

USVI Renewable Energy Roadmap

Renewable Energy Working Group

Dan Olis, NREL



Credit: Don Buchanan, VI Energy Office



Credit: Don Buchanan, VI Energy Office

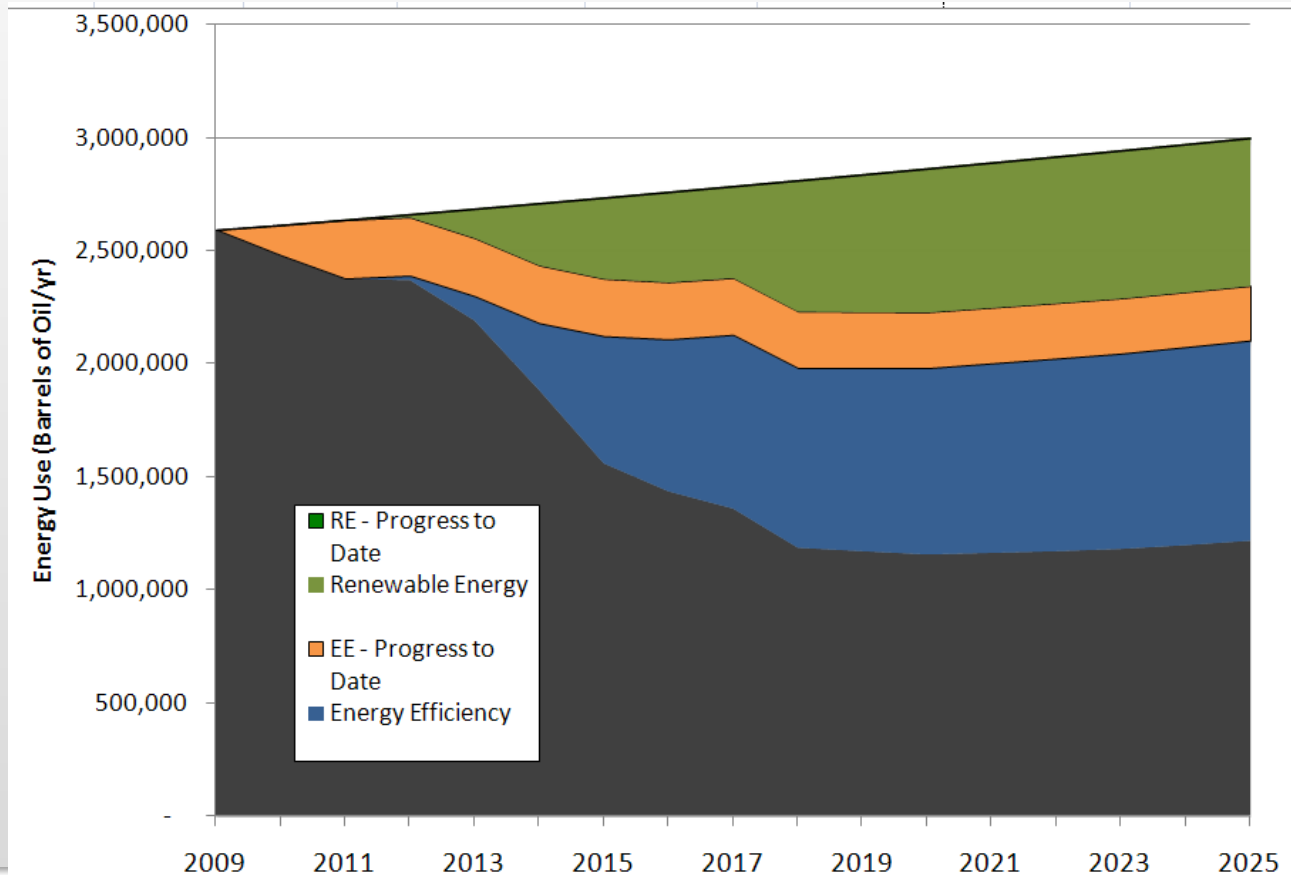


Credit: Warren Gretz, NREL



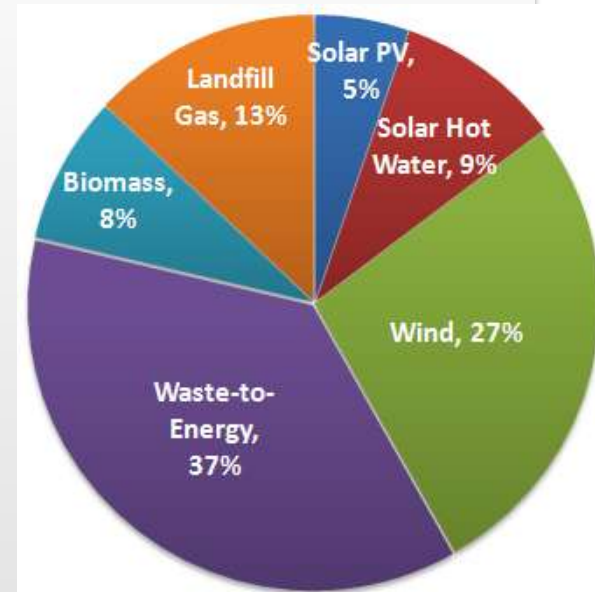
RE – How Do We Get There?

RE 2025 Goal	655,000 Barrels of oil/yr
To Date	<u>- 3,000</u>
“To Do” by 2025	652,000 barrels (base case)



Installed Capacities by 2025

Technology	Aggressive EE	Base Case	Aggressive RE
Utility PV (MW)	5	8	12
Net metered PV (MW)	1	1	1
Utility Wind (MW)	12	22	33
Net meter. Wind (MW)	0.5	0.5	1
Waste to Energy (MW)	16.5	16.5	16.5
Biomass (MW)	0	3	3
Landfill gas (MW)	5	5	5
SHW adoption (%)	40 %	40 %	50 %
% of oil reduction goal	28%	37 %	43%



Base Case RE Breakdown

Technologies

Solar Hot Water

Solar PV

Wind

Waste-to-Energy / Biomass / Landfill

Challenges

Technical

Financial

Policy

Social, Environmental

Technologies

Solar Hot Water

Solar PV

Wind

Waste-to-Energy / Biomass / Landfill

Challenges

Technical

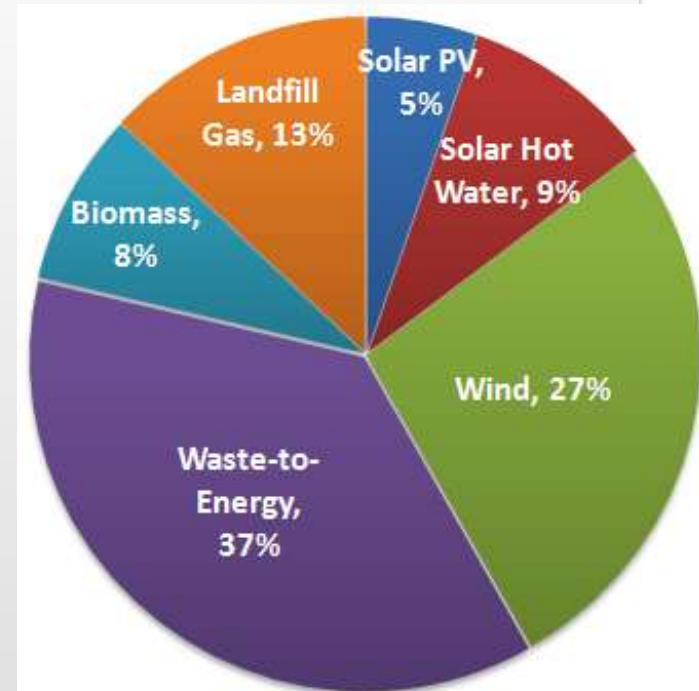
Financial

Policy

Social, Environmental

Solar Hot Water Roadmap

	Aggressive EE	Base Case	Aggressive RE
SHW adoption (%)	40%	40%	50%
60x2025 goal	2.1 %	2.1 %	2.9 %



Base Case RE Breakdown

Solar Hot Water

- Best value for residential RE

Simple Payback for SWH		
With tax incentives	+ Rebate	+ Loan
8 years	4 years	<1 year
35gal/day, 21sf/50gal thermosyphon unit, \$3500 installed replaces electric water heater, 1% cost of energy escalator, \$20/yr maintenance		

- Act 7075 + good economics = 'easy' wedge
- Revolving Loan Program: \$3.5M in Loans and \$1M in Rebates budgeted
- Energy Office, WAPA, Economic Development Authority

Solar Hot Water

Achievements

EO/WAPA/EDA solar loan program + grant program = 450 units in process

Act 7075 req. for new construction

Short-term goals (1-3 yrs)

Exhaust grant money

Continue to build robust, competitive local industry

Long-term goals (4-8 yrs)

SWH on 40 – 50 % of homes

Significant com'l and hospitality penetration

Technologies

Solar Hot Water

Solar PV

Wind

Waste-to-Energy / Biomass / Landfill

Challenges

Technical

Financial

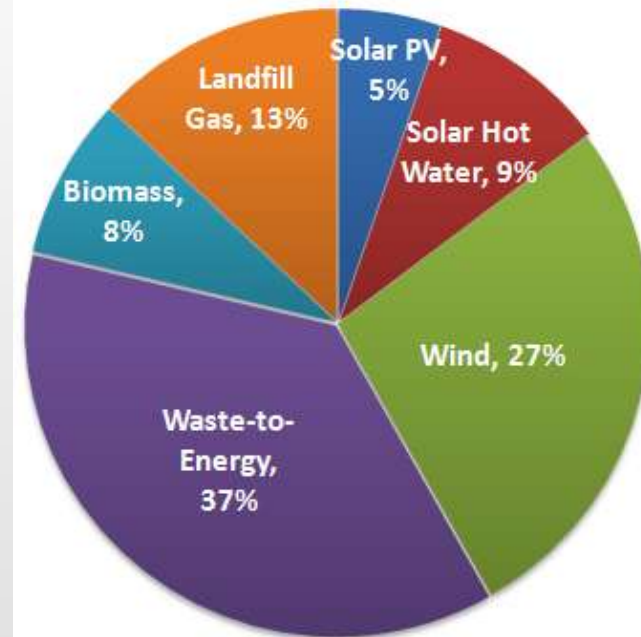
Policy

Social, Environmental

Photovoltaics Roadmap

	Aggressive EE	Base Case	Aggressive RE
Utility PV	5 MW	8 MW	12 MW
Net metered PV	1 MW	1 MW	1 MW
60x2025 goal	0.7 %	1.2 %	1.5 %
% MWh	1.3 %	1.9 %	2.3 %
% MW peak	4.4 %	6.7 %	9.6 %
Acres of roof*	9	13	19
Acres of land*	18	27	39

* Approximates. Assumes 50% on rooftop 50% ground mount, 8W/ft² rooftop, 1MW/6acres ground mount



Base Case RE Breakdown

WAPA PV Power Purchase Agreement

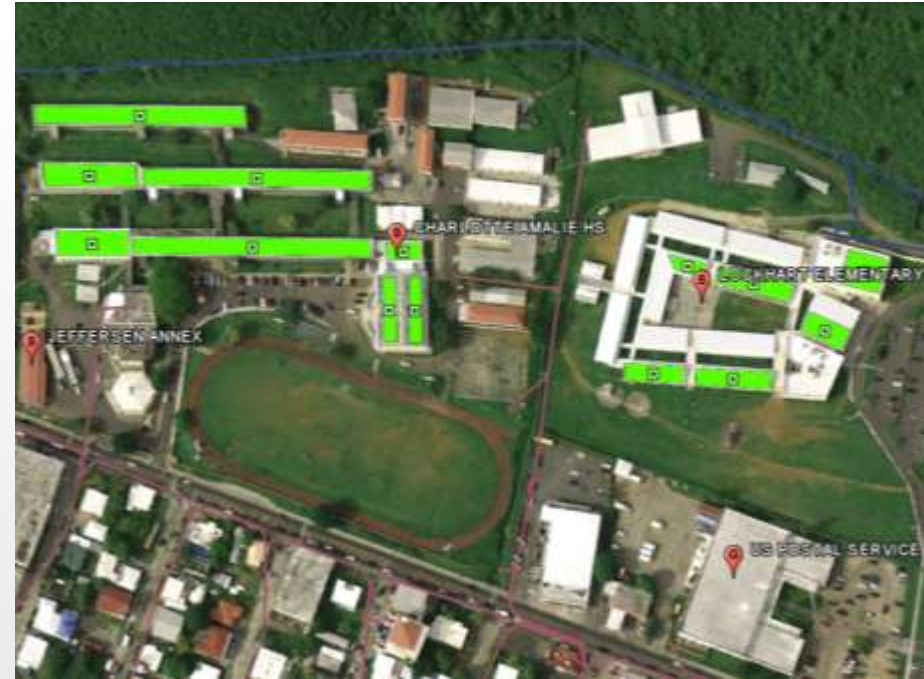
PPA Details

- Up to 10 MW total
- 20 year term
- RFP complete
- Model PPA complete
- Feeder load studies on-going
- Interconnection requirements under review
- WAPA working with P&P to identify, secure open space for 3MW+
- Uncertainty on market/potential offers, Go/No-Go price point

	Aggressive EE	Base Case	Aggressive RE
Utility PV	5 MW	8 MW	12 MW

Roof Survey

- GVI + Tutu Park Mall roofs
- 30 acres of rooftop identified
- Uncertainty on roof conditions, appropriateness for PV
- Perhaps 1 in 5 is good ?
- = 6 acres ?
- Add in residential and commercial rooftop



	Aggressive EE	Base Case	Aggressive RE
Acres of roof*	9	13	19

* Approximates. Assumes 50% on rooftop 50% ground mount, 8W/ft² rooftop, 1MW/6acres ground mount

St. Thomas	15.8 acres
Potential PV Capacity Identified	5.5 MW
St. Croix	15.5 acres
Potential PV Capacity Identified	5.4 MW

GVI Open Land

- Large parcels on STX, some located close to substations (good)
- STX: 18ac secured, well-placed
- Larger load on STT, but few parcels
- STT: uncertain



	Aggressive EE	Base Case	Aggressive RE
Acres of land*	18	27	39

* Approximates. Assumes 50% on rooftop 50% ground mount, 8W/ft² rooftop, 1MW/6acres ground mount

Photovoltaics

Achievements

Solar resource maps

Anemometry/solar
measurements contract
signed

Ground breaking for
448kW system at STT
airport

WAPA RFP 95% complete

WAPA feeder analysis

Short-term goals (1-3 yrs)

Anemometry/solar
deployed

WAPA RFP released

PPA developer selected,
PPA signed, 3-10 MW
deployed

Distribution system
modeling

Long-term goals (4-8 yrs)

6-13 MW deployed total

Technologies

Solar Hot Water

Solar PV

Wind

Waste-to-Energy / Biomass / Landfill

Challenges

Technical

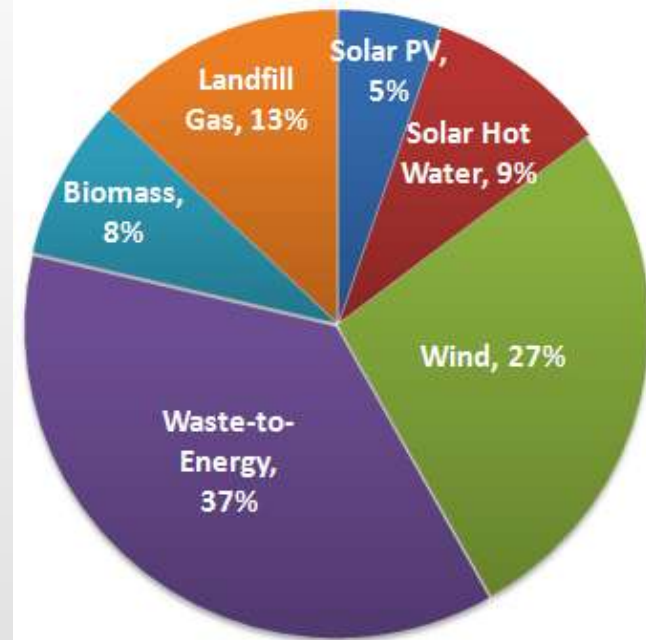
Financial

Policy

Social, Environmental

Wind Roadmap

	Aggressive EE	Base Case	Aggressive RE
Utility Wind	12 MW	22 MW	33 MW
Net metered Wind	0.5 MW	0.5 MW	1 MW
60x2025 goal	3.3 %	5.9 %	8.9%
% MWh	5.7 %	9.5 %	13.8 %
# large turbines	4 – 12	7 - 22	11 - 33
# small turbines	100 - 178	100 - 178	200 - 356
Acres of land	300 - 550	500 - 1000	900 - 1500



Base Case RE Breakdown

Wind Power

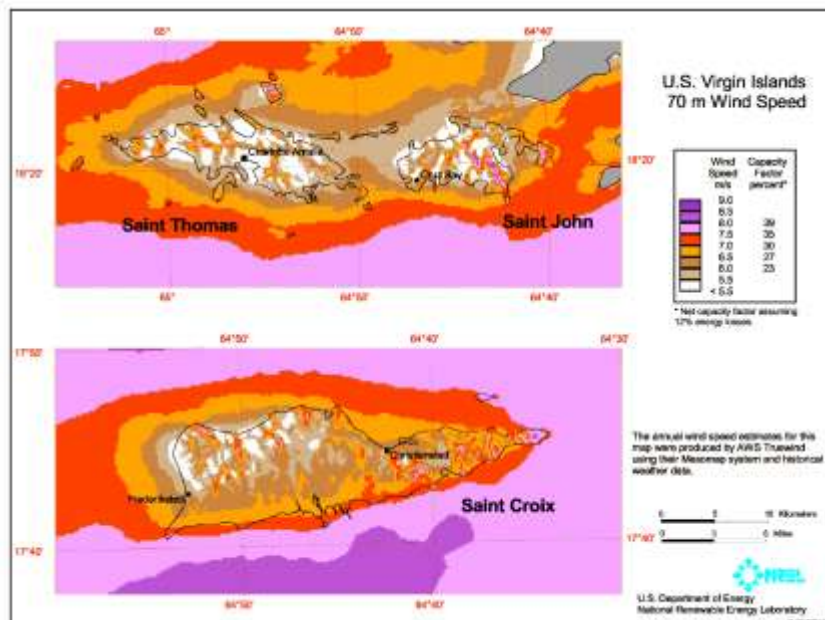
- Wind is economically competitive, ***according to models***
- Energy generated is highly sensitive to wind speed
 - +/- 25% wind speed = 2x energy generated
- Wind resource can change significantly over short distances
 - Micro-siting issues
- Utility scale requires big investment. Investors require “bankable data”
 - Anemometry!

Wind resource characterization



- VIEO/DOE/NREL wind map
 - Models based on limited measurements
 - Tells us where to look

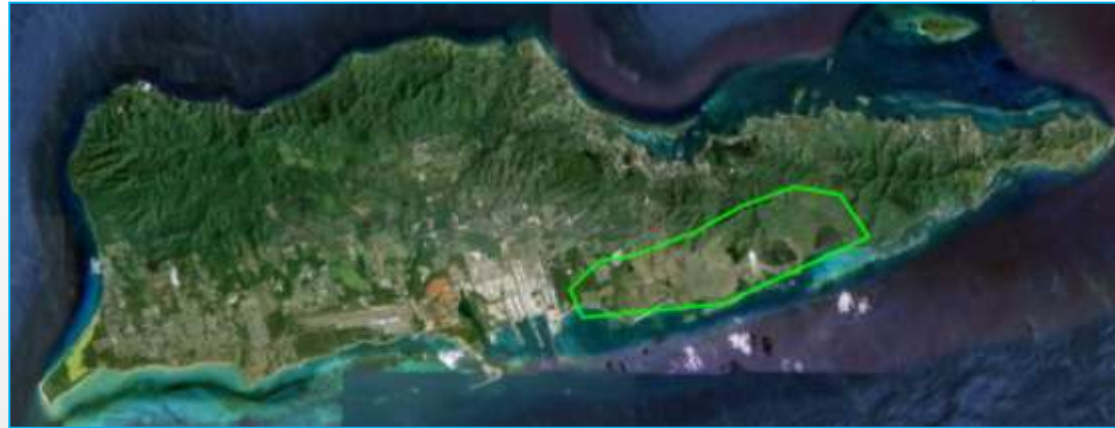
- Current anemometry task
 - ‘Bankable Data’
 - Revised maps
 - Data will support utility scale RFP



Anemometry

Current focus

- Ridge crest STX
- Southern, flat STX
- Bovoni STT



Anemometry status

- Contract signed
- Energy Office and P&P working through leases and permitting



Wind

Achievements

Potential wind sites identified

Wind anemometry contract signed

Wind regulations reviewed

Short-term goals (1-3 yrs)

Anemometry

Updated wind maps

Wind regulations updated

EIS completed

Sites selected

RFP released, developer selected

Distribution system modeling

Long-term goals (4-8 yrs)

13-34 MW Deployed



Technologies

Solar Hot Water

Solar PV

Wind

Waste-to-Energy / Biomass / Landfill

Challenges

Technical

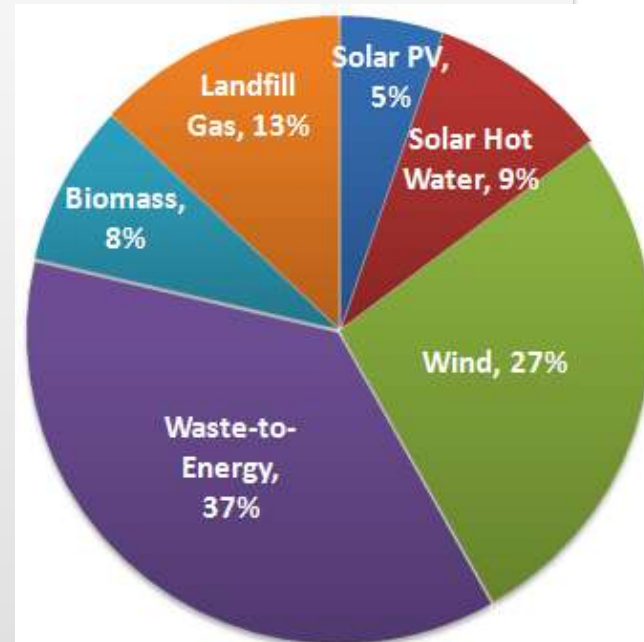
Financial

Policy

Social, Environmental

Waste to Energy, Biomass, Landfill Gas Roadmap

	Aggressive EE	Base Case	Aggressive RE
Waste to Energy	16.5 MW	16.5 MW	16.5 MW
60x2025 goal	8.1 %	8.1 %	8.1 %
Biomass	0 MW	3 MW	3 MW
60x2025 goal	0 %	1.8 %	1.8 %
Landfill gas	5 MW	5 MW	5 MW
60x2025 goal	2.8 %	2.8 %	2.8 %



Base Case RE Breakdown

Potential Biomass & Waste Feedstocks

Solid waste, landfill gas

Rum bottoms, sludge

Fats, oils, grease (FOGs)

Sewage/sludge

Dedicated feedstocks

- Tan-tan
- Guinea grass
- Australian pine
- Jatropha? Palm?

Long term: algae?



USVI Biomass Feedstock Characterization

Preliminary survey STX:

- 34,000 trees/Hectare
- 79 tonnes/Ha
- 8.8 tonnes/Ha-year



Feedstock energy and chemical analysis

Feedstock	As Received		Dry				lb ash/Mmbtu	lb alkali/MMBtu
	Moisture Content	Btu/lb	Btu/lb	Ash	Nitrogen	Chlorine		
Rum Bottoms	94%	409	6,881	18.0%	1.7%		26.42	10.96
Tan-Tan (Green)	46%	4,483	8,254	2.6%	1.0%	0.22%	3.09	0.62
Tan-tan (dry)	20%	6,573	8,167	3.6%	1.0%	0.22%	4.35	1.04
Guinea Grass	76%	1,824	7,703	9.8%	1.1%	1.20%	12.76	3.87
Australian Pine	48%	4,453	8,493	3.3%	0.8%	0.39	3.94	0.68

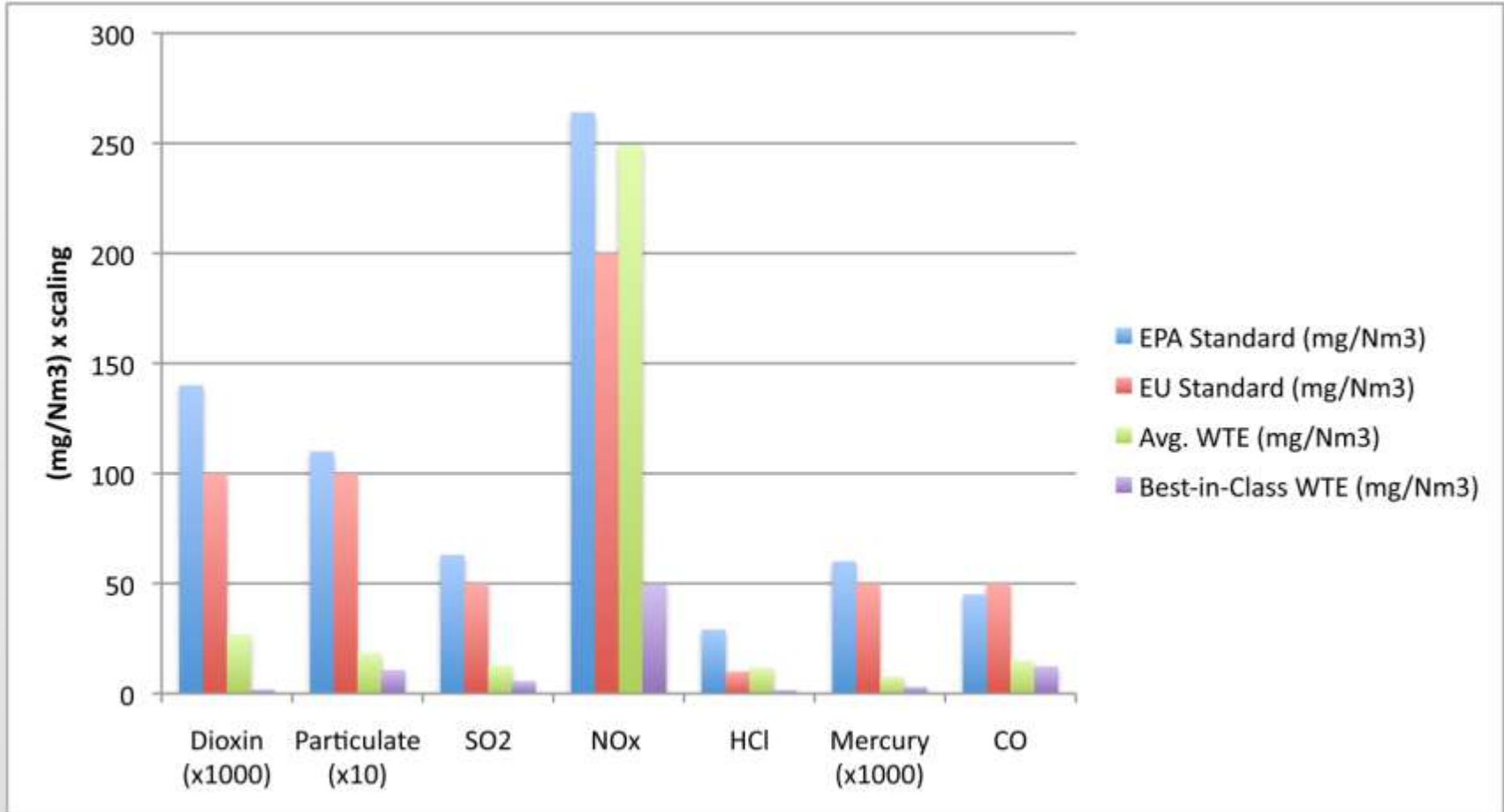
Background

- WAPA signed a Power Purchase Agreement (PPA) with a **Waste-to-Energy (WTE)** developer in 2010 to provide 16 MW in St. Croix (~32%)
- Several stakeholders were concerned with **environment and health impacts** and requested NREL conduct a survey of existing WTE plants in the US

Operating WTE Facilities in the U.S. (87)



Comparison of WTE to EPA & EU Standards

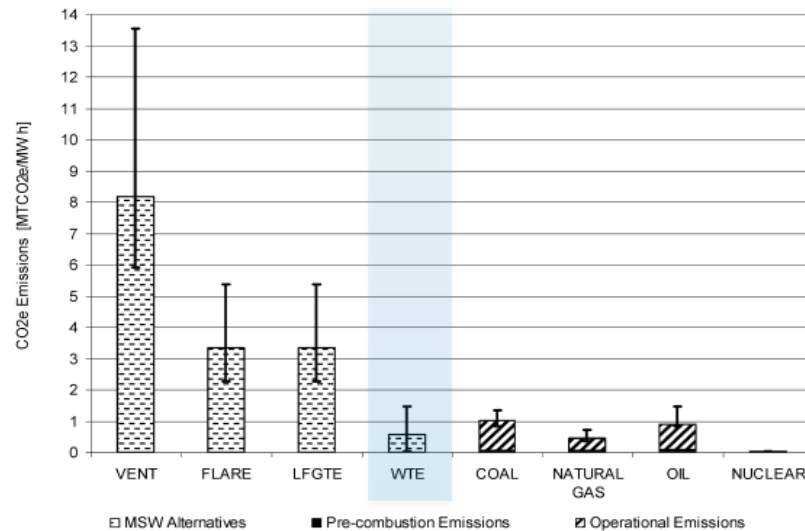
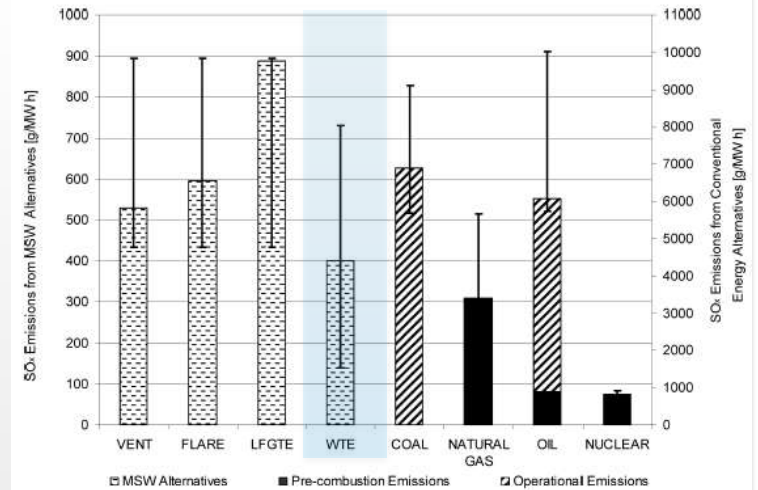
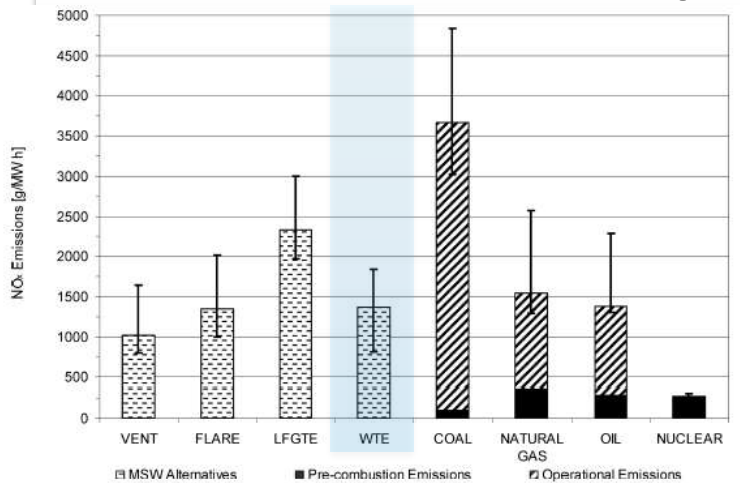


Ref:

Lauber J.D., Morris M.E., Ulloa P., Hasselriis F., 2006. Local waste-to-energy vs. long distance disposal of municipal waste. In: AWMA Conference, New Orleans, Louisiana, June 21.

Themelis N.J., 2007. Thermal review, Waste Management World (July-August), 37-45.

Comparison to Alternatives



Ref:

Kaplan P.O., Decarolis J., Thorneloe S., 2009. Is It Better To Burn or Bury Waste for Clean Electricity Generation?, Environmental Science Technology, 43, 1711-1717.

Waste to Energy, Biomass, Landfill Gas

Achievements

Preliminary biomass assessment (SCEA)

Biomass energy value tests

WAPA WTE PPA signed

Industry overview presentation (NREL)

Short-term goals (1-3 yrs)

WTE plant on-line

Survey of waste fats, oils, greases (FOGs) complete (UVI)

Waste FOG included in generation mix

Biomass resource assessment (SCEA)

Biomass harvesting equipment trials (SCEA)

Biomass cultivation demonstration (SCEA)

Long-term goals (4-8 yrs)

Landfill gas STT & STX

Biomass energy industry starting up

Small WTE on STT (no shipping waste to STX)

Technologies

Solar Hot Water

Solar PV

Wind

Waste-to-Energy / Biomass / Landfill

Challenges

Technical

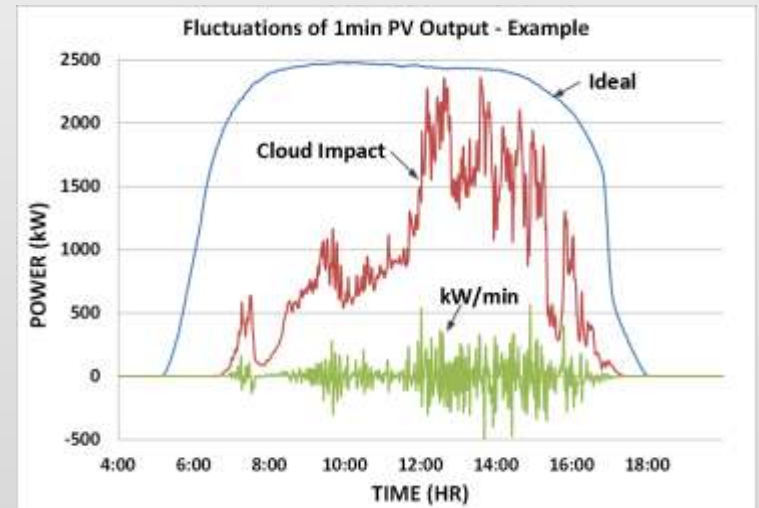
Financial

Policy

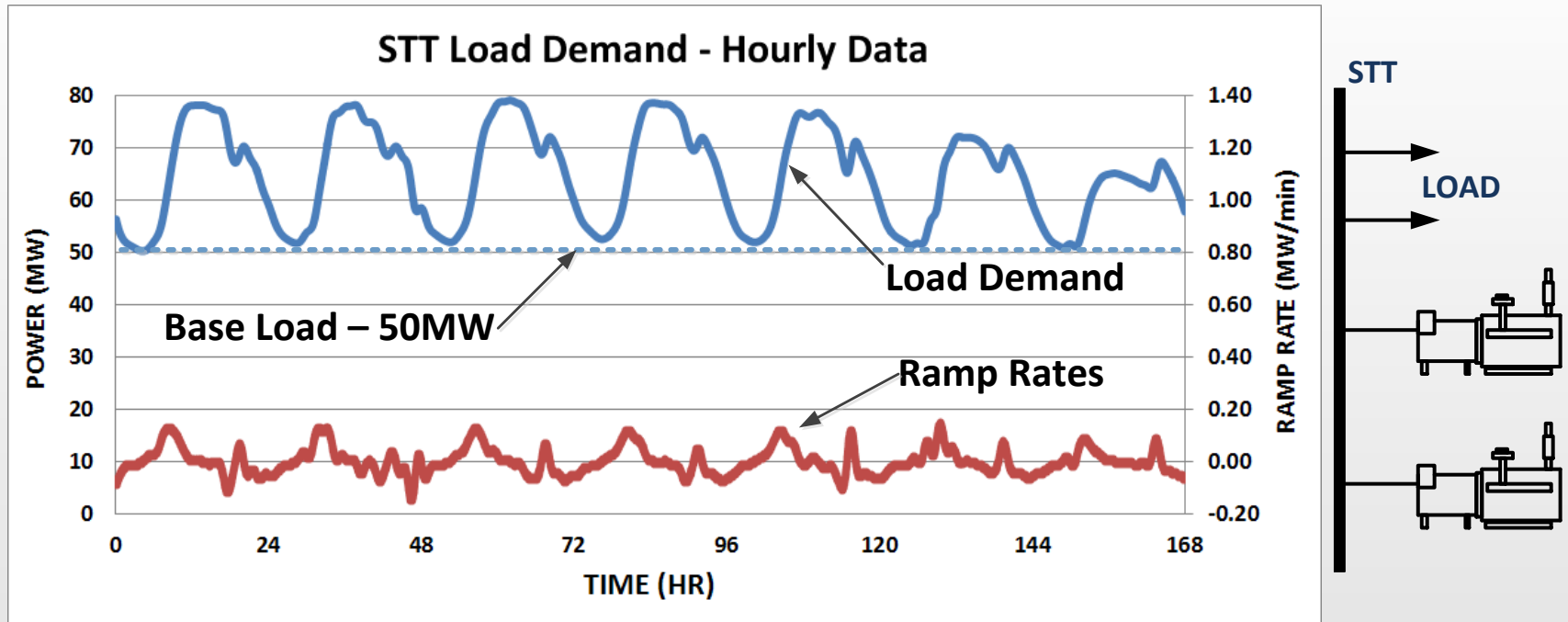
Social , Environmental

High Penetration of Variable RE

- Wind and Solar are highly variable resources, creating variable energy
- Wind varies by season, day, hour, and minute
- Solar
 - Varies from day to night
 - Varies with cloud conditions
- Biomass, WTE, Landfill Gas generation are not intermittent (base load generation) -> “Dispatchable Power”



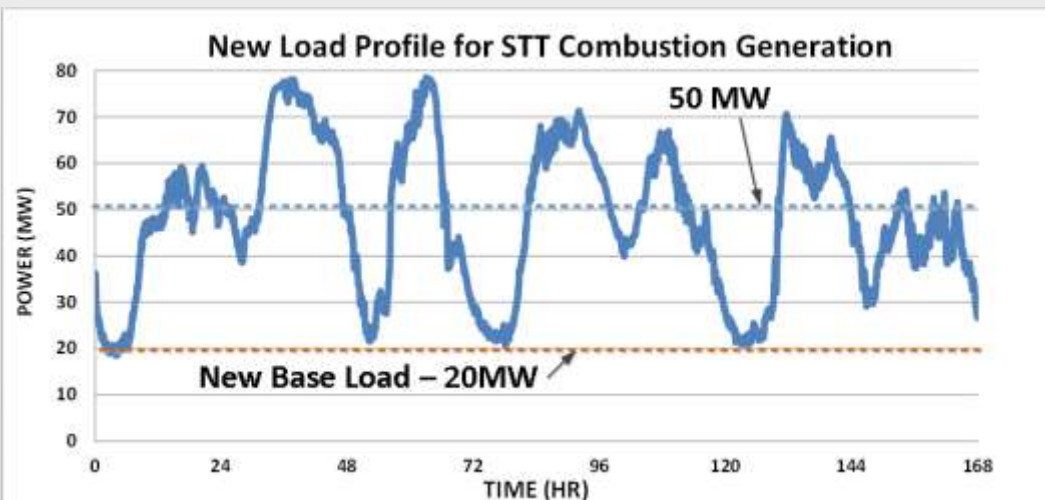
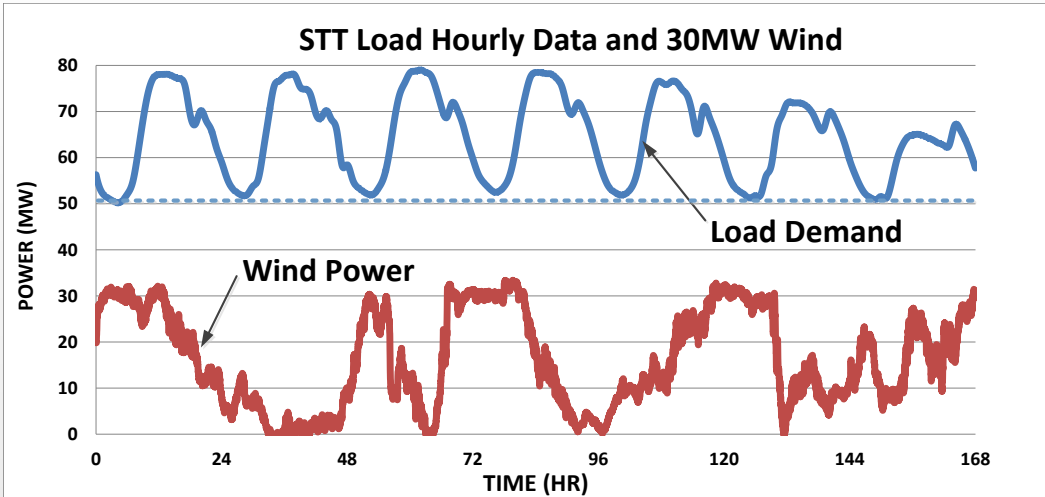
STT Load Profile – 1 week



Typical week:

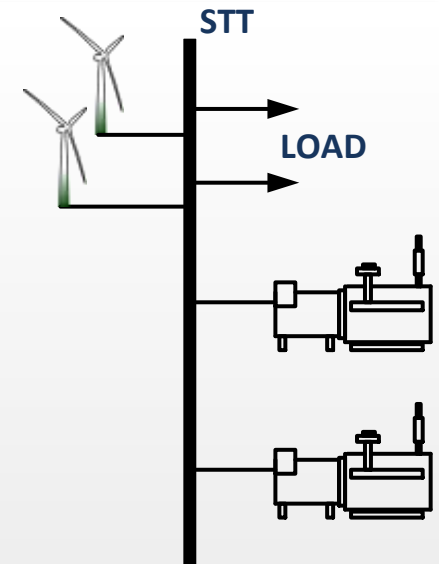
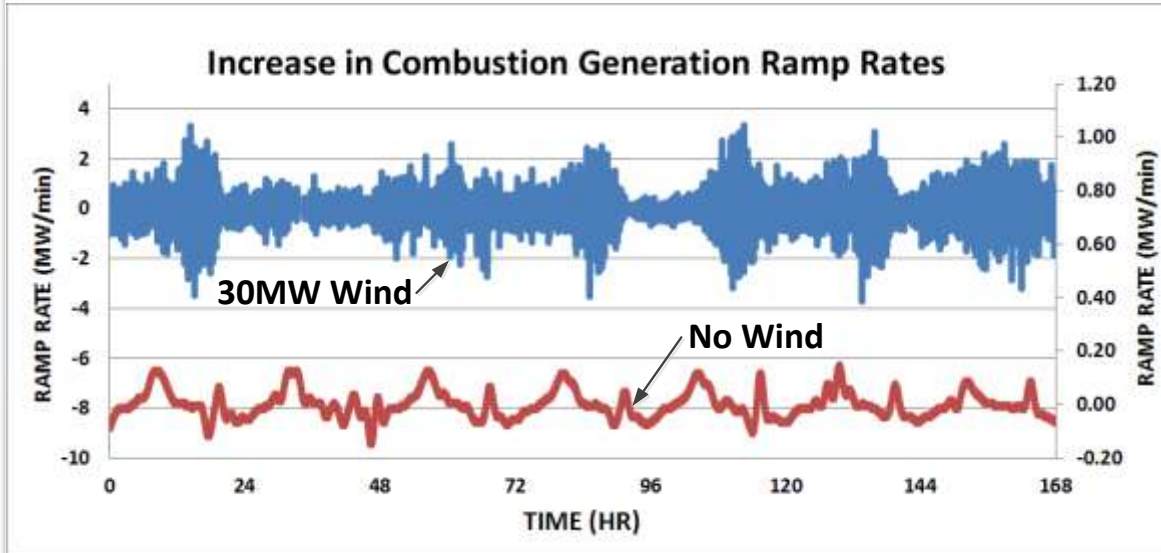
- 50 MW base load
- Day /night peaks
- 30 MW variable load
- 0.2 MW/minute average ramp rates

Adding 30 MW Wind (Extreme Scenario)



- High variable generation will challenge existing control systems
- Higher ramp rates
 - Increase combustion generation wear and tear
 - Increase emissions
 - Reduce generator efficiency

Impact of 30 MW Wind on WAPA Ramp Rates



- High variable generation increases regulation requirements, 'ramp rates'
- Higher ramp rates
 - Increase combustion generation wear and tear
 - Increase emissions
 - Reduce generator efficiency

High Penetration, Variable Generation Impact Study

- Model distribution system
- Add target levels of wind and solar penetration
- Identify and quantify potential system performance and operation problems
- Identify and evaluate possible mitigation strategies
 - Advanced control strategies
 - Load shedding
 - Energy and power storage
 - Interconnection to other generation systems through undersea cable
 - Wind farm and PV system forecasting



Technologies

Solar Hot Water

Solar PV

Wind

Waste-to-Energy / Biomass / Landfill

Challenges

Technical

Financial

Policy

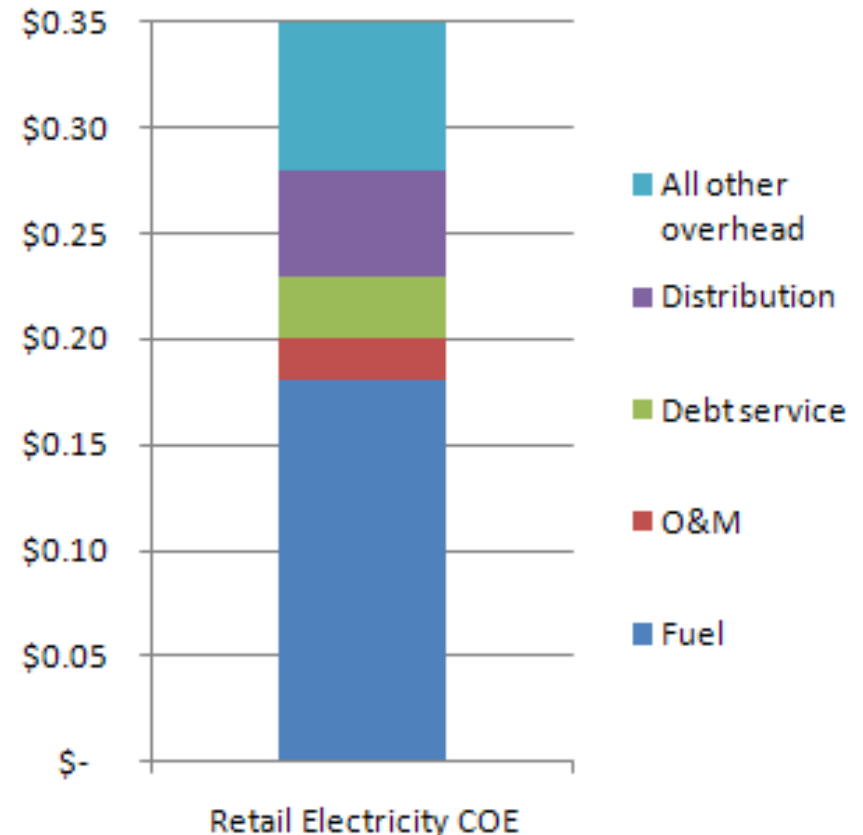
Social , Environmental

Cost of Energy (COE)

Retail electricity cost includes:

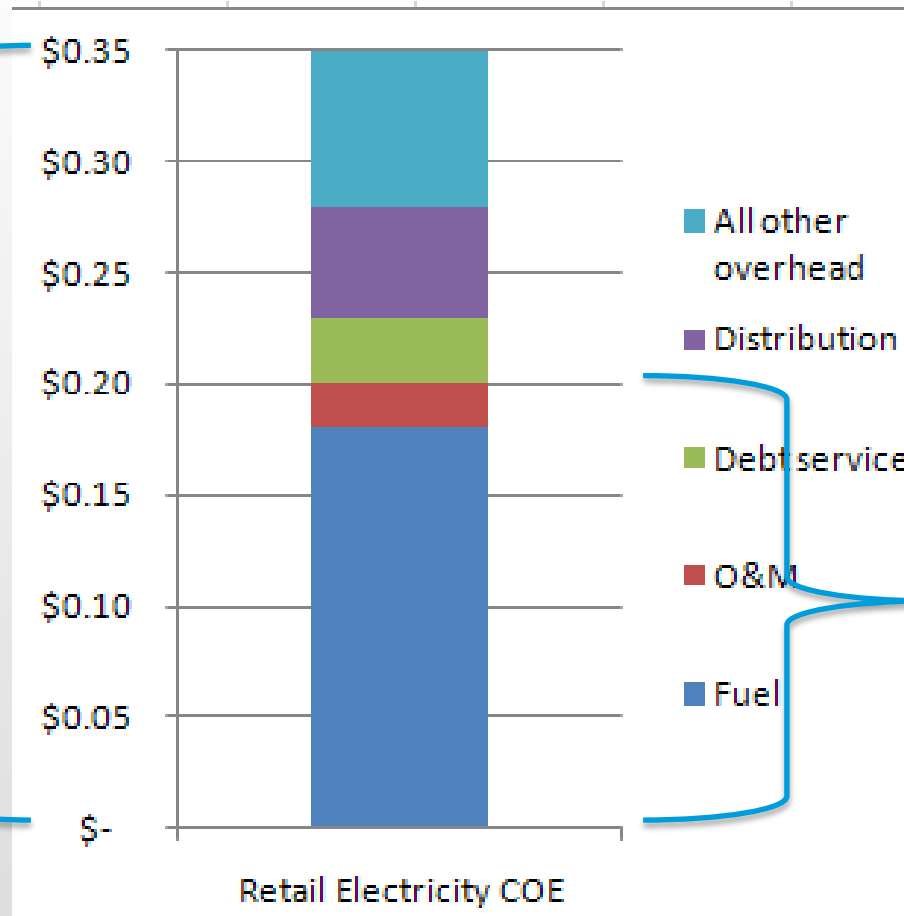
- Fuel – This is the LEAC
- Power plant equipment and distribution system costs
- Plant O&M
- Distribution O&M
- Overhead of salaries, trucks, billing & collection, etc.

Possible retail breakdown



COE Perspective

RE competes with this for retail customer



RE competes with this 'Avoided Cost' for utility

Technologies

Solar Hot Water

Solar PV

Wind

Waste-to-Energy / Biomass / Landfill

Challenges

Technical

Financial

Policy

Social, Environmental

Technologies

Solar Hot Water

Solar PV

Wind

Waste-to-Energy / Biomass / Landfill

Challenges

Technical

Financial

Policy

Social, Environmental

What it should be

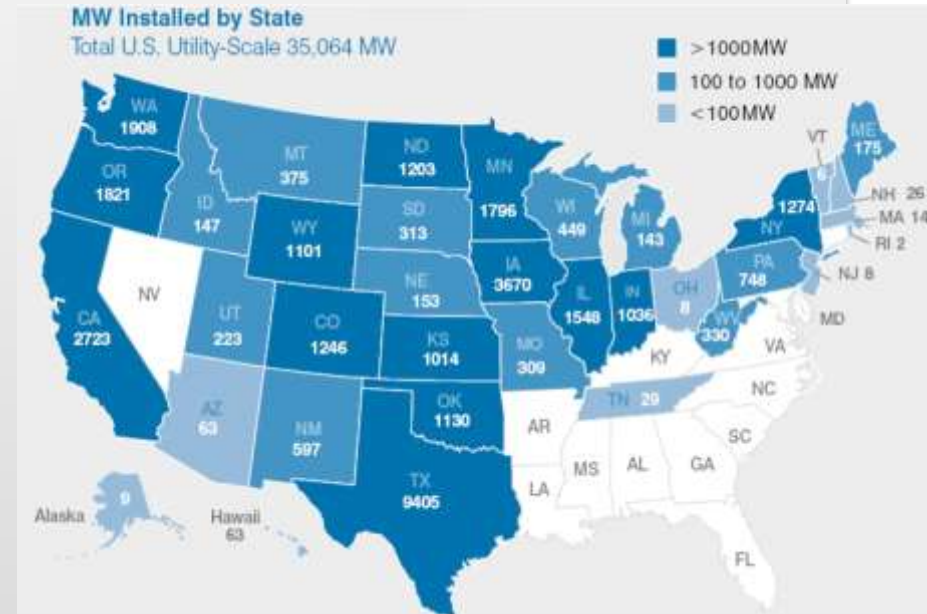
- Reflection of goals, needs, values
- Clear

What it shouldn't be

- Confusing
- Contradicting

Benefits to Good Policy

- Reduces unknowns
- Promotes markets



Policy Considerations

- Large wind Regulations and Permitting
- Interconnection
- Utility decoupling of revenue from total energy sold
- Implementation of Renewable Portfolio requirements (RPS) in Act 7075, feed-in-tariff
- Energy Efficiency and Renewable Energy tax incentives
- Building codes, e.g. 'solar ready' requirements

Technologies

Solar Hot Water

Solar PV

Wind

Waste-to-Energy / Biomass / Landfill

Challenges

Technical

Financial

Policy

Social, Environmental

Wind Development

- Wind is big and visible. It gets your attention.
- NIMBY/IMBY: viewscape, noise, land values, tourism
- Wildlife impact mitigation

- Start and be active in the public discussions
- Recognize the concerns, discuss the facts
- Discuss wind in the context of the alternatives



Thank You!



Questions or Comments?



Bonus slides

Technologies

Solar Hot Water

Solar PV

Wind

Waste-to-Energy / Biomass / Landfill

Challenges

Technical

Financial

Policy

Social, Environmental

Solar Hot Water

Barriers to progress / Areas of uncertainty

Higher capital costs than electrical water heaters

Current EO grant funds will run out

Photovoltaics

Barriers to progress / Areas of uncertainty

Space constraints

Borderline cost competitiveness

Generation and grid impacts at scale

Permitting for ground mount (?)

...

Wind

Barriers to progress / Areas of uncertainty

Bird / Bat concerns

Noise, visual concerns

Land constraints, challenging terrain, narrow roads,
limited heavy construction equipment

Generation and grid impacts

Regulatory uncertainty, permitting

Small wind – reaching the resource

Large wind – bankable data on the resource

Waste to Energy, Biomass, Landfill Gas

Barriers to progress / Areas of uncertainty

Biomass uncertain resource, cultivation model, economics

WTE public perception

- Permitting in process

- Financing

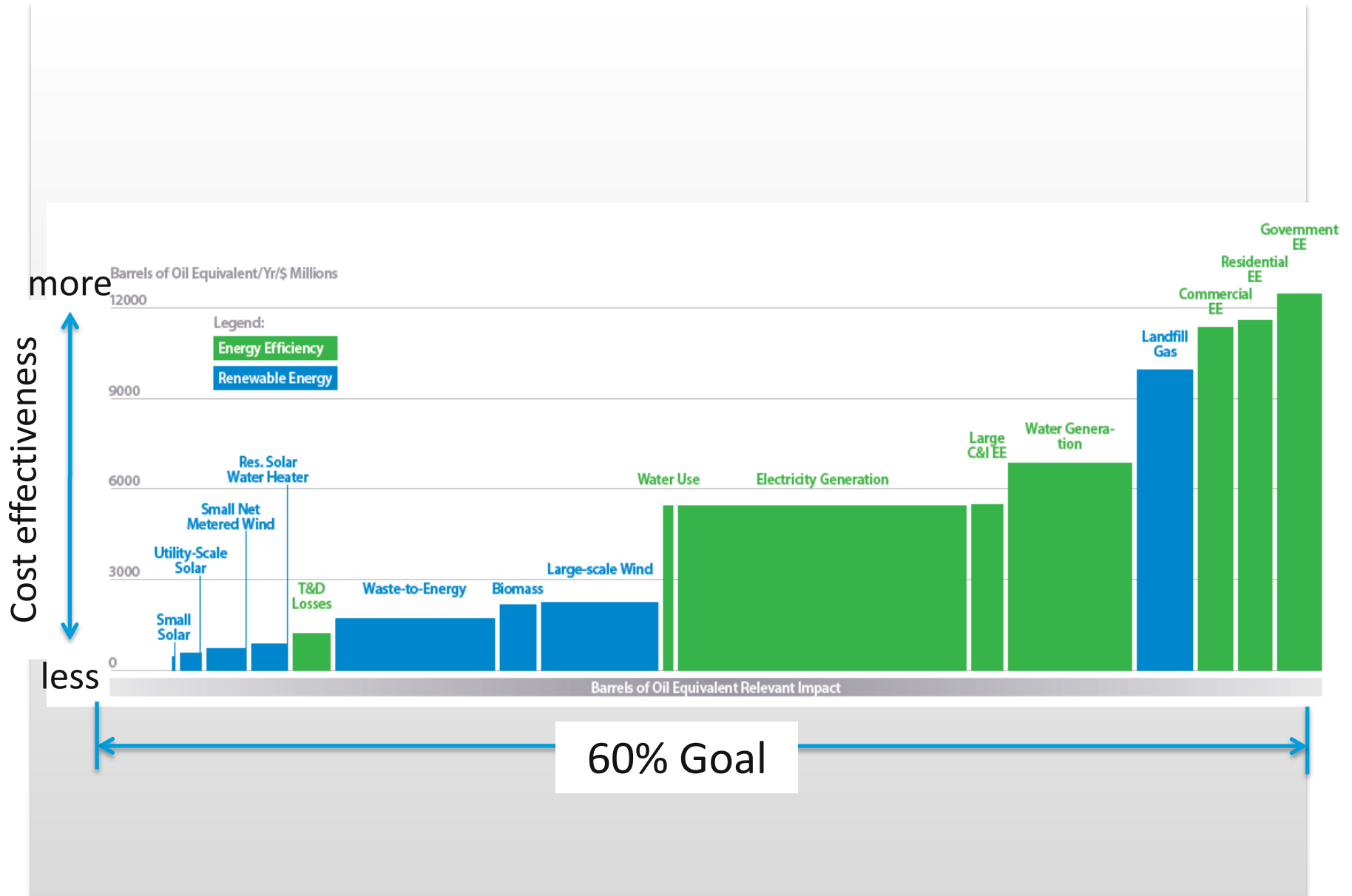
Challenges at scale

- NIMBY – ‘viewscape’, primarily wind
- Space constraints
- Wildlife, open space impacts
- Regulatory, political
 - Utility rate structure
 - Regulations, permits
 - Uncertainty, or counter productive (‘screened wind turbines’)
 - Show map of US PV or wind development by state
- Capital/Financing
- PV COE
- PV, wind are non-dispatchability
 - Central plant requires higher capacity reserve (has negative impact on plant efficiency)
 - Grid integration
 - Infrastructure designed for central plant operation (energy flow)
 - Voltage, frequency
 - (Can be addressed with deferrable loads, demand-side reduction strategies, energy storage systems)

Wind Development

- Wind is big and visible. It gets the public's attention
- NIMBY/IMBY: viewscape, noise, land values, tourism
- Wildlife impact mitigation
- Start and be active in the public discussions
- Recognize the concerns, discuss the facts
- Discuss wind in the context of the alternatives





Renewable Energy - Wind

Technically Feasible

<i>Estimated Percentage of Retail Sales (for utilities with > 100 MW of wind)*</i>	
Minnkota Power Cooperative	38.0%
Empire District Electric Company	18.1%
Turlock Irrigation District	18.0%
Otter Tail Power	14.0%
Sunflower Electric Power Corp.	13.2%
Xcel Energy	11.1%
Austin Energy	10.3%
Great River Energy	10.1%
Westar	10.1%
Western Farmers' Electric Cooperative	9.8%
MidAmerican Energy	9.6%
Snohomish Public Utility District	8.5%

} < 12%

Kodiak, Alaska

- Endeavor to produce 95% of energy sales with cost effective renewable power solutions by the year 2020. KEA Board Feb 2007
- Isolated island electric grid
 - About 12,000 people
 - Peak Load – 25 MW, Minimum Load – 11 MW
- Power Generation
 - 2 x 10 MW Hydroelectric Units
 - 3 x GE 1.5 MW Wind Turbines
 - 7 MW Diesel Fired Combined Cycle Plant
 - 7 Diesels totaling 25 MW's
- Wind Project
 - Some limited frequency issues and large swings in turbine output
 - Operating above expectations

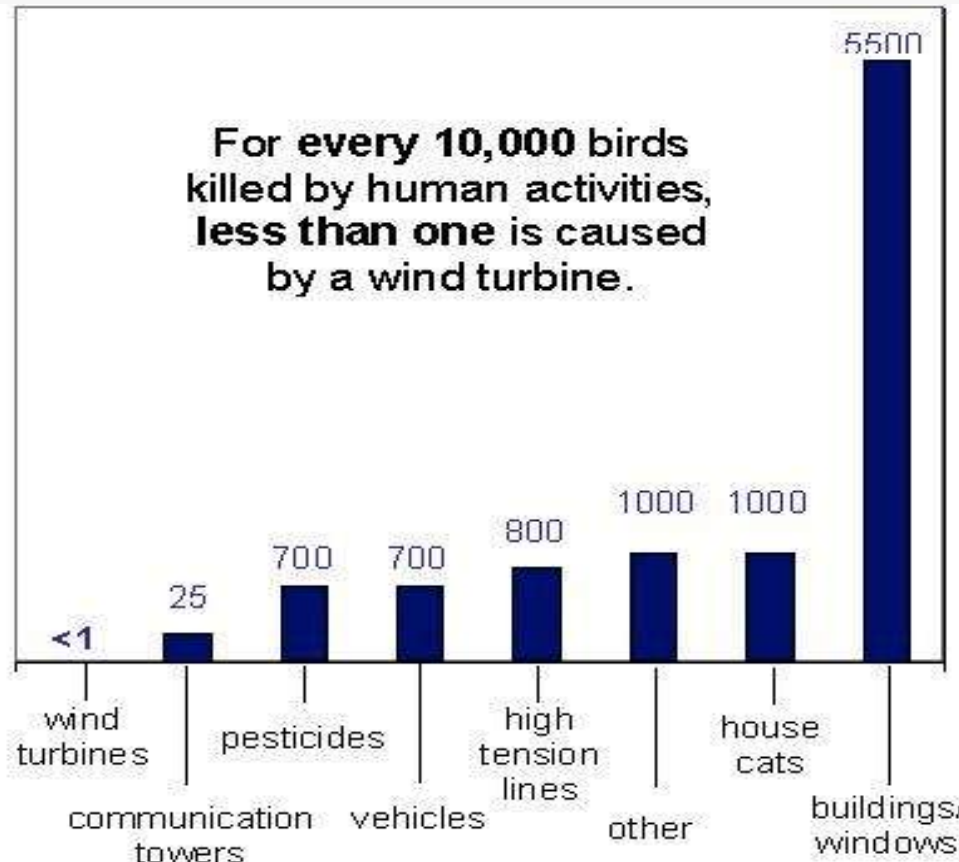


Avian (Bird) Research

- Over 200 projects, two problem sites.
- Biggest problem was in the Altamont Pass.
- Managed by careful site selection.



Installation of enough wind power to eliminate all anthropogenic CO2 emission worldwide would result in between 1.4 to 14 million deaths – less than 1% that were killed by the Avian flu pandemic in 2005 – Jacobson Dec 2008



Summary of Anthropogenic Causes of Bird Mortality,

- Erickson et. al., 2002

Implementation mitigating

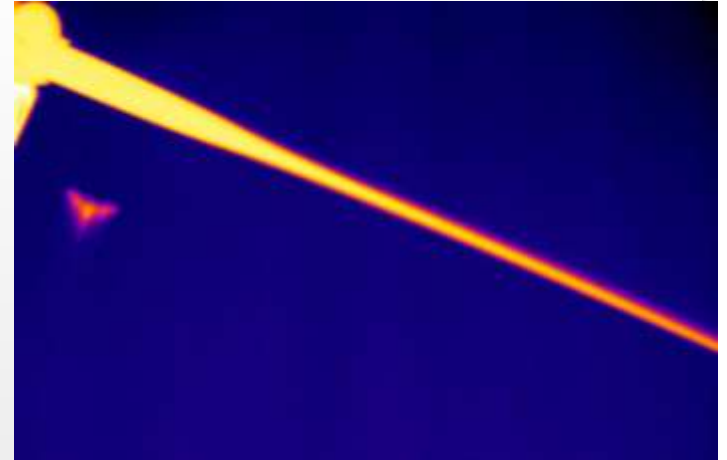
- Pre-Construction Assessment...
- Determine and avoid high risk areas
- Impact Mitigation

Operational mitigation...

- Curtailment during high risk periods that may be predictable

Technological...

- Development of techniques that deter or alert animals



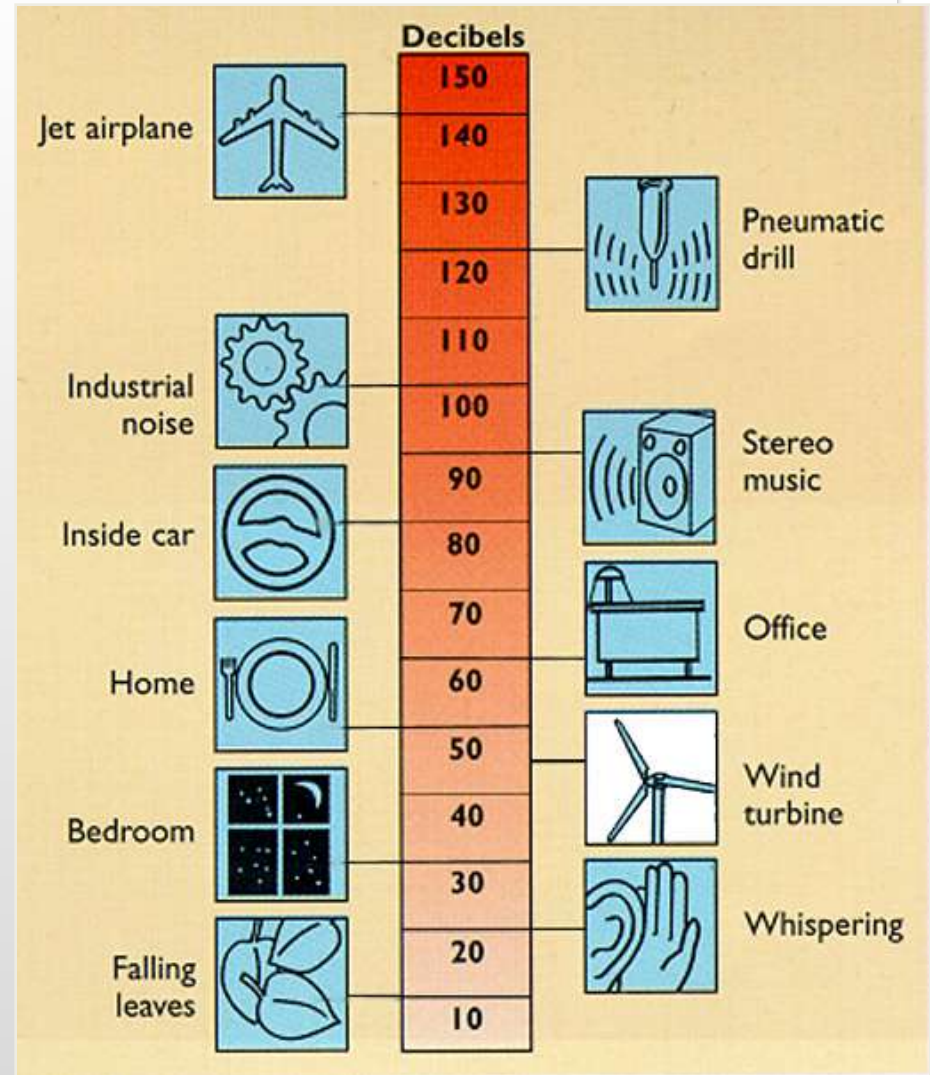
Yes – they make noise and that noise has an impact.

What is the sound level of a wind turbine?

- 45 decibels at 350 meters

But that's not the whole story

- Relative level of noise which relates to background level
- Noise can impact health – typically though:
 - Those who “use” the land – its not an issue
 - For those that “own” the land – it is an issue





Kasigluk, Alaska

- Clear, but not very well documented impact.
- Based on data from new and existing wind plants - no clear long term cost impact to housing near wind farms, even for large homes
- People who have demonstrated economic benefit are much more likely to support the project



San Cristobal, Galapagos

Mitigation options

- People generally fear the unknown
- Define the discussion, don't let project proponents do that.
- A large number of visualization tools are available to allow people to see what the site will look like – take advantage of them