

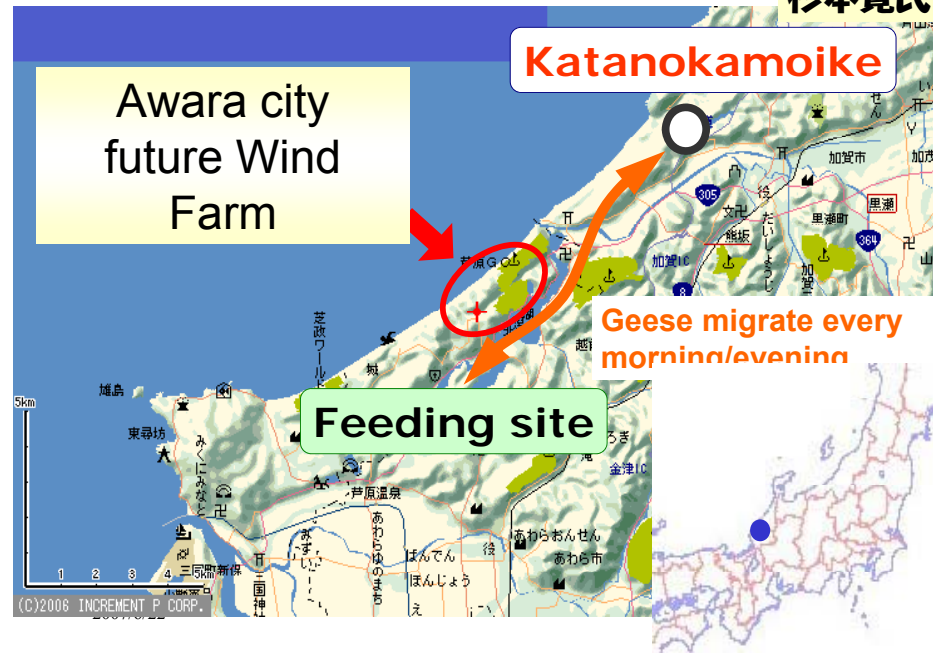
Risk of wind farms on white-fronted geese by avian collisions

- Risk-tradeoff
- Development of renewable power generation
- vs. Collision risk of endangered birds
- Possible risk of wind turbines on birds
 - 障壁効果 (Disturbance leading to displacement or exclusion, including barriers effect)
 - 衝突による死亡 (collision mortality)
 - 生息地の喪失 (Loss of, damage to, habitat resulting from wind turbines and associated infrastructure)



1

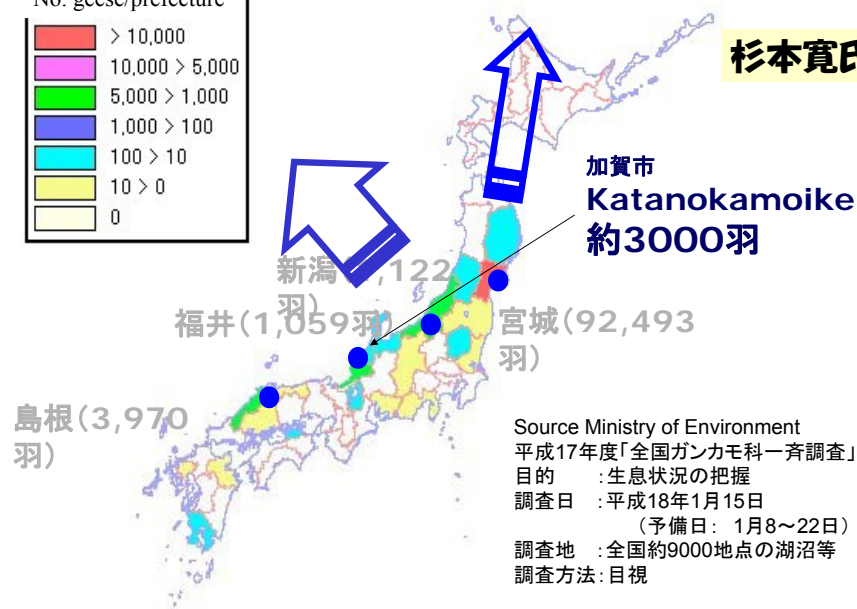
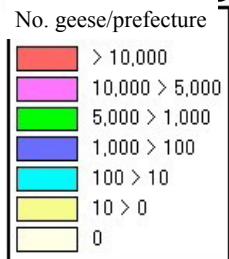
杉本寛氏



国土地理院承認 平14総復 第149号

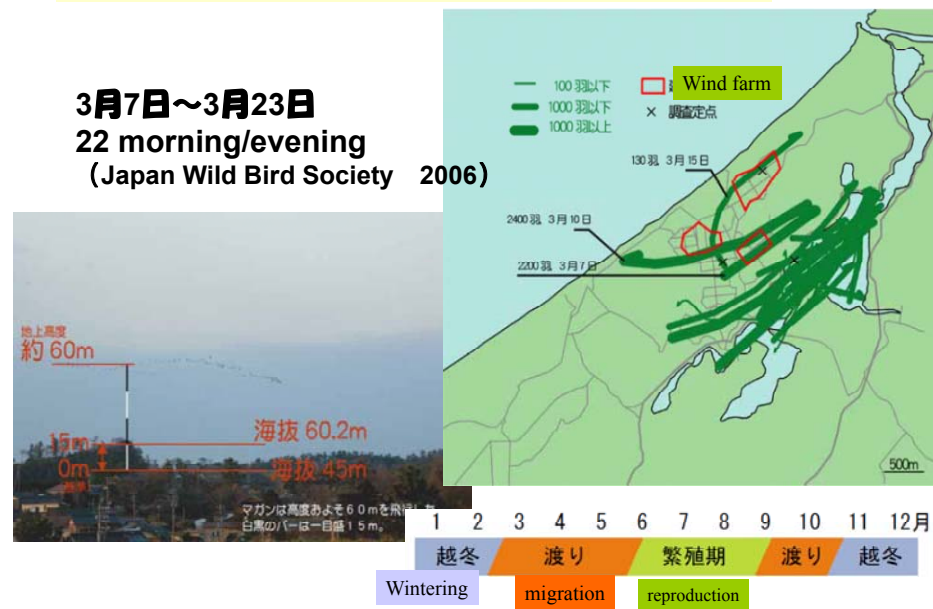
Overwintering Habitats of geese

杉本寛氏

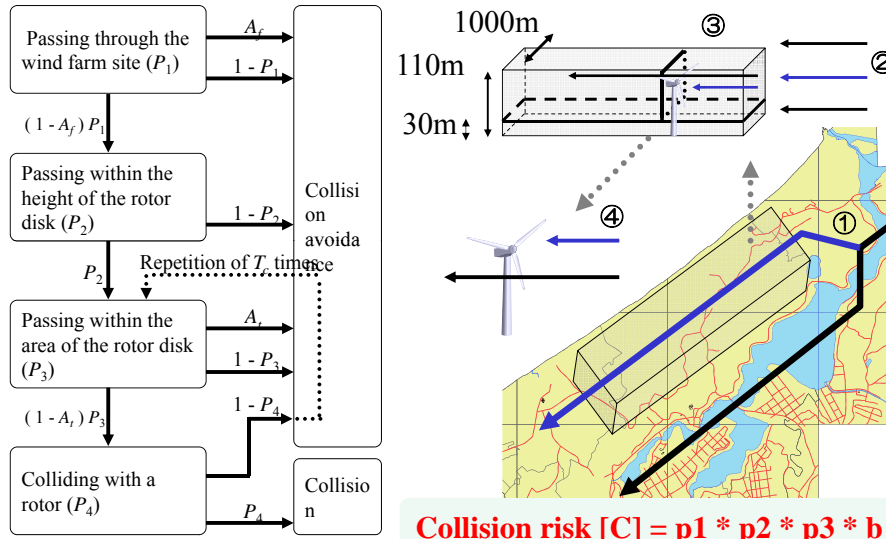


Do geese pass through wind farm? 雁

3月7日~3月23日
 22 morning/evening
 (Japan Wild Bird Society 2006)



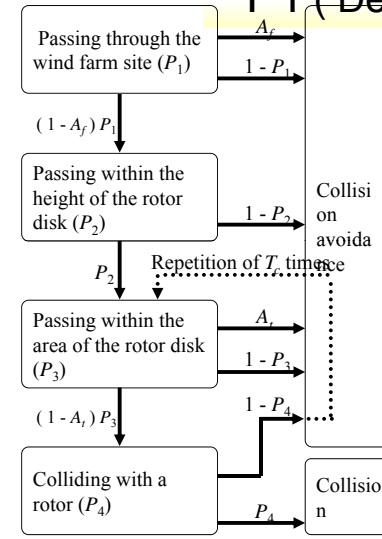
Method



Collision risk [C] = p1 * p2 * p3 * b

(Desholm et al. 2006)

P1 (Desholm et al. 2006)



	geese
#observations	103
#passing W.F.	2
# geese	3000
Average size of flock	200
p1 [%]	0.1

105 / 133

2 / 103

on for Dr. Amanno

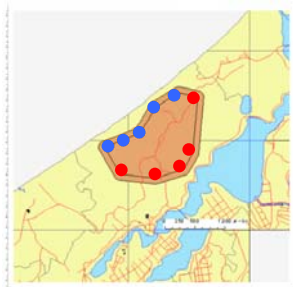
$p3 = \frac{\text{風車の断面積} \times 2}{\text{計画地断面積}}$

Method P3

③風車の断面積 [p3]

パラメータ

- p3 : passing within cross section of turbine



	マガン・ヒシクイ
Area of WF cross section [m2]	80000 (80 * 1000)
Area of turbine cross section [m2]	10053 (40 * 40 * π * 2)
p3 [%]	12.6

※風車10基、2列と仮定
風車の壁は5つ

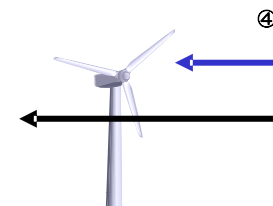
2016/1/3 Presentation for Dr. Amanno

パラメータ 値: マガン

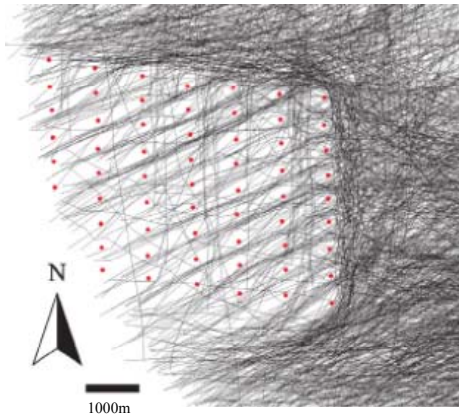
パラメータ	値: マガン
K 1D or 3D (0 or 1)	1 ※
b # blades	3
c Width of blade (m)	2.8 ※
y Pitch angle	15 ※
l Body length of bird (m)	0.8 (1.0)
w Width of bird wings	0.8 (1.0)
F Glider?	1 ※
v Velocity of bird (m/sec)	16.7
R Radius of blade (m)	40
s Period of rotation (sec)	2.46
β 鳥の縦横比	1.0 (1.0)
Ω speed (rad/s)	2.55 ※
r 鳥の通過地点の半径	
α Entering angle of bird	v/(r*Ω)

$$b = \frac{1}{\pi R^2} \iint p(r, \varphi) r dr d\varphi$$

$$= 2 \int p(r) \left(\frac{r}{R} \right) d \left(\frac{r}{R} \right)$$



Geese avoided wind farm in Denmark



Before establishment of wind farm, 40% of geese passed through the farm
 After the establishment, 4.5% of geese passed there, 0.6% of geese approached within 50m

Figure 1. The westerly oriented flight trajectories during the initial operation of the wind turbines. Black lines indicate migrating waterbird flocks, red dots the wind turbines. Scale bar, 1000 m.
 2007/6/22 Desholm & Kahlert 2005. Biology Letters 1:296-298. 9

Avoidance behavior

⑤ avoidance

パラメータ

• Af : avoiding W.F.

$$A_f = 1 - (0.045 / 0.404)$$

• At : avoiding turbine

$$A_t = 1 - (1 - (1 - 0.123)^{1/8}) \times (480 / 82)$$

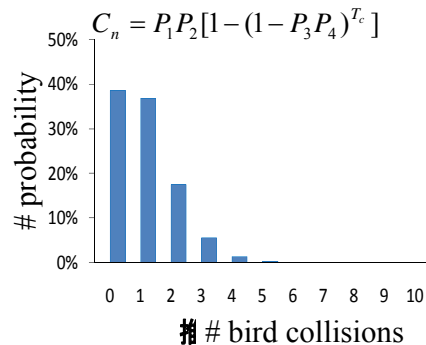
	ガン・カモ類
# turbines	72 (98)
# blade length [m]	41
interval turbine [m]	850
interval turbine [m]	480
% passing W.F.	40.4
Passing Farms	4.5
Passing turbines	12.3
Pass <50m [%]	0.6
Avoiding farm [%]	88.9
Avoiding turbine [%]	90.5

(Desholm et al. 2005)

If geese avoid wind turbines 0.95羽)

If geese do not avoid turbines (87.1羽)

$$C_a = (1 - A_f) P_1 P_2 \{ 1 - [1 - (1 - A_t) P_3 P_4]^{T_c} \}$$



$$\Pr[N_c = x] = \binom{N}{x} P_c^x (1 - P_c)^{N-x}$$

Comparison with P1 data from Japan wild bird society

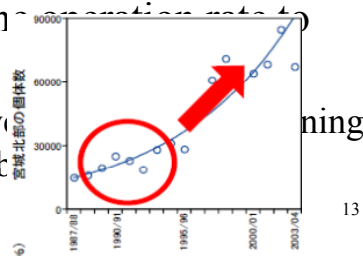
	JPEC	JWBS
#observation n	103	39
Passing WF m	2	4
Average flock size p	200	1632
# individuals through WF mp/n	3.9	167.4

マガン

P1	0.1
P2	78.9
P3	12.6
P4	13.0
Af	88.9
At	90.5
Cn : collision risk without avoidance	0.0081
Ca : collision risk with avoidance	0.0001

Potential biological removal

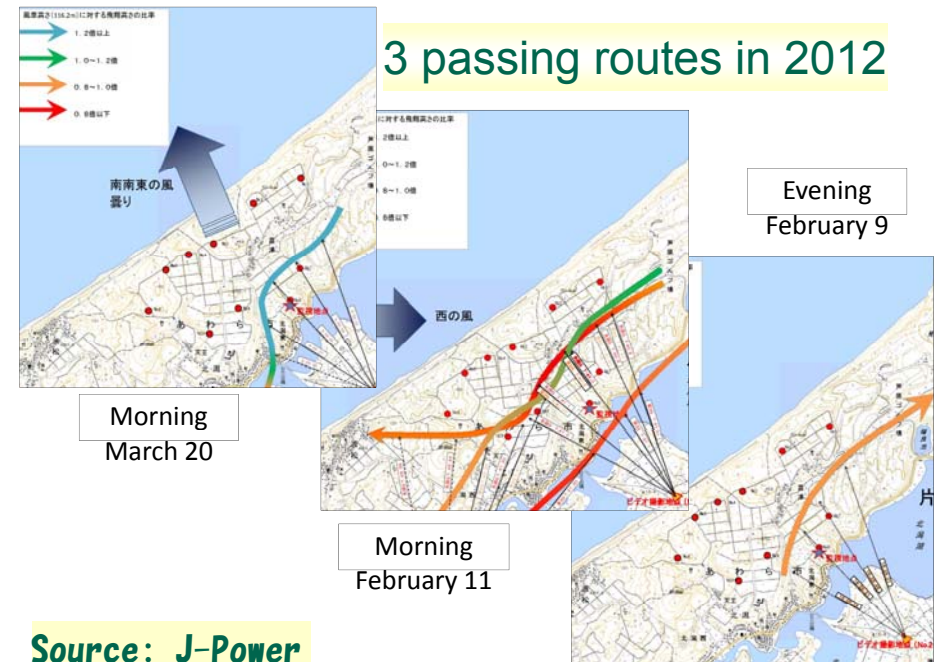
- $PBR = N_{min}/2 \times R_{max} \times F_r$ (Barlow et al. 1995)
- マガンPBR = $3000/2 \times 0.12 \times 0.5 = 90$ 羽
- Adaptive management:
If collision frequency is larger than we expected, we regulate the operation rate to reduce collision risk
 - E.g., we stop turbines even for a short time (2 hours), collision will be reduced



2007/6/22 13

13

3 passing routes in 2012



Source: J-Power

Collision risk estimate

under the assumption that avoidance rate is the same as Denmark.
Collision risk depends on E[individuals through WF]

We can calculate the risk from either data

	J Power	JNBS
#observation n	103	39
Passing WF m	2	4
Average flock size p	200	1632
indvdl through WF per day mp/n	3.9	167.4
E(No. collision) with avoidance	0-2	12-30
E(No. collision) no avoidance	42-71	1700

Consensus of Awara Wind Farm Management with Japan Wild Bird Society

	Mitigation Measures	Monitoring	Purpose
2010	Watch every morning/evening; stopping operation when flock approaches	Collect the frequency of passing the site (depending weathers)	Improve the collision risk assessment Detect risk factors
2011	Watch during snow season Improve regulation condition		Improve mitigation measures
2012	Watch with limited regulation	Video monitoring	Consensus of very low collision risk
2013 ~	Follow-up	Mitigation may restart if collision occurs,	Accountability in risk communication

Source J-Power

Adaptive risk management and consensus building

16

Landscape controversy

視点場E: 伊良湖国民休暇村西側海岸より風車建設計画地点を望む



計画前現況

2007/6/22

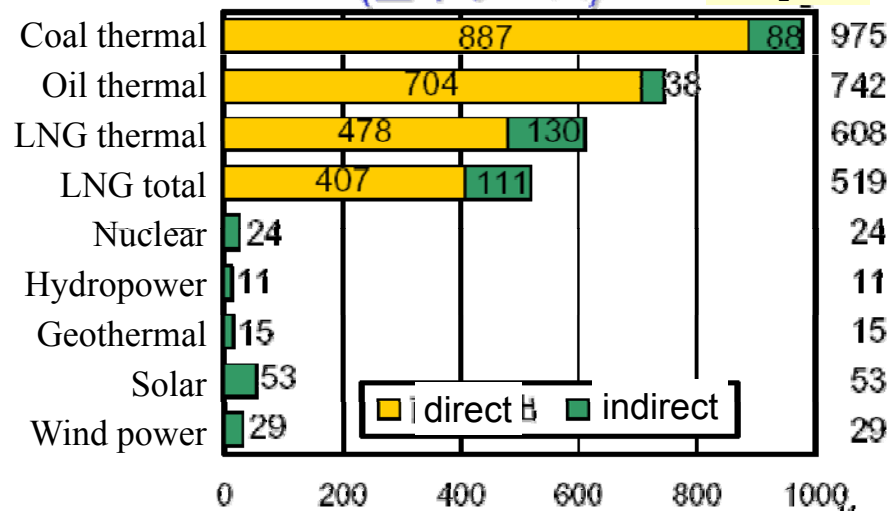


フォトモンタージュ

17

発電 Lifecycle CO2 emission 出原単位

(基本ケース) gCO₂/kWh h



Source: Hondo H (2005): Energy 30(11), 2042-2056

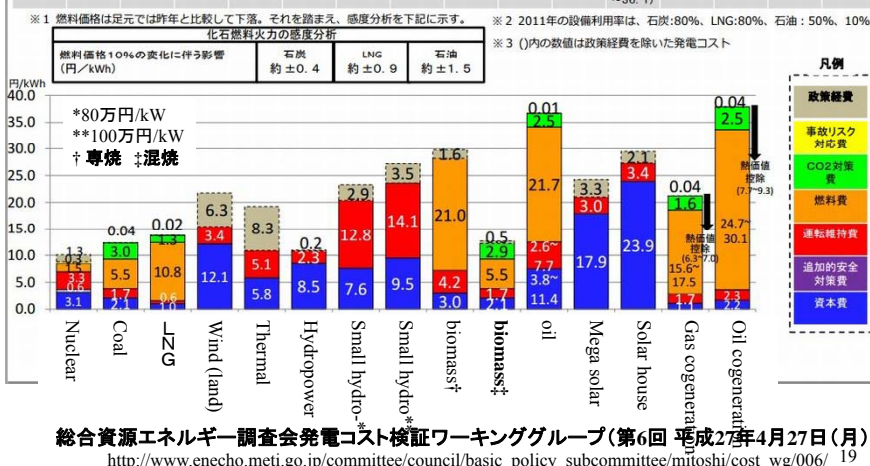
Does wind power generation pay?

島田泰夫氏の試算
一部改変

- Does not pay without any support from government
- If price is as high as solar power, it pays.
- Consumer price is >20yen/kw.

	Unit	Case 1	Case 2	Case 3
a.Price (supply side)	Yen/kw	10	10	13
b.Power capacity	kW	932	932	932
c.#days /year	day	365	365	365
d.#hours/day	hour	24	24	24
e. operation performanc	%	20%	20%	20%
①Income / year	1000\	16,329	16,329	21,227
f. Mitigation cost	1000\	?		
h. Cost of establishment	1000\	233,000	233,000	233,000
i.Support from Governm	%	33.3%	0.0%	0.0%
interest / year	%	4%	4%	4%
j.term of repayment	年	17	17	17
②repayment/year	1000\	12,283	19,152	19,152
③Running cost	¥/yr	2,000	2,000	2,000
④net income(①-②-③)		2,045	-4,824	75

電源	原子力	石炭火力	LNG火力	風力(陸上)	地熱	一般水力	小水力	小水力	バイオマス	バイオマス	石油火力	太陽光(幼)	太陽光(住宅)	ガスコジェネ	石油コジェネ
設備利用率 稼働年数	70% 40年	70% 40年	70% 40年	20% 20年	83% 40年	45% 40年	60% 40年	60% 100万円/kW	87% 40年	70% 40年	30-10% 40年	14% 20年	12% 20年	70% 30年	40% 30年
発電コスト 円/kWh	10.1~ (8.8~)	12.3 (12.2)	13.7 (13.7)	21.9 (15.6)	19.2 (10.9)	11.0 (10.8)	23.3 (20.4)	27.1 (23.6)	29.7 (28.1)	12.6 (12.2)	30.6 ~43.4 (30.6 ~43.3)	24.3 (21.0)	29.4 (27.3)	13.8 ~15.0 (13.8 ~15.0)	24.0 ~27.9 (24.0 ~27.8)
2011コスト 等検証費	8.9~ (7.8~)	9.5 (9.5)	10.7 (10.7)	9.9~ 17.3	9.2~ 11.6	10.6 (10.5)	19.1 ~22.0	19.1 ~22.0	17.4 ~32.2	9.5 ~9.8	22.1 ~36.1 (22.1 ~36.1)	30.1~ 45.8	33.4~ 38.3	10.6 (10.6)	17.1 (17.1)





丸山康司氏

Local community establishes
Wind farm in Shirakami world heritage

市民風車の波及効果

白神ツアー・特産品の開発