

Local Power Plant Follies

New Mexico Adventures in SuperComputing Challenge

Final Report

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Team 066

Shiprock High School

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Executive Summary

The Northwest corner of New Mexico is brimming with natural wonders and man-made pollutants. Our project, Local Power Plant Follies, started out trying to link the creation of the Arizona Power Service (APS) and the Public Service Company of New Mexico (PNM) power plants with global warming. However, our project developed slightly differently. It now involves how far sulfur dioxide (SO₂) emissions travel and what effects the proposed Desert Rock power plant will have on our already polluted atmosphere.

We chose to focus on SO₂ emissions because SO₂ causes acid precipitation, which can affect the earth and wildlife negatively. Also, sulfur dioxide's main sources are coal-fired power plants like the two in our area. The APS power plant emits 35,000 tons of SO₂ per year. The PNM power plant emits 15,000 tons. According to the Farmington Daily Times, the proposed Desert Rock will emit about 5,000 tons per year.

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Our StarLogo program has been a great visual model for SO₂ dispersion. It shows the two power plants emitting SO₂ and then the Desert Rock power plant is added. This shows that the pollution in the area increases by ten percent after the addition. Using sliders that show wind direction and speed, you can change dispersion rates and direction.

Pollution from the power plants can travel tremendous distances. According to our calculations we have found that emissions can travel 1.46 miles per foot of chimney. This means that pollution can travel between 365 and 554.8 miles on a windy day.

Power Plant Follies has taught us a great deal. We know now how building a new power plant would affect our atmosphere and how greatly the pollution can travel. We should not be building a new power plant that would increase pollution, but be investing in alternate energy providers such as windmills. We hope this project will inform others about the negative effects of building a coal-fired power plant. Even if you do not have a power plant in your area, you are still receiving pollution from hundreds of miles away.

Introduction

Do you know what it is like to have a power plant in your area? Well we have two; the Four Corners Power Plant generated by the Arizona Power Service (APS) and the San Juan Generating Station run by the Public Service Company of New Mexico (PNM). Both plants are coal-fired electricity producers. The side effects of these plants are numerous. We will be looking at the pollution levels of these two plants and what a new plant would do to the environment.

Many small children see the large plumes of water vapor, sulfur dioxide, mercury, nitrogen dioxide, carbon dioxide, and sulfuric acid emitted from the power plants. They often ask if that is where clouds are made. In actuality, that is where acid rain, smog, and greenhouse gases are made. Like other community members, we were concerned about how far these chemicals go and how they affect us.

Another power plant is being proposed near Burnham, New Mexico, just thirty-five miles from our home. Although this plant would provide jobs and electricity, it will also take up water and produce more pollution. We hope our project will encourage people to veto the power plant and raise concerns about controlling the pollution.

Description

Our project has progressed in different directions from the start. The project originally was about global warming and determining if we could link the rising temperatures to the creation of the power plants. Realizing that this project was too complex, we created a StarLogo program that we felt would be useful in demonstrating what the area looks like with pollution. This program shows the APS and PNM power plants emitting Sulfur dioxide (SO_2), where the pollution is headed, and how quickly it is diffused. Next, we added the third power plant to show how pollution would increase in the area. Focusing mainly on SO_2 limited our scope, and made our project more workable.

We chose to focus on SO_2 emissions because SO_2 is the main cause of acid rain. Sulfur dioxide combines one sulfur atom and two oxygen atoms. When these gases react with water, they form acidic compounds, which may come down in precipitation or dry deposits in the wind. What is the big deal about acid rain? Acid rain can wear down buildings and rocks, as well as poison plants, streams, and animals if there is too much acid in the atmosphere. According to the Environmental Protection Agency (EPA), 2/3 of the entire SO_2 pollution in the U.S comes from electric power generation that burns fossil fuel, like coal. The Four Corners, APS power plant currently emits 35,000 tons of SO_2 per year. The San Juan Generating Station, PNM power plant currently emits 15,000 tons of SO_2 per year. The

proposed power plant, Desert Rock, run by Sithe Global would emit about 5,000 tons of SO₂ per year.

Pollution from power plants can travel different distances. Wind speed, direction, and chimney heights can affect this distance greatly. Our StarLogo program incorporates this by including our hometown, Shiprock and the three power plants putting out SO₂. There is one slider that increases wind speed, making pollution go farther. Another controls wind direction.

Desert Rock can be introduced into the program after it has been running by pressing a button, indicating it will create this plant. This will show how much more pollution is being added to the area.

Although our project has changed from its original design, we feel that we have accomplished a great deal. Not only have we learned from our project, but we hope the community will also learn from it.

Results

The results we have acquired from our research and StarLogo program have been numerous. We have not only figured out how far pollution travels from the power plants, but also how much more SO₂ (in percent) will be put into our atmosphere by building a new power plant.

According to Acid Rain, a book by Sally Morgan, pollution from a chimney 33 ft. high travels 75 miles in a day. Pollution from a chimney 164 ft. high travels 105 miles in a day. Unfortunately, we were unable to find a third ratio in order to create a linear graph which would show us exactly how far the pollution would travel.

Math Model:

Instead we figured out miles per foot of chimney for both ratios.

$$75 \div 33 = 2.27 \text{ miles per foot} \quad 105 \div 164 = .64 \text{ miles per foot}$$

Next we averaged the results to get the average mile(s) pollution will travel per foot of chimney. (numbers rounded)

$$2.27 + .64 = 2.91 \quad 2.91 \div 2 = 1.46$$

On average, pollution from a one foot tall chimney will travel 1.46 miles in a day. The APS power plant chimneys are 250 and 380 ft. tall. The PNM power plant chimneys are 350 ft. high. This means SO₂ pollution travels about 365 miles, 554.8 miles, and 511 miles each day. (See Appendix B for graph) This is tremendously far. According to the New Mexico Air Quality Bureau, the strongest winds are most frequently to the East, Northwest, Northeast, and West. This means that Utah,

Nevada, Arizona, Colorado, Western Texas and New Mexico are most affected by our pollution. As our research shows, it is not only our community's concern if a new power plant is built. (See appendix C and B for map and wind rose)

As we have noted before, APS emits 35,000 tons of SO₂ per year, PNM emits 15,000 tons per year, and Desert Rock will emit about 5,000 tons per year. Currently, we are receiving a total of 50,000 tons of SO₂ air pollution a year. When the Desert Rock power plant is built, it will increase SO₂ pollution by ten percent. Is the electricity worth an increase in pollution?

Conclusion

In conclusion, our project is making a great political statement; the Desert Rock power plant should not be built. Our project has lead us to this conclusion because pollution can travel great distances and adding a power plant would increase acid rain caused by SO_2 by ten percent. There are many alternate energy sources to be tapped. Our community and others that will be affected, should vote on whether a new power plant should be built. Our ability to model our project with Star Logo has been a great visual tool to demonstrate our numbers and results. We have gotten involved in and challenged community issues. We hope other students take a critical look at what is happening around them.

Recommendations

We would recommend finding better data to calculate the dispersion of pollution based on chimney heights. The New Mexico Air Quality Bureau had a great website (www.nmenv.state.us.com) about dispersion modeling. We would be interested in meeting with them or learning more about what they do. It would be very valuable to learn more about alternative energy sources that could be used in our area without creating more pollution. For example, are solar or wind power cost efficient to produce enough switch power? This project is important because of the controversy of building a third power plant, and therefore it would be crucial to show the community and politicians the effects of pollution.

Acknowledgements

We would like to thank Mr. Nathan Tohtsoni and the APS power plant staff for a wonderful tour of the power plant in December. It was very informative and insightful. We are also very thankful for the questions they answered for us.

We extremely appreciate the help with our StarLogo program from Irene Lee and Rodger Critchlow. We could not have done it without their help.

We would like to acknowledge our sponsors, Mrs. Noble, Mrs. Hines, Mrs. Johnson and Mary Herrmann. They keep the Super Computer Challenge going in our school as well as supporting us.

Last, but definitely not least, we would like to thank our mentors, Judy Pino and Betty Strietelemeier for answering our questions and providing information.

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New Mexico Air Quality Bureau Website: www.nmenv.state.us.com

Appendix A:

StarLogo programming code

```
globals [aps pnm dr winddist pnmx pnmy apsx apsy drx dry diff windx windy]

patches-own [news02 so2]

to setup
  clearall
  ; draw shiprock
  draw-map
  ask-patches [setso2 0]
  ;set the so2 production rate
  setaps 96
  setpnm 41
  ; set the diffusion rate
  setdiff 5
  ; set the wind distribution
  ; using the unbiased distribution for now
  set windx [0 1 1 1 0 -1 -1 -1]
  set windy [1 1 0 -1 -1 -1 0 1]

end

to draw-map
  setapsx 3
  setapsy -3
```

```
setpnmx 7
setpnmy 3
create-turtles-and-do 1 [ setxy 0 0 setc blue ]; shiprock
create-turtles-and-do 1 [ setxy pnmx pnmy setc brown ]; pnm
create-turtles-and-do 1 [ setxy apsx apsy setc brown ]; aps
end
```

```
; new plant
to newplant
create-turtles-and-do 1 [ setxy drx dry setc brown ]; dr
  setdrx 0
  setdry -15
  ask-patches [setso2 0]
  setdr 14
  setdiff 5
end
```

```
to go
  ; pump out so2 from plants
  ask-patch-at apsx apsy [ set so2 ( aps + so2 ) ]
  ask-patch-at pnmx pnmy [ set so2 ( pnm + so2 ) ]
  ask-patch-at drx dry [ set so2 ( dr + so2 ) ]
  ; difuse so2 down the gradient
  ; but don't wrap around the screen edges
  ask-patches-with [ xcor = screen-half-width ] [setso2 0]
```

```

ask-patches-with [ ycor = screen-half-height ] [setso2 0]

ask-patches-with [ xcor = (0 - screen-half-width) ] [ setso2 0]

ask-patches-with [ ycor = (0 - screen-half-height) ] [ setso2 0]

diffuse so2 (diff / 100)

; let wind move theso2 down wind

; choose-wind -use the sliders

; this code simply moves all of the so2 down wind

;ask-patches [setnewso2 so2-towards winddir windspd]

; ask-patches [setso2 newso2]

blow-wind item (1 + winddir) windx item (1 + winddir) windy (windspd / 50)

;scale the patch color to grey

ask-patches [ scale-pc brown so2 0 50]

end

```

```

to blow-wind :x :y :fraction

  ask-patches [setnewso2 0]

  ask-patches [setnewso2 (newso2 + :fraction * (so2-at :x :y))]

  ask-patches [setnewso2 (newso2 + (1 - :fraction) * so2)]

  ask-patches [setso2 newso2]

end

```

```

to choose-wind

; this is an even distribution of directions and speeds

; with no bias to preserve direction or speed

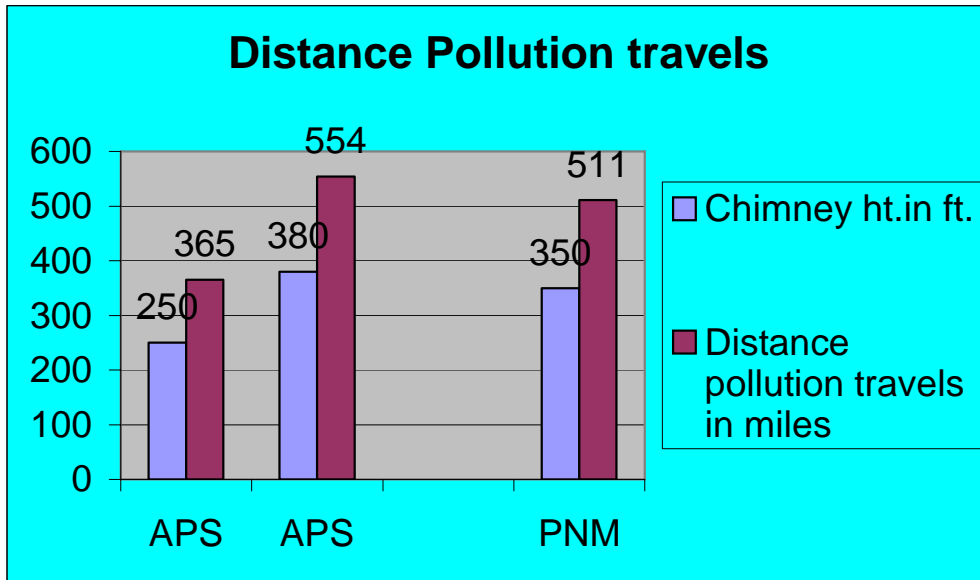
set winddir 45 * (random 8)

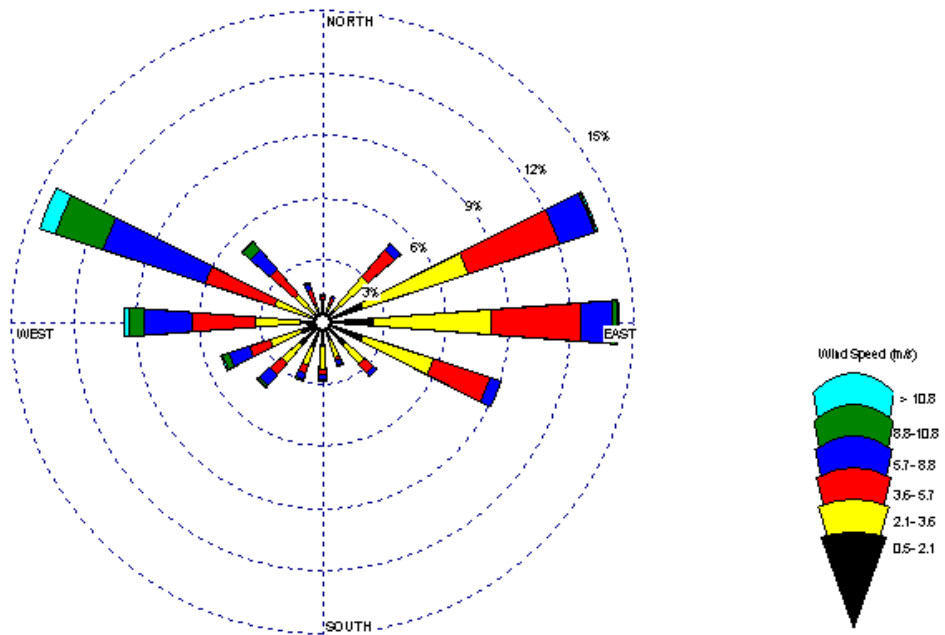
```

```
set windspd 5 * (random 8)
```

```
end
```

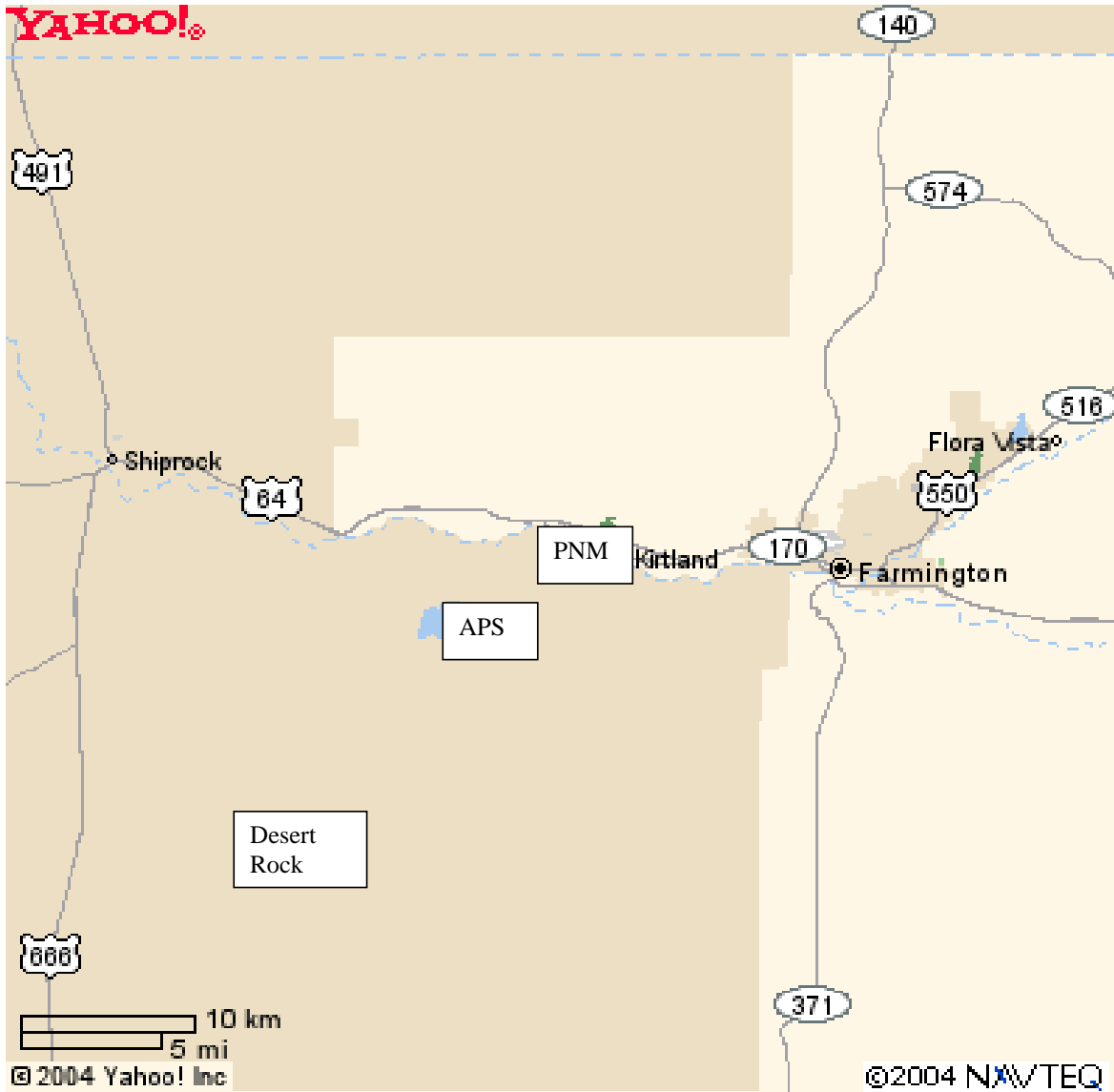

Appendix B:





Wind Rose of NW New Mexico

Appendix C:



Location of current and proposed Power plants.

Map of distance pollution can travel.

