

Public choice in the mix of electric power generation

Climate and Energy Decision-Making Center Advisory
Board Meeting

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Public acceptance can be a major obstacle to energy infrastructure development

People hold gaps and misconceptions about low-carbon electricity technologies...

- Many public opinion studies provide un- or under-informed and unreliable results

In two studies, we have aimed to:

- Better inform people about low-carbon electricity technologies and portfolios
- Overcome the barriers of their misconceptions and knowledge gaps
- Elicit preferences informed by correct and balanced information



Nuclear Power Gambles with our Lives +++
Risk of Worst-Case Scenario Nuclear Incident in Europe: 16 Percent

www.nuclear-free.com



CLEAN COAL

<http://blogs.chron.com>

Participants receive "homework materials" that ...

- are technically accurate and understandable
- present 10 electricity technologies
- provide multi-attribute descriptions of the costs, risks and benefits of each technology
- facilitate a ranking of technologies at home

Coal (CO₂ is captured)

How it Works: This is the same plant described in "Coal, CO₂ released". But in this plant, additional equipment is added to capture the CO₂ before it escapes to the air. This CO₂ is turned into a liquid. A pipeline takes it from the plant and puts it permanently in rock formations more than 200 feet down.

Nuclear

How it Works: Nuclear plants use uranium that has been slightly processed, or "enriched". In a nuclear plant, the uranium atoms break apart and release heat that is used to make steam. The steam is used to power a type of engine, called a "turbine". This turbine runs a generator to make electricity. Nuclear plants built in the future will have a more advanced design than existing ones. While existing plants are very safe, the new design is expected to make a nuclear accident virtually impossible.

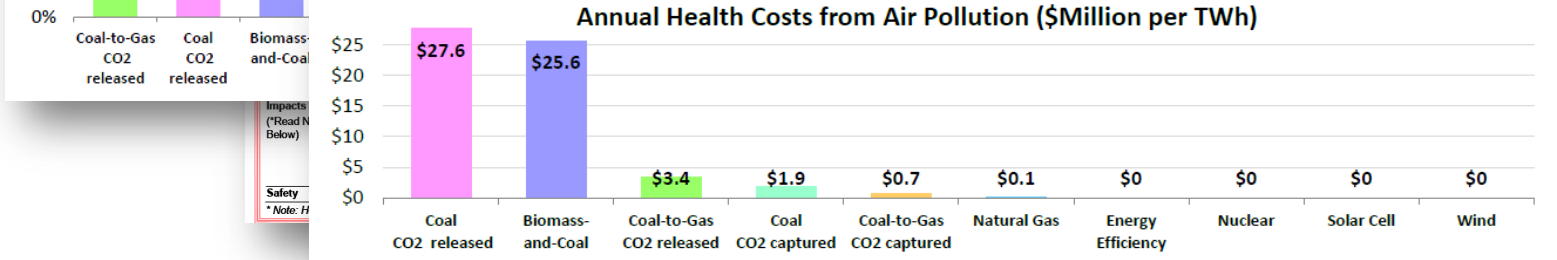
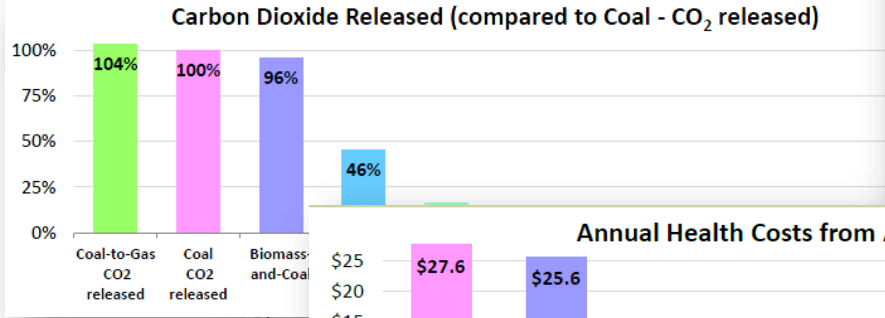
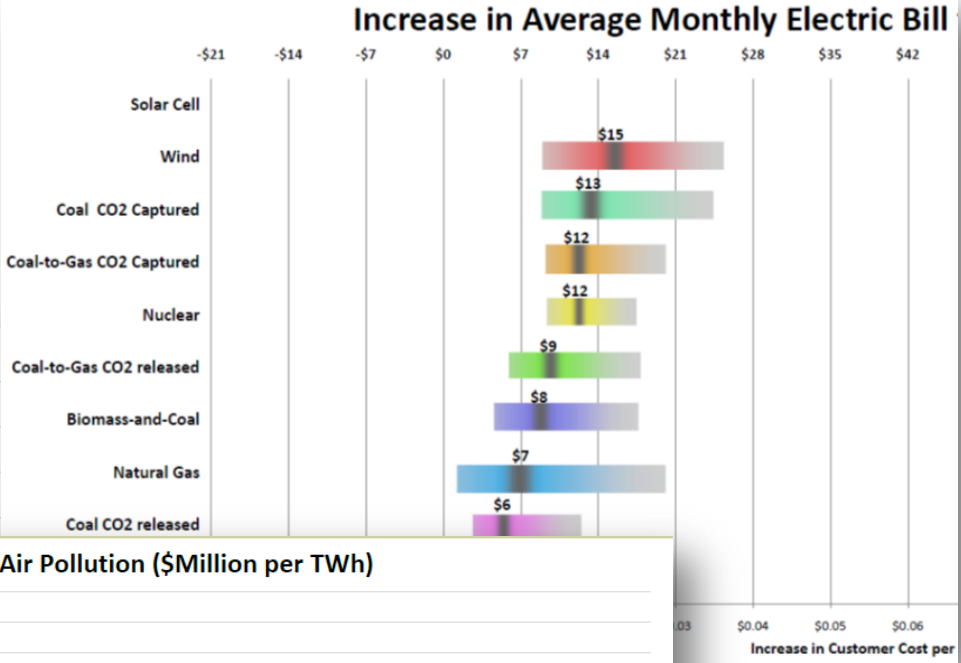
Nuclear plant near Shippingport, PA

Wind

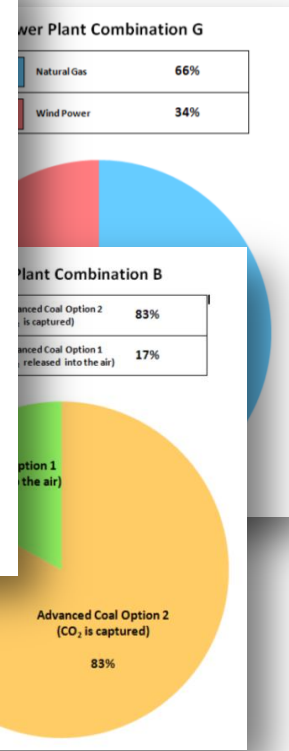
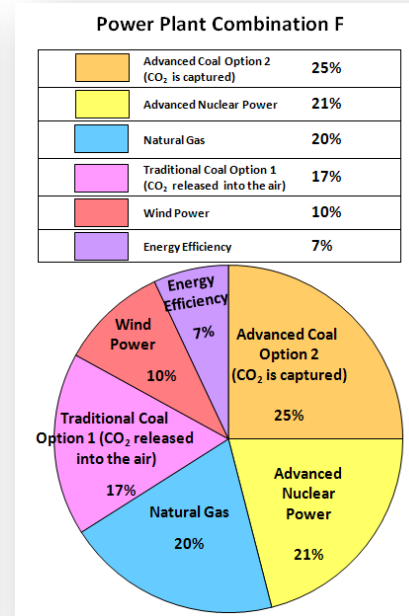
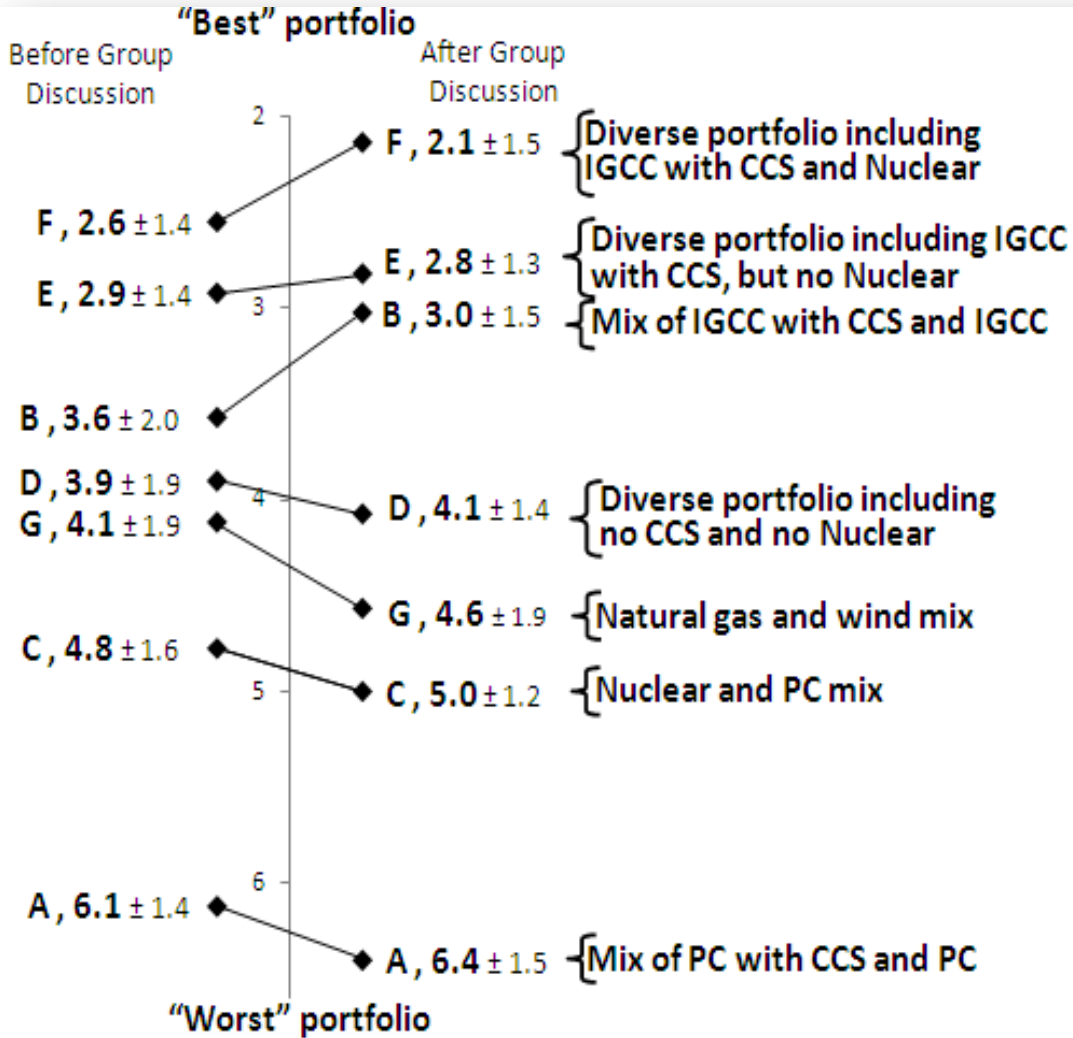
How it Works: Modern wind machines are much larger than the old windmills in Holland, or the metal windmills that pumped water for cattle in the American West. They are often between 100 and 300 feet high. That is about as tall as a 10 to 30 story building. The machines have blades that look like an airplane propeller. The wind turns the blades, and this runs a generator to make electricity.

Modern wind turbines in Somerset, PA

Wind farms work well when built in windy areas. PA has lots of wind on hilltops in the center of the state. However, even the best wind farms in PA only make 20% of the power



In a first study, participants asked to rank pre-determined low-carbon portfolios before and after a group discussion



Mean participant portfolio rankings (±SD), from 1 (best) to 7 (worst)

In a second study, participants are asked to create a low-carbon portfolio with a decision tool

MAKE YOUR OWN POWER PLANT COMBINATION

IMPACTS

	Original Plan	Your Combination	% Change
Water Use (Olympic Pools/year)	56,000	42,900	-23%
Land Use (Football Fields)	3.400	9.500	179%

SAVE UP TO THREE COMBINATIONS

REVIEW & SAVE

combo 1
combo 2
combo 3

Recall
Delete
Compare

RESET

\$13.71 or 17%

Cost of everything else you buy will increase by: 2%

Monthly Electric

Category	Original Plan	Your combination
Monthly Electric	\$11	\$14

Increased Cost per

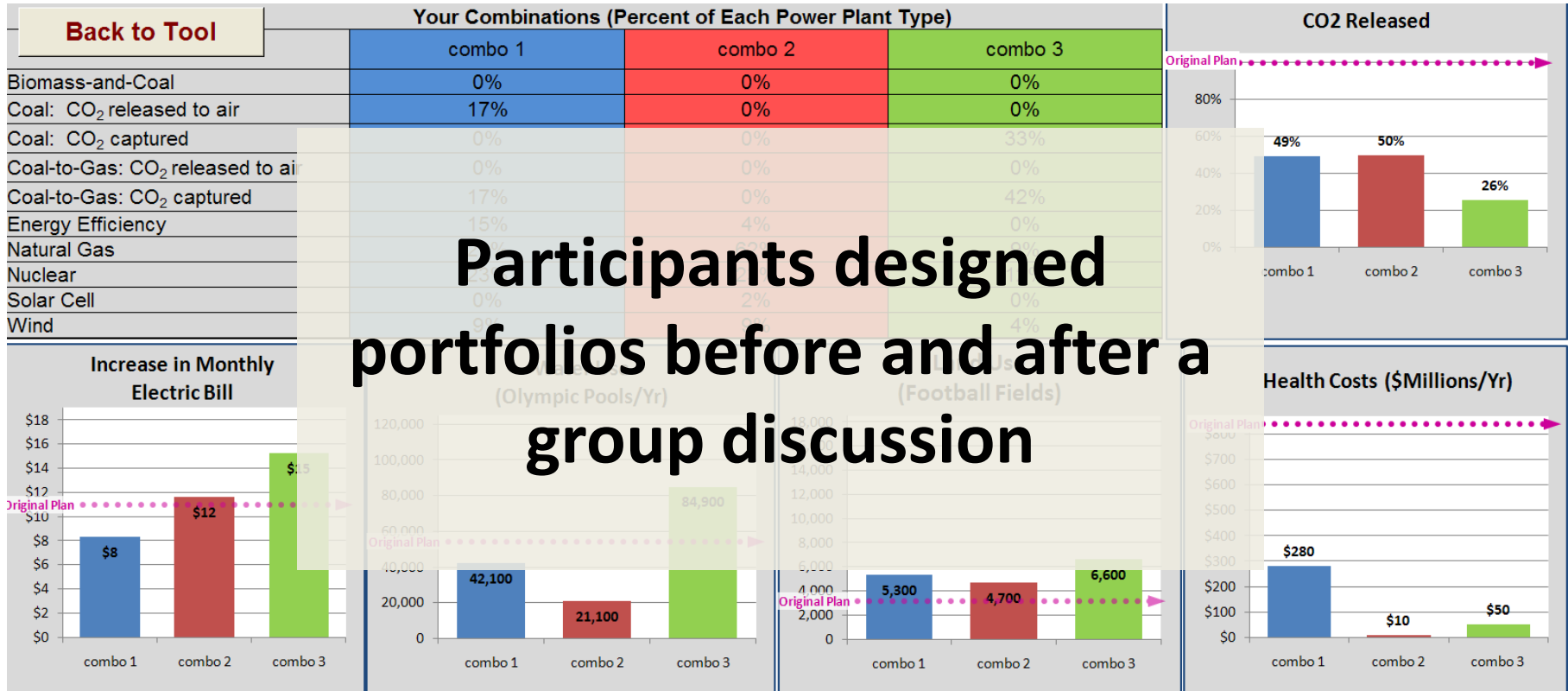
Category	Original Plan	Your combination
Increased Cost per	\$0.01	\$0.02

Electricity Produced (TWh)

Category	Original Plan	Your combination
Electricity Produced (TWh)	48	54

been released using the original plan [carbon] / Energy mix.

Compare Screen



Participants designed portfolios before and after a group discussion

When you have saved 3 combinations you like, hit the “compare” button. Compare the combinations and decide which one you would like to use as “your advice to the governor”

Participants

10 Workshops:

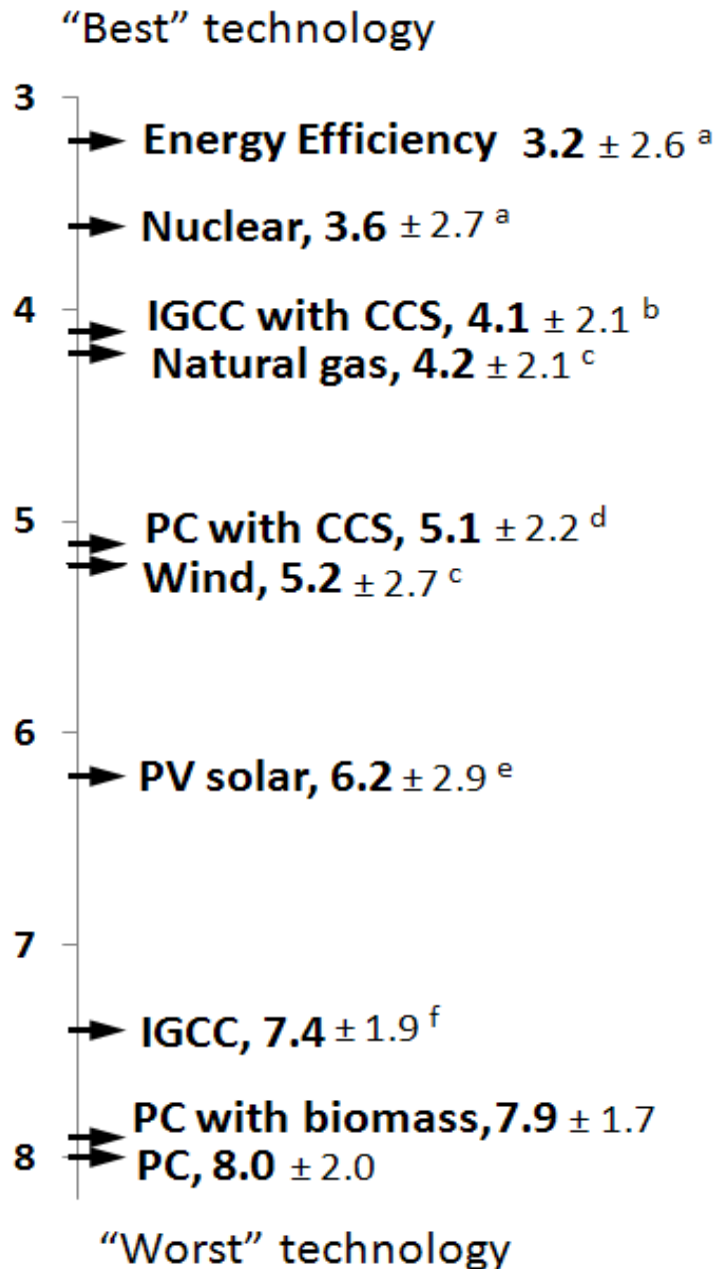
- Held at local community organizations
- Including 4-9 participants each
- Lasting 2.5 – 3.5 hours
- Carefully scripted following Risk Ranking procedures
- Paid \$95 (to keep or donate to organization)

69 Participants:

- Ages 22 to 85 years old (m=53.9)
- 70% Females, 13% African-American or other minority
- All had HS diploma, 58% at least a Bachelor's degree

Technology Rankings

Graph shows mean participant technology rankings (\pm SD), from 1 (best) to 10 (worst)



- Energy efficiency, nuclear, IGCC with CCS and natural gas were not ranked significantly different from one another
- Both coal technologies with CCS were ranked better than IGCC and PC
- IGCC with CCS ranked better than PC with CCS

Note: Superscripted letters next to mean technology rankings refer to Wilcoxon paired-rank tests results ($p < 0.01$), suggesting that:

a: PC with CCS, Wind, PV Solar, IGCC, PC with biomass and PC were ranked significantly worse

b: PC with CCS, PV Solar, IGCC, PC with biomass and PC were ranked significantly worse

c: PV Solar, IGCC, PC with biomass and PC were ranked significantly worse

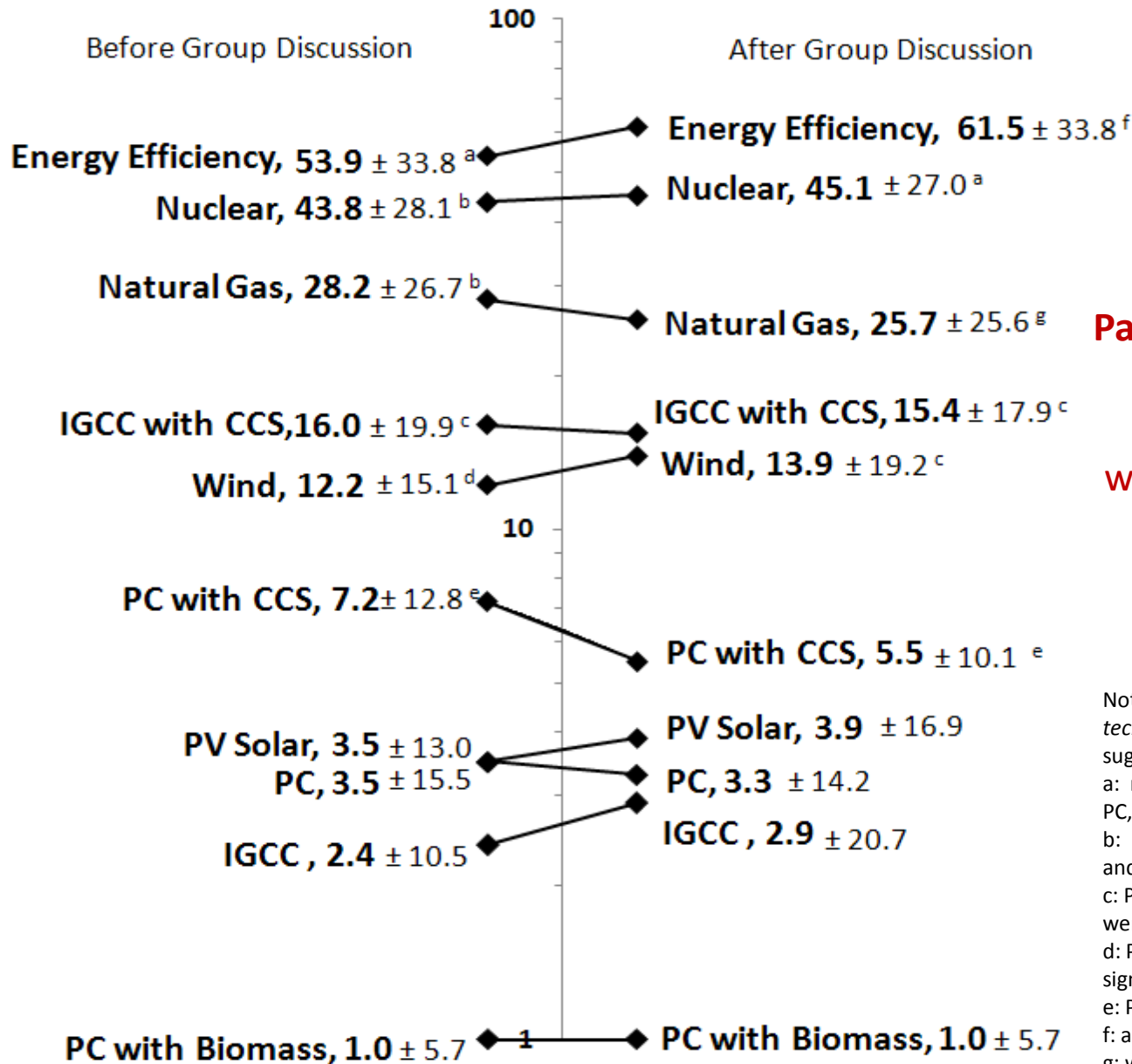
d: IGCC, PC with biomass and PC were ranked significantly worse

e: PC with biomass and PC were ranked significantly worse

f: PC was ranked significantly worse

Portfolio Designs

Mean Technology Inclusion
Percent of Possible \pm SD



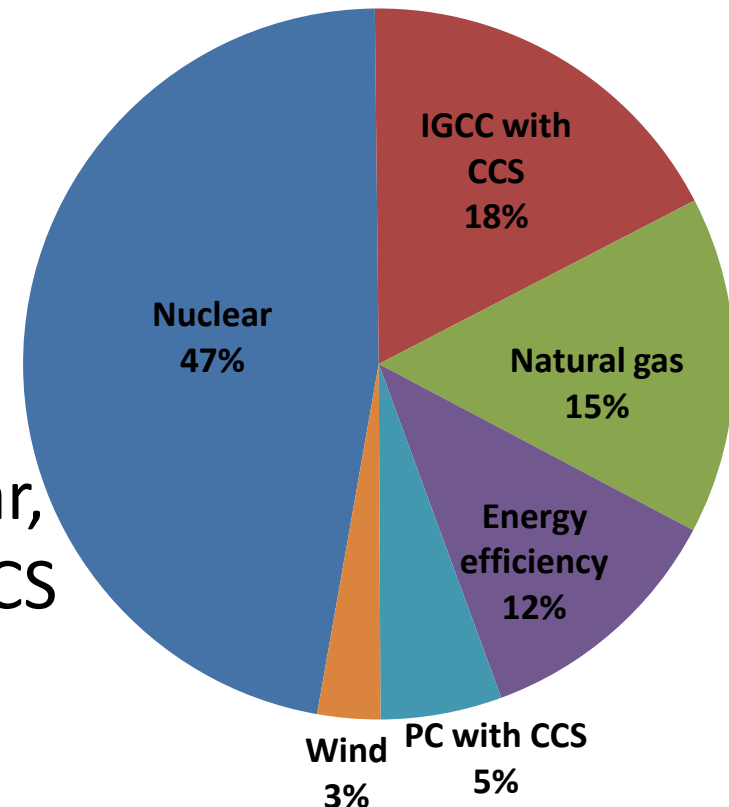
Participants' mean standardized technology percentages \pm standard deviation, where 0 is no inclusion and 100 is full inclusion in portfolio

Note: Superscripted letters next to mean *standardized technology percentages* refer to *t*-test results ($p < 0.01$) suggesting that *standardized technology percentages* of:
a: natural gas, IGCC with CCS, wind, PC with CCS, PV solar, PC, IGCC, and PC with biomass were significantly less
b: IGCC with CCS, wind, PC with CCS, PV solar, PC, IGCC, and PC with biomass were significantly less
c: PC with CCS, PV solar, PC, IGCC, and PC with biomass were significantly less
d: PV solar, PC, IGCC, and PC with biomass were significantly less
e: PC with biomass was significantly less
f: all other technologies were significantly less
g: wind, PC with CCS, PV Solar, PC, IGCC, and PC with biomass were significantly less

Portfolio Designs

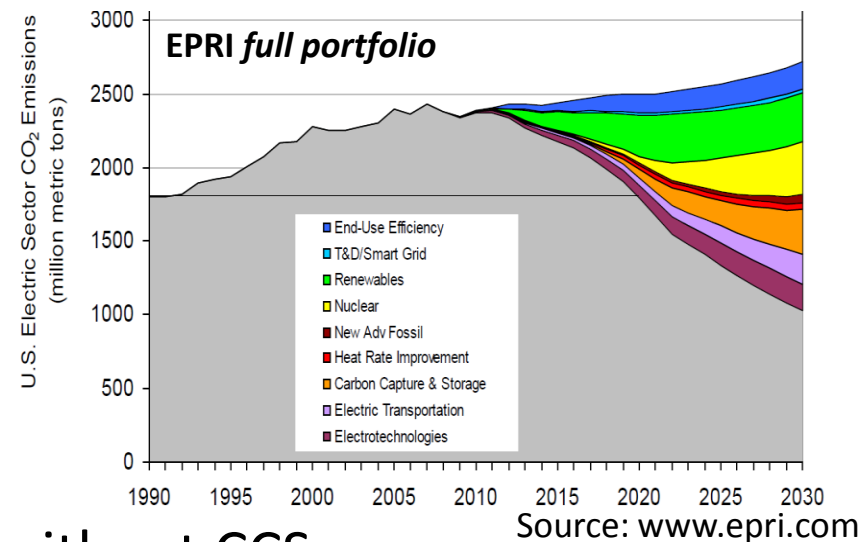
- Participants had to include at least one low-carbon baseload technology (natural gas, coal with CCS, nuclear) in portfolio
 - **Most frequent design included all three** (58.2% *pre-discussion*, 60.3% *post-discussion*)
- The most common portfolio included energy efficiency, nuclear, natural gas, wind and coal with CCS (31% *pre-discussion*, 38% *post-discussion*)

Most common portfolio,
on average,
post-discussion



Overall Conclusions

- It is possible to design communications to inform people about the costs, risks, benefits and limitations of low-carbon electricity technologies and portfolios
- Our informed participants
 - designed diverse portfolios including nuclear, CCS, energy efficiency, wind and natural gas
 - similar to EPRI *full* →
 - preferred coal with CCS to coal without CCS
- Results contrast those of other studies showing much lower preference of CCS and nuclear
 - our participants were given balanced and comparative information and adequate time



Thank You!

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Fleishman LA, Bruine de Bruin, W and Morgan, MG. Informed Public Preferences for Electricity Portfolios with CCS and Other Low-Carbon Technologies, 2010, *Risk Analysis* 30(9):1399-1410.

Materials: <http://www.cedm.epp.cmu.edu/tool-public-lowcarbon.php>

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Back Up


Group Workshop Procedure

Step 1: “Homework Assignment”

Received:
Technology-related information

Provided:
Pre-discussion technology rankings

Experimenter explanation of “homework” materials & introduction of computer tool



Step 2: Computer Tool (*pre-discussion*)

Received:
Computer tool

Provided:
Pre-discussion portfolio designs

Group discussion: Participants present portfolio designs on a projected “Compare” screen



Step 3: Computer Tool (*post-discussion*)

Received:
Pre-set portfolios

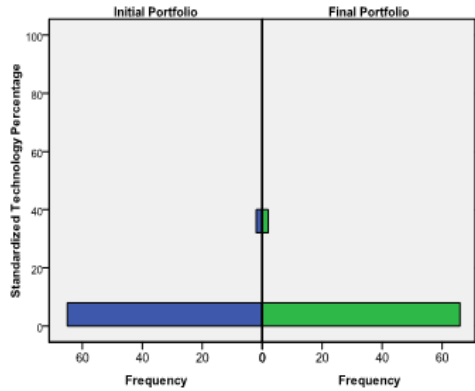
Provided:
Post-discussion portfolio designs

Participant comprehension and satisfaction

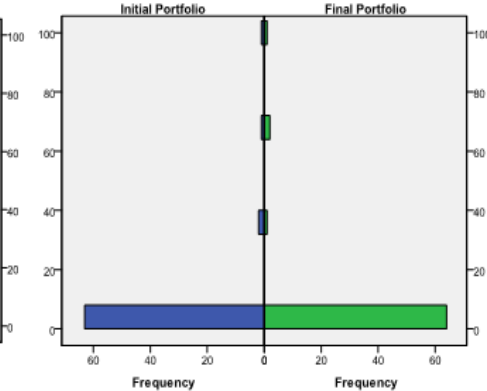
- 24 true-or-false homework knowledge questions
 - $M=90\%$, $SD=11\%$, range: 46-100%
 - Scores significantly better than chance ($t=28.2$, $p < 0.001$)
- 13 computer knowledge questions
 - $M = 93\%$, $SD = 10\%$, range 62-100%
- Participants thought that using the computer tool was:
 - “an enjoyable experience” ($M=6.5$, $SD=1.0$, $t=20.3$, $p<0.001$) and
“a valuable use of [their] time” ($M=6.4$, $SD=1.2$, $t=17.9$, $p<0.001$)
- They “learned a great deal about the different electricity options” ($M=6.4$, $SD=1.2$, $t=16.3$, $p<0.001$)

Standardized Technology Distributions

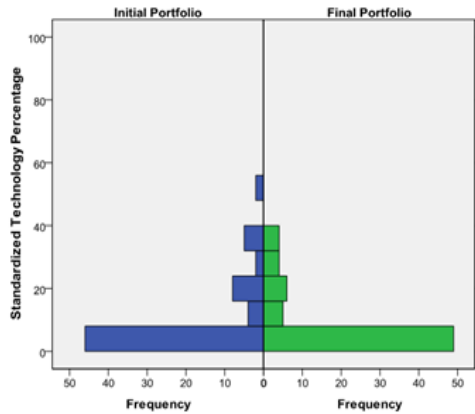
Biomass



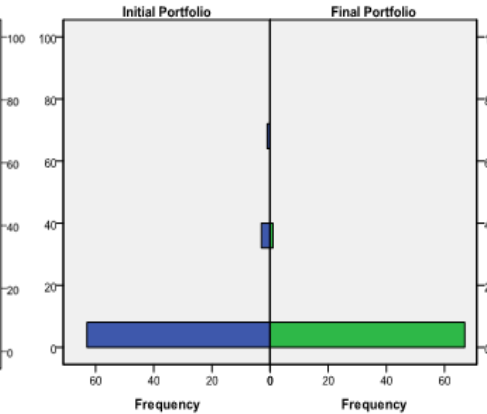
PC



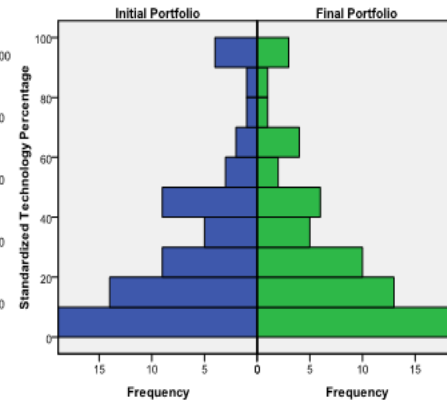
PC with CCS



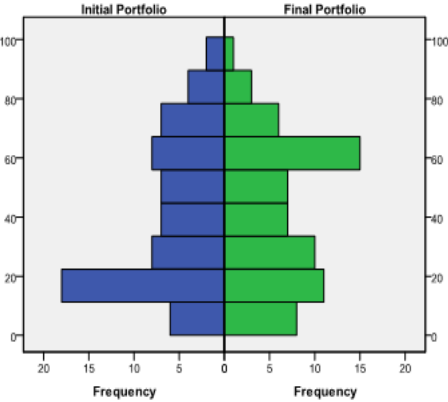
IGCC



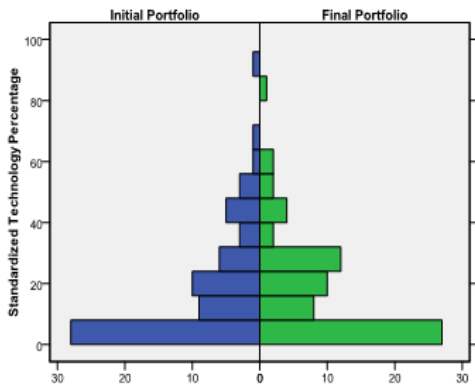
Natural Gas



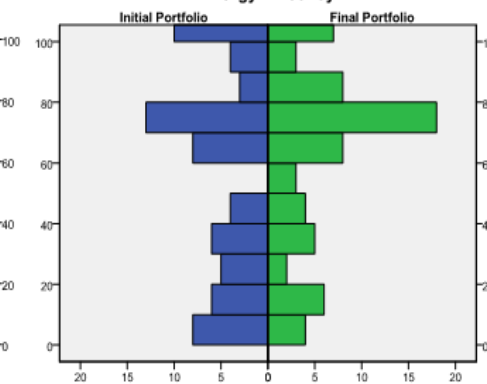
Nuclear



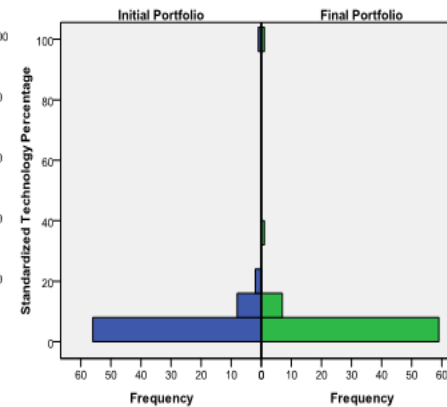
IGCC with CCS



Energy Efficiency



PV Solar



Wind

