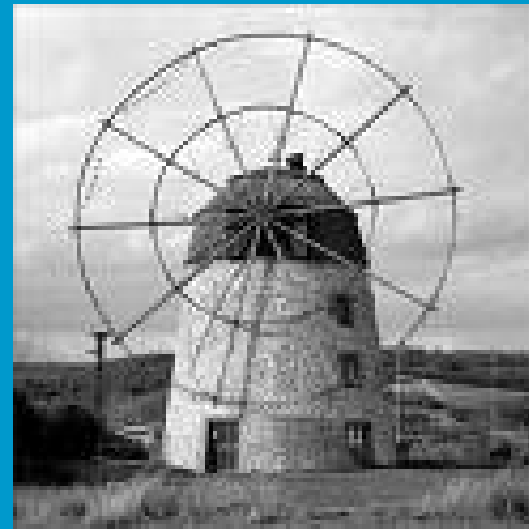
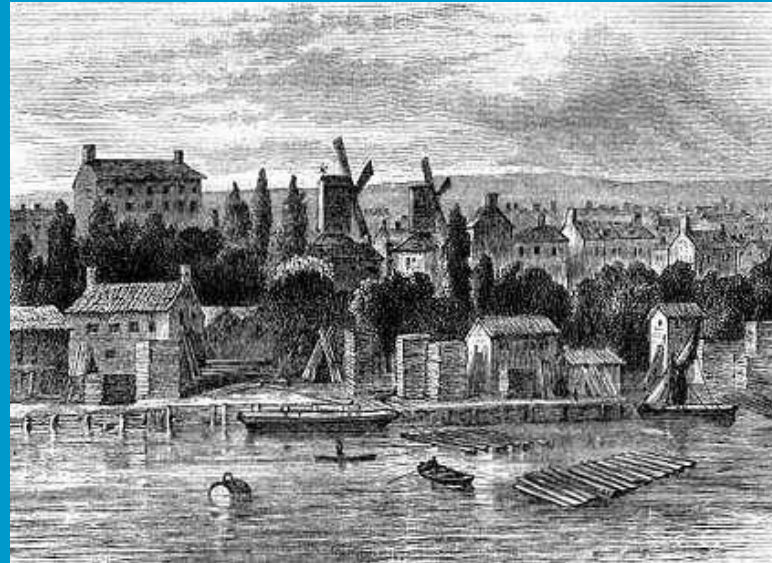


A Geographical Analysis of Wind Turbine Placement in Northern California

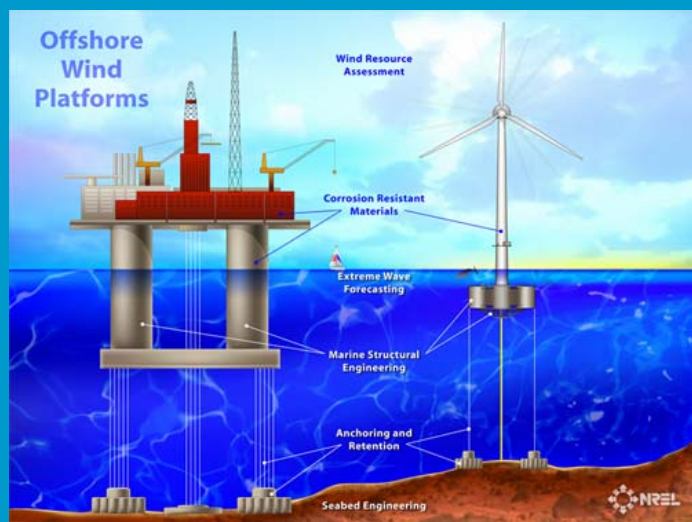


Laura Rodman
Advanced GIS, Sonoma State University (2003)

Wind Energy History



Modern Wind Turbines



Eyesore

A2 San Francisco Chronicle

☆☆☆☆

SUNDAY, NOVEMBER 21, 2004

Residents upset over Cape Cod wind-farm plan

Clean power source would be unsightly, opponents argue

By Anna Badkhen
CHRONICLE STAFF WRITER

BARNSTABLE, Mass. — Lou Emrich is as sensitive as anyone when it comes to environmental concerns. A native Cape Codder, he knows firsthand the value of the pristine beaches of nearby Martha's Vineyard and the untamed vastness of Nantucket Sound, both situated in one of the nation's most coveted vacation spots.

But when it comes to building the world's largest offshore wind farm that would provide pollution-free energy for much of the Cape Cod area and beyond, Emrich is not so sure.

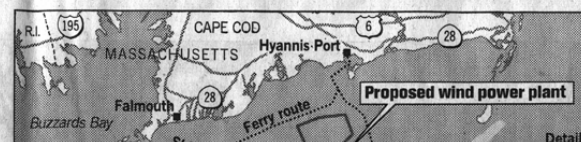
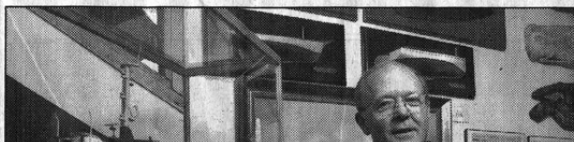
"We certainly need energy conservation, we need alternative sources of power, but we don't want it where they want to put it," said Emrich, 62, who works at a jewelry shop in the coastal town of Barnstable, whose waterfront district of Hyannis would be looking out on the installation. "Where should they put it? Somewhere out of sight. We just would hate to see these things out there."

Right now, Boston-based Cape Wind Associates wants to locate the wind farm — America's first offshore wind-power installation — about 10 miles off Cape Cod.



Photos by JODI HILTON / Special to The Chronicle

Audra Parker, assistant director of the Alliance to Protect Nantucket Sound, holds a photo model of the proposed wind farm.



temporary jobs during the month construction and about 150 permanent jobs when turbines are installed in the square-mile area on Horseshoe Shoal, 6 miles south of Hyannis.

The draft report said the damage to wildlife in the area would be minimal. Effects on local shellfish and fish populations would be felt only during construction, it said, while the turbines would kill an average of 364 birds per year — less than a day. Biologists and environmentalists estimate that the turbines in the Altamont Pass east of Livermore kill between 1,766 and 4,721 birds annually.

"The turbines don't produce pollutants, they don't make waste, they don't emit radiation, they aren't likely terrorist targets," Rogers said.

Report questioned

This did not satisfy Susan Nickerson, one of the leaders of the Alliance to Protect Nantucket Sound, an activist group opposed to the project. Nickerson said the report was biased toward the project because Cape Wind paid for the Army Corps of Engineers research, as required by the federal agency.

"It is difficult to fully appreciate the impact the project could have on local environment," said Nickerson, an environmentalist whose family has been living on Cape Cod since 1639.

Audra Parker, who also

Endangers Birds

Key source of renewable energy often lethal for birds ^{A1}



LIZ HAFALIA / The Chronicle

Raul Jimenez, a plant manager for G3 Energy, looks at mid-1980s turbines that his company is replacing in the Altamont Pass.

Taming the deadly wind farm

By Jane Kay
CHRONICLE ENVIRONMENT WRITER

If environmentalists and state officials have their way, the towering windmills that dot the Altamont Pass will be replaced and moved to prevent the killing of thousands of birds annually, including species protected under federal and state laws.

In an effort to curtail the carnage, they say the turbines — which provide one-third of California's wind power — should be newer, taller models and be concentrated on the leeward side of the hills.

This spring, Alameda and Contra Costa counties, home to the state-designated Altamont Pass Wind

Resource Area, will decide whether to include those recommendations and others when renewing permits on scattered parcels owned or leased by a dozen energy companies.

With 5,000 windmills in a 50-square-mile area, the Altamont Pass is the world's largest wind farm, producing enough electricity to power 200,000 households annually. But it is also the worst in the country for slaughtering birds.

Altamont Pass is a prime hunting ground for golden eagles and other raptors, and scientists estimate conservatively that the turbines kill some 4,700 birds every year.

► WIND: Page A19

“Any time you put up wind turbines, you’re going to kill birds. But there’s nothing as bad as Altamont.”

LINDA SPIEGEL
wildlife biologist

from the state energy commission.

The study, conducted over a five-year span by scientists under contract to the agency, documented bird kills and recommended solutions such as replacing thousands of older turbines with fewer, larger-capacity modern turbines that — because of their greater height — don’t appear to pose such a hazard to the birds. Scientists also advised clustering the windmills on the leeward sides of hills.

Clean wind energy is favored by environmental groups. But they

at the silent hawks hovering overhead. One time, he said, he saw a bald eagle.

Jimenez is scanning the ridges to point out the 1984-1985-era windmills that are coming down. For \$40 million, the company will replace — or “repower” — all 179 old windmills at the site with 38 new Mitsubishi turbines. To keep the blades above the birds’ hunting elevations, some of the new models are 211 feet high — the height of a 21-story building, more than twice the height of the old, 75-foot windmills.

PORTION OF ITS 2,000 WINDMILLS IN ALTAMONT. The company has removed 180 older turbines at the Diablo Winds farm and is putting in 31 newer, taller ones.

FPL is taking precautions to reduce bird kills under permit requirements by moving turbines out of dips and valleys, removing old equipment and putting electrical lines underground. In contrast to G3 Energy, however, FPL isn’t adhering to new Energy Commission recommendations when locating the turbines.

At this point, wind is the most economically viable renewable source — and under the Renewable Portfolio Standard passed by the Legislature last year, California utilities have to double their percentage of electricity production from wind, solar, geothermal or biomass burning by 2010. The in-state production of renewable electricity currently stands at 10.4 percent, with 1.3 percent from wind.

What happens in the next few months will bear consequences for

Radar Interference?

THE PRESS DEMOCRAT • SUNDAY, JUNE 11, 2006

NATION

Midwestern wind-farm projects halted

Defense Department says turbines may interfere with military radars

By KARI LYDERSEN
WASHINGTON POST

CHICAGO — More than 130 wind turbines are proposed for the hilltops of central Wisconsin, but that project and at least 11 others have been halted by the Defense Department as it studies whether the projects could interfere with military radar.

Wind-farm developers, Midwestern legislators and environmentalists say the farms pose no risk, noting that there are already numerous wind farms operating in military radar areas. They say a renewable, domestic source of energy such as wind is crucial to energy security and independence.

They say their wind turbines are victims of the ongoing dispute between Cape Cod residents and developers of the proposed Cape Wind farm in Nantucket Sound. The Defense Department study was put in the 2006 Defense Authorization Act — inserted, say wind farm developers, by senators who want to block Cape Wind.

“This legislation was intended to derail Cape Wind, but it had a boomerang effect and affected a lot of projects around the country,” said Michael Skelly of Horizon Wind Energy, a Texas company constructing the country’s largest wind farm near Bloomington, Ill.

This spring, facilities in the works in North Dakota, South Dakota, Illinois and Wisconsin received “proposed hazard” letters from the Federal Aviation Administration saying the projects must be halted pending

the Defense Department study.

FAA spokeswoman Diane Spitaliere said the letters are in keeping with the agency’s usual review process, which has been slowed by the quickly increasing number of permit applications for wind turbines nationwide.

The FAA has received more than 4,100 wind turbine applications so far this year, compared with about 4,300 in 2005 and 1,982 in 2004. An offshore wind farm of as many as 170 turbines is planned in the Gulf of Mexico off South Padre Island, Texas. The \$2 billion project will generate enough electricity for 125,000 homes. At meetings in Madison, Wis., and Toledo, Ohio, this month, industry and government officials will discuss an offshore wind farm in the Great Lakes.

Sen. Richard Durbin, D-Ill., said the Defense Department

study could have a chilling effect on the development of wind power nationwide.

A June 2 letter to the Defense Department signed by Durbin and five other Midwestern senators said, “Since much of the nation is in radar line of sight, this interim policy has a sweeping effect.” It noted that multiple wind farms are already operating in the radar line of sight of military and Homeland Security installations, “without any problems that we are aware of.”

Critics of Cape Wind, including Sen. John Warner, R-Va., and Sen. Edward Kennedy, D-Mass., have said that the 130 proposed turbines about six miles offshore would hurt views, tourism and migratory birds.

Some neighbors of the Midwestern projects oppose them on similar grounds.

Neighborhood Wind Turbines?

Unsightly, Noisy



Local News 2003

Sonoma looks at easing windmill laws

Supervisors may make it a breeze to install wind energy systems in urban fringes

By Pamela J. Podger
CHRONICLE STAFF WRITER

Facing an annual energy bill of \$3,200, Kris and Jim Foster decided to erect a small windmill on their breezy three-acre farm in west Petaluma.

The Fosters' goal is to be energy self-sufficient. A four-kilowatt windmill would get them there, augmenting their existing solar panels and helping trim energy

costs for their century-old home, well and two greenhouses, where they grow orchids as a hobby.

But the landscape changed shortly after the Fosters' spent \$1,400 for the required Sonoma County permits in August and completed the state paperwork needed for a \$10,000 rebate on a \$25,000 windmill. In December, the Fosters were told their planned 65-foot windmill would be illegal because just-released

federal census maps placed part of their land inside the Petaluma urban lines where windmills are prohibited.

Today, county supervisors will consider a new windmill ordinance. If adopted, the new rules would eliminate the mapping roadblocks for the Fosters and help ease the uncertainty for several people in the county's unincorporated areas who have been waiting to erect windmills. Super-

visors say a local ordinance is needed because the broader state rules don't provide visual protections in Sonoma County's urban fringes.

Supervisor Mike Kerns, who represents the area where the Fosters live, said the proposed ordinance gives graduated levels of oversight, depending on the property's acreage, proximity to a city

► WINDMILL: Page A21 Col. 4



Jim and Kris Foster, surrounded by sheep on their property, are in limbo with their windmill plans.

Sonoma supervisors to vote on relaxing windmill laws

► WINDMILL
From Page A17

and windmill height.

"I think this encourages people to build these kinds of wind systems, which I think is a good thing, and the areas where they would be allowed is more clearly defined and is more consistent throughout the county."

The issue became politically charged two years ago when rural Sonoma resident William Hammett applied to build an 80-foot windmill, a bid that was eventually denied. Towers on the wind energy systems typically run from 40 to 80 feet tall, and some people told supervisors that the wind turbines are ugly, noisy and shouldn't be permitted near urban areas. The public uproar resulted in a temporary moratorium in October on small wind systems within 2,500 feet of water and sewer connections.

County planner David Hardy said the proposed ordinance would clarify the procedure for

the four county residents who have applied for windmills in the past 18 months and several more people in Cotati, Jenner and Bodega Bay who have called recently with inquiries on local windmill rules.

Under the complex proposal, the siting of windmills would depend on height, parcel size and proximity to cities and urban fringes.

For instance, county residents who live more than a half-mile from water and sewer connections would be allowed to install a windmill without a permit and without officially notifying their neighbors. Windmills would remain banned from cities and most residential subdivisions. Wind turbines within 2,500 feet of cities would require permits, as would those between 40 to 65 feet in height. Wind towers over 65 feet tall would be banned on property less than five acres.

Supervisor Mike Reilly said it is important for supervisors to encourage alternative energy sources,

including windmills.

"While I understand that people are concerned about the visual impacts (of windmills), people have gotten used to telephone poles and I think we'll get used to these wind energy towers," Reilly said. "Some people even think they are graceful."

Meanwhile, Jim Foster, 54, said the couple is caught in an irksome limbo waiting for the county to act.

"My sense is the proposal going to the board will be very simple and straightforward," he said. "If they can't vote on it, then I'm going to bag it."

He hopes that's not the case.

"A wind system would almost make us energy independent. At dusk the wind is blowing when the sun is going down," Foster said. "We cut our bill almost in half with the solar system and we could equal or exceed that production with the wind."

E-mail Pamela J. Podger at ppodger@sfchronicle.com.

Local News 2006

Green Energy

How alternative resources have gone from responsible to cost-effective

By Clark Mason and Michael Coit

The Press Democrat

November 26, 2006

The steam plumes rising from The Geysers geothermal field may be accompanied in a few years by another conspicuous sight - wind turbines as high as 30-story buildings.

As part of the growing push to develop renewable energy sources, a group of cities that includes Healdsburg and Ukiah is exploring the possibility of harnessing wind power at The Geysers to create electricity.

The fledgling project is one of the latest strides being made along the North Coast to develop more renewable - "green" - energy sources. From The Geysers geothermal field, producing enough power for 1 million households, to solar electric systems on large commercial buildings, to methane gas-generated power at both the Sonoma County central landfill and Santa Rosa's regional sewage plant, the North Coast region is at the forefront in generating renewable power.

"We have a tradition and we're just building on that. We're not trailblazing anymore. We're finally in that phase where people know it works and there's more of it," said Alexandra von Meier, a Sonoma State University associate professor of environmental studies and an energy industry expert.

Some new, large projects include:

The former Agilent Technologies campus in Rohnert Park where Coddling Enterprises just installed a massive solar electric system as part of its plans to redevelop the site into a 1,900-home community, with jobs and services for residents. The \$7.5-million system will generate 1 megawatt of solar power, enough to meet daily demand for about 1,000 homes.

Fetzer Vineyards this summer installed the largest solar array in the wine industry at its Hopland bottling facility. The system will supply 80 percent of the plant's electrical needs, the equivalent of providing power to 900 homes annually.

Wind Energy Support

- New energy sources are needed
- Renewable energy is in demand
 - Concern over global climate change
 - Enforcement of air quality standards
 - Opposition to domestic oil production
- Wind power has many advantages
 - Flexible placement
 - Distributed power generation
 - Economics

Wind Energy Opposition (Geographic)

- Environmental concerns
 - Bird mortality
 - Wildlife impact
 - Habitat destruction
- Human impact
 - Visual nuisance
 - Noise
 - Danger due to moving rotor, electric generator

Objectives

- Develop an analytical framework for evaluating site suitability for wind turbines
 - Physical features
 - Environmental factors
 - Human impact factors
- Perform spatial analyses using combinations of the above factors
- Identify supporting/opposing factors in a given location

Large-Scale Wind Energy Production

- Each wind turbine may generate up to 1000 kW
- Tower heights up to 80 meters
- Rotor diameters up to 27 meters
- Requires annual average wind speed of 7-9 m/s (15 – 20 mph)
- California wind industry produced 3.5 billion kWh in 2001 (1.5% of total)



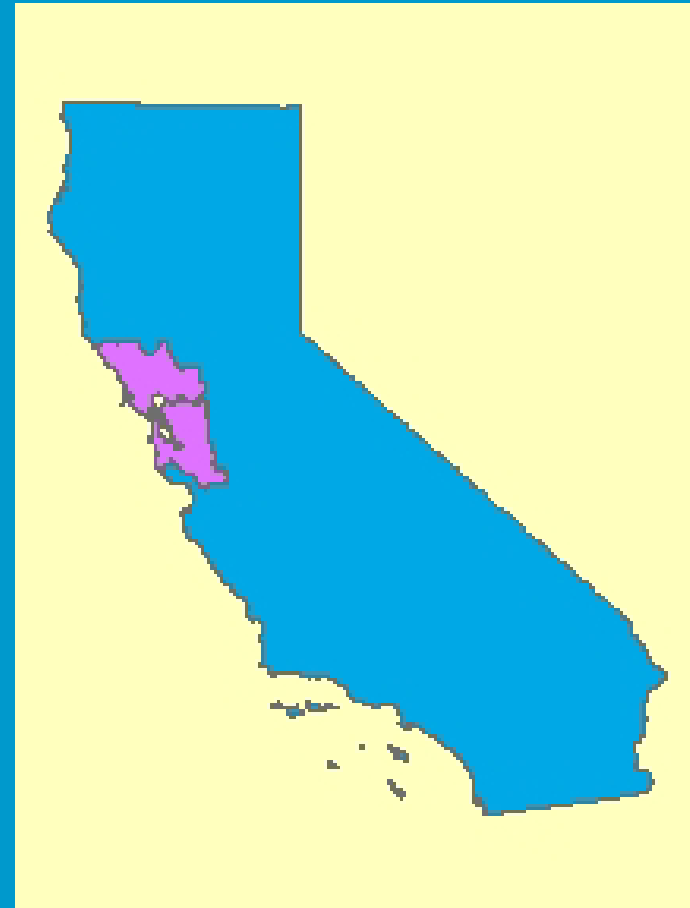
Small-Scale Wind Energy Production

- Private home or community use
- Wind turbines generate less than 10 kW
- Tower heights between 9 and 30 meters
- Rotor diameters between 1 and 4 meters
- Requires annual average wind speeds of 3 m/s if standalone, 4.5 m/s if grid-connected (7-10 mph)



Study Area

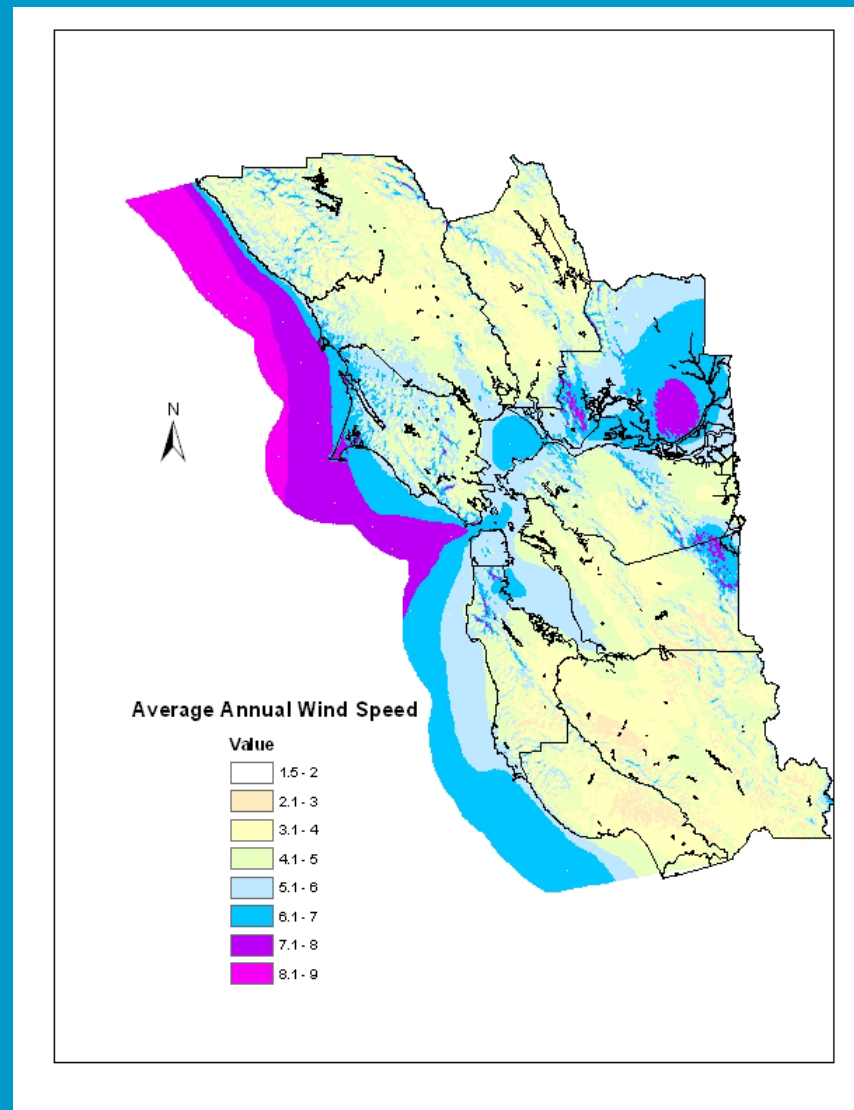
- San Francisco Bay Area (nine counties)
- Heavily populated area
- Region includes two of the top five wind power producing areas in California (Altamont Pass and Solano County)



Data Sources

- AWS Truewind
 - Modified meteorological model coupled with wind model
 - Includes terrain and surface roughness
 - 200 m resolution
- California Gap Analysis Project
 - Vegetation and land use (30 m resolution)
- USGS DEM (30 m)
- CERES (public lands)

Bay Area Wind Resources



Database Development

- Physical Data
 - Wind resources
 - Terrain
 - Obstacles
- Environmental Habitat
 - Vegetation types
 - Wetlands
 - Endangered plant species
- Human Impact
 - Urban development
 - Recreational areas

Multi-Class Index Overlay Model

$$\bar{S} = \frac{\sum_i^n S_{ij} W_i}{\sum_i^n W_i}$$

where S_{ij} = class scores,
 W_i = weights of each map

Physical Model

$$[(3 * \text{wind}) + (2 * \text{obstacles}) + (\text{terrain})] / 6$$

terrain = valley or ridge

Physical Suitability Model

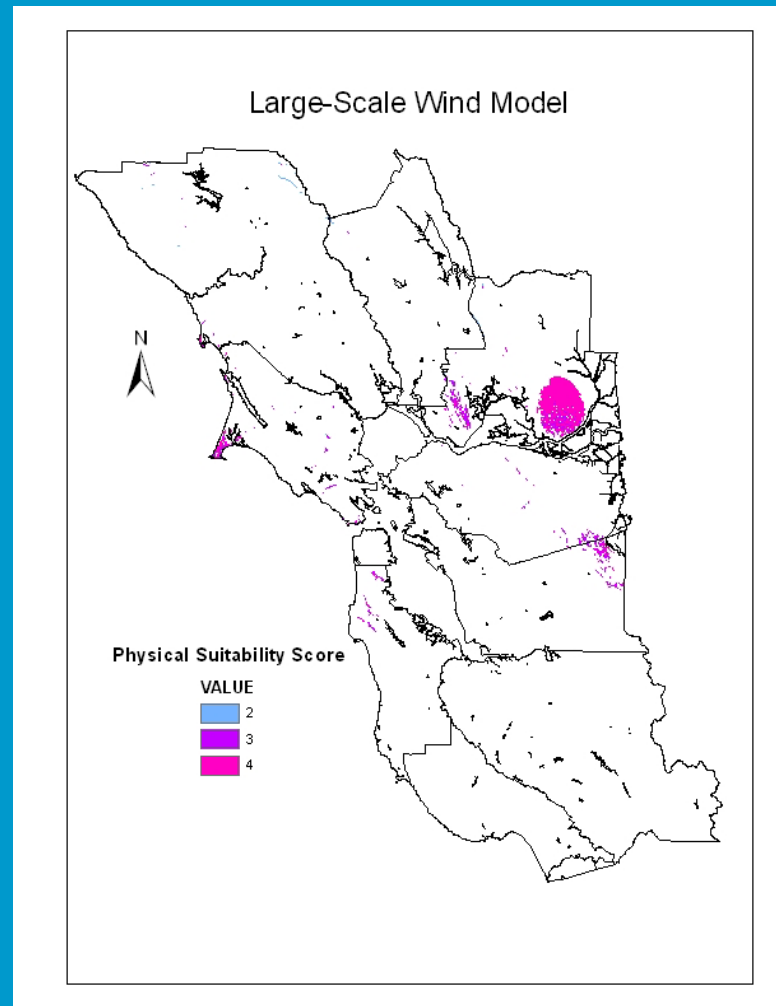
Suitability Score	Wind Speed			Obstacles (trees)
	Large	Small (grid)	Small (alone)	
Excellent 4	> 7 m/s	> 4.5 m/s	> 3 m/s	Primary != trees Secondary != trees
Good 3				Primary != trees Secondary == trees
Fair 2				Primary == trees Secondary != trees
Poor 1				
Unsuitable	< 7 m/s	< 4.5 m/s	< 3 m/s	Primary == trees Secondary == trees

Physical Suitability Model, cont.

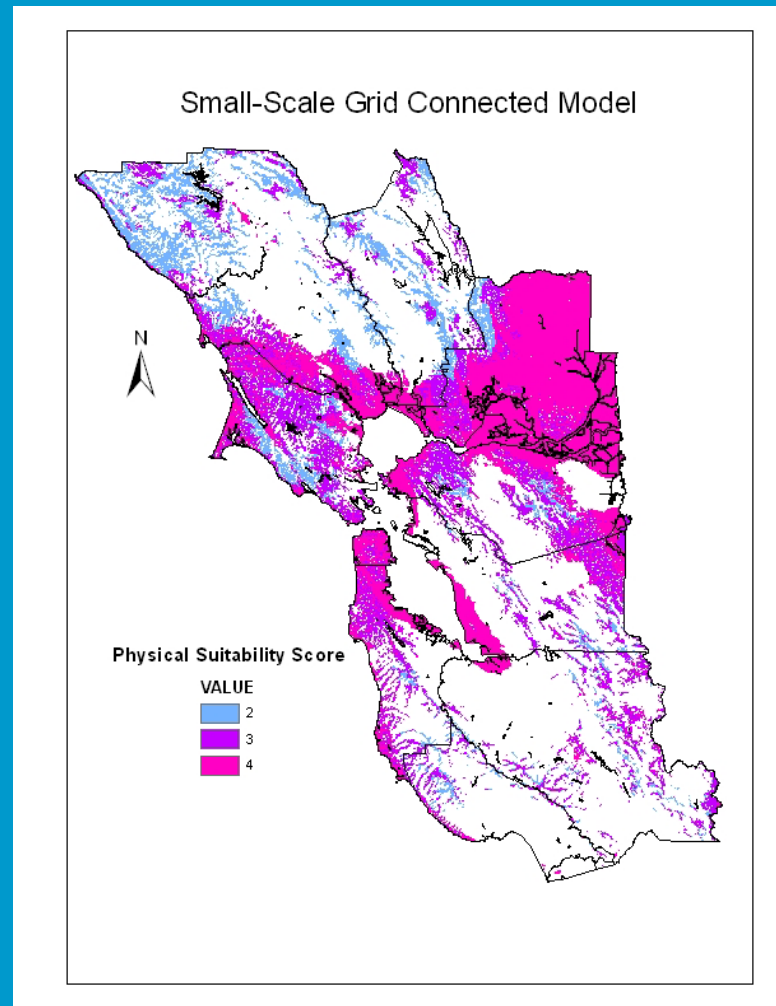
Suitability Score	Valley (majority slope over 150x150 m area)	Distance to Ridge
Excellent 4	0° - 7°	< 10 m
Good 3	7° - 16°	10 – 30 m
Fair 2	16° -30°	30 – 50 m
Poor 1	30° - 40°	50 – 100 m
Unsuitable	> 40°	> 100 m

Terrain score = max (Valley, Distance to Ridge)

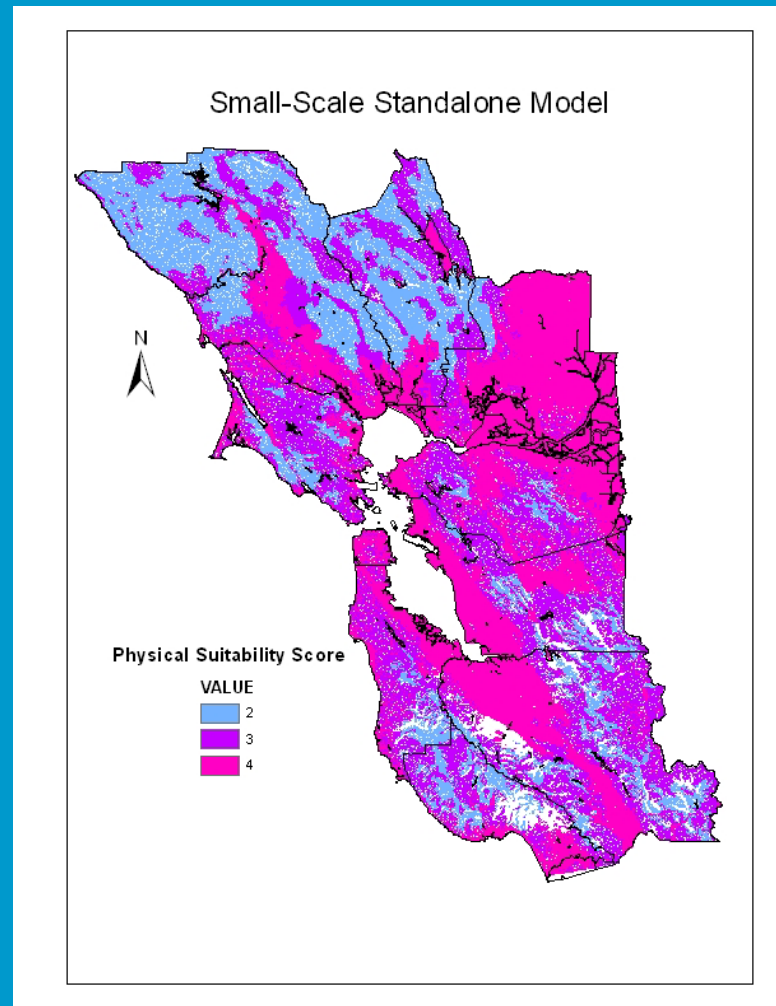
Physical Suitability



Physical Suitability



Physical Suitability

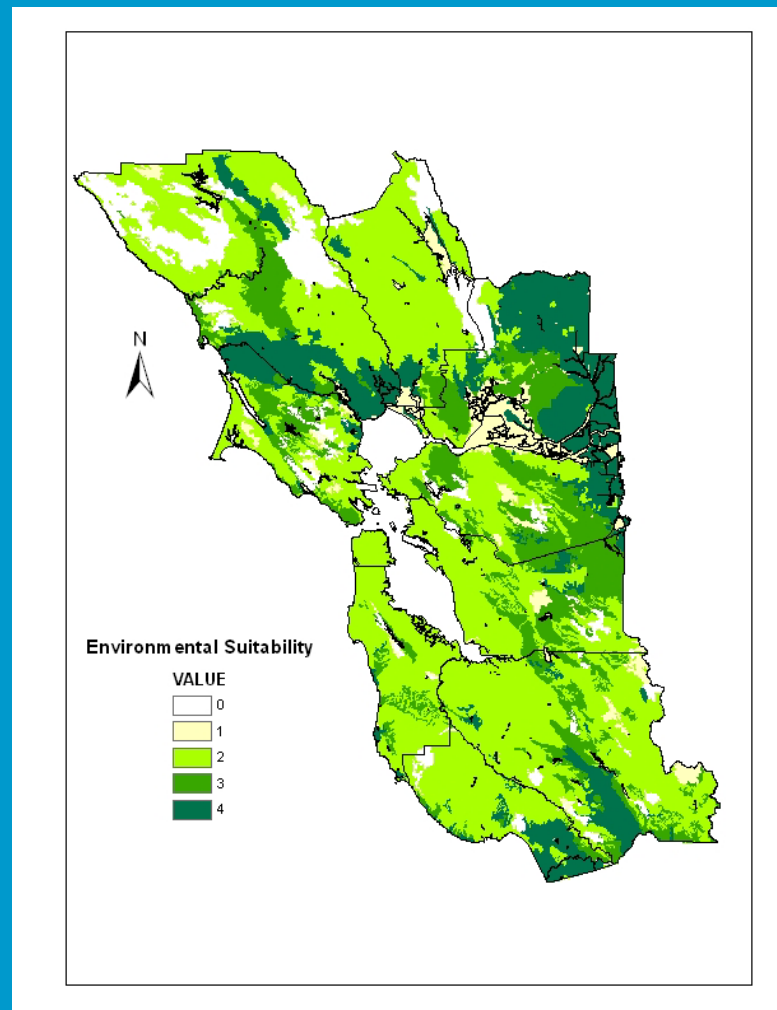


Environmental Suitability Model

$$[(3 \times \text{vegetation}) + (2 \times \text{endangered}) + (\text{wetlands})] / 6$$

Suitability Score	Land Use Vegetation	Endangered Plant Species	Wetlands
Excellent 4	Farmland Barren	No endangered species present	No wetlands present
Good 3			
Fair 2	Grass		
Poor 1	Shrubs/Chaparral		
Unsuitable	Forest Wetlands	Endangered species present	Wetlands present

Environmental Suitability

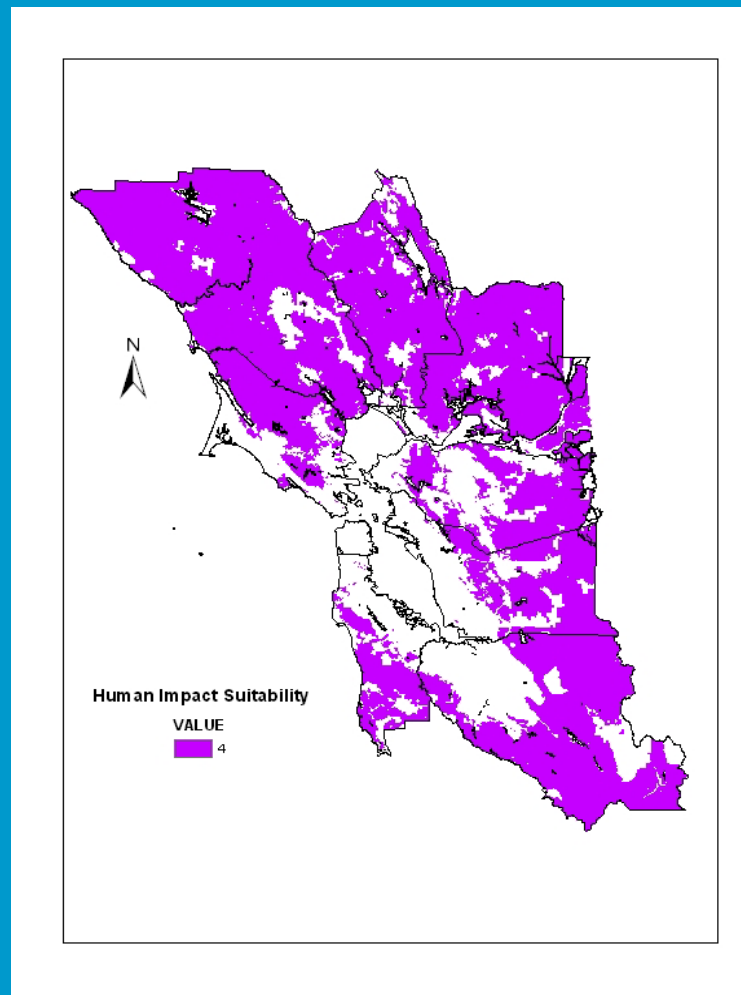


Human Impact Suitability Model

$$[(\text{urban}) + (\text{recreation})] / 2$$

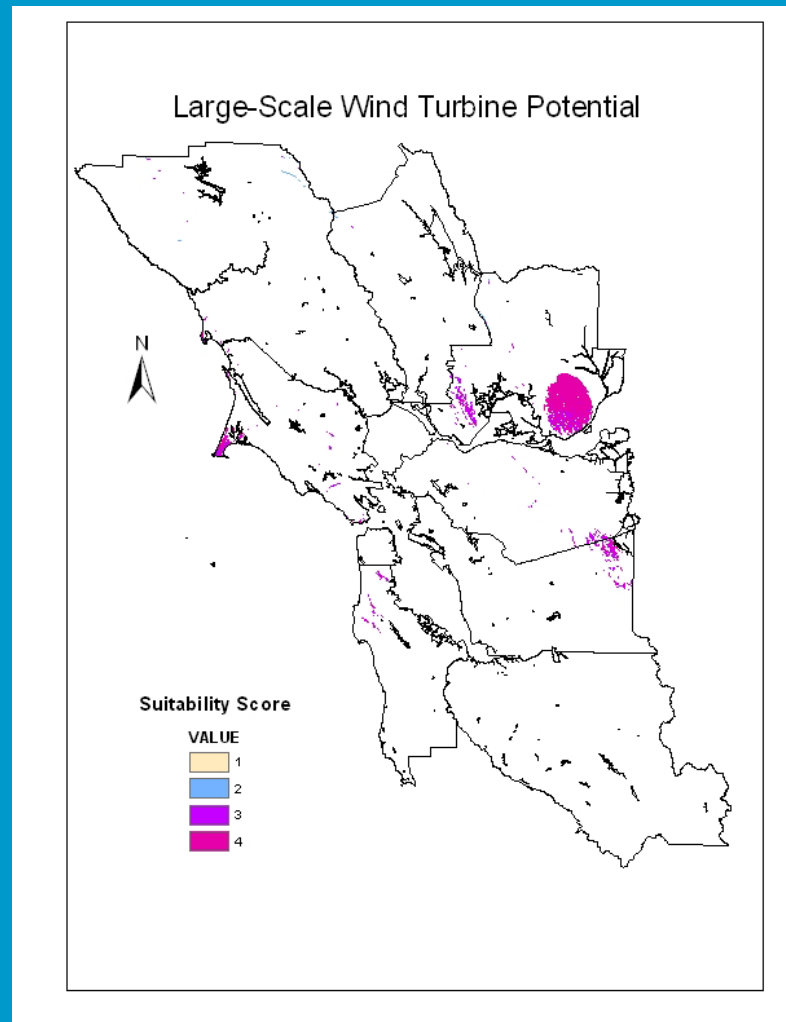
Suitability Score	Urban	Recreational
Excellent 4	Not urban	No public parkland
Unsuitable	Urban	Public parkland

Human Impact Suitability



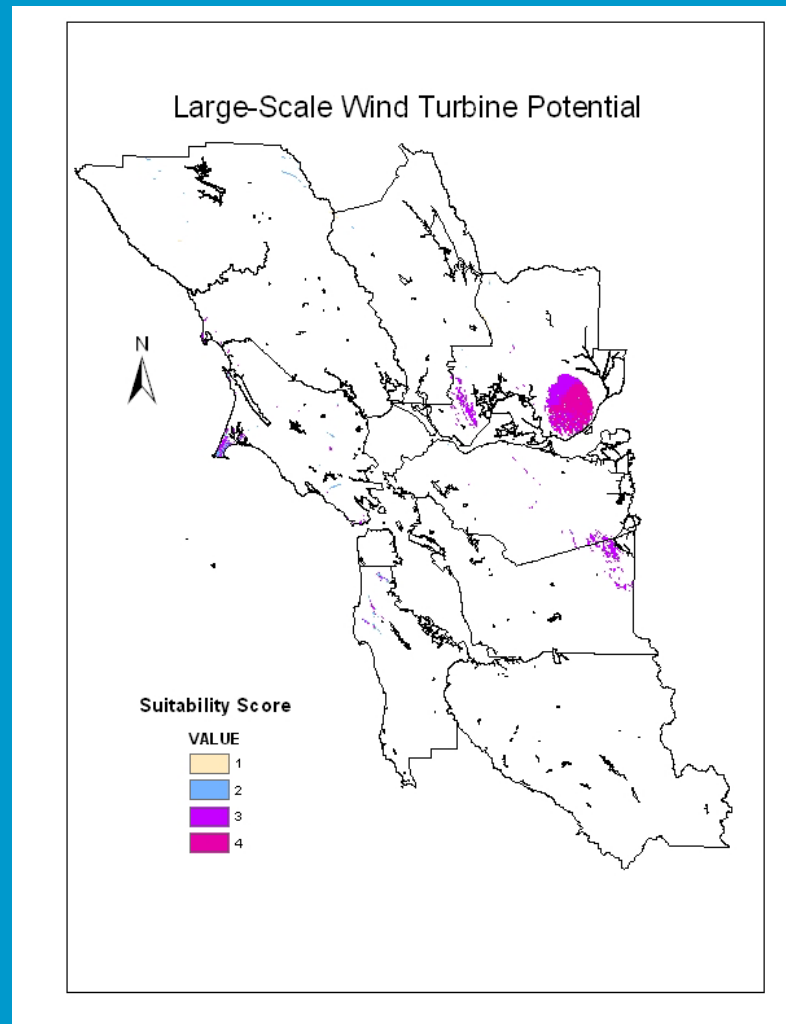
Large-Scale Wind Energy Potential

Physical Model Only



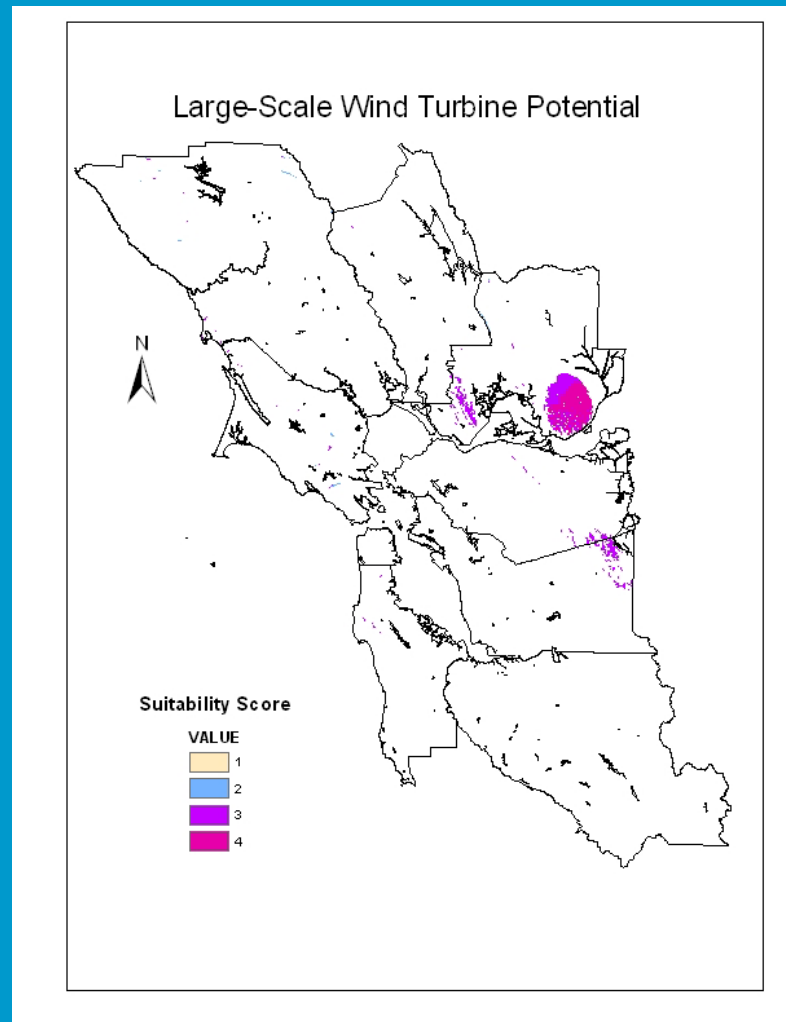
Large-Scale Wind Energy Potential

Physical and Environmental Models



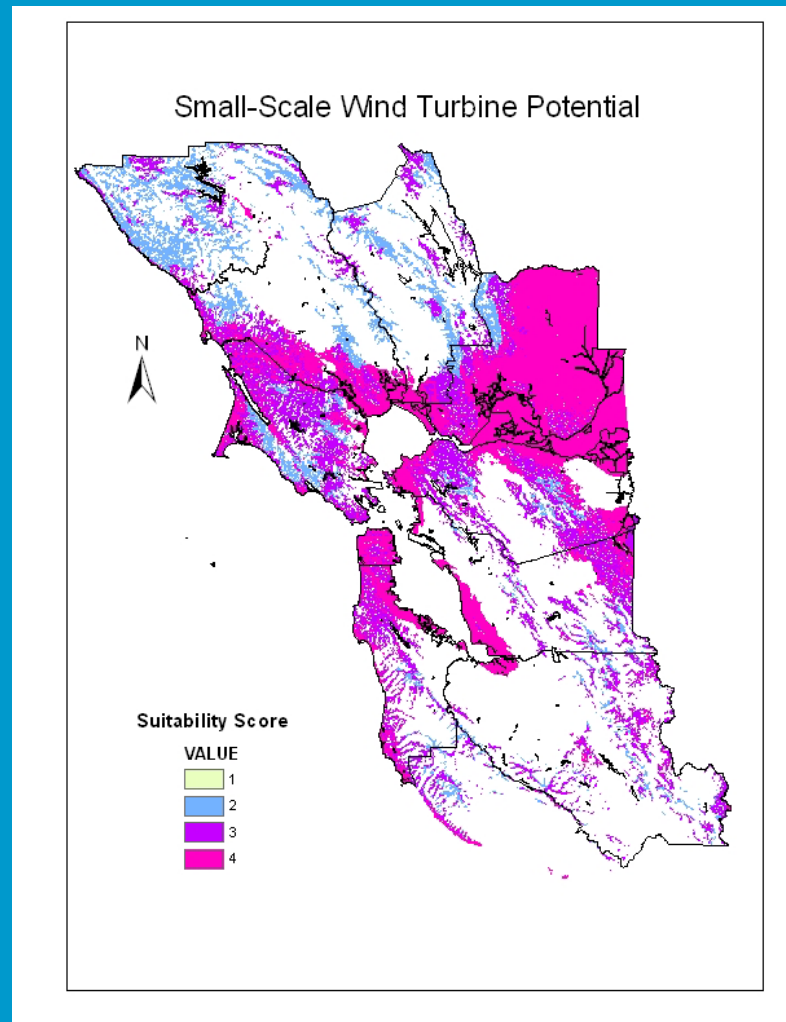
Large-Scale Wind Energy Potential

Physical, Environmental, and Human Models



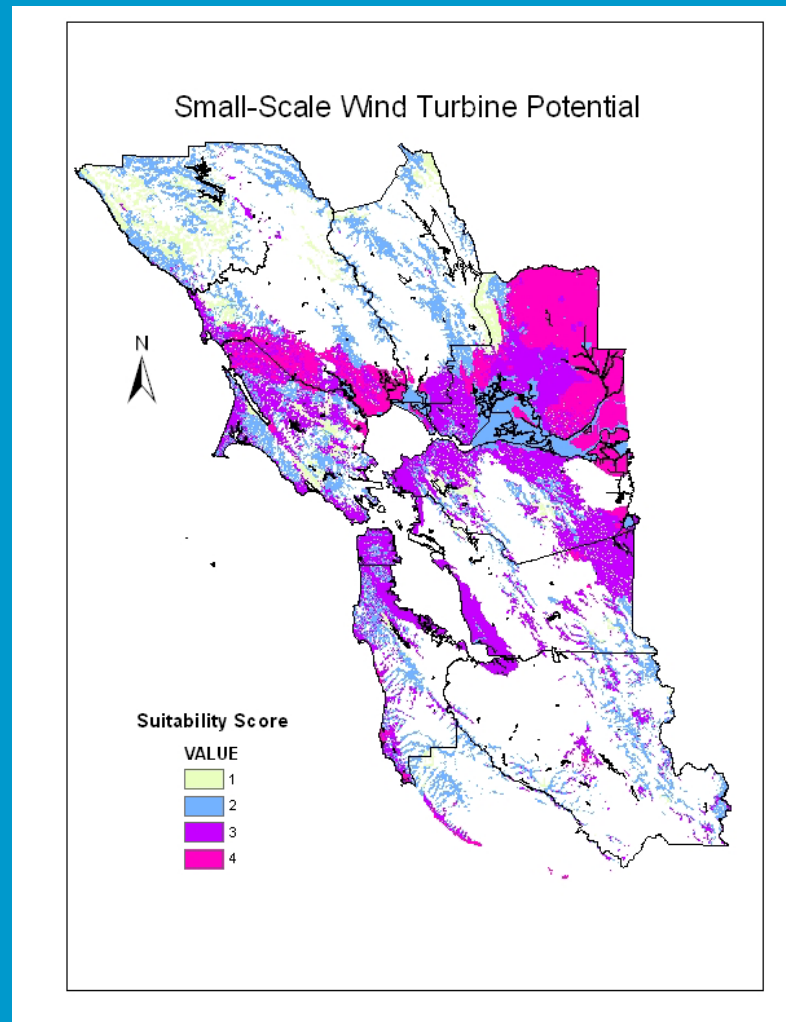
Small-Scale Wind Energy Potential

Physical Model Only (Grid Connected)



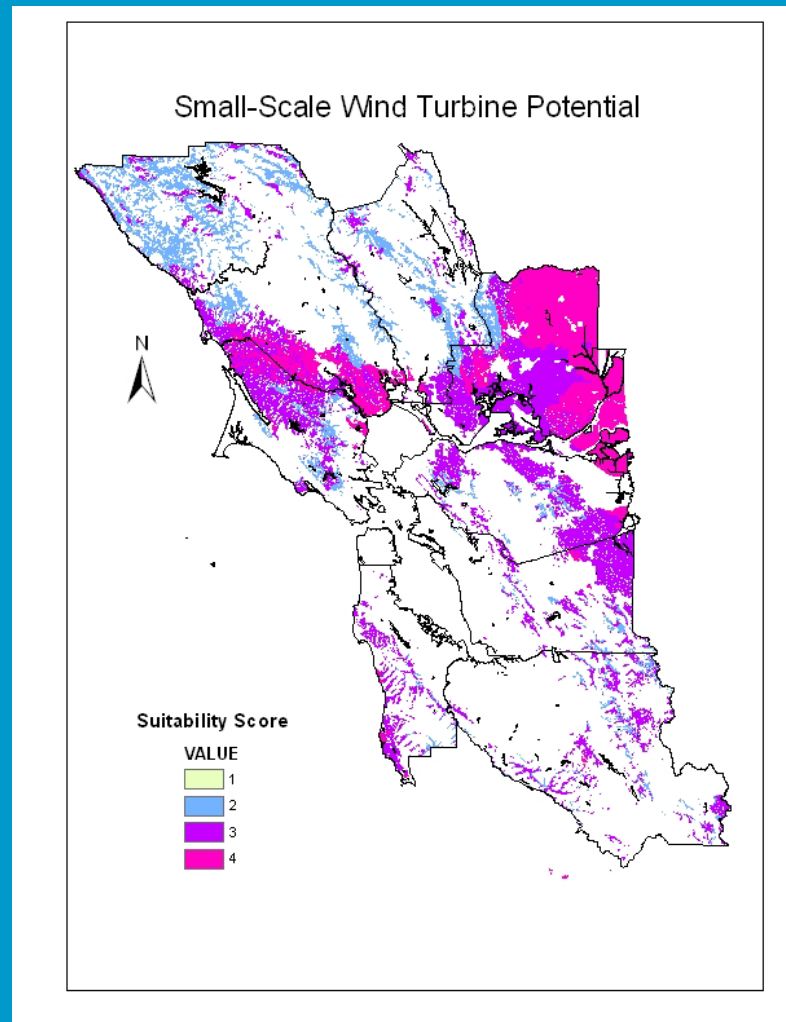
Small-Scale Wind Energy Potential

Physical and Environmental Models



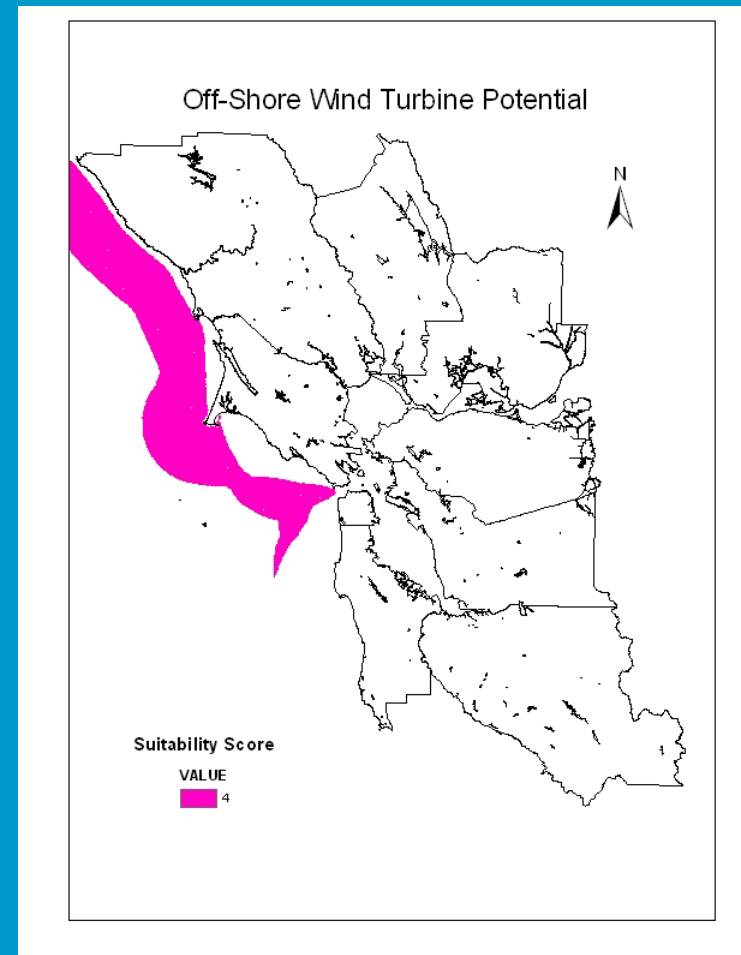
Small-Scale Wind Energy Potential

Physical, Environmental and Human Models



Off-Shore Wind Energy

- Physical model only
- High winds available
- Further analysis should account for ocean depth and distance from shore



Concluding Remarks

- The developed technique allows suitable wind turbine sites to be identified
- Suitability factors originating from physical, environmental, and human impact can be evaluated individually
- The framework correctly identifies large-scale wind turbine sites currently in use
- Future work includes model expansion and refinement, increased study area