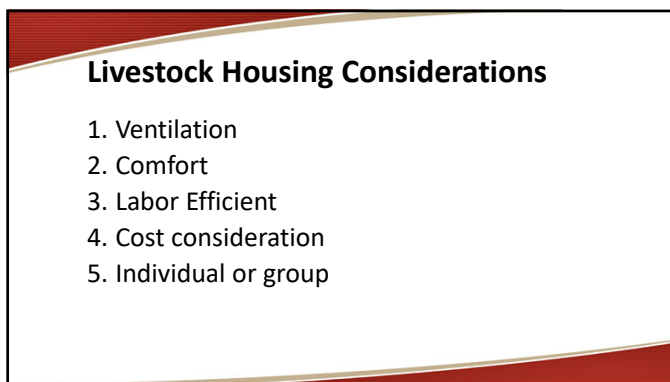


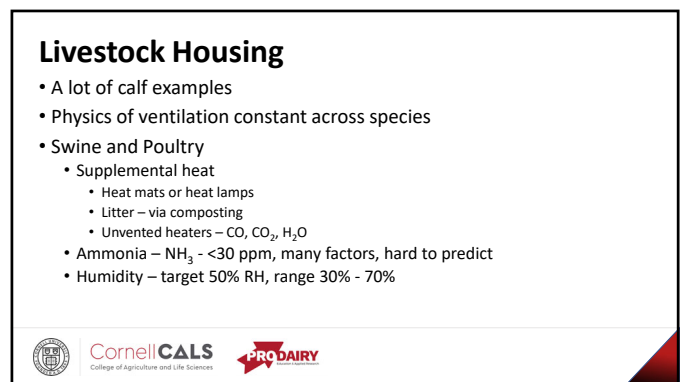
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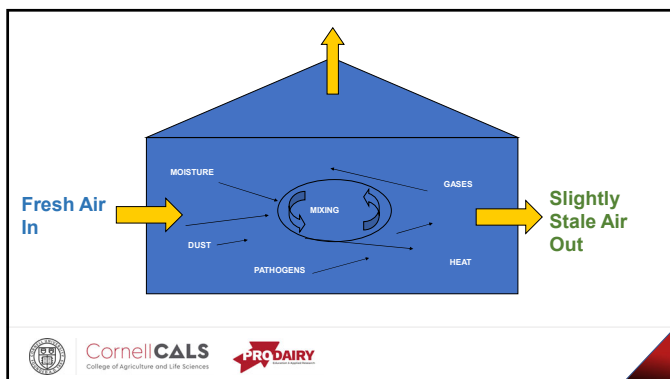
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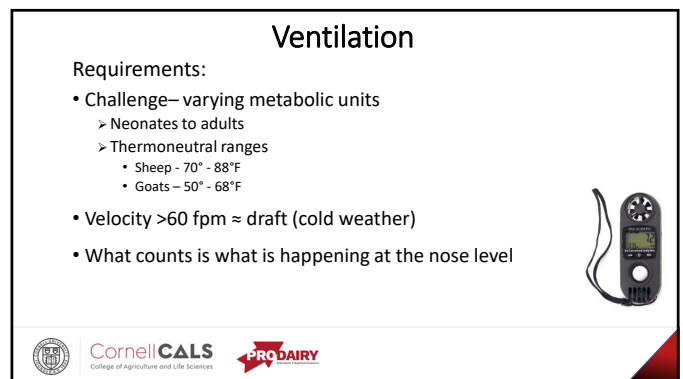
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6

## Ventilation System Options

- Natural
- Natural Assisted/Mechanical Assist
- Mechanical
  - Positive pressure
  - Negative Pressure
  - Neutral Pressure



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## Naturally Ventilated Barns

What is naturally ventilated?

- Use of eaves or sidewall openings that allow prevailing winds to force fresh air into the building
- Ridge openings that allow warmed air to rise by thermal buoyancy and exit the building
- Wind is greater factor than buoyancy
- This is a cold facility -  $\pm 5^{\circ}\text{F}$  outside



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May need some *help* to facilitate airflow



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## Requirements

- Good Site Selection
  - Adequate but not excessive exposure
  - Upwind, not downwind, from other livestock facilities
  - Well Drained
- Building Orientation
  - Building long axis perpendicular to prevailing wind
- Open Ridge
  - 2" per 10' barn width, min. 8" opening, max. bldg. width - ~36'
- Eave Openings
  - 1" per 10' barn width, both sides



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## Requirements

- Roof Interior Slope
  - Min. 3/12, most are 4/12 or 5/12



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## Requirements

- Roof Interior Slope
  - Min. 3/12, most are 4/12 or 5/12
- Sidewall
  - Potential to open >50% of sidewall/endwall area
  - Prefer split curtains to allow air to enter at calf levels
  - Roll-up / Drop-down easier to automate, easier to keep clean
- Absence of Barriers to Wind (windshadows)



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## Open Ridges

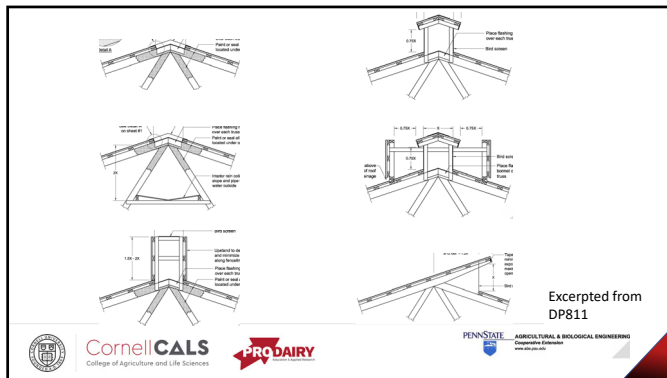
- Important for ventilation from both wind and thermal buoyancy
- 2" per 10' of building width, 3"/10' for cows
- Usually need to be covered because of animals housed directly below ridge opening
- Elevated ridge cap with upstands preferred



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University Park, PA 16802

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## Curtain Management

- Curtains used to moderate temps in warm & hot weather
- Thermoneutral zones:
  - Sheep - 70° - 88°F
  - Goats - 50° - 68°F
- Recommended curtain position vs. temperature
  - <50°F - ONLY eave & ridge opening with mechanical system
  - 50° - 75°F - variable, depending on temperature, wind, rain, population, etc.
  - >75°F - completely open



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## Windshadows / Barriers

- Can be buildings, woodlots, hedgerows, seasonal cornfields, etc.
- Minimum spacing between buildings:
 
$$D_{min} = 0.4[\text{height of obstruction (ft)}] \times [\text{length of obstruction (ft)}]^{0.5}$$

$$= 0.4(\text{height})(\sqrt{\text{length}})$$
- Ex. - How far downwind should a new building be sited from a structure 13' high x 96' long?
 
$$D_{min} = 0.4(13)(\sqrt{96}) = 50.9 \rightarrow 51'$$




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### Limitations of Natural Ventilation

- Wind tends to enter only on one side – problem in wide buildings




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### Outside Colder than Inside

Air enters on windward side


Width??  
36' max.



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### Limitations of Natural Ventilation

- Wind tends to enter only on one side – problem in wide buildings
- Negative pressure assists tend to draw from windward side only
- Internal barriers – rooms, solid pen panels – prevent even distribution




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### Outside Colder than Inside

Air enters on windward side


Internal Barriers?  
Polluted Air



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### Limitations of Natural Ventilation

- Wind tends to enter only on one side – problem in wide buildings
- Negative pressure assists tend to draw from windward side only
- Internal barriers – rooms, solid pen panels – prevent distribution
- Warmer outside air tends to rise above animals – leaves lower portions of barn with stagnant air




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### Outside Warmer than Inside

Air enters on windward side


Polluted Air



24

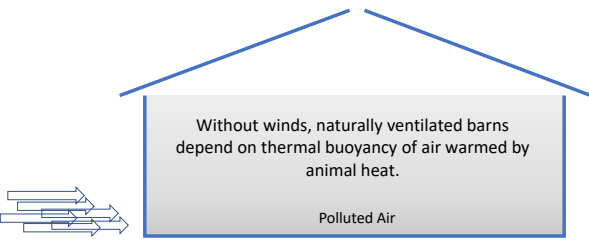
### Limitations of Natural Ventilation

- Wind tends to enter only on one side – problem in wide buildings
- Negative pressure assists tend to draw from windward side only
- Internal barriers – rooms, solid pen panels – prevent distribution
- Warmer outside air tends to rise above calves – leaves lower portions of barn with stagnant air
- Still conditions cause dependency on thermal buoyancy, but small ruminants produce minimal heat




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### No Wind



Without winds, naturally ventilated barns depend on thermal buoyancy of air warmed by animal heat.

Polluted Air




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### Mechanically Ventilated Barns

What is mechanical ventilation?

- Automated systems – do not rely on natural airflow.
- Can be positive, negative, or neutral pressure
- Required when barns are wider than 36' or poor wind exposure
- Or when desired to operate as a warm barn

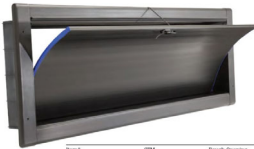
Generally, as systems get more automated and complicated, costs increase and managers need to understand how the system and controllers work to manage them effectively. Properly matching fans, inlets, and controllers is critical.




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### Mechanical ventilation – Negative Pressure Systems

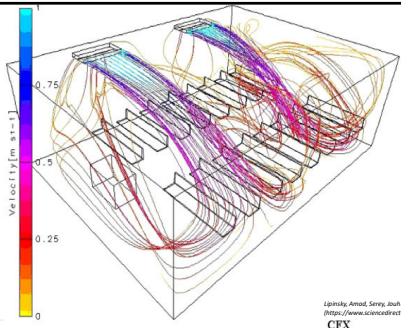
- Fans & inlets cause air exchange
- Fans exhaust from barn
- Designed inlets distribute fresh air
- **Tight Construction**



Model	CFM	Roof Opening
1000000000	3000	17' x 61"
1000000000	1000	67' x 64"




28



CFX



Epirasty, Arnold, Seney, Joubert, <http://www.cfdjournal.com> Vol. 7, 4, 2004  
<https://www.cfdjournal.com/viewarticle.php?id=256532103033242>



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### Mechanical Ventilation-Positive Pressure Systems

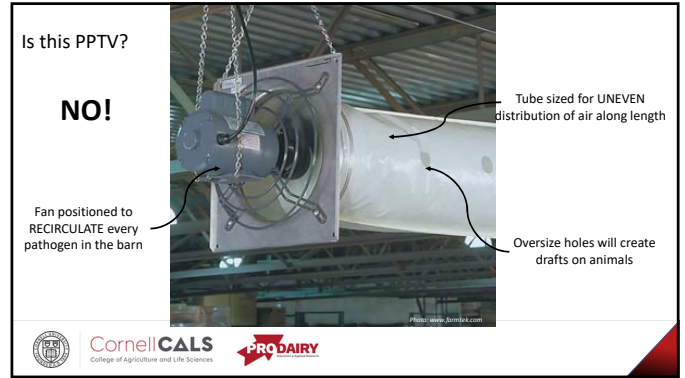
- Fans cause air exchange
- Fans force air into barn
- Ducts distribute fresh air
- Requires outlets – Min. 2½ ft<sup>2</sup>/1000 cfm
- **Tight Construction Not Required**

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### Why PPTV?

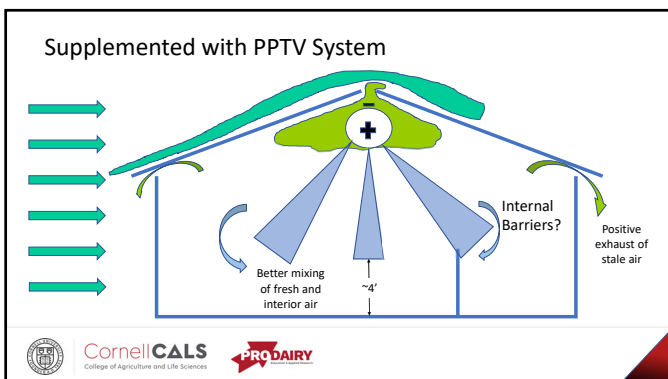
- Designed to supplement a properly designed natural ventilation system
- Provides ~4 air changes of interior air volume via a tube non-stop 24/7/365
- Uniform air discharge down the length of the tube – no dead spots
- Air jets from the tube reach “still” conditions just above the standing animal – NO DRAFTS
- Increased ventilation rates as weather warms are provided via open sidewalls and end walls – curtains and overhead doors

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### Why PPTV?

- “Our observations of automated feeder facilities are consistent with this recommendation, and barns that did not have a positive pressure ventilation system in use were associated with an 80.6% increase in the odds of a calf being detected with fever on the day of the visit ( $P = 0.025$ ).” (Jorgensen, et al 2017)
- “...have never seen a fully mechanically ventilated calf barn deliver results equivalent to the best combination of tube+ natural barns.” (Nigel Cook, Univ. of Wisconsin – Madison)

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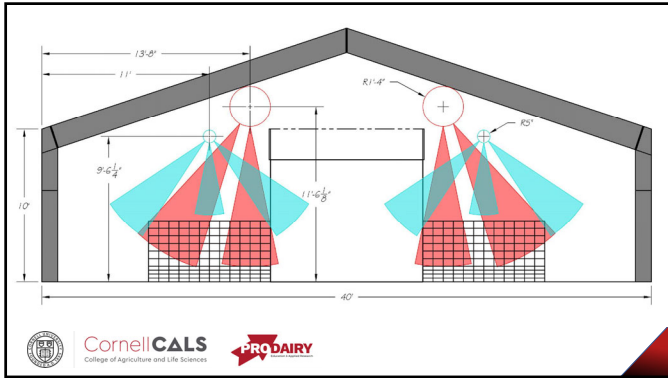
35

### PPTV Guidelines

- Animal level velocities
  - > Winter -  $\leq 60$  fpm ~4' above floor level
  - > Summer – 200- 250 fpm 1' – 2' above floor level

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### PPTV Guidelines

- Animal level velocities
  - > Winter -  $\leq 60$  fpm  $\sim 4'$  above floor level
  - > Summer - 200- 250 fpm  $1' - 2'$  above floor level
- Hooded intakes -  $2\frac{1}{2}$  ft<sup>2</sup>/ 1000 cfm

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40

### PPTV Guidelines

- Animal level velocities
  - > Winter -  $\leq 60$  fpm  $\sim 4'$  above floor level
  - > Summer - 200- 250 fpm  $1' - 2'$  above floor level
- Hooded intakes -  $2\frac{1}{2}$  ft<sup>2</sup>/ 1000 cfm
- Holes staggered to maintain tube integrity
- Tube properly supported to avoid bends


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42

### PPTV Guidelines

- Animal level velocities
  - > Winter - ≤60 fpm ~4' above floor level
  - > Summer – 200- 250 fpm 1' – 2' above floor level
- Hooded intakes – 2½ ft<sup>2</sup>/ 1000 cfm
- Holes staggered to maintain tube integrity
- Tube properly supported to avoid bends
- Single speed fans on thermostats – no variable speeds!
- Protect tube at potential contact points with structure
- System must be designed by a trained professional



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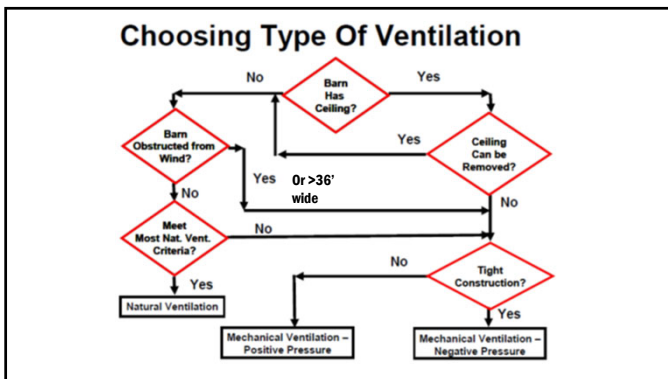
### Fans 101

- Myth: Fans of equal size have equal capacity
- Fact: Capacity is a function of...
  - Diameter
  - RPM
  - Number of blades
  - Shape & pitch of blades
  - Shape of housing
  - Motor Hp
  - Direct Drive vs. belt
    - > Pulley size ratios
    - > Wrap angle
  - Age

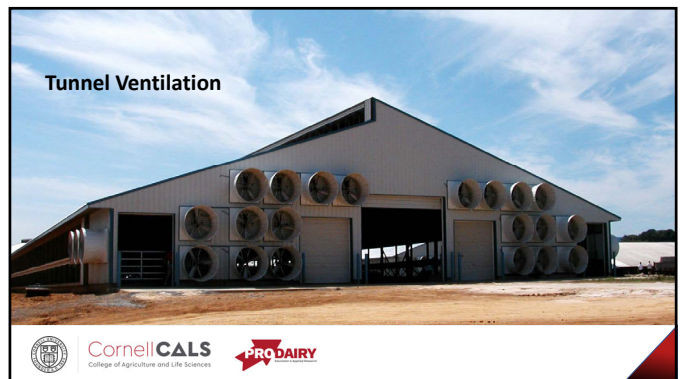
Capacity – cubic feet of air per minute – “cfm”



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### Tunnel Ventilation

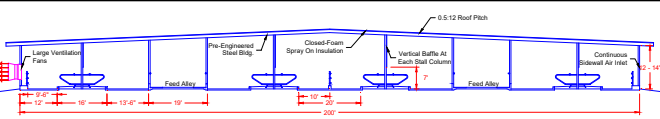
- 1 season system – hot
- Negative pressure system
  - ▮ All or nothing
- Minimum velocity 440 fpm
- Longitudinal flow – maximum ~600' in length
  - ▮ Example – 1°-natural, 2°-tunnel
- Need sufficient inlet openings
- No other systems operating concurrently




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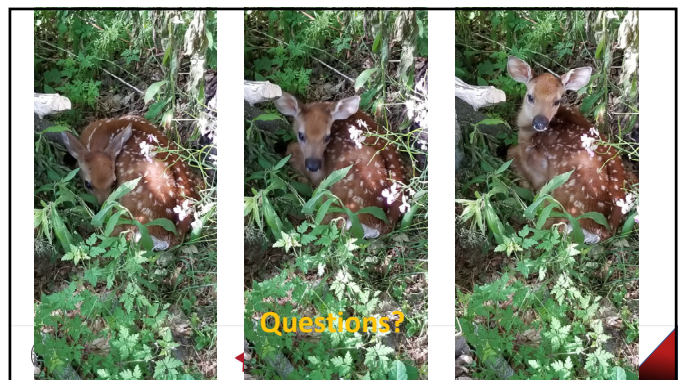
50



- One season system ?
- Building Width - ~200'
- One sidewall – all fans, other sidewall – all open / screen
- Low roof pitch or flat ceiling - insulated
- Baffles to force air to animal level & maintain velocity
- Aim for 440 fpm velocity

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