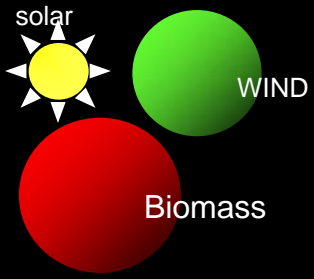
TIDES<sup>1</sup>  
0.3 per year

0.3-2  
per year  
Geothermal<sup>1,7</sup>

900  
Total reserve

COAL<sup>1,8</sup>

© R. Perez et al.



Coal

Natural Gas

However this is not (yet) the prevailing view

Uranium

© Richard Perez

Petroleum

Thanks for your attention