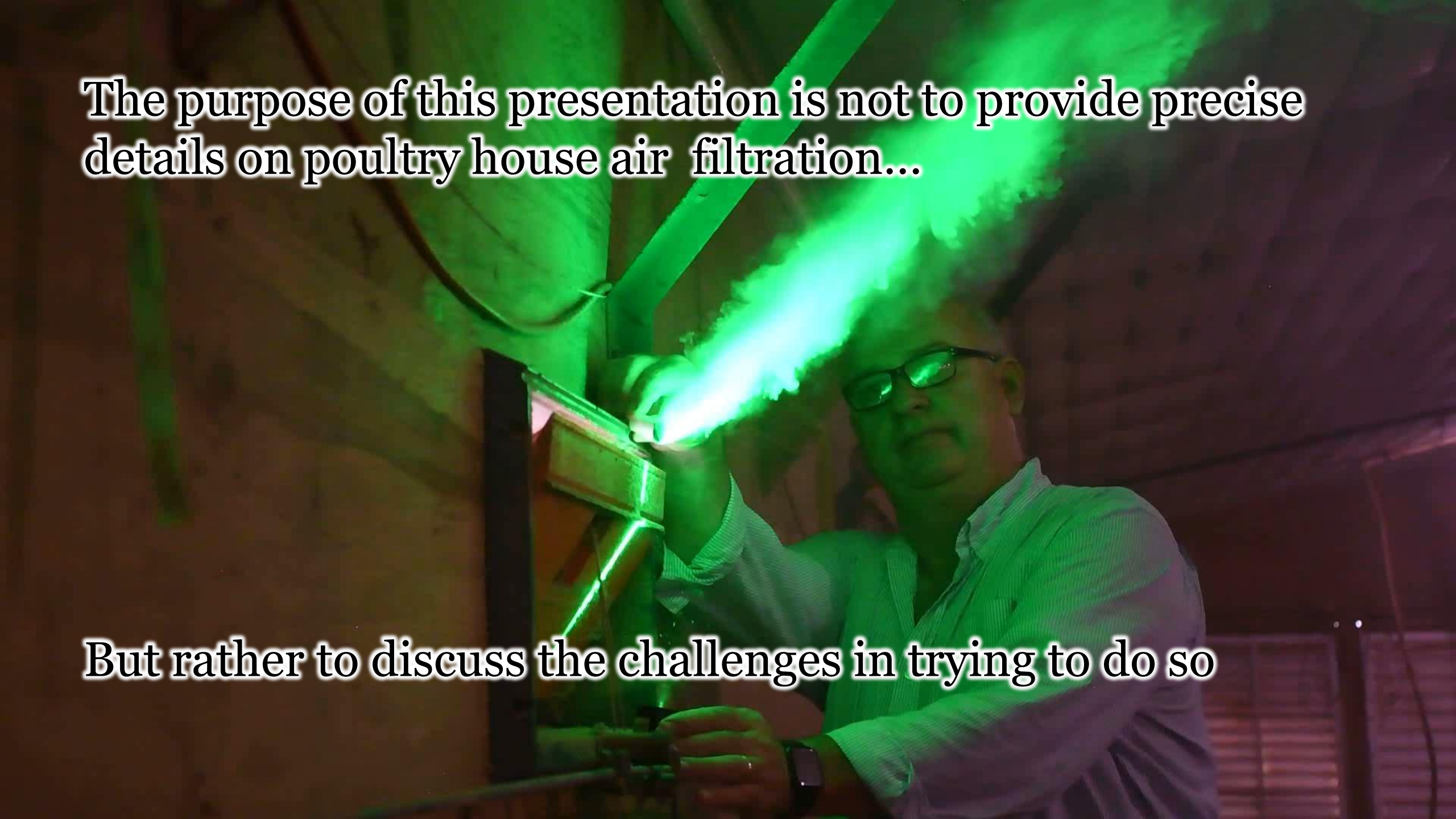
Poultry House Air Filtration 101

Michael Czarick
The University of Georgia


The purpose of this presentation is not to provide precise details on poultry house air filtration…
But rather to discuss the challenges in trying to do so

Though viruses are around 0.1 microns in size…

- they tend to travel on “larger” particles (bioaerosols) which are generally one micron and larger
- It’s these larger particles which we are actually interested in keeping out of our houses

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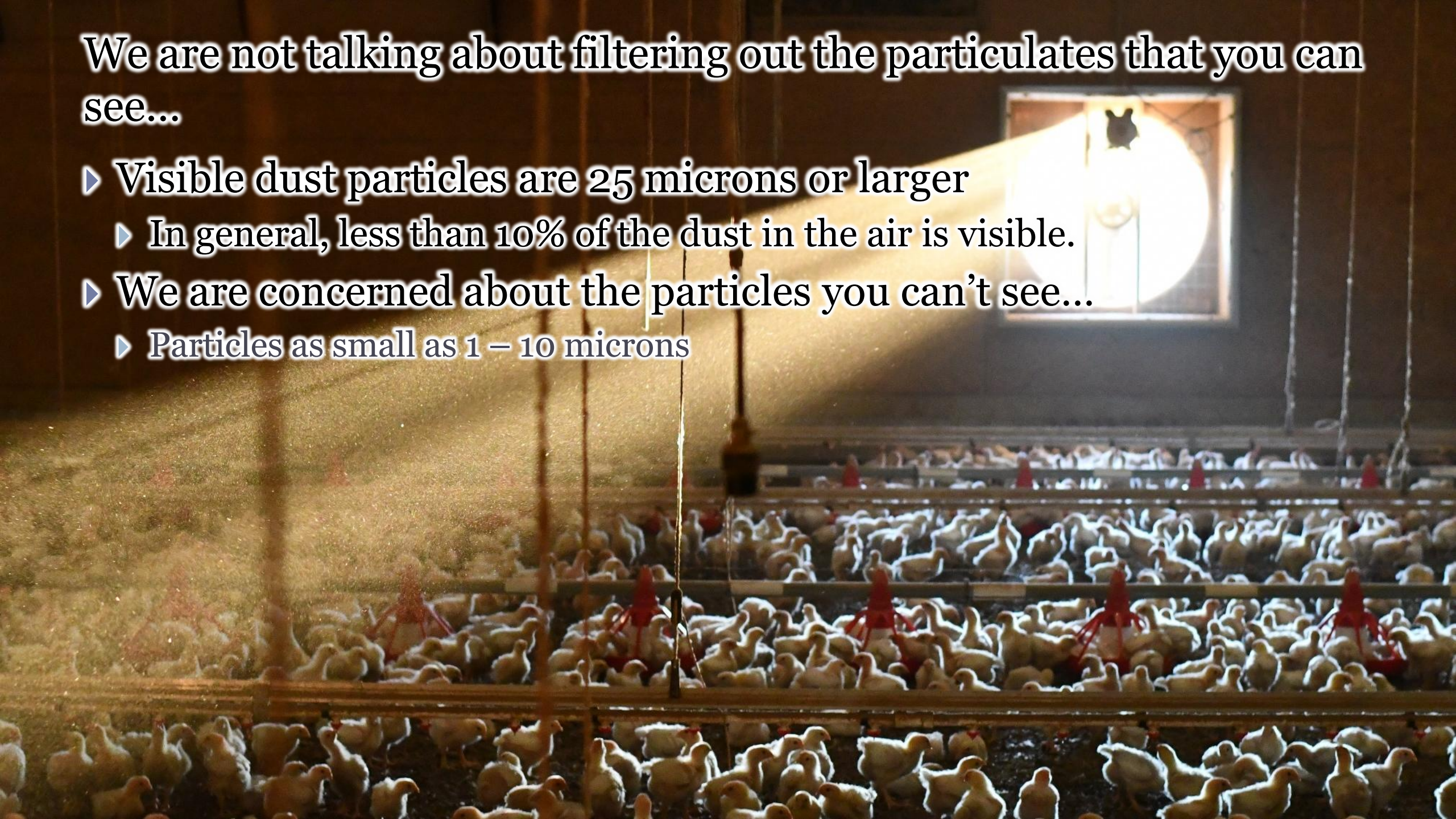


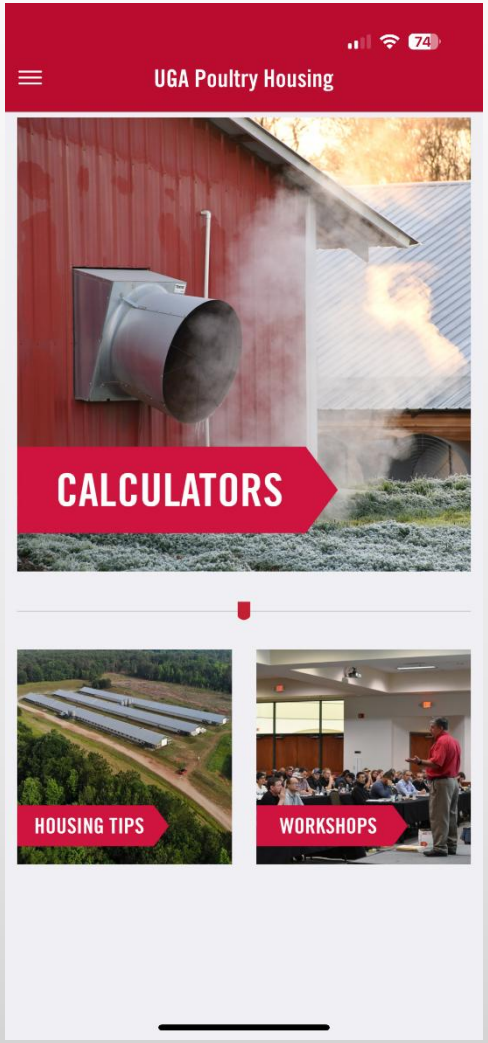
We are not talking about filtering out the particulates that you can see…

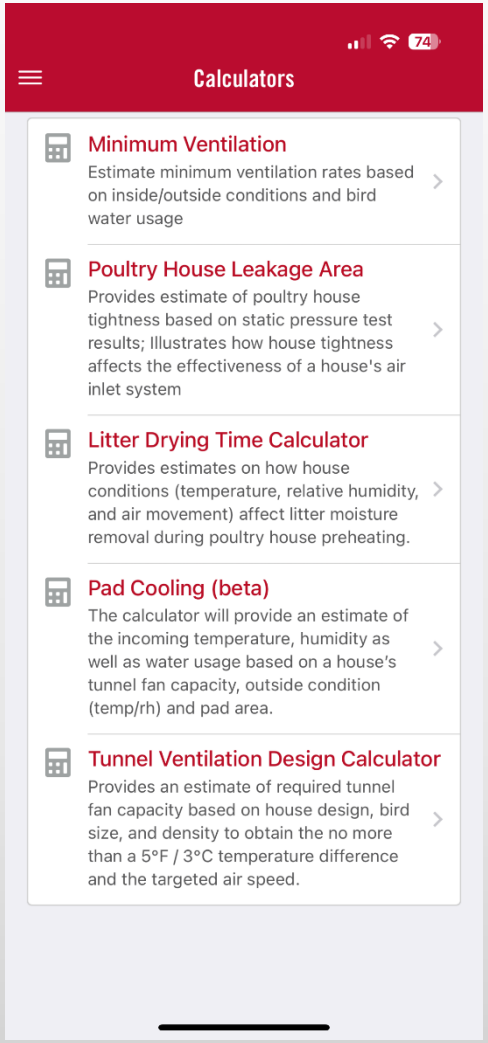
- Visible dust particles are 25 microns or larger
  - In general, less than 10% of the dust in the air is visible.
- We are concerned about the particles you can't see…
  - Particles as small as 1 – 10 microns

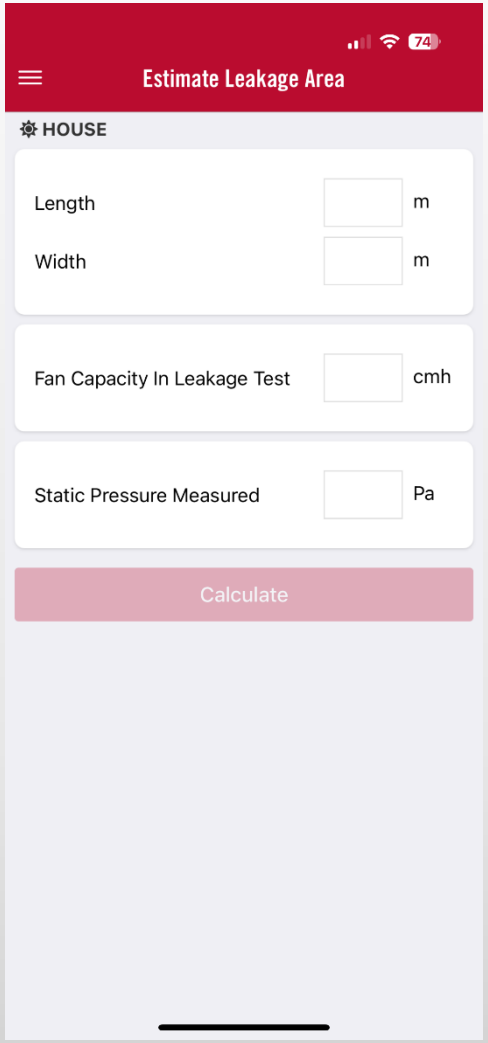
Challenge #1:

- Even our tightest poultry houses are still relatively loose when it comes to air filtration.
- For example…

The Poultry House Leakage Area Calculator (Poultry411) allows you to quickly determine a poultry house's level of tightness







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To use the App you need to conduct a “pressure test”…

- Close up a house tight…
- Turn on an exhaust fan or two…
  - Approximately 20 m^3/hr per m^2 of floor space
  - 15 m X 100 m = approx. 30,000 m^3/hr
- Measure the resulting pressure
- Input information into the calculator

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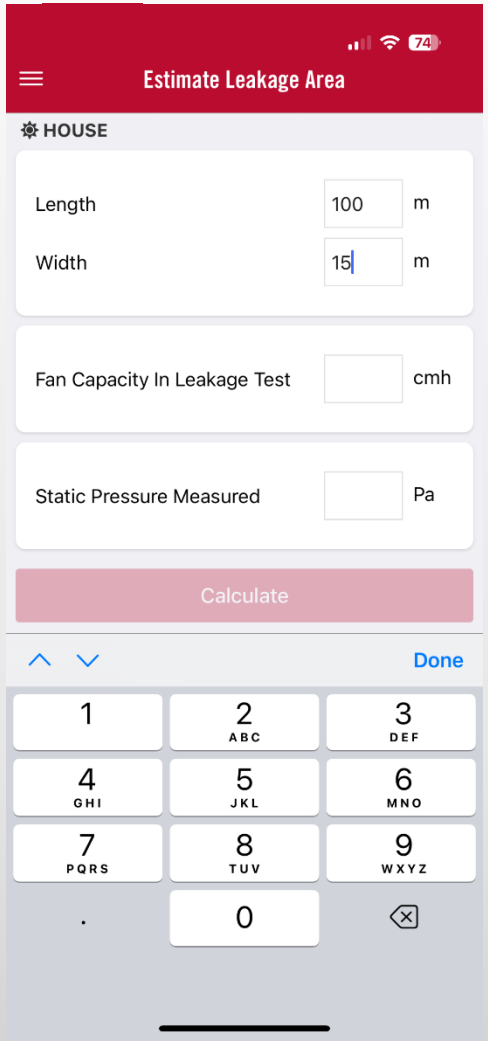
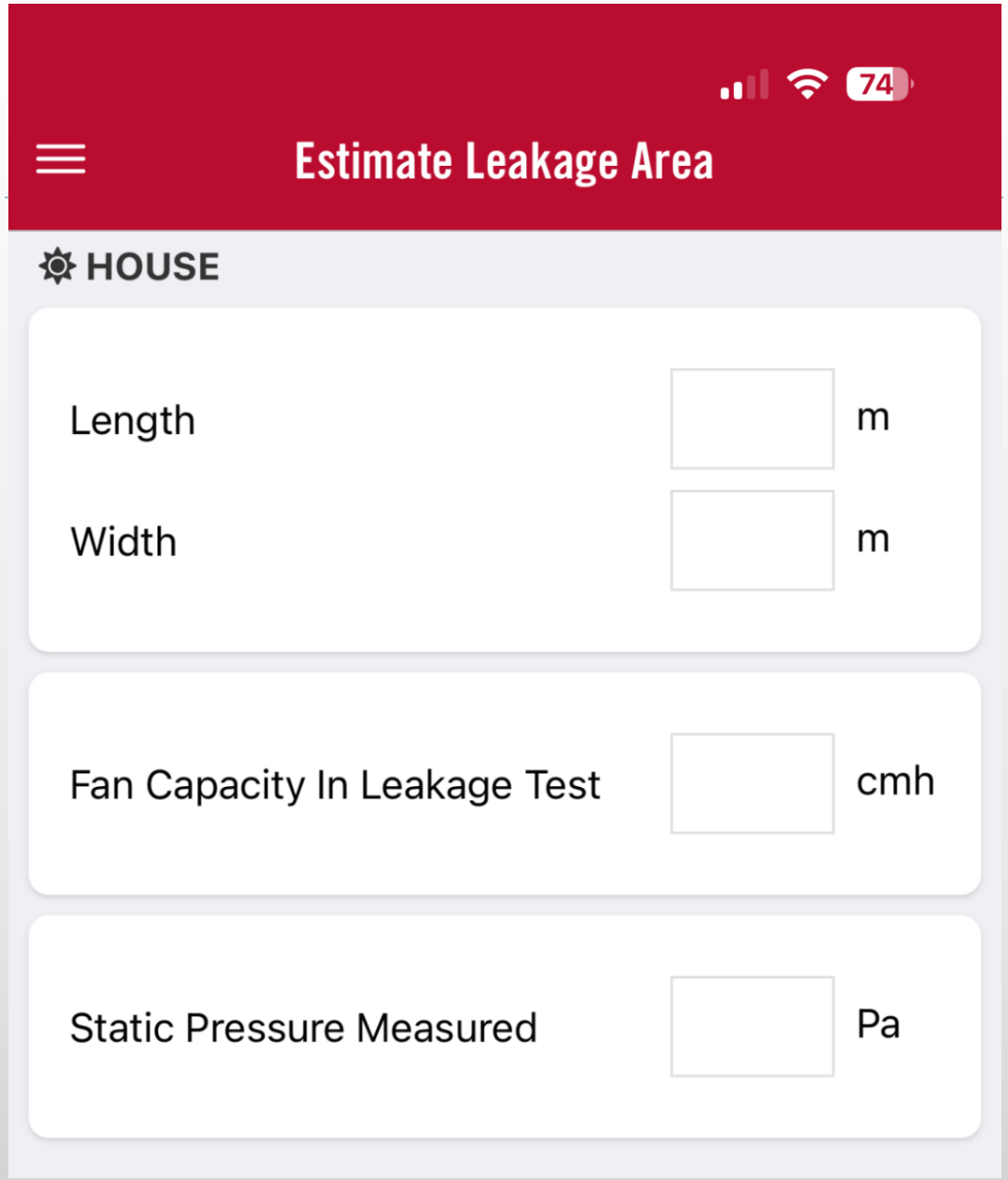
Input house dimensions





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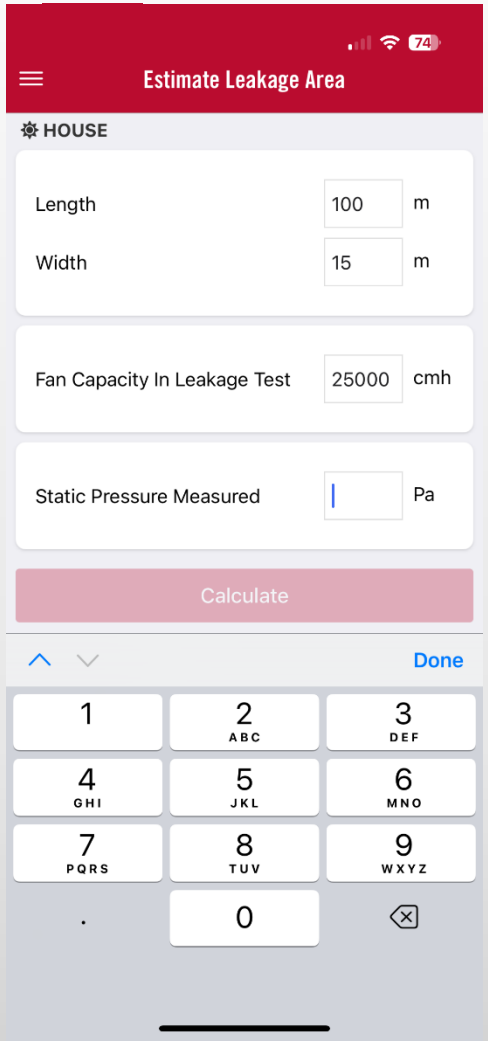
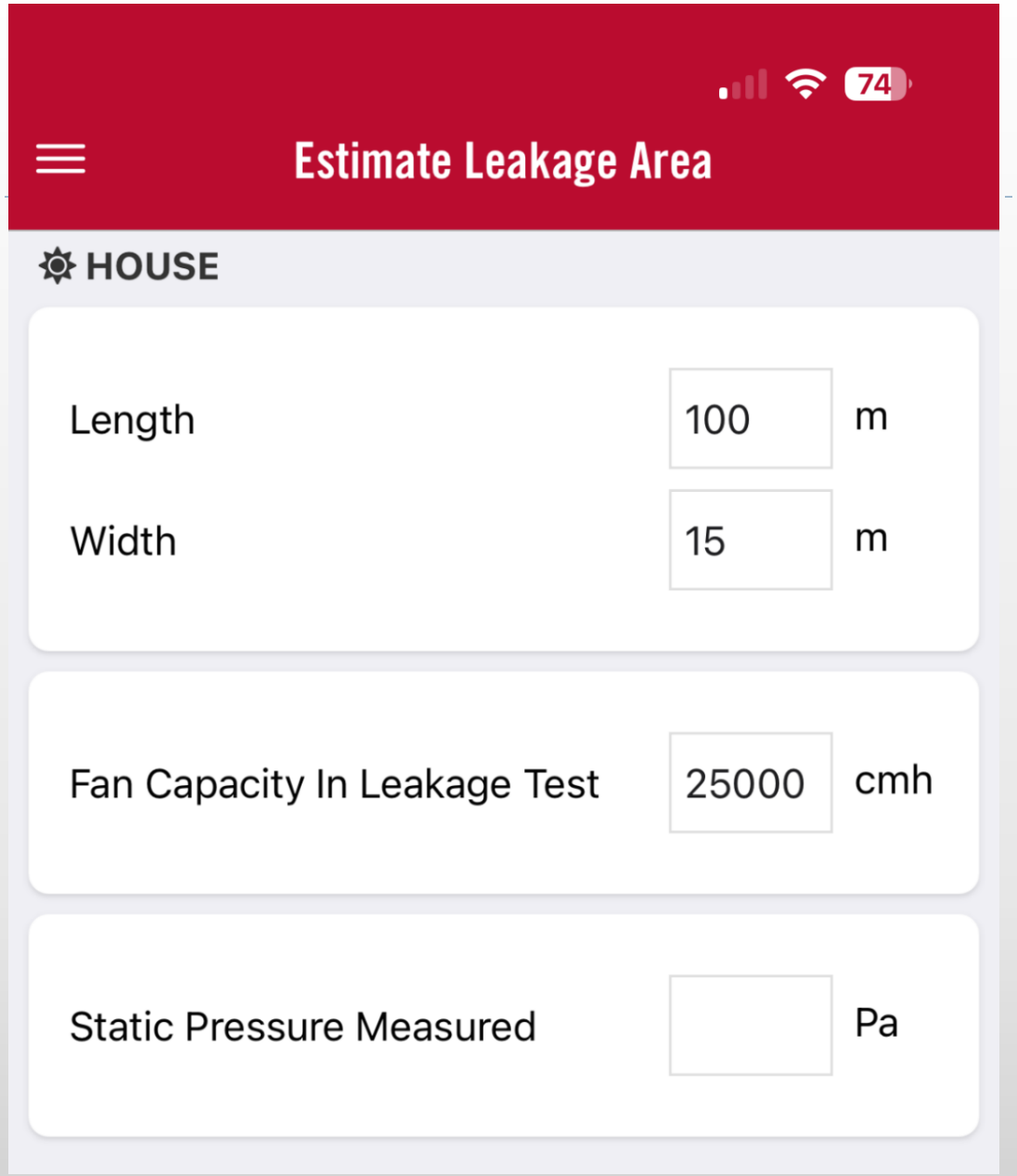
Input the air moving capacity of the test fan(s)





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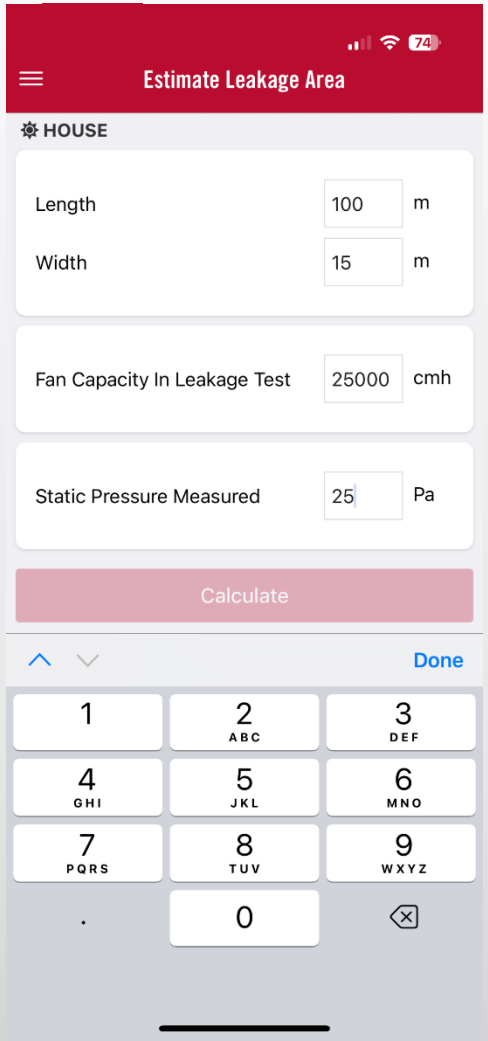
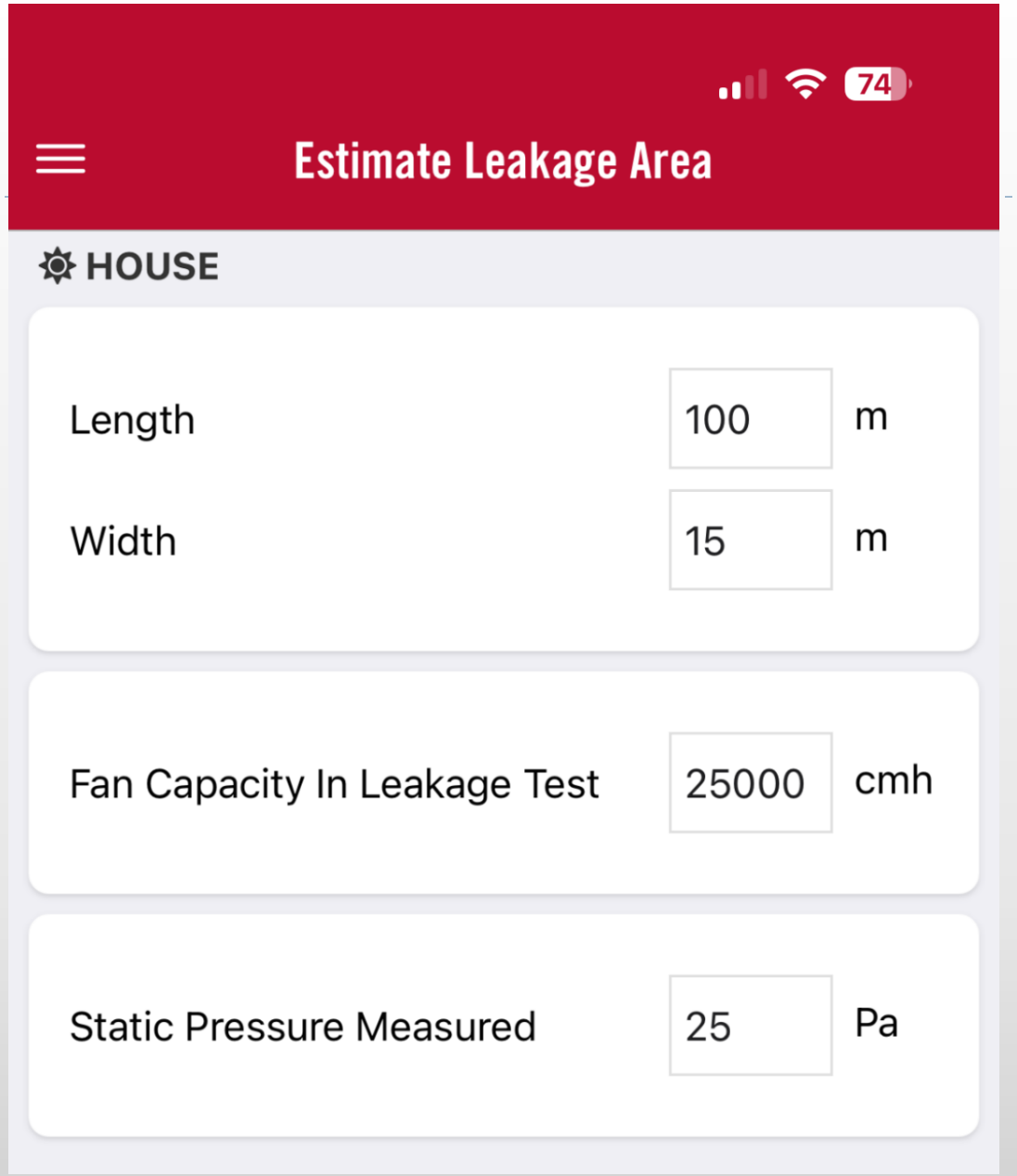
Input the pressure measured





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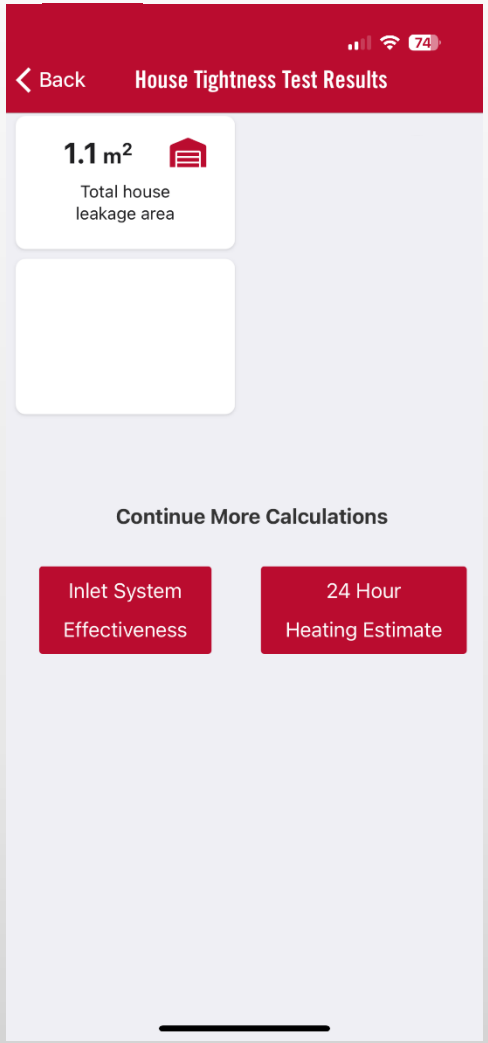
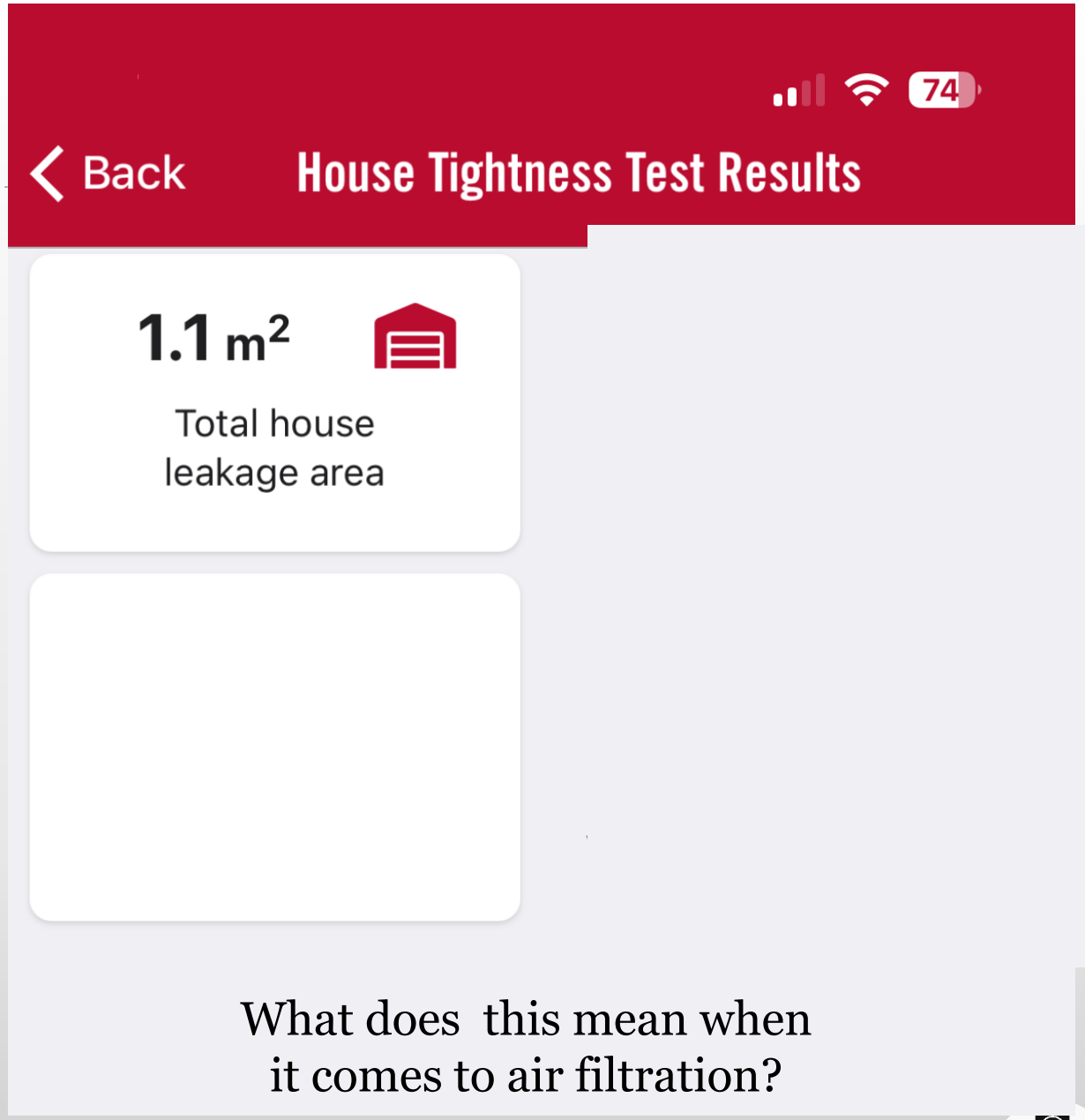
Results:





What does this mean when it comes to air filtration?

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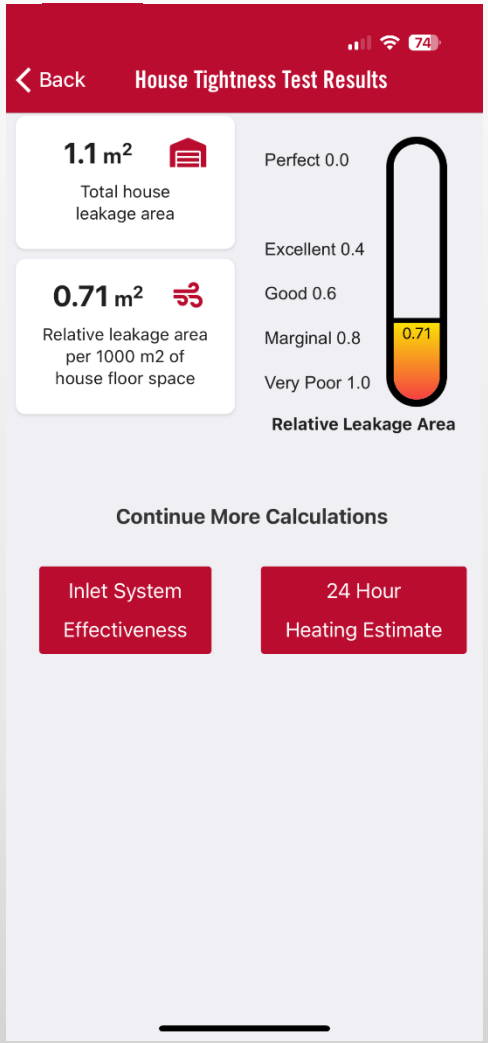
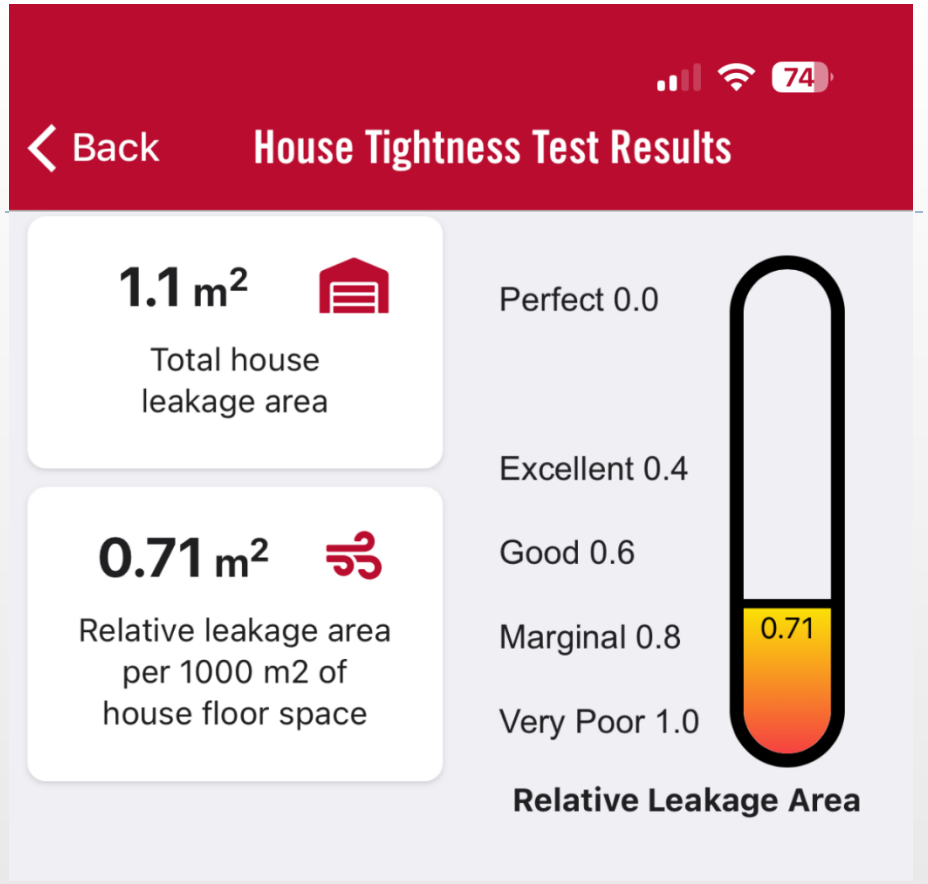
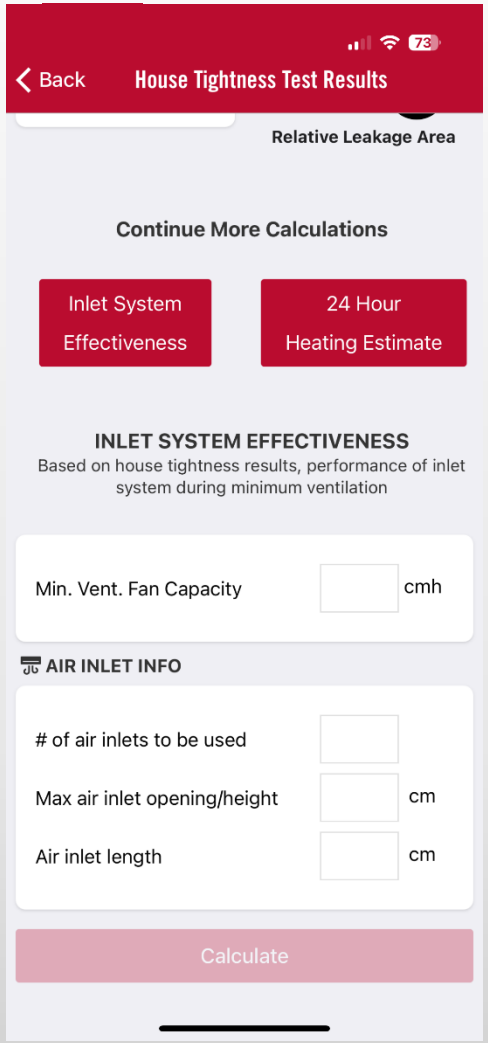
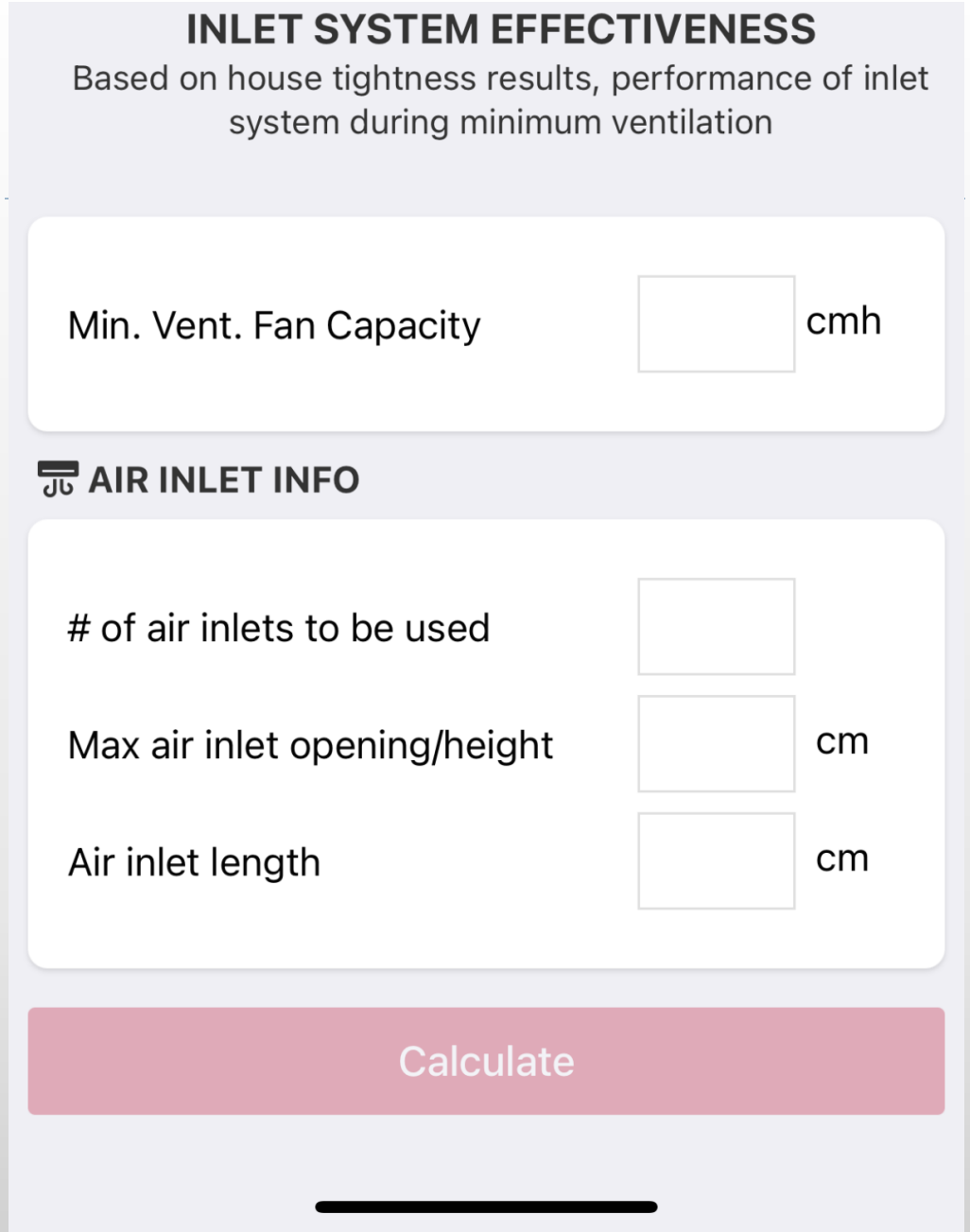
Select “Inlet System Effectiveness”



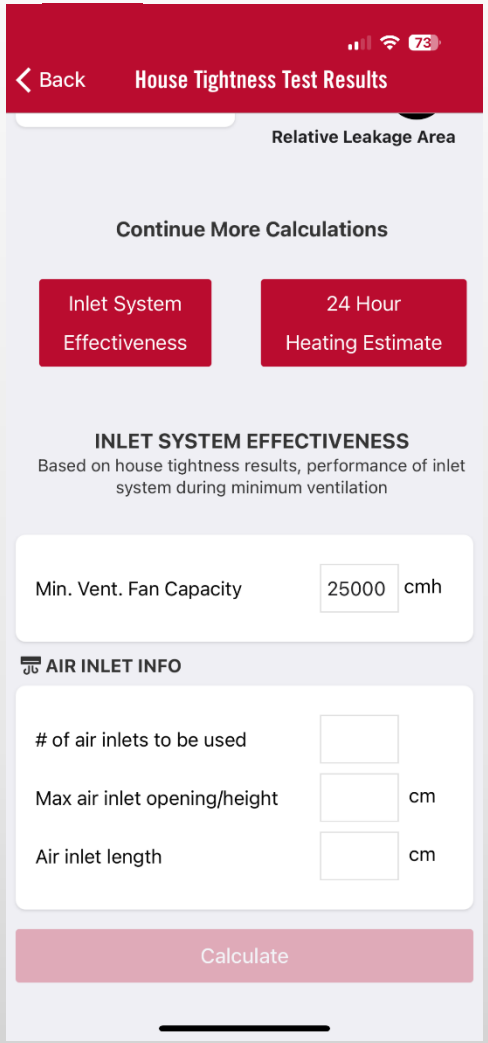


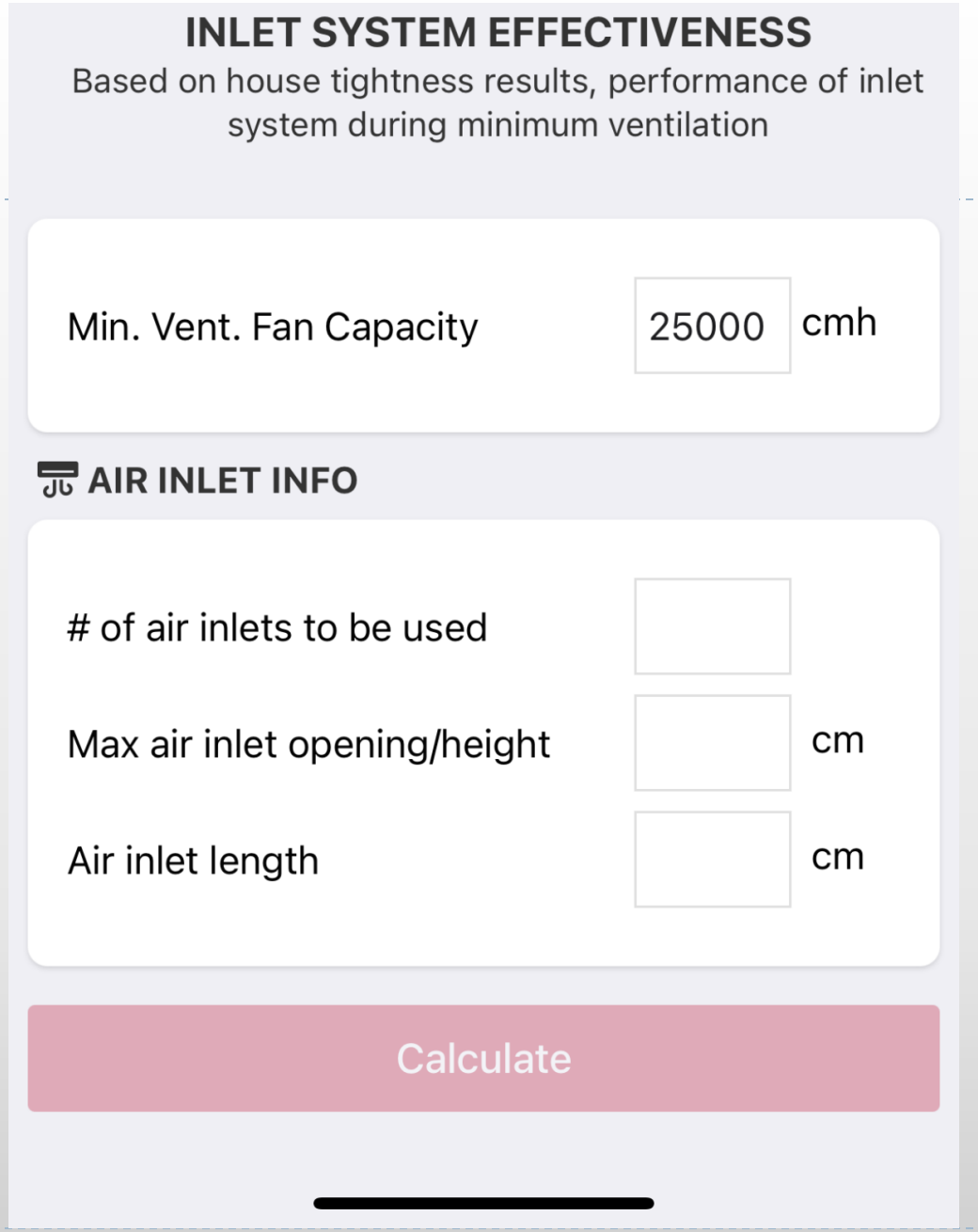
Input capacity of minimum ventilation fan(s)





Input capacity of minimum ventilation fan(s)





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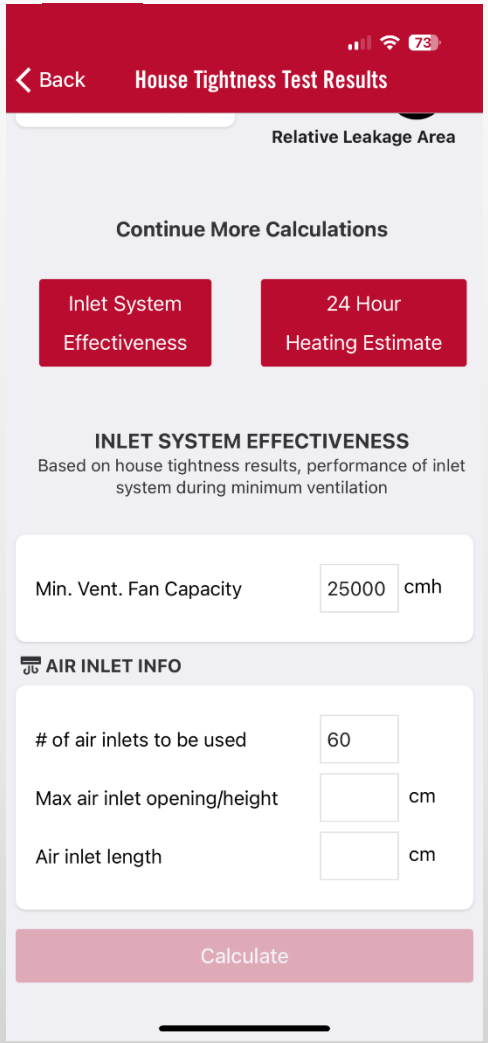
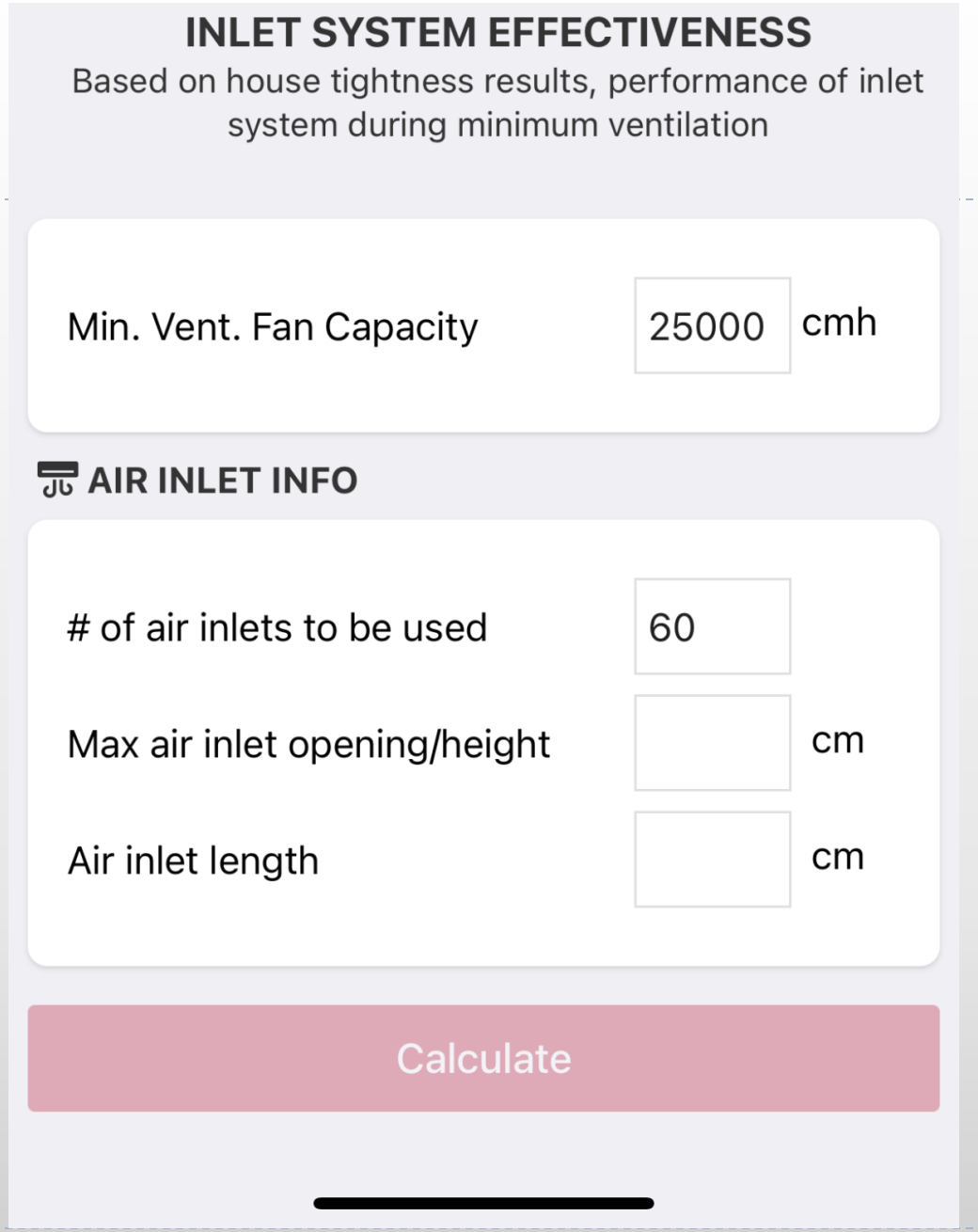
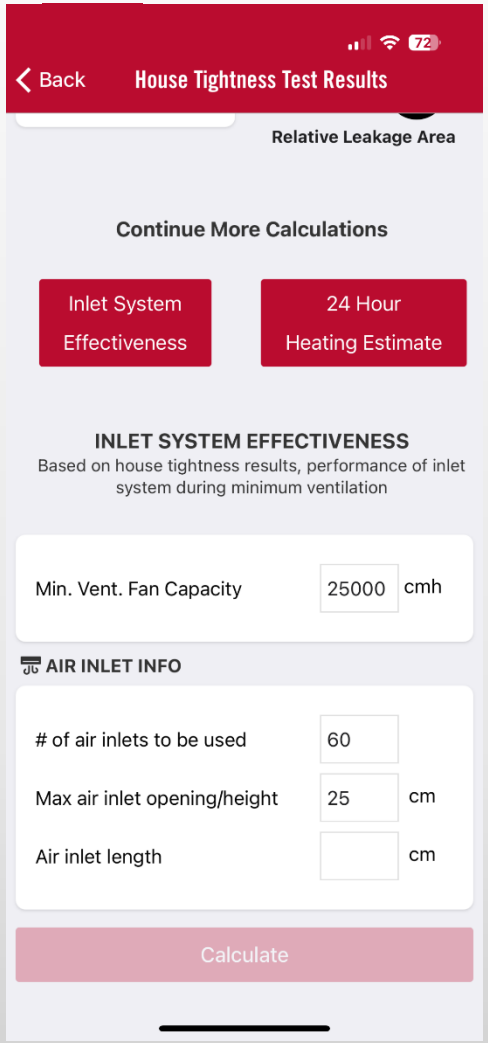
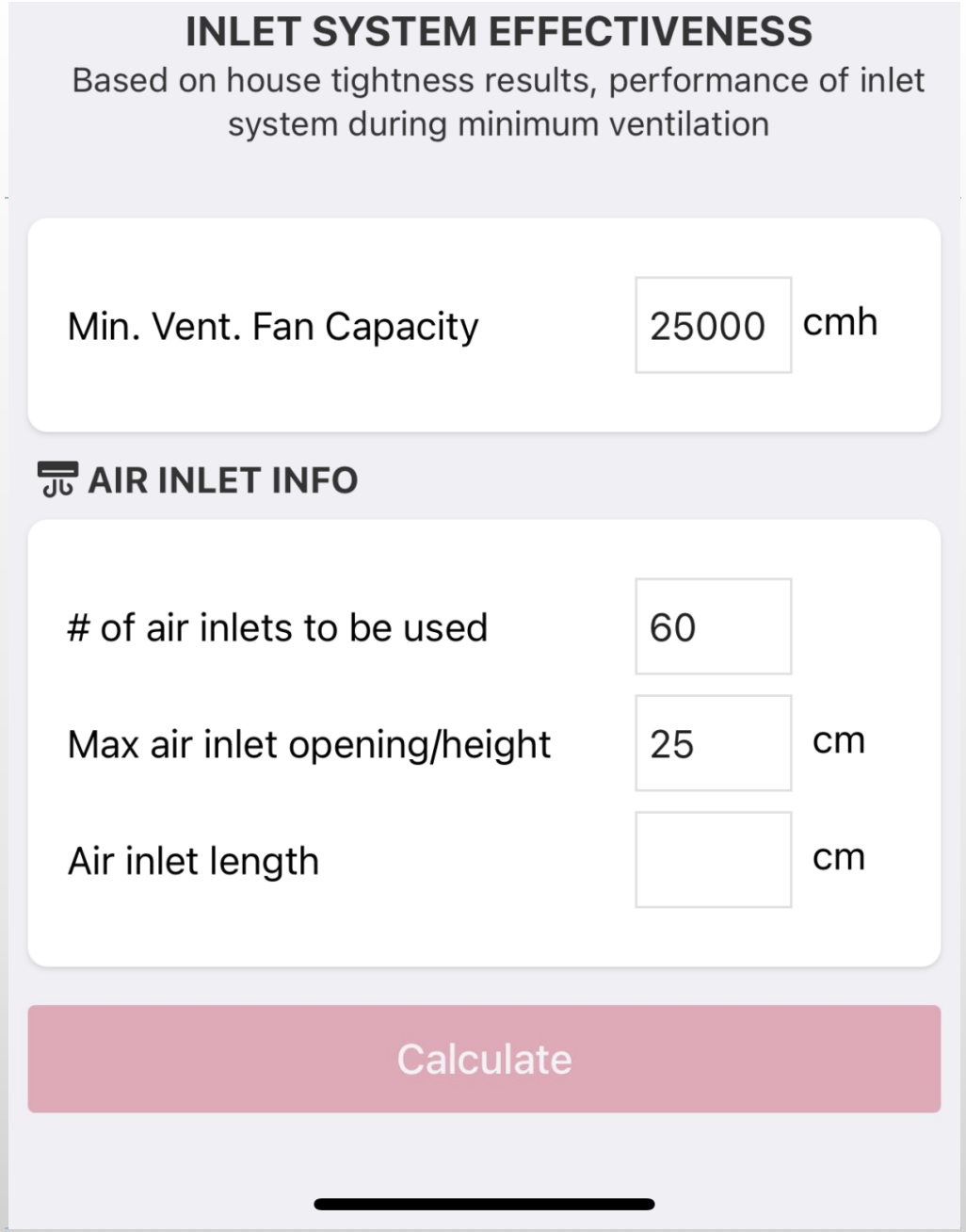
Input number of inlets to be used



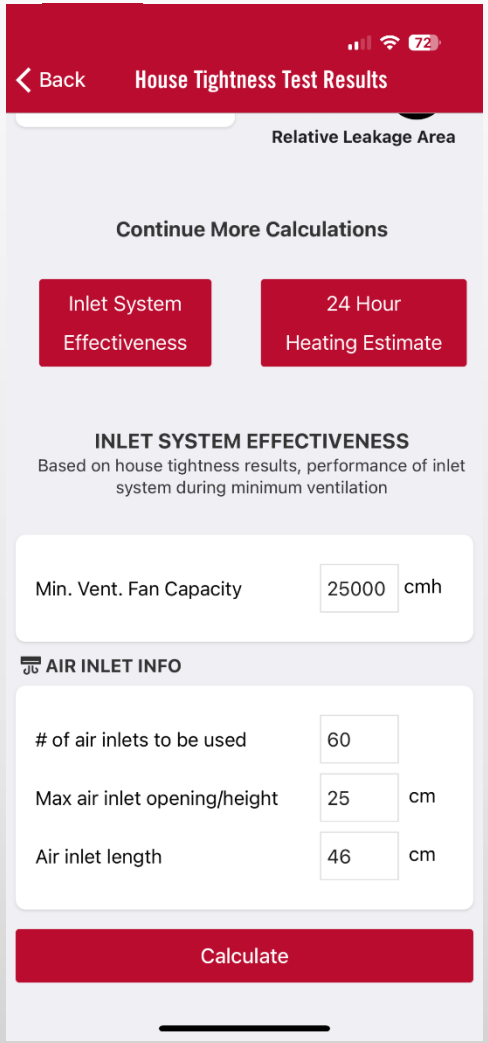


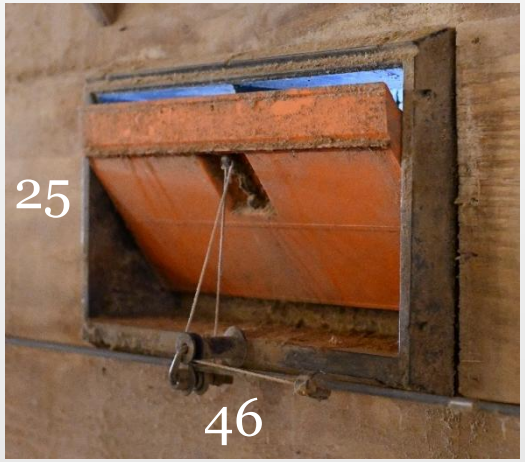
Input maximum inlet opening

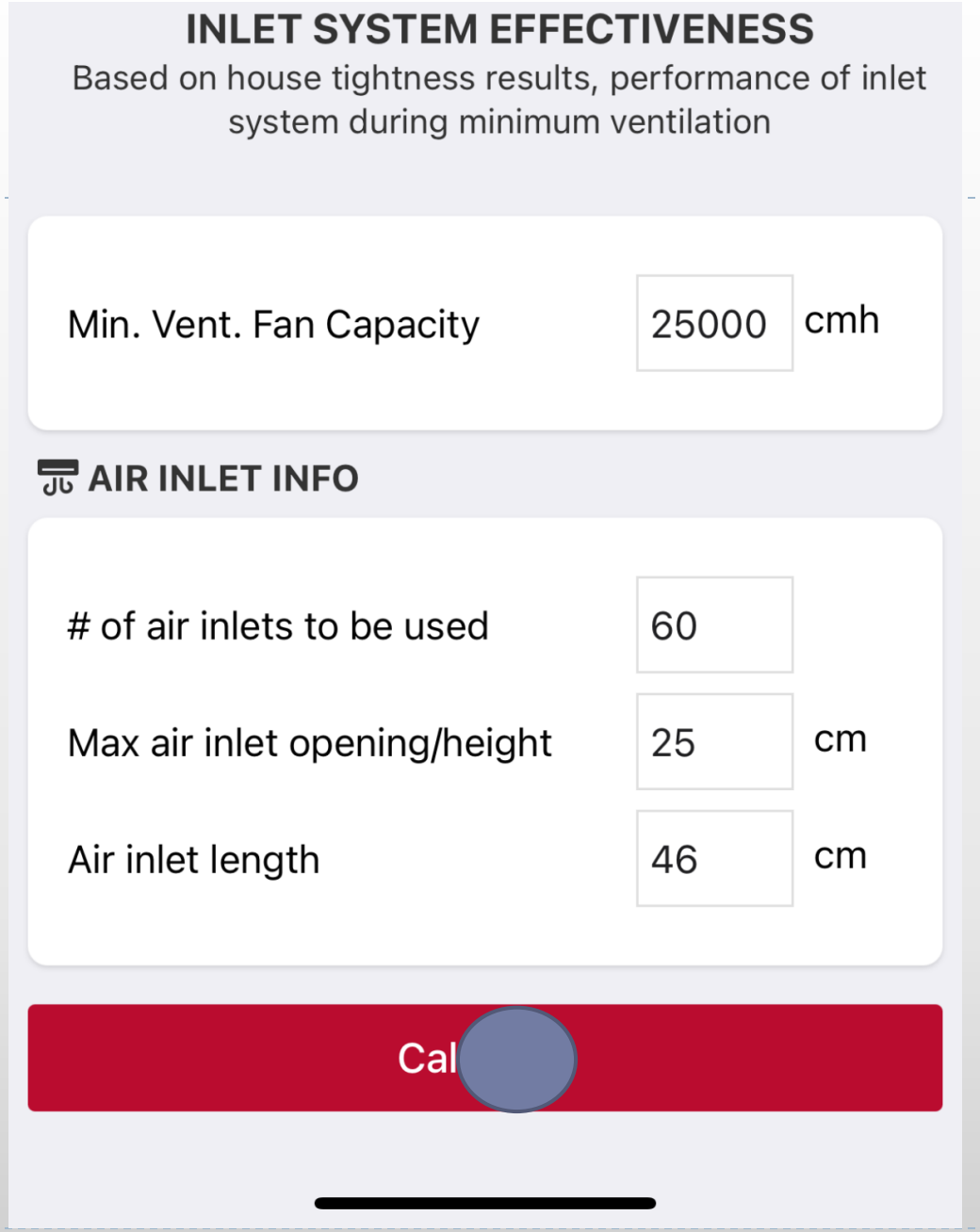




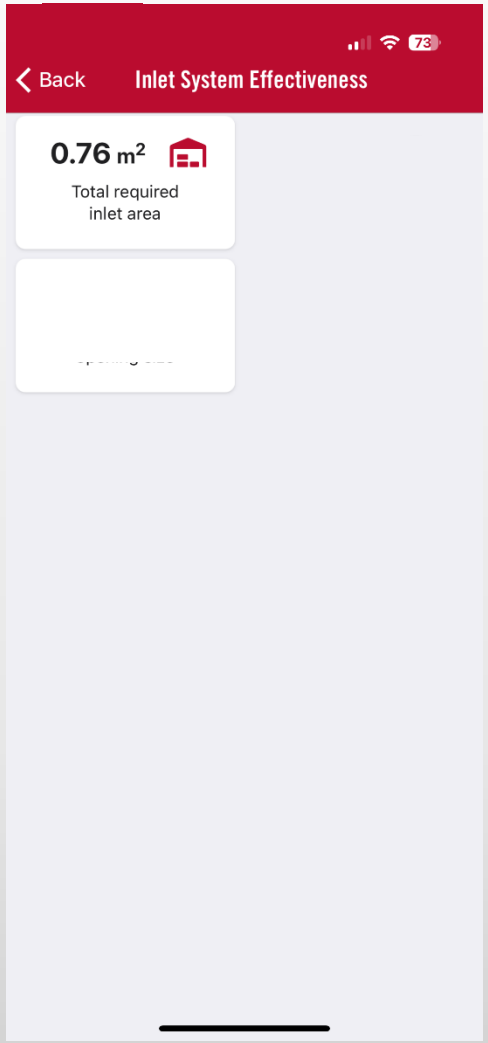
Input inlet length

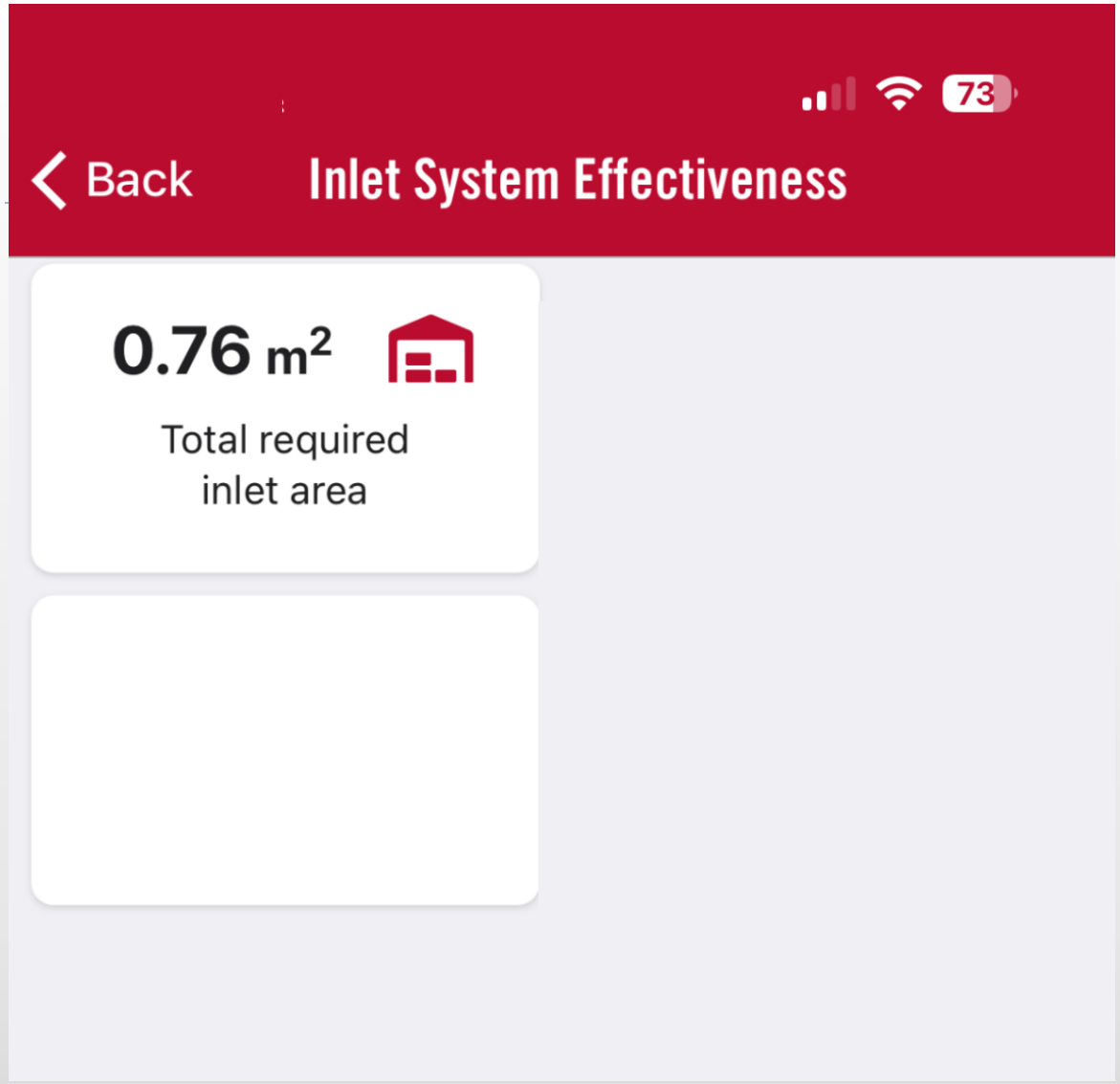






Results:





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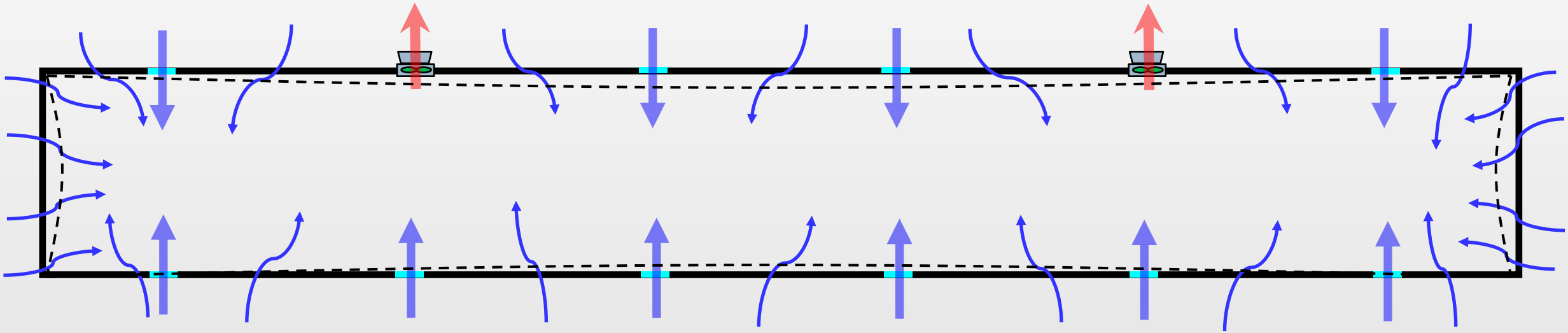
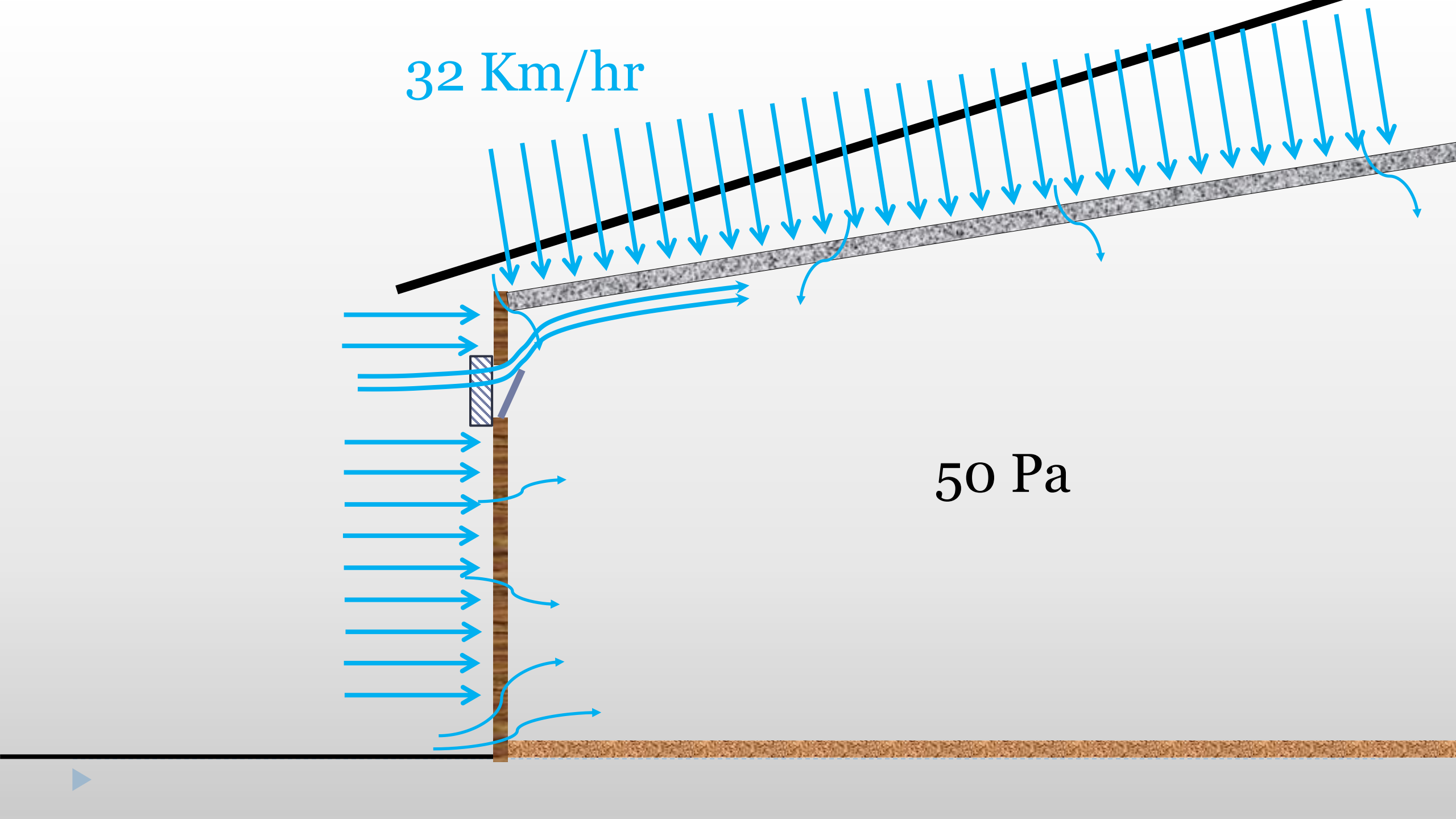
So, during minimum ventilation at a typical operating pressure 25 Pa

- The inlets will open 2.8 cm,
- 10,500 cmh of 25,000 (42%) will enter the house through the inlets



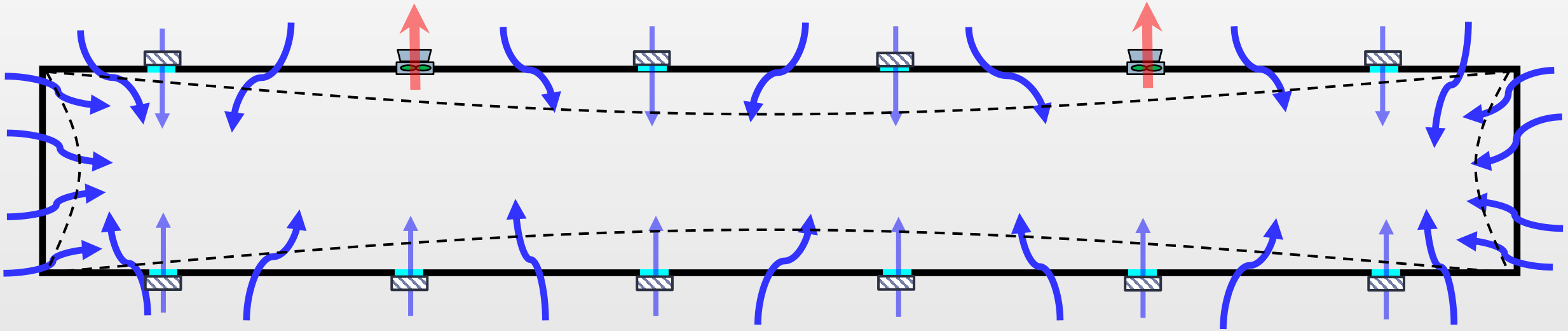
- 16,000 cmh of 25,000 (58%) will enter the house through cracks

Making matters worse is that filters can easily increase the operating static pressure to between 50 and 80 Pa…


32 Km/hr
50 Pa

Making matters worse is that filters can easily increase the operating static pressure to between 50 and 80 Pa…

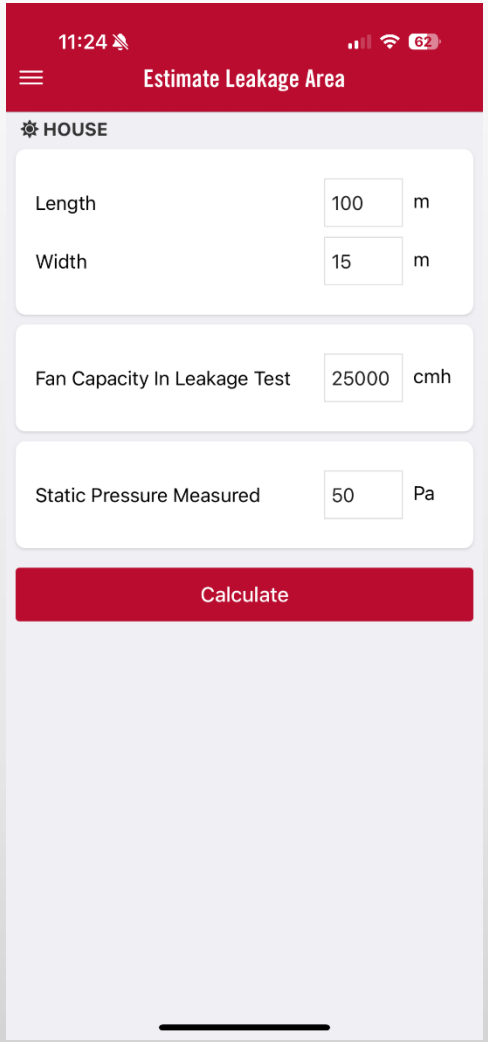
- Less than 5,000 cmh (20%) of the air will enter through the inlets

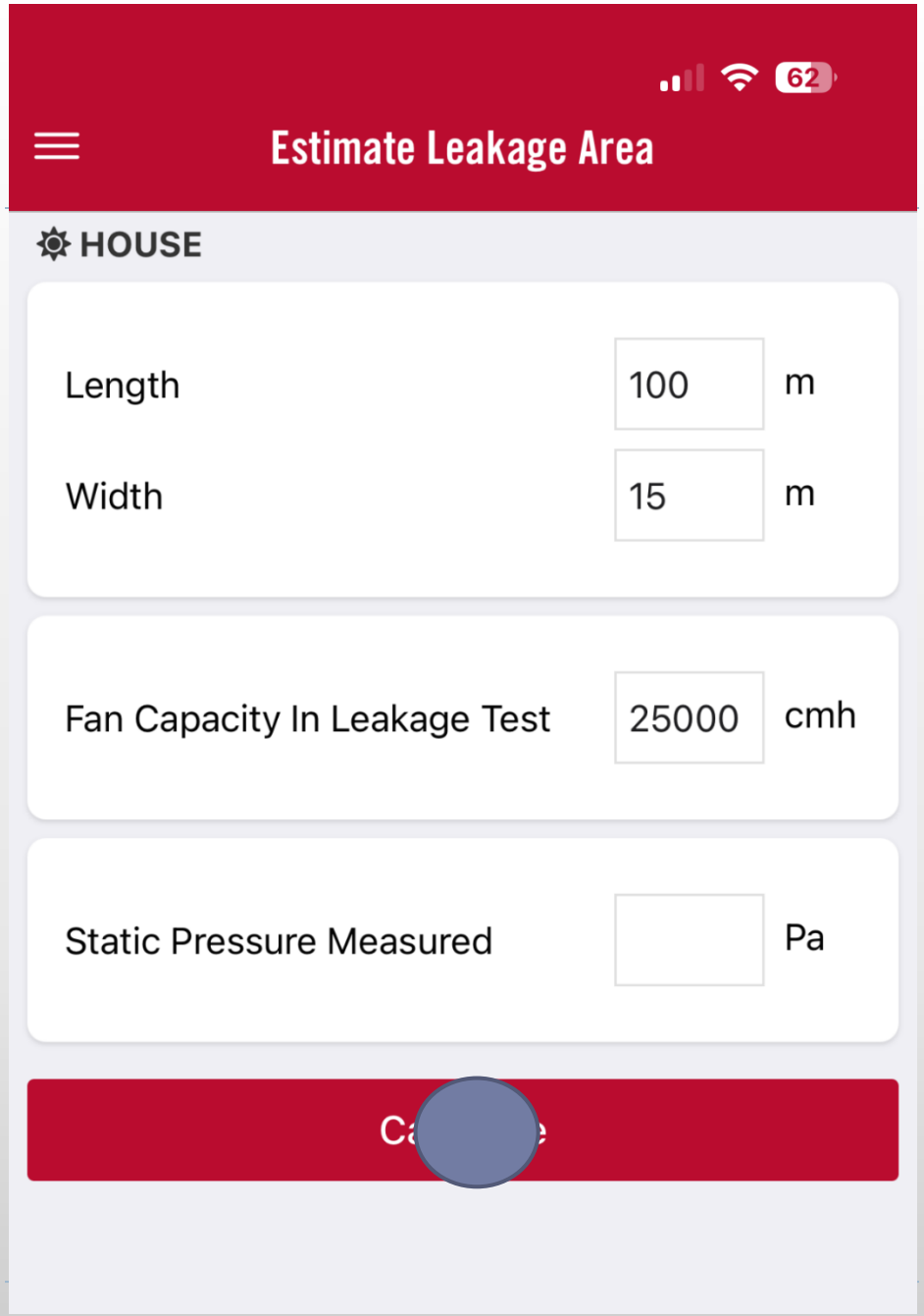


- 20,000 cmh+ (80%+) will enter through the cracks, unfiltered


What happens if we dramaticallyincrease house tightness?

Test pressure = 50 Pa?





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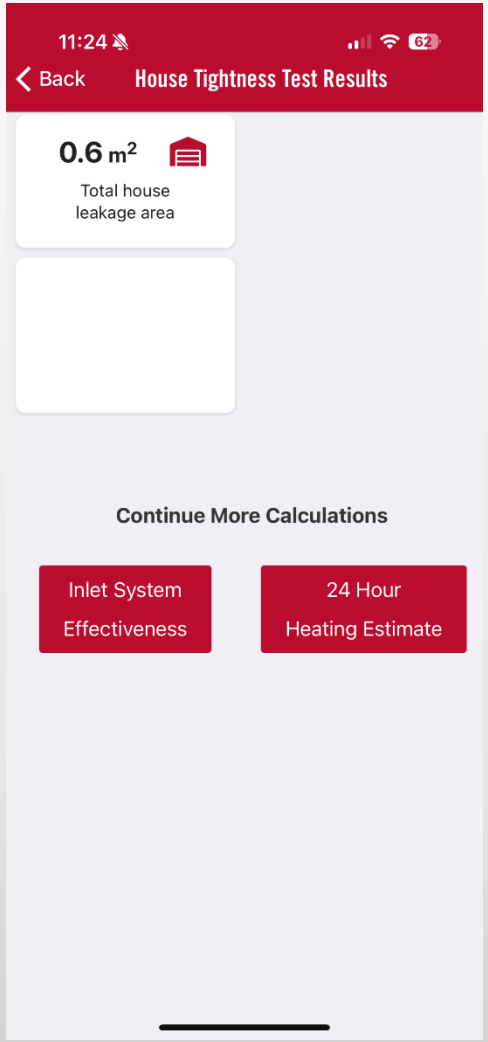
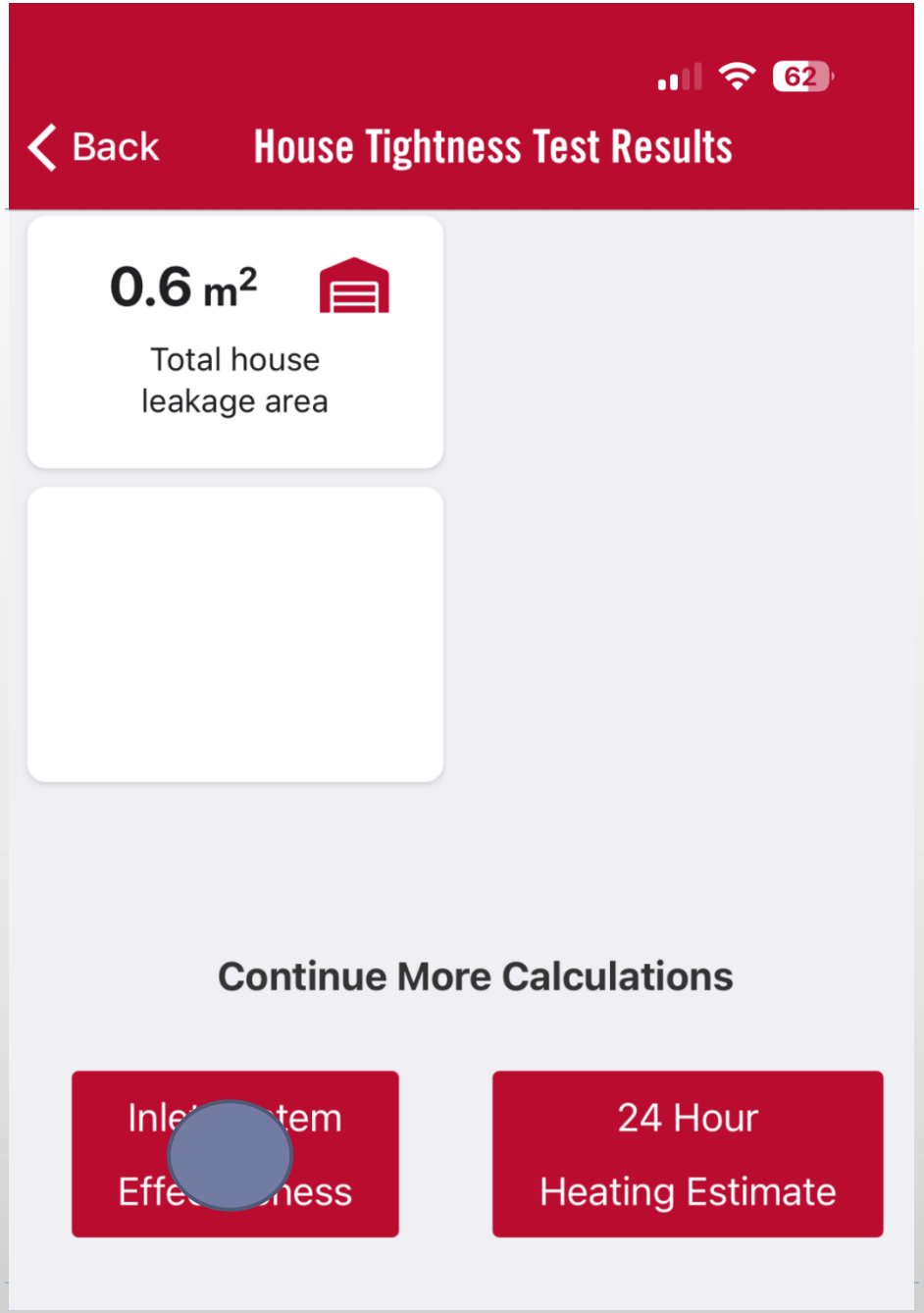


Was 1.1 m²

Was 0.71



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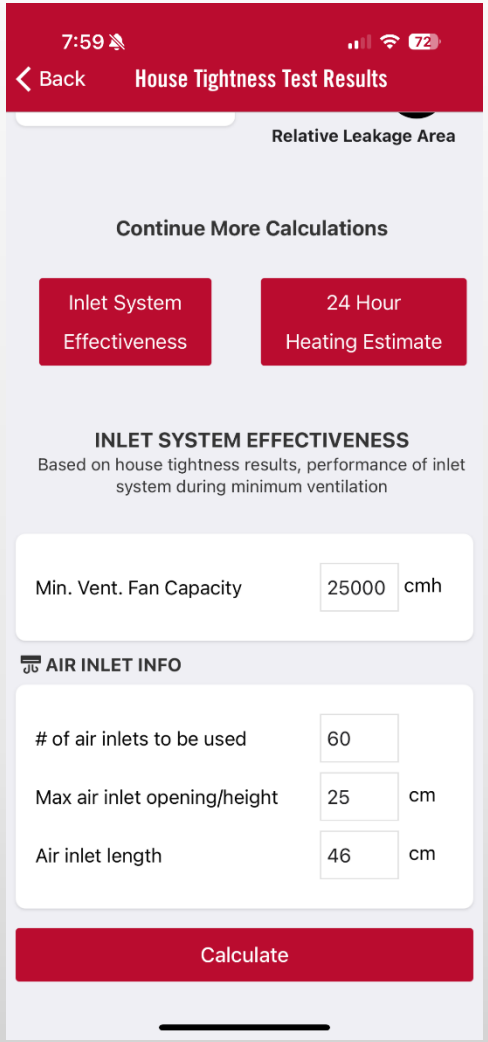
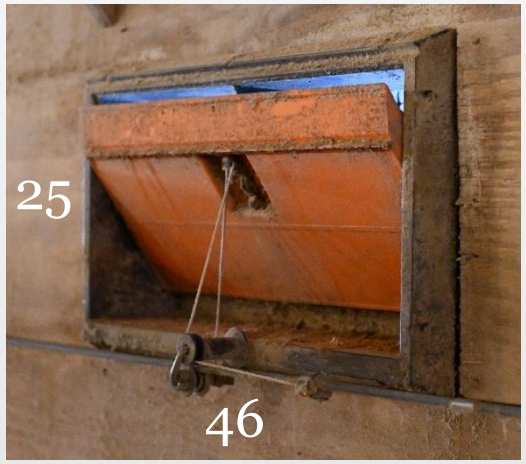
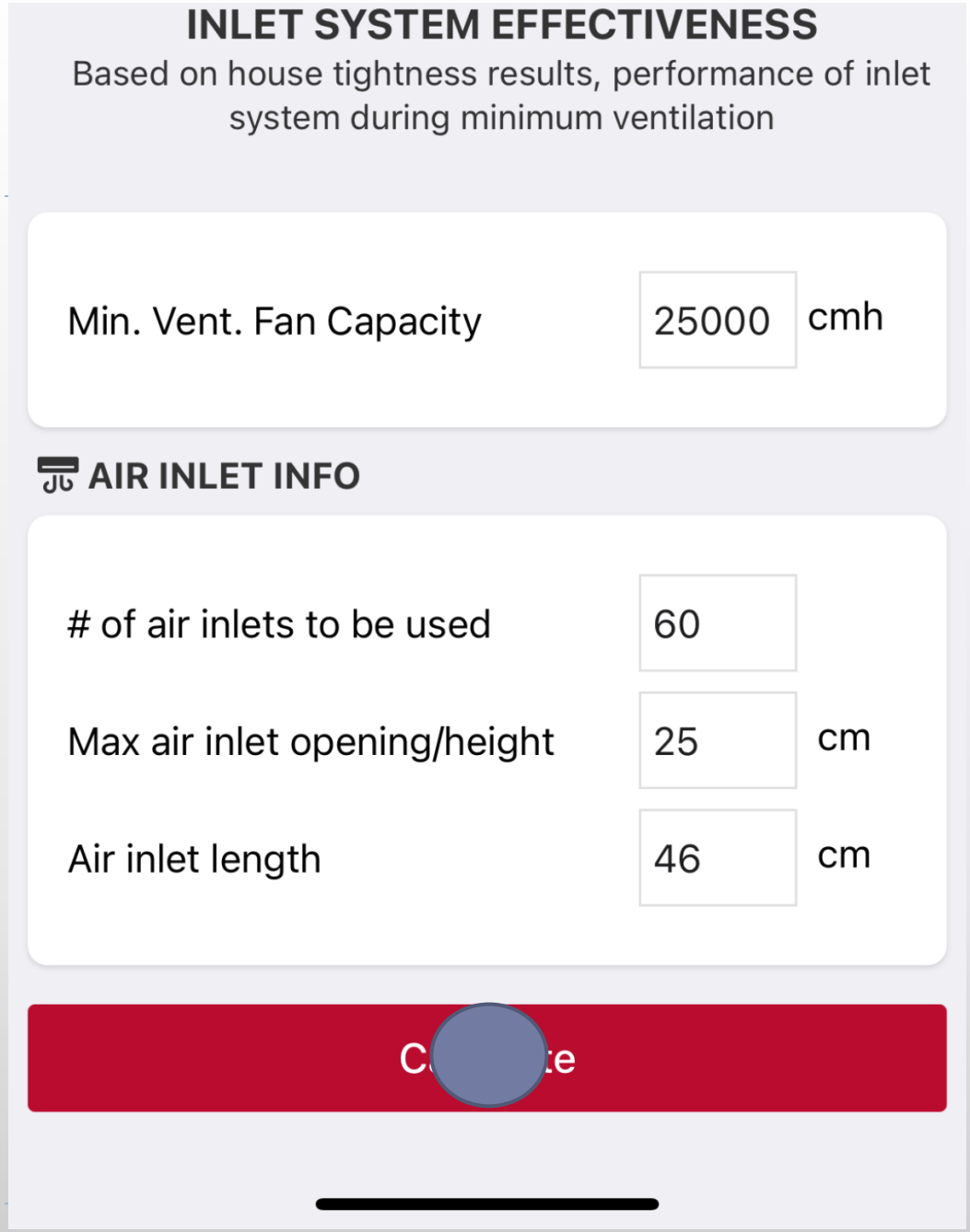
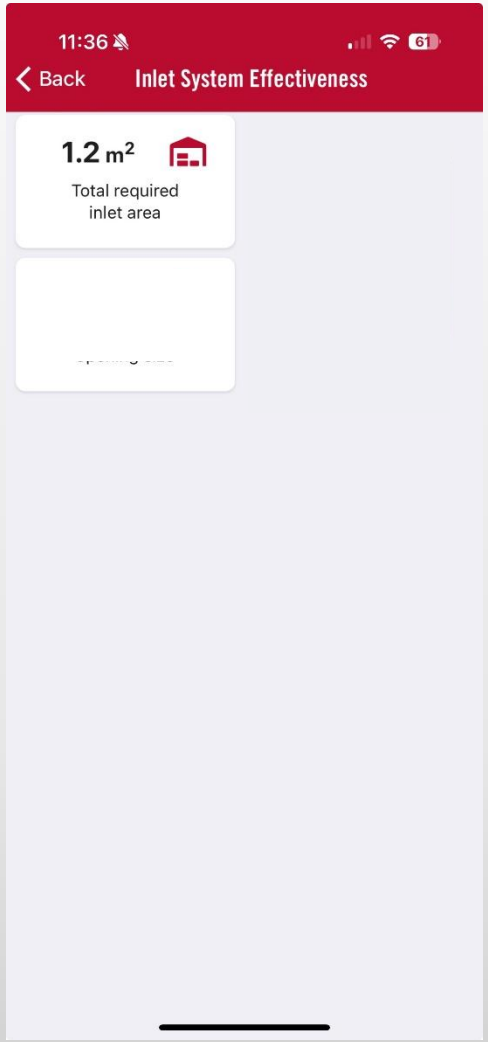
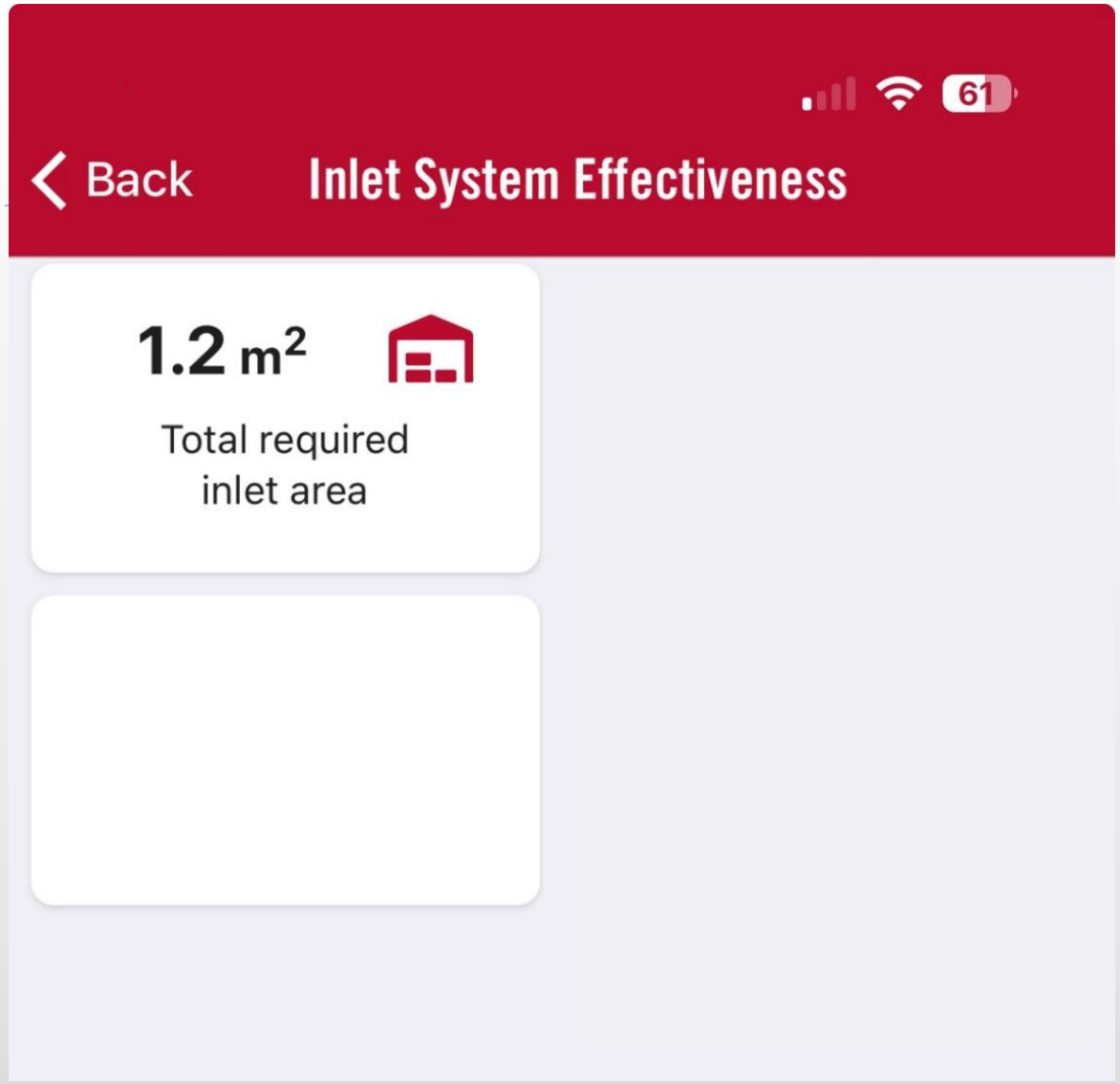
Input minimum ventilation and inlet information











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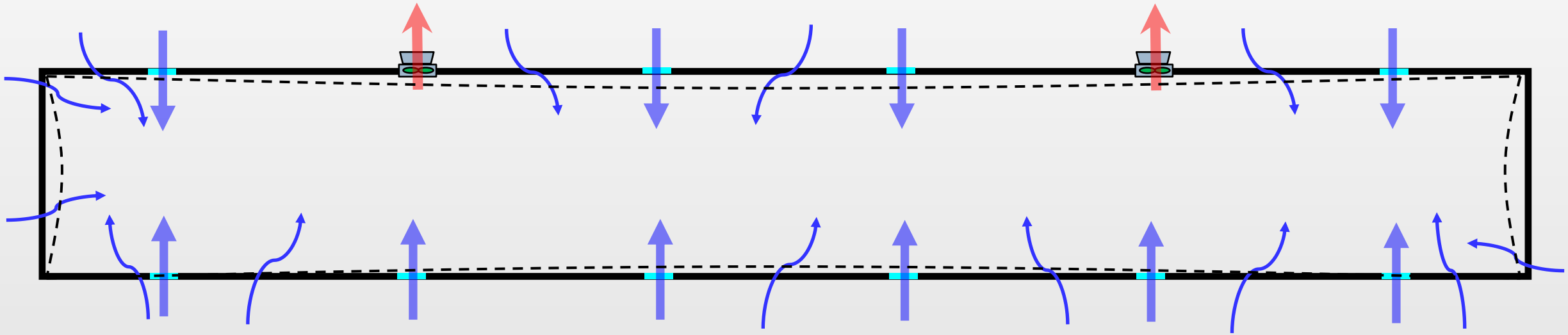
So, at a typical operating pressure of 25 Pa

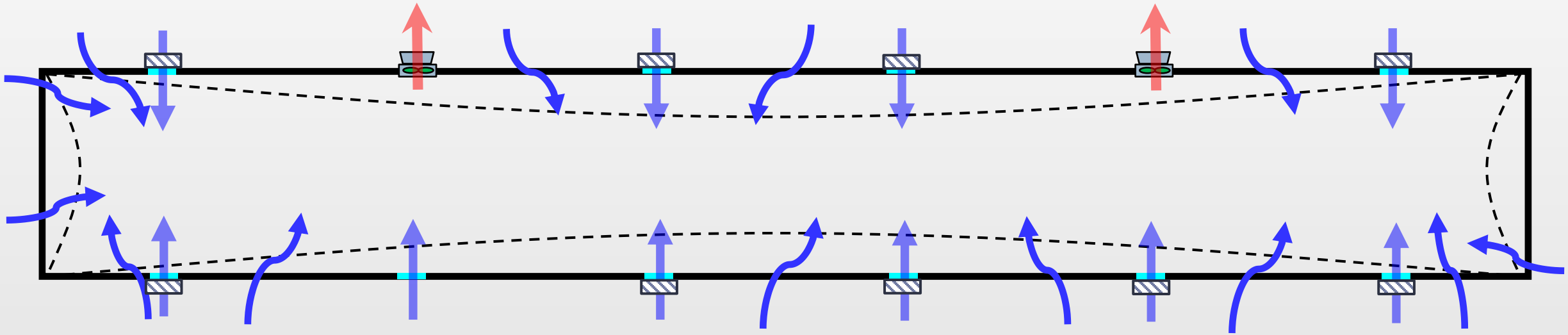
- 15,500 cmh of 25,000 (66%) will enter the house through the inlets



- 9,500 cmh of 25,000 (34%) will enter the house through cracks during minimum ventilation

But again, if were to install filters on the inlets the pressure would increase (+50 Pa) and in turn so would leakage

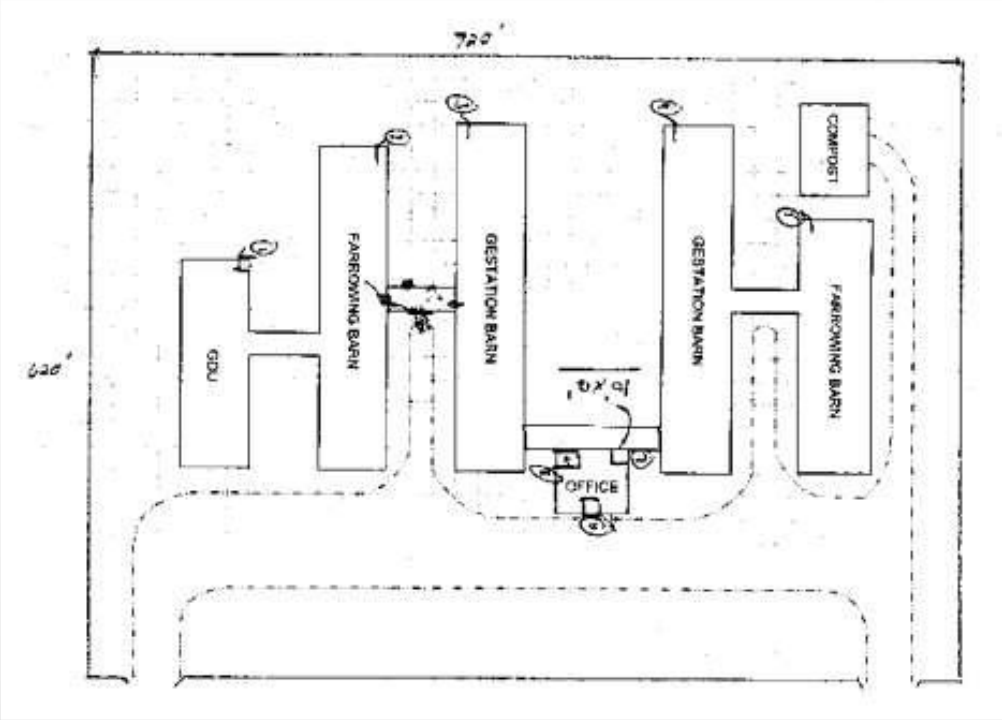
- 12,500 cmh of 25,000 (50%) will enter through inlets



- 12,500 cmh of 25,000 (50%) will enter unfiltered through cracks

A 3,000 head sow operation installed filtration systems in their four houses

- Spent $18,000 just on caulk
  - Used 100 cases of caulk
  - Four men spent two weeks sealing small cracks



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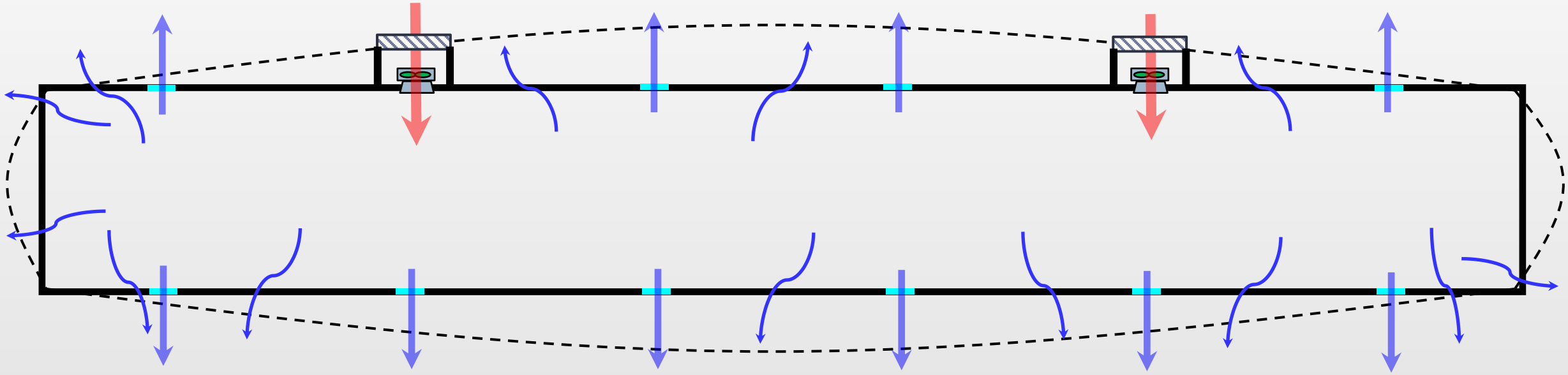
The only true way of totally eliminate pulling a portion of the incoming air through cracks…

- is to use a positive pressure ventilation system



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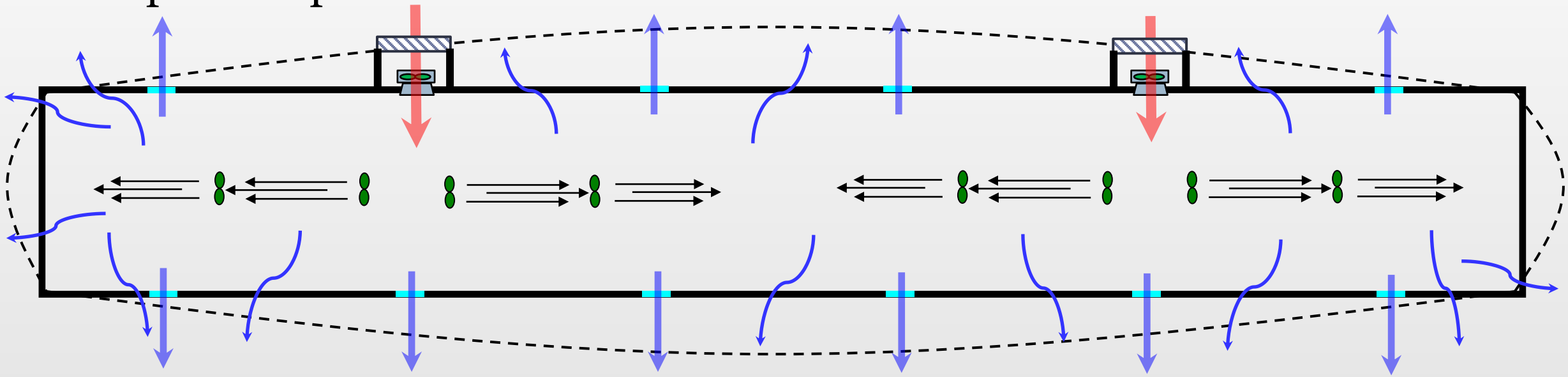
A few of the challenges:

- Outlet openings size have to be controlled to maintain a moderate level of positive pressure



- Can push moisture into walls resulting in building/insulation deterioration
- Circulation fans/Ducts are required to help distribute fresh air

Challenge #2: It is very difficult to pull air through filters

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Air filters ratings are classified by their MERV rating

- Minimum
- Efficiency
- Reporting
- Value

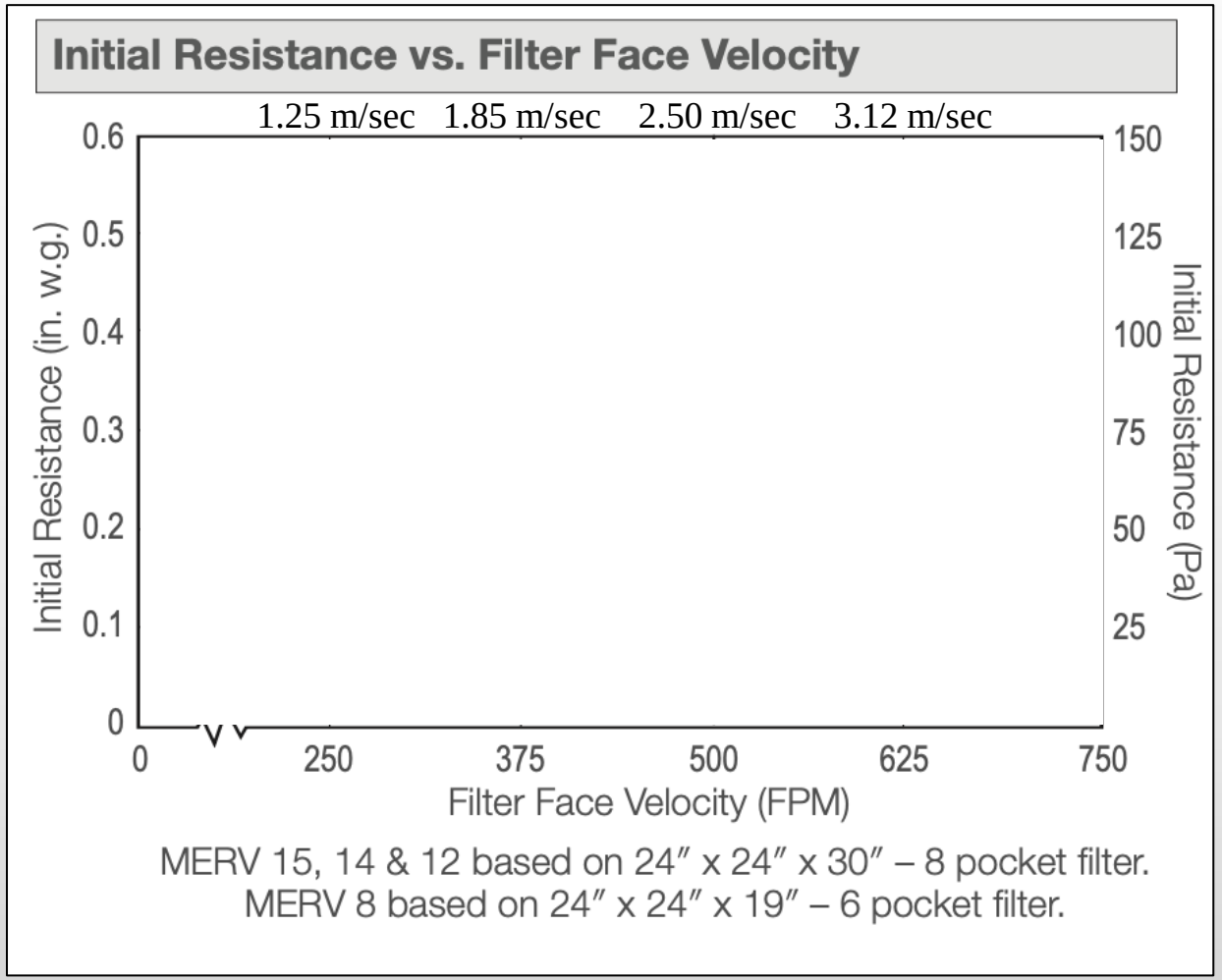
MERV Rating	Will trap air particles size 0.3 to 1.0µm	Will trap air particles size 1.0 to 3.0µm	Will trap air particles size 3.0 to 10.0µm	Filter Type / common particles removed
MERV 1	<20%	<20%	<20%	Fiberglass & aluminum mesh / Pollen, Dust Mites, Spray Paint
MERV 2	<20%	<20%	<20%	
MERV 3	<20%	<20%	<20%	
MERV 4	<20%	<20%	20-34%	
MERV 5	<20%	<20%	35-49%	Cheap disposable filters / Mold spores, cooking dusts, hair spray, furniture polish.
MERV 6	<20%	<20%	50-69%	
MERV 7	<20%	<20%	70-85%	
MERV 8	<20%	<20%	>85%	
MERV 9	<20%	<50%	>85%	Better home box filters / Lead dust, flour, auto fumes, welding fumes.
MERV 10	<20%	50-64%	>85%	
MERV 11	<20%	65-79%	>90%	
MERV 12	<20%	80-90%	>90%	
MERV 13	<75%	>90%	>90%	Superior commercial filters / Bacteria, smoke, sneezes.
MERV 14	75-84%	>90%	>90%	
MERV 15	85-94%	>95%	>90%	
MERV 16	>95%	>95%	>90%	
MERV 17	99.97%	>99%	>99%	HEPA & ULPA / Viruses, carbon dust.
MERV 18	100.00%	>99%	>99%	
MERV 19	100.00%	>99%	>99%	
MERV 20	100.00%	>99%	>99%	

It is not known precisely what the level of filtration is actually required

- But what we do know is that the higher the MERV rating…
- the higher level of insurance

The downside of a higher MERV rating…

- Is the higher the rating, the harder it is to pull air through them…
- and the greater the amount of work required of a house's exhaust fans



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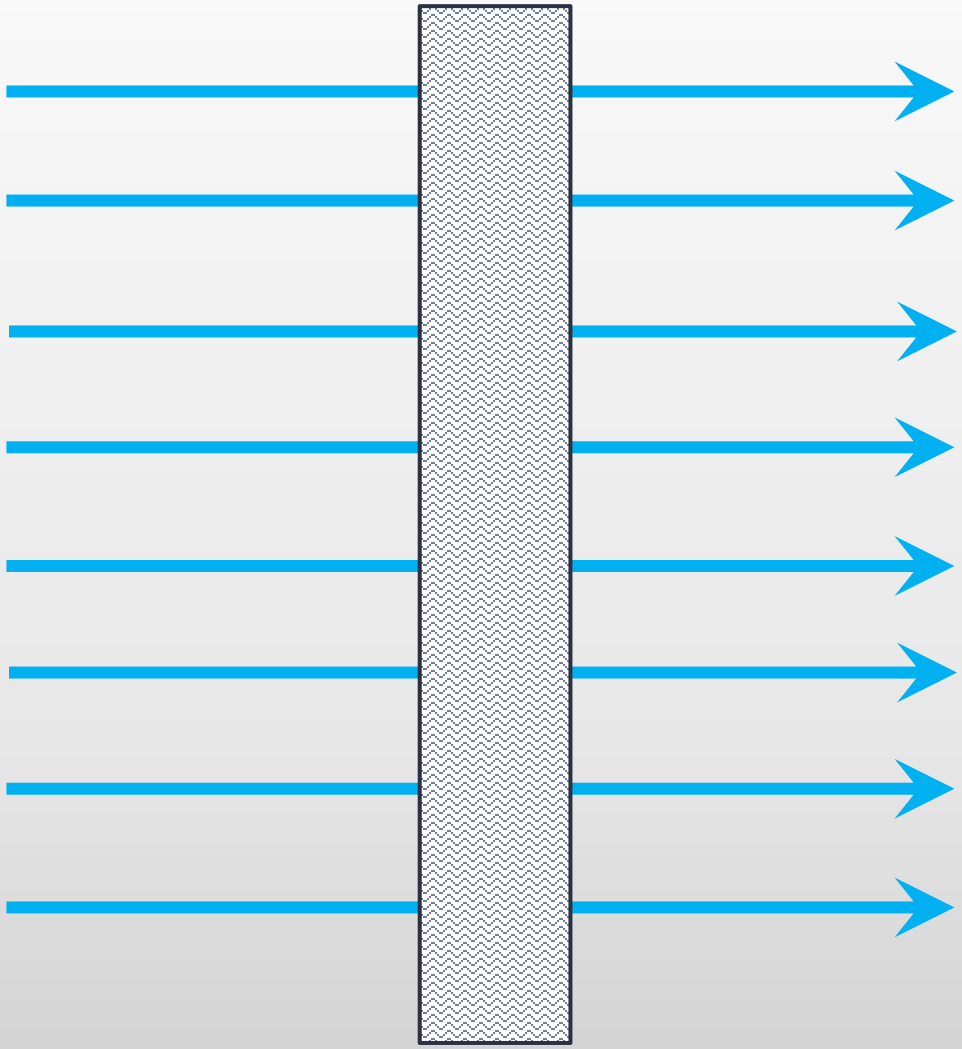
Suggested MERV ratings?

- It is generally recommended MERV 14-16 for use in animal housing
  - MERV 14 = 75-84% effective at trapping 0.3 to 1.0 um particles
  - MERV 16 > 95% effective at trapping 0.3 to 1.0 um particles
- MERV 17-20 (HEPA)
  - 100% effective at trapping 0.3 to 1.0 um particles
  - But exhaust fans have to work over 10 times harder than in a house without any filters

How much work is required to air through a MERV 16 filter?



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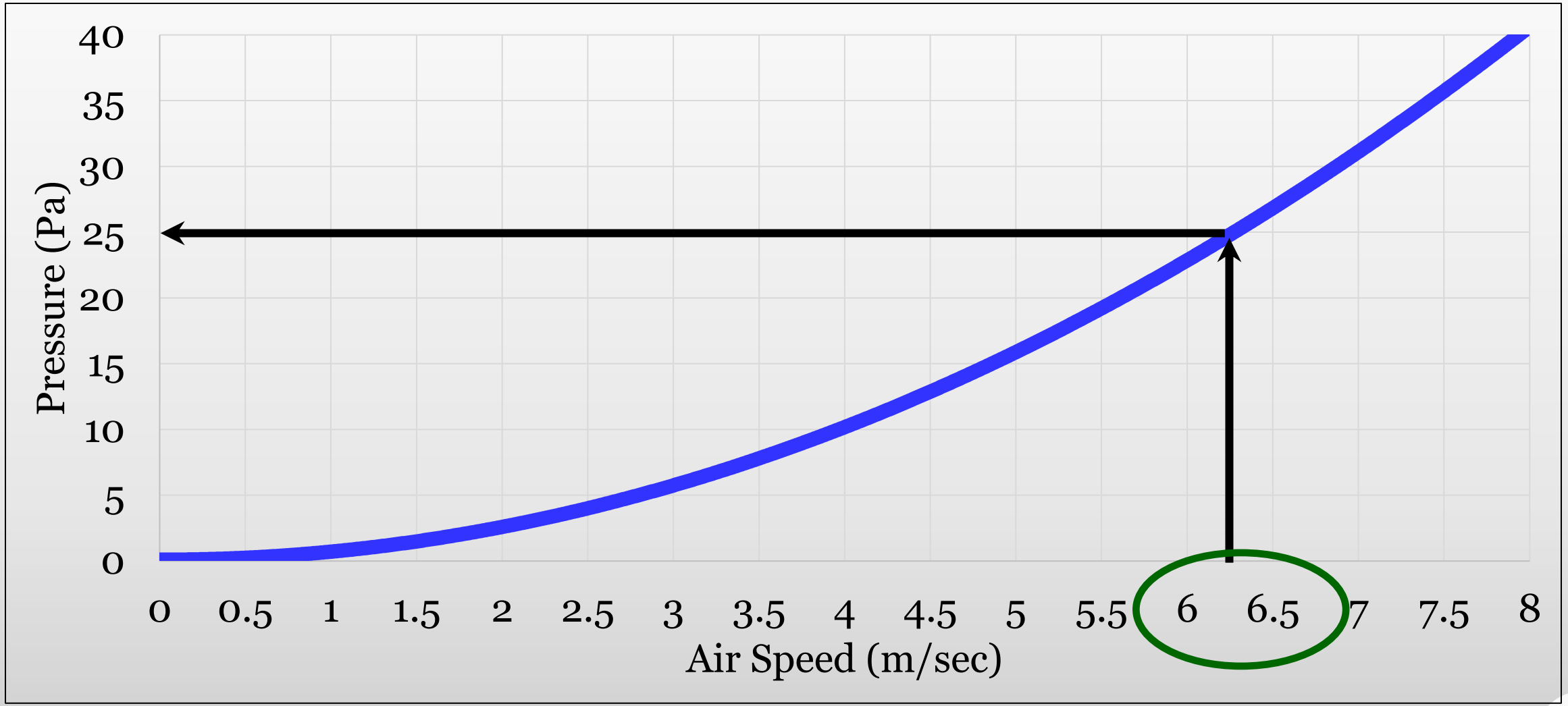
We use static pressure as a measure of work required of an exhaust fan

Work is essentially determined by speed at which the air enters through an inlet…and what is in the inlet



Standard air inlet with no light traps, filters, etc.

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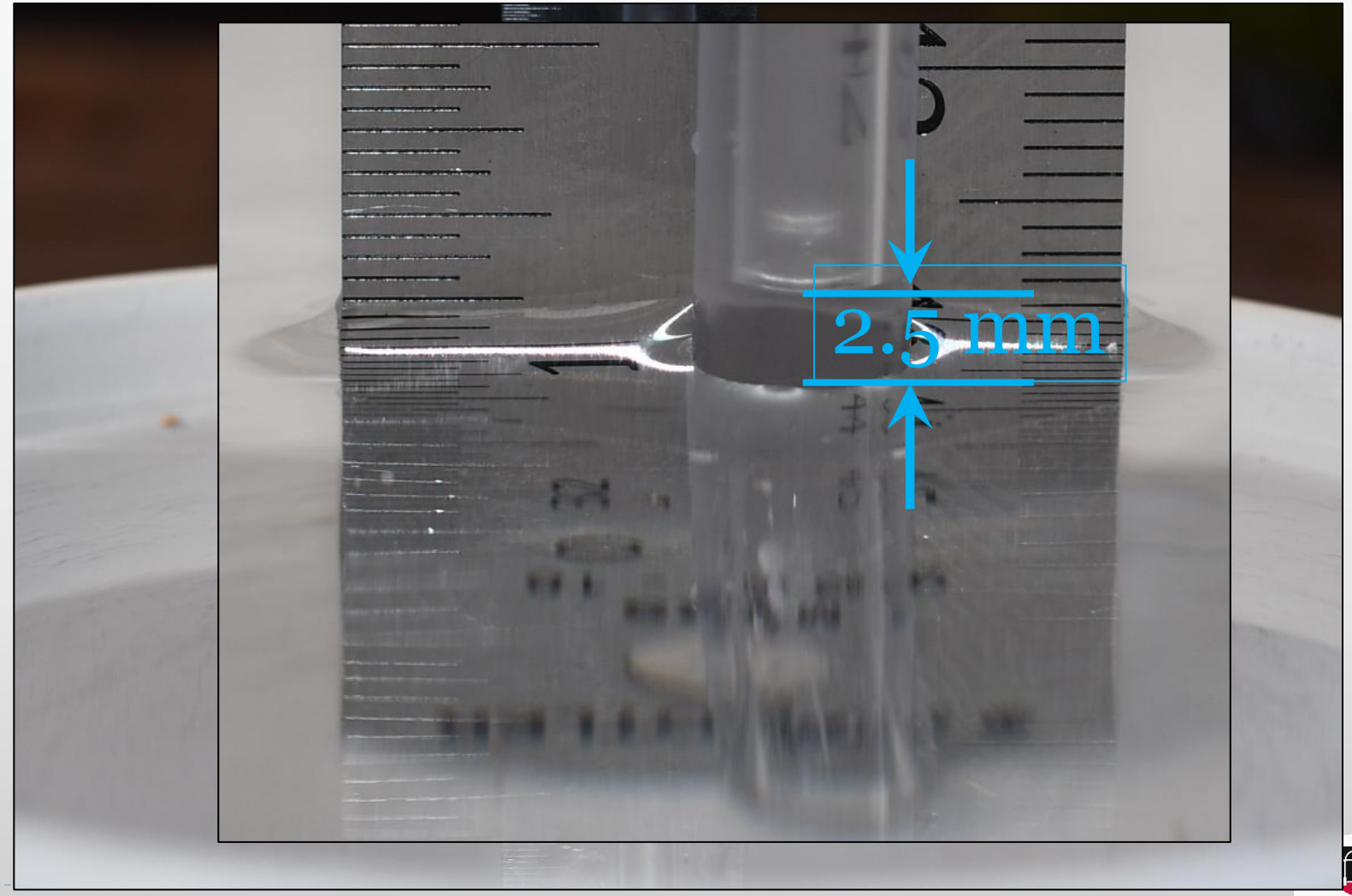
In case you were wondering what 25 Pa really means…



25 Pa is the pressure required to pull water up a straw 2.5 mm

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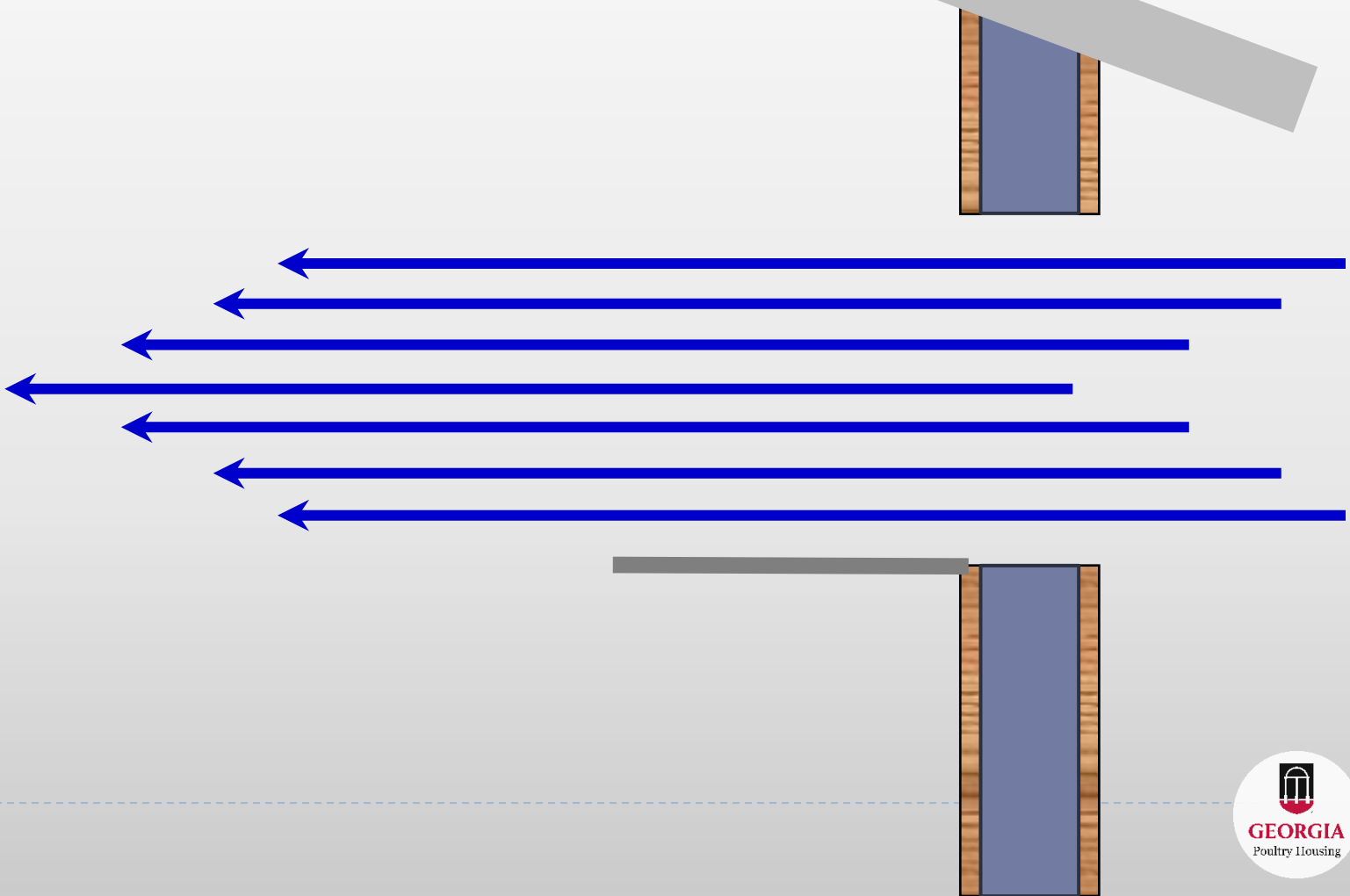
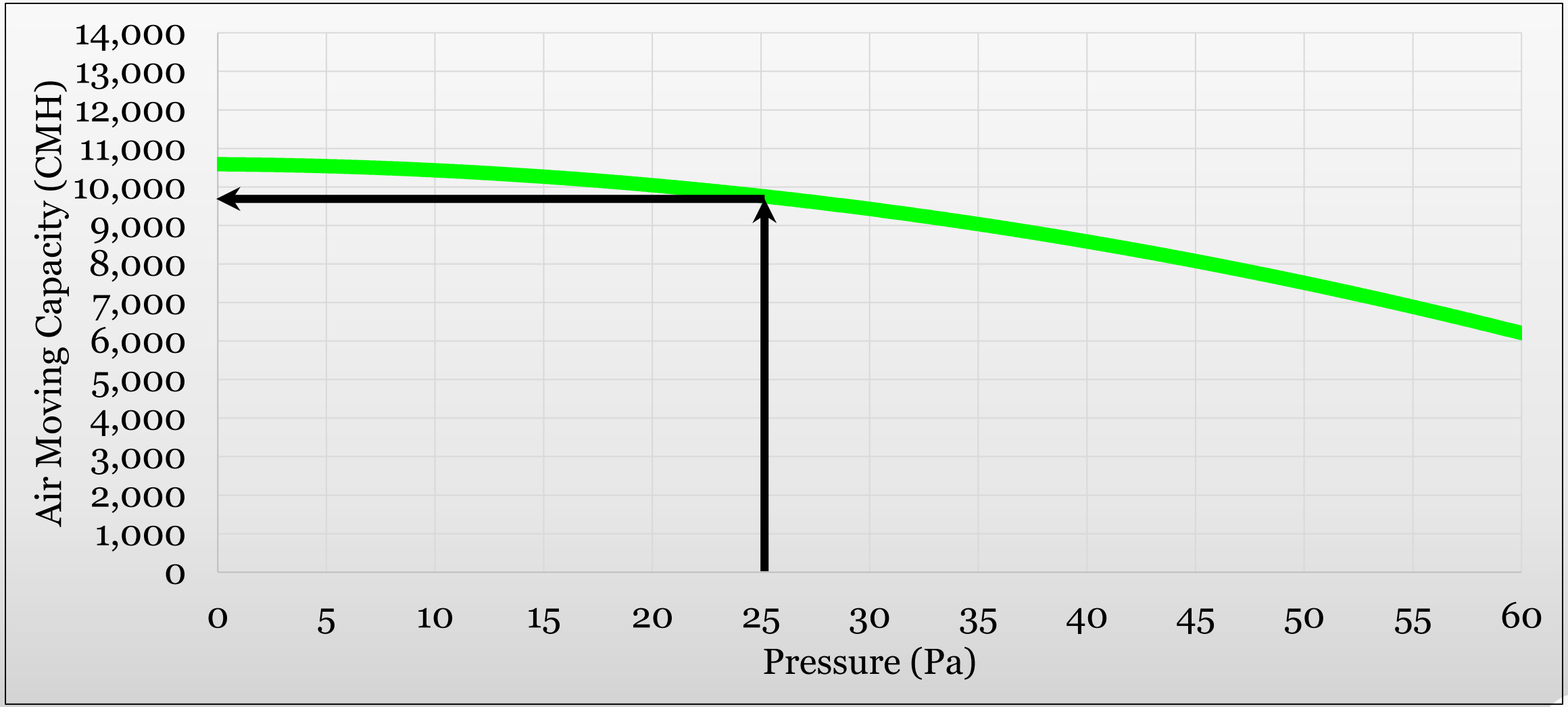
Standard inlet pressure

- Inlet = 25 Pa



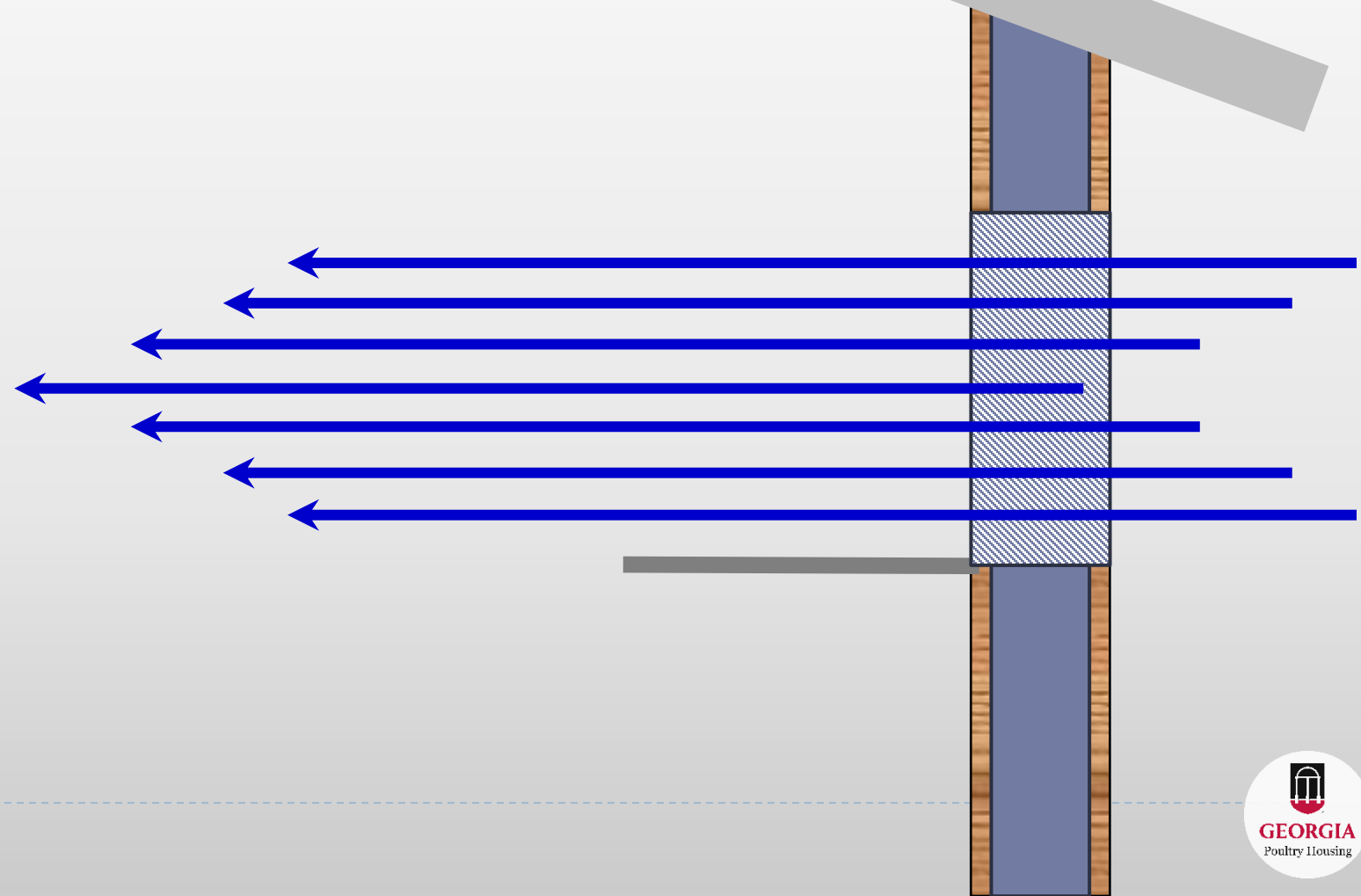
Fairly typical axial 60 cm exhaust fan performance



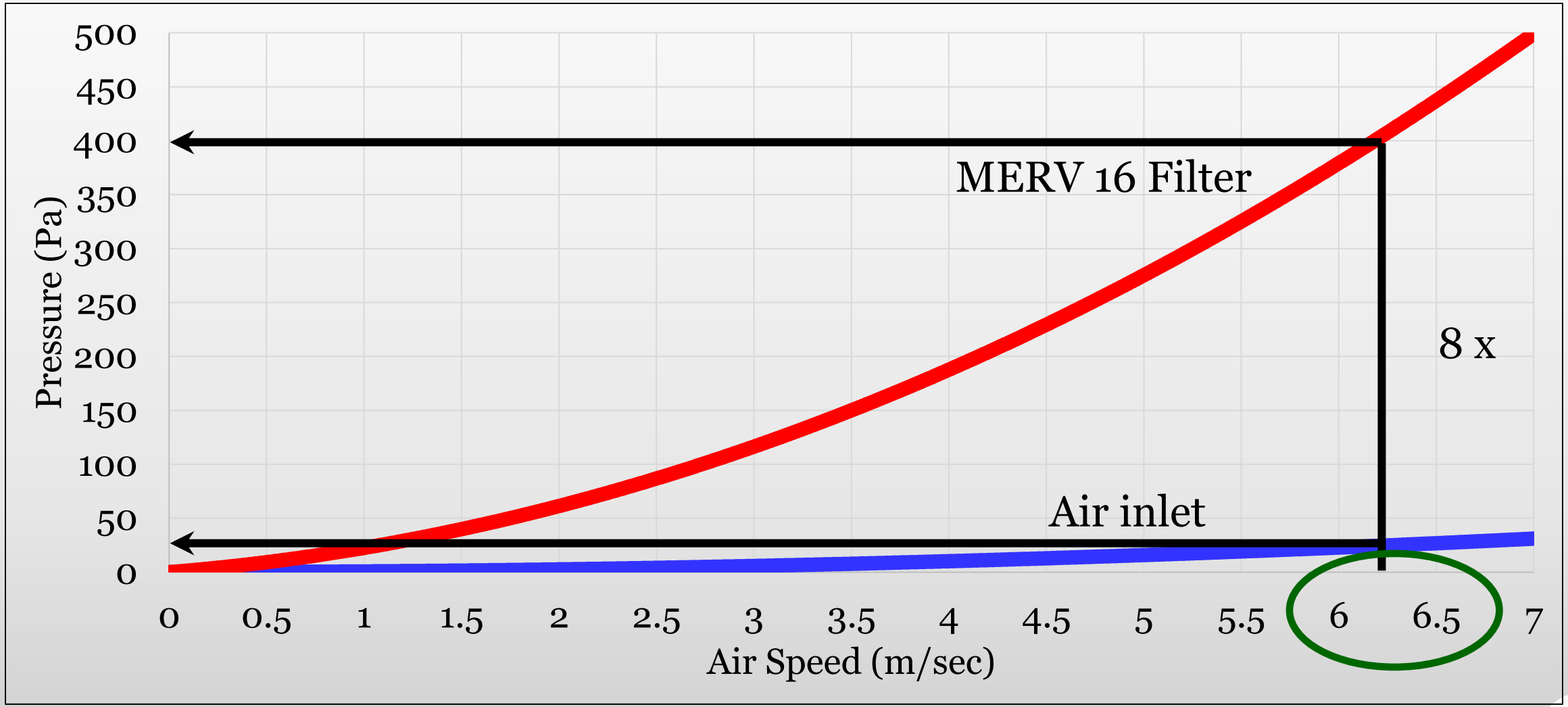
Install a MERV 16 filter in the same opening…

and the work/pressure the exhaust fans are working against will increase

How much?

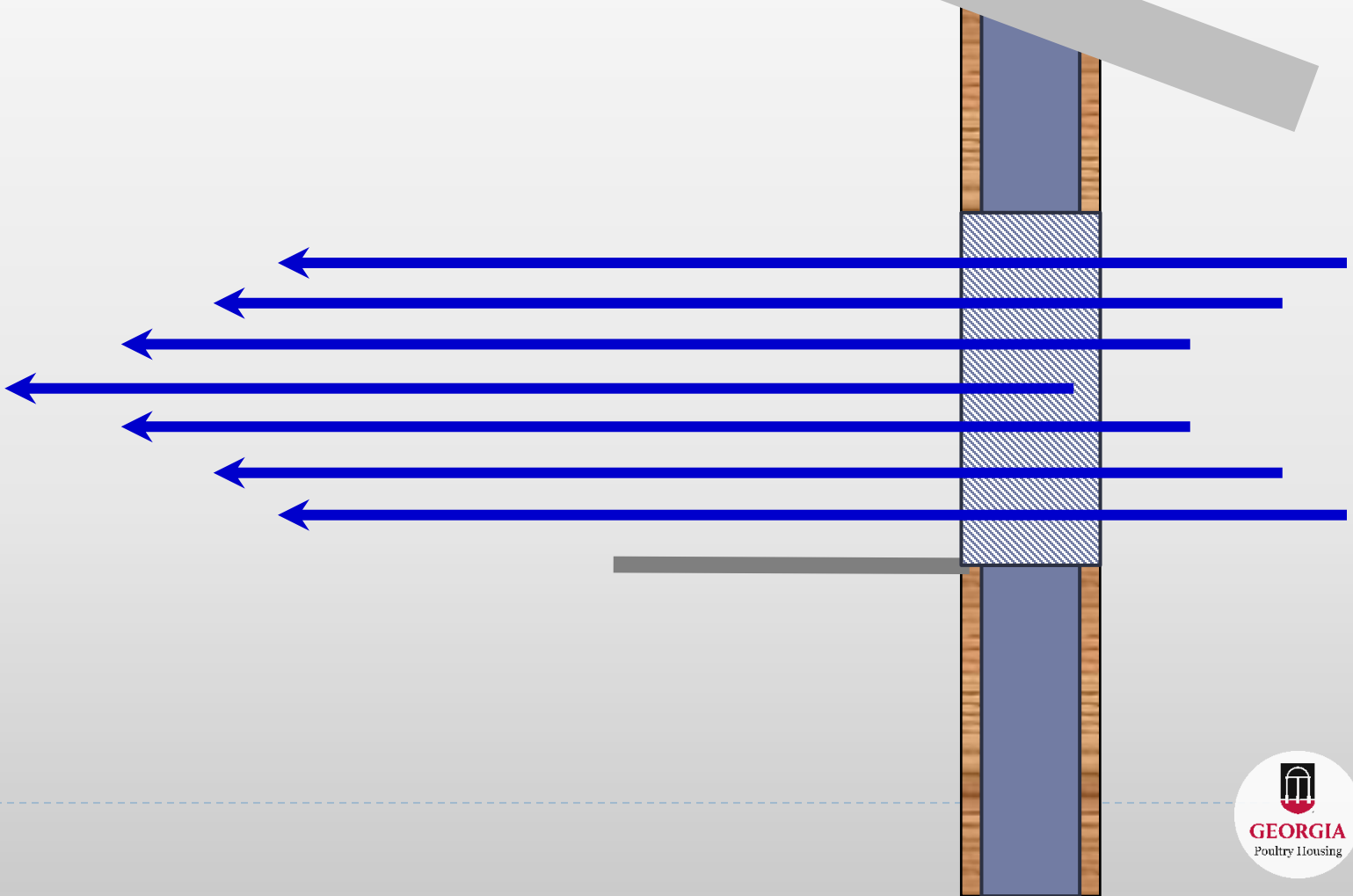


Pressure vs. air velocity



Install a MERV 16 filter in the same opening

- MERV 16 = 400 Pa



Challenge #3: Poultry house exhaust fans are relatively weak

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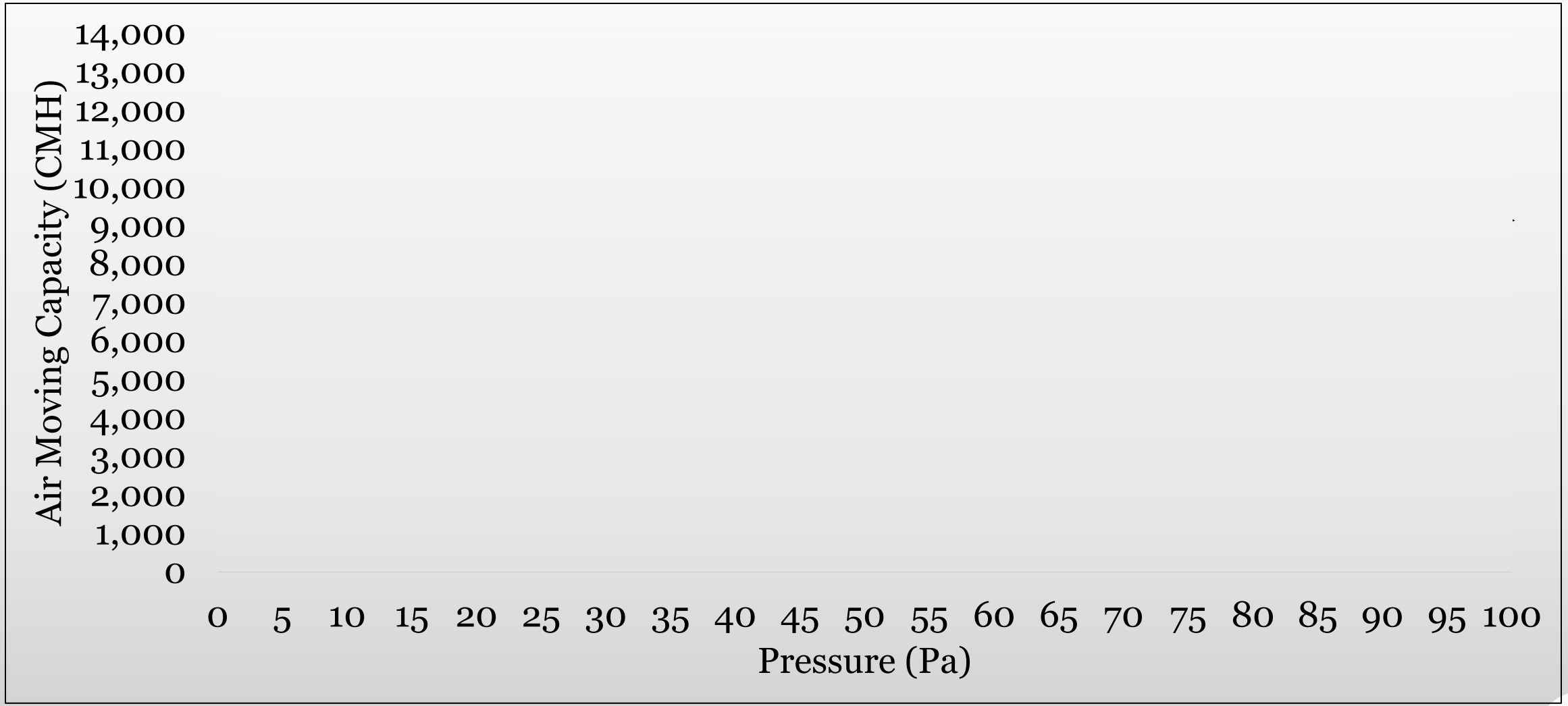
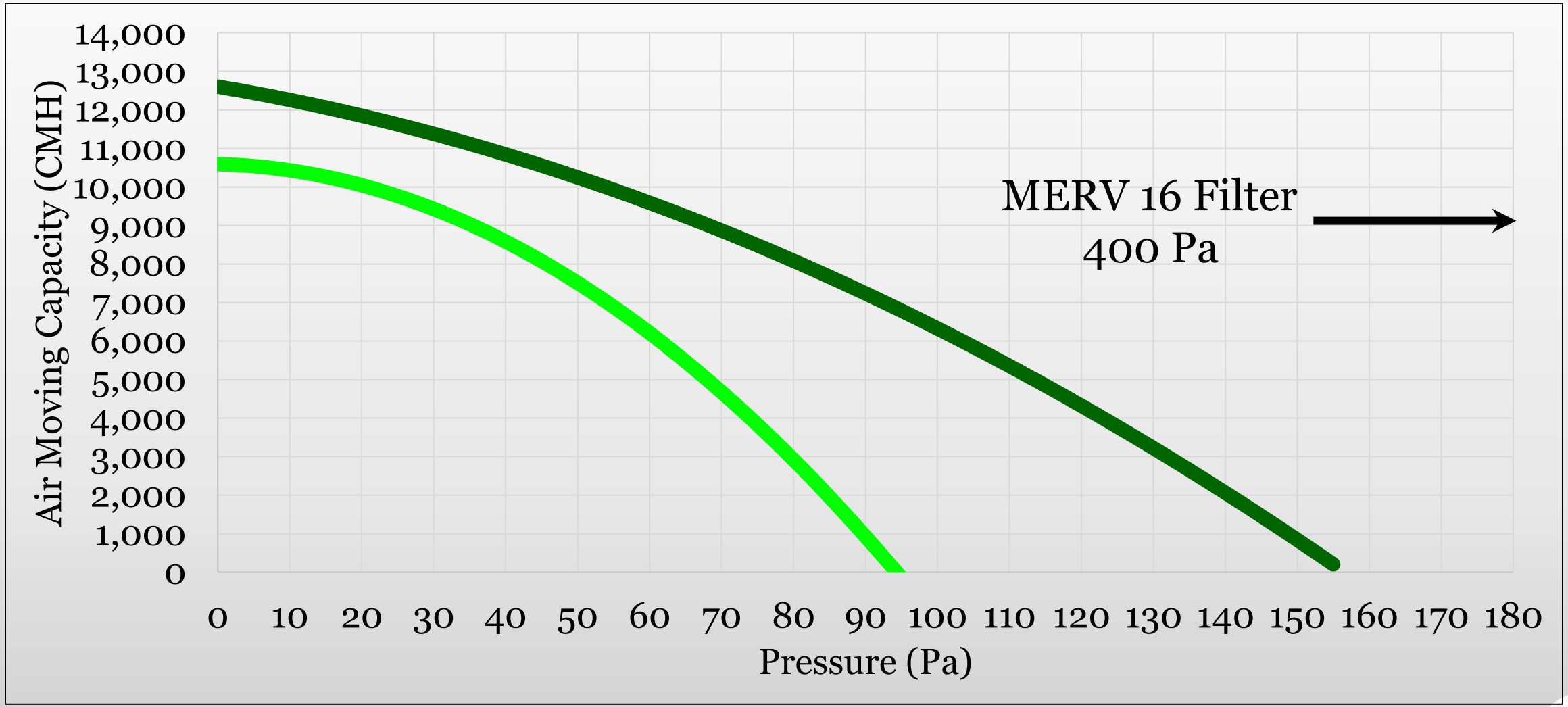
Fairly typical axial 60 cm exhaust fan “stalls” around 80 Pa of pressure



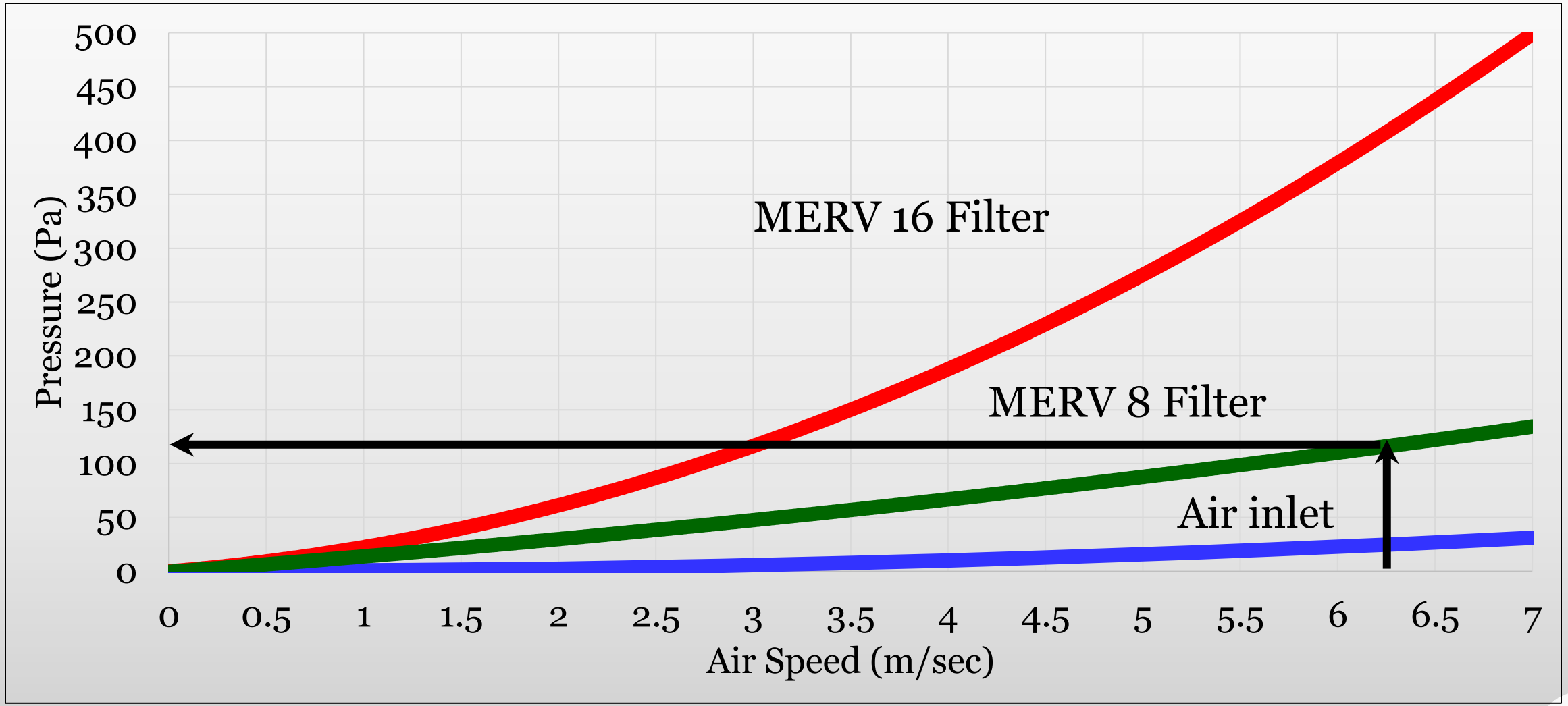
Even our most powerful axial 60 cm exhaust fans can't operate that level of pressure



Making matters worse…

- MERV 8
  - Will trap less than 20% of the particles between 0.3 and 1 micron
  - Will trap > than 85% of the particles between 3 and 10 microns

A prefilter will of course add pressure



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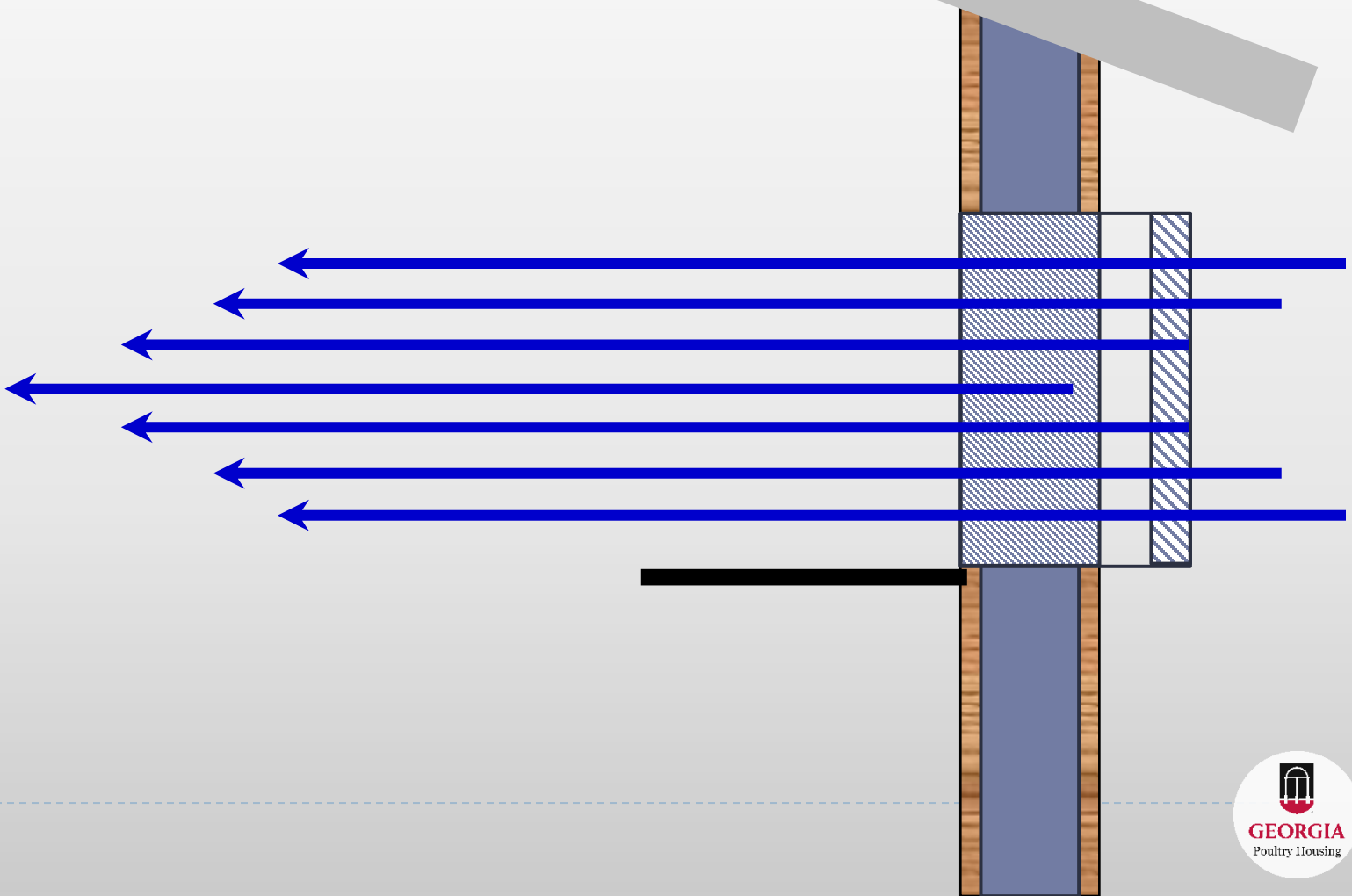
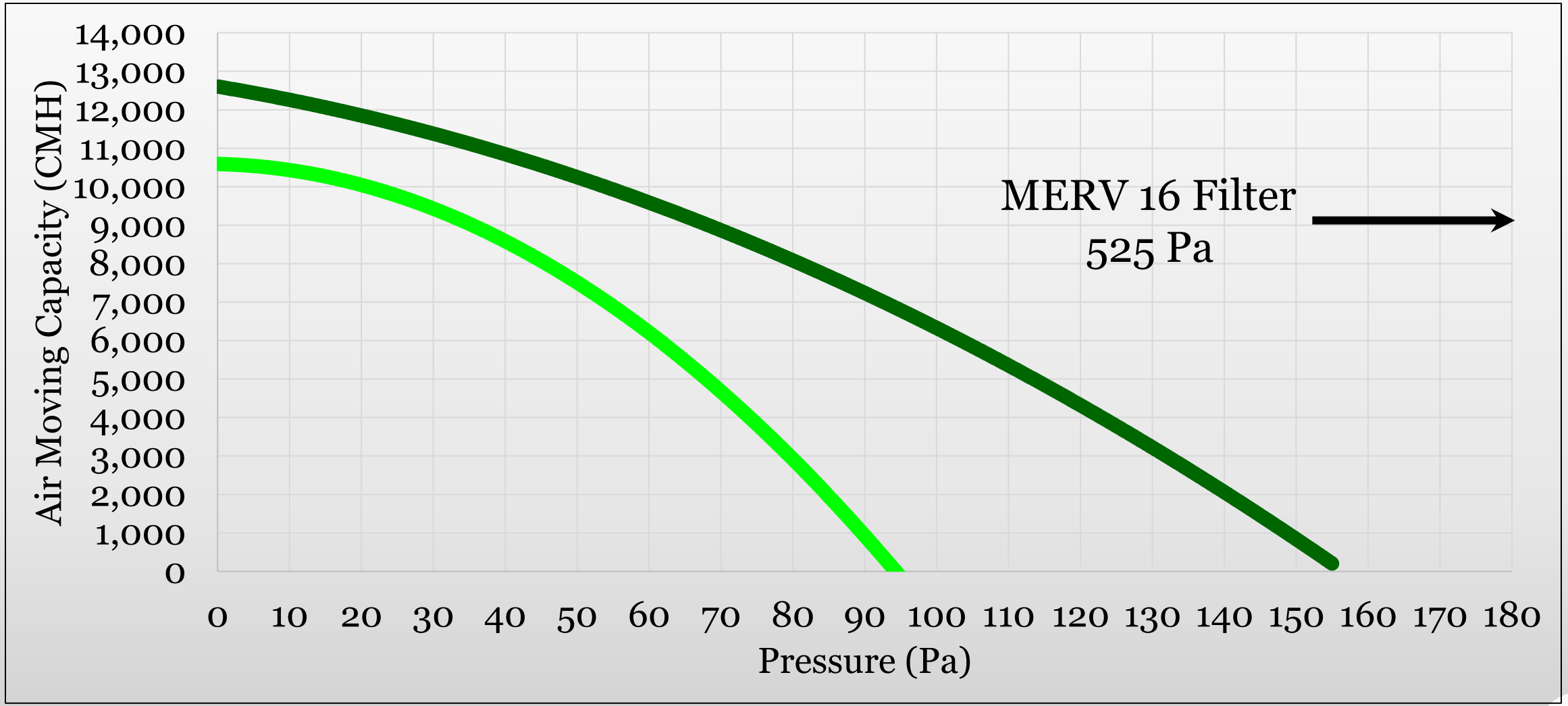
Add a prefilter

- MERV 16 = 400 Pa
- MERV 8 = 125 Pa
- = 525 Pa



Which is obviously well beyond the operating range of any poultry house fan

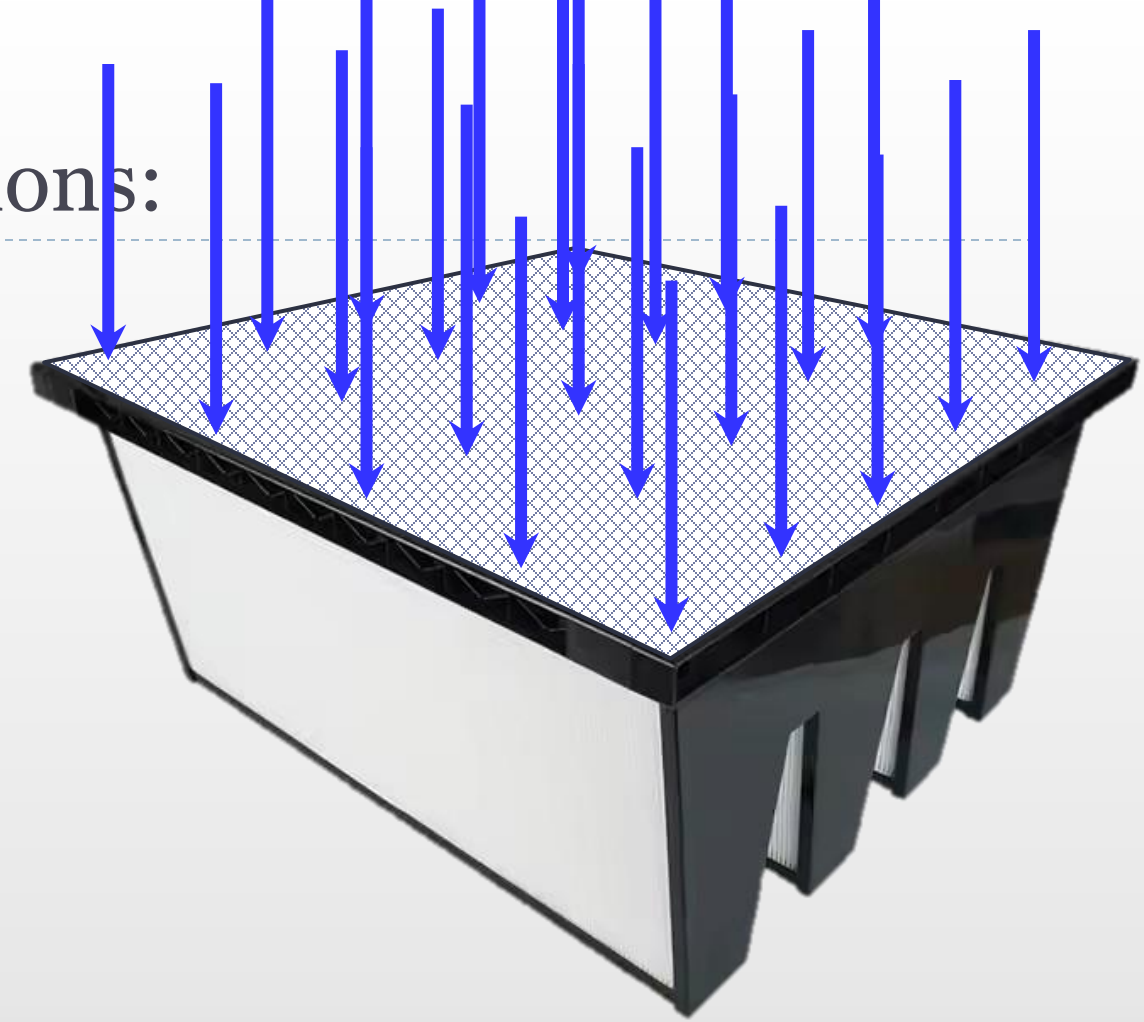


To decrease pressure, we must increase filter area…

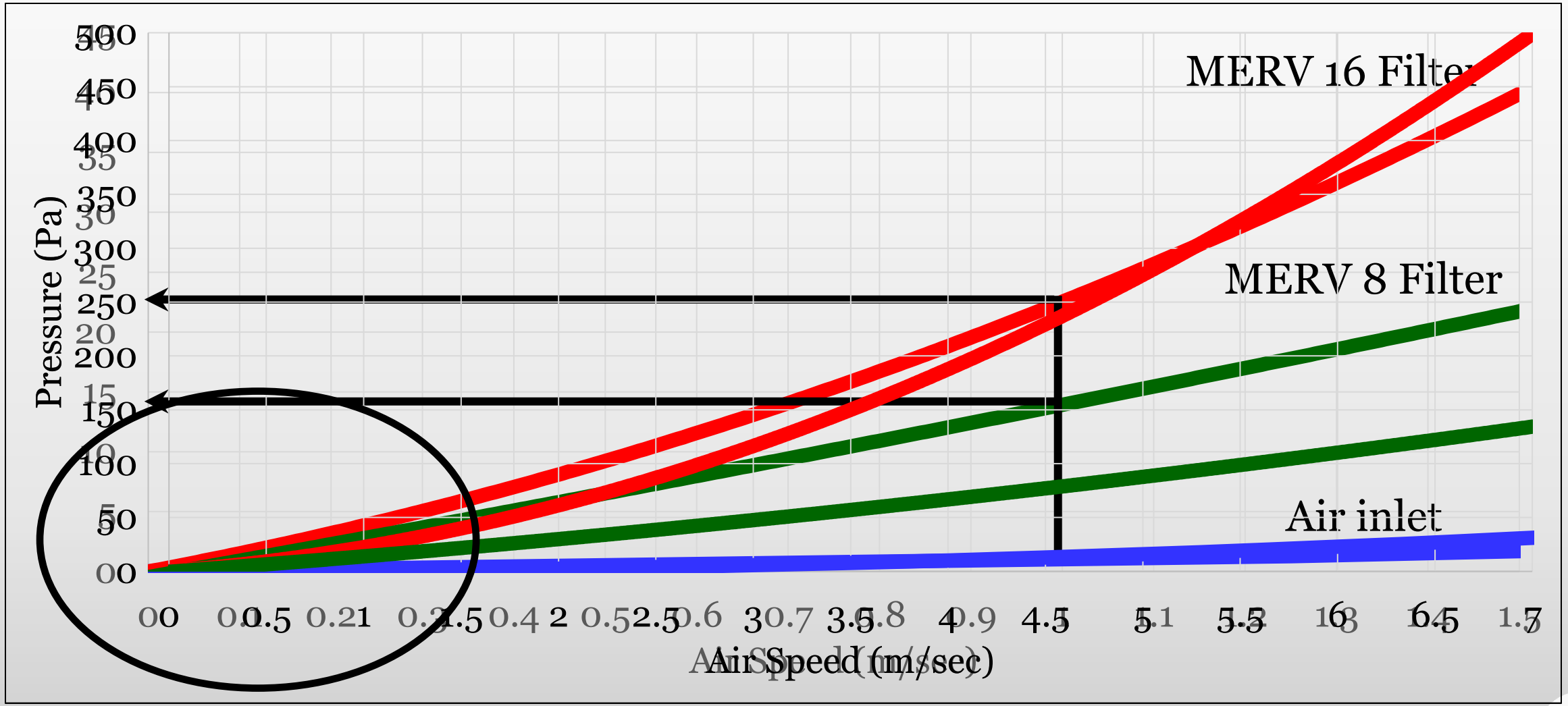
- Increase filter area = reduced filter velocity
- Reduced filter velocity = reduced pressure
- Ideally the total pressure drop across the both filters would not exceed 50 and 60 Pa when using conventional poultry house fans

General filter area recommendations:

- Maximum air speed through the filters should be around 1 m/sec
- At least 1 square meter of filter “area” for every 3,500 m^3/hour of fan capacity.
  - This will vary significantly with:
    - MERV Rating
    - Filter design
    - Manufacturer

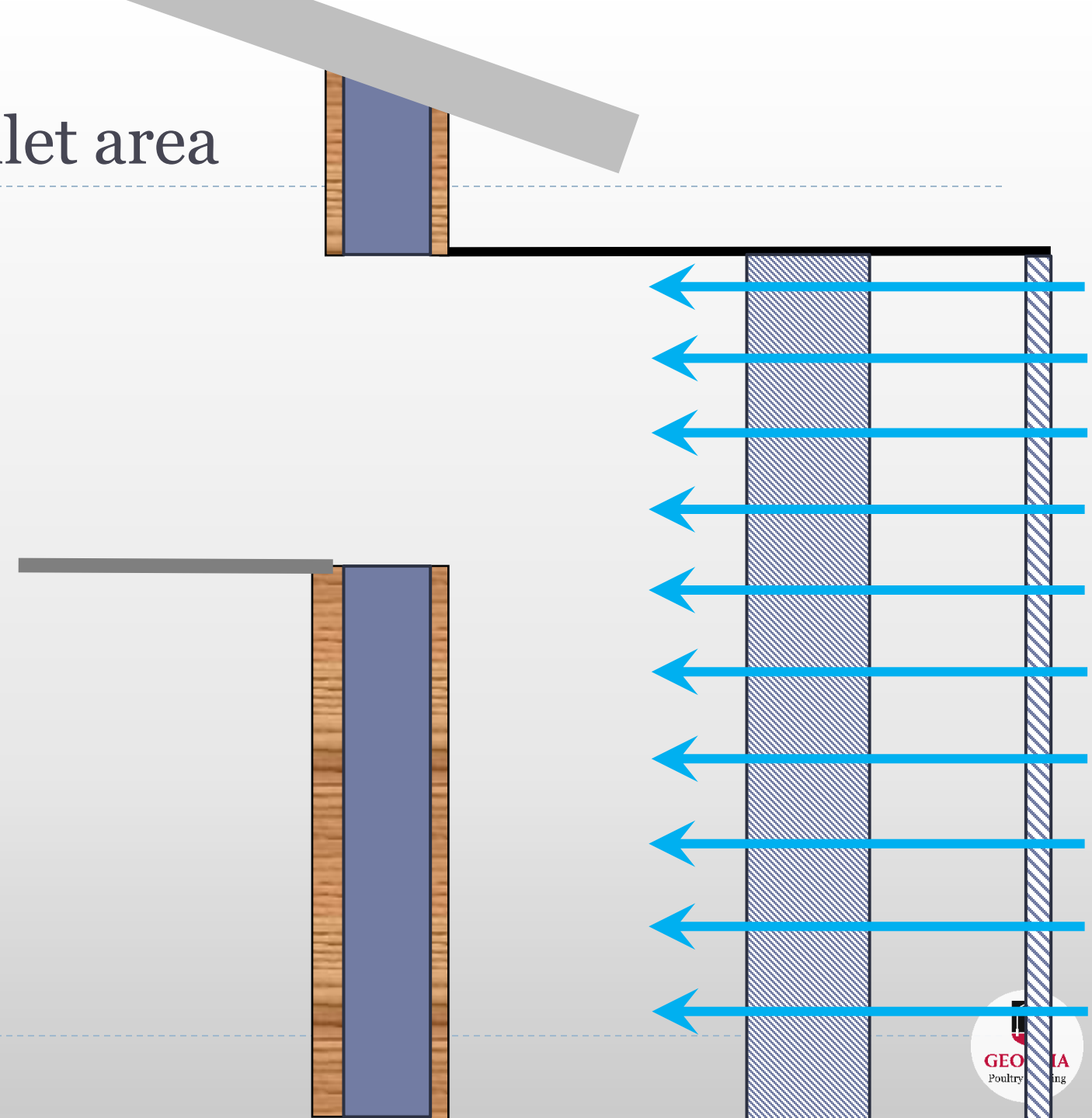


Lower velocity…



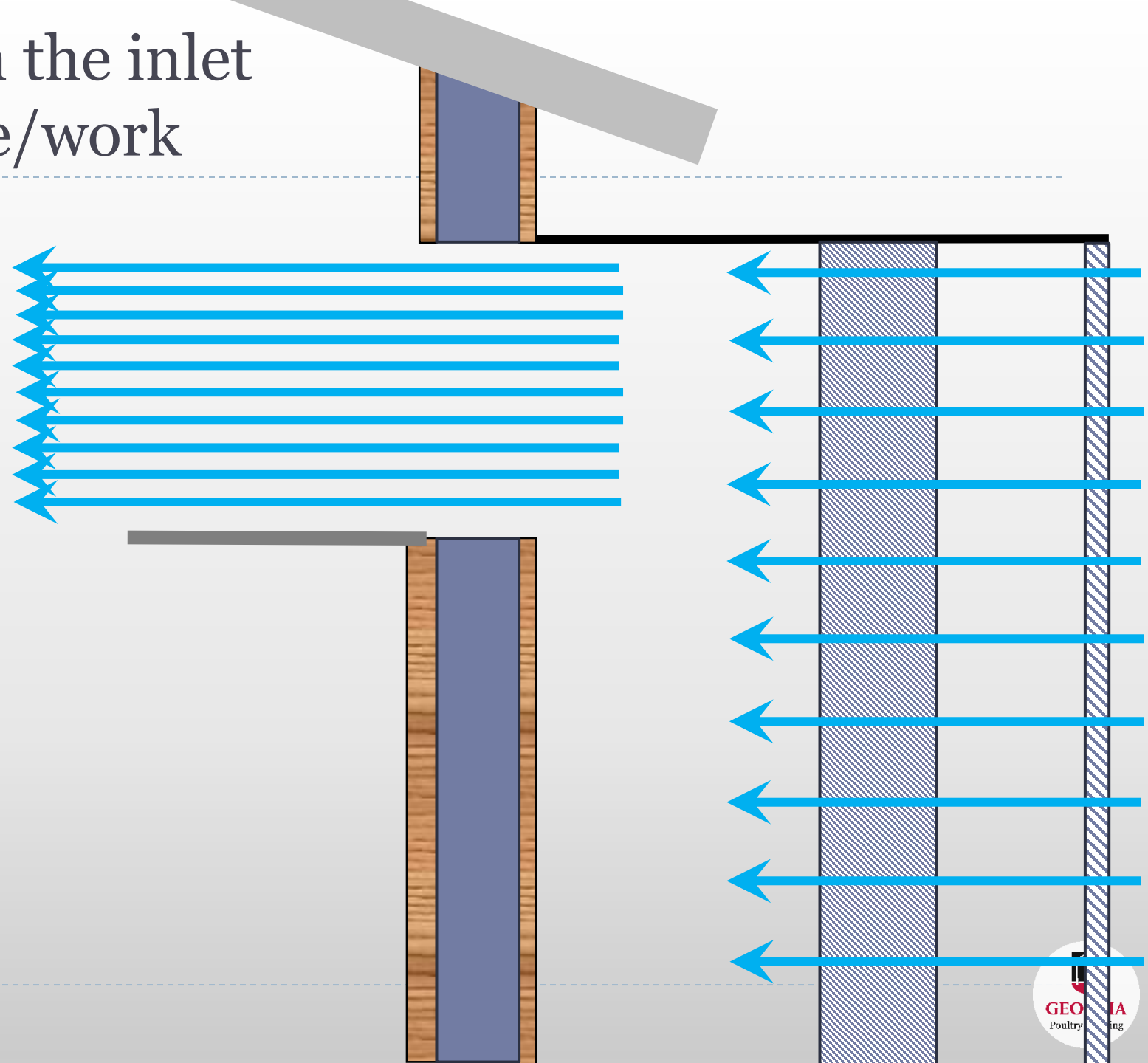
Filter area = at least 4 X inlet area

- MERV 8 = 15 Pa
- MERV 16 = 22 Pa
- = 37 Pa



Pulling the air through the inlet will add more pressure/work

- MERV 16 = 22 Pa
- MERV 8 = 15 Pa
- Inlet = 20 Pa
- = 57 Pa



Fairly typical air inlet = 2,000 m^3/hr

- 1 m^2 of filter for every 3,400 m^3/hr of capacity
- 2,000 m^3/hr inlet = 0.6 m^2 of filter area
  - 2,000 m^3/hr / 3,400 m^3/hr = 0.6 m^2
- Standard filter size = 0.4 m^2 (55 cm X 55 cm)
  - 0.6 m^2/0.4 m^2 = 1.5 filters

=

+

+

+

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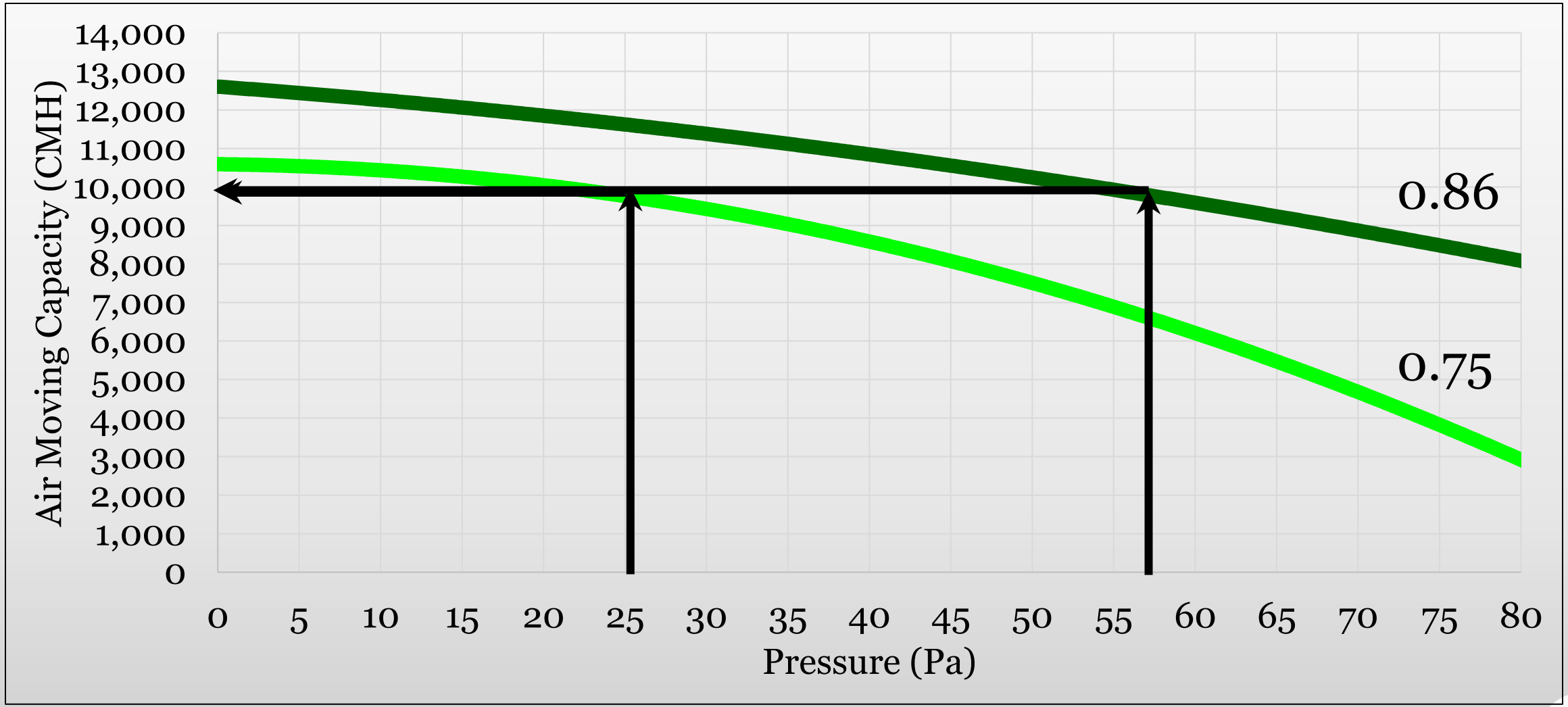
Desirable exhaust fan pressure characteristics:

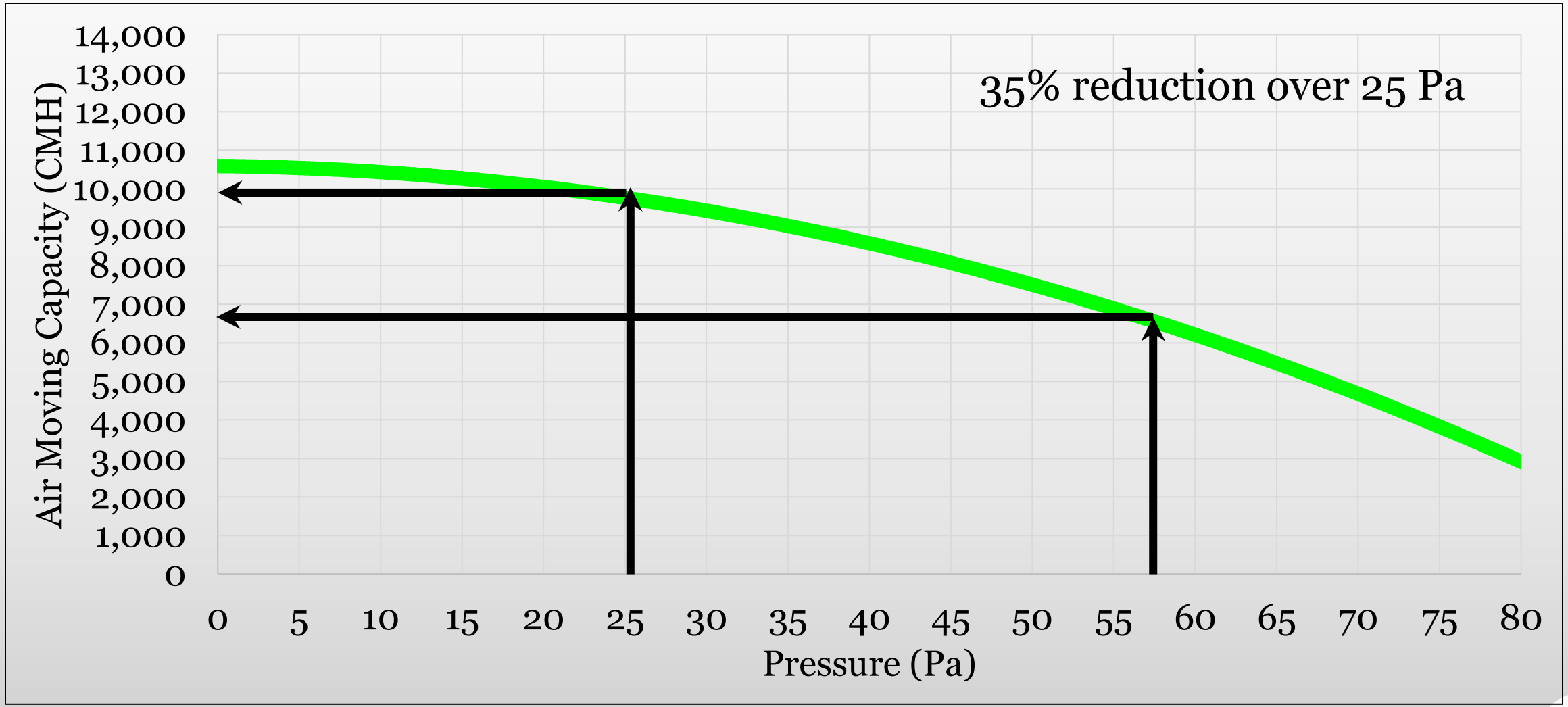
- We need fans that can hold up under high static pressures
  - Air flow ratio = 0.80 or greater.
- A fan's air flow ratio is determined by dividing its air moving capacity at 50 Pa by its air moving capacity at 13 Pa.
- The higher the air flow ratio the less a fan's air moving capacity will decrease as the pressure it is working against increases

High and low AFR axial 60 cm exhaust fan



Challenge #4: Reduced exhaust fan performance

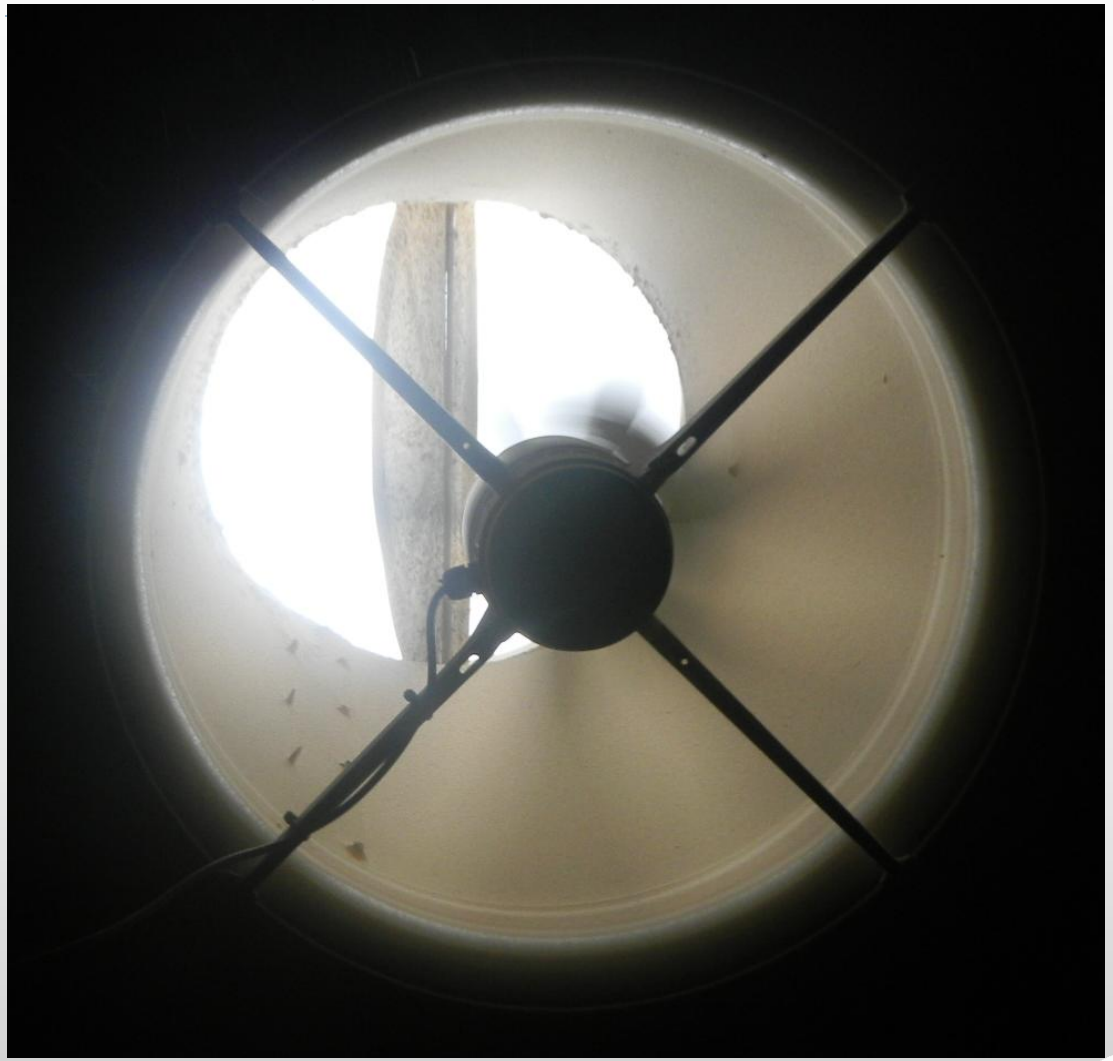
Fans will move less air at the higher operating pressure



25 Pa vs. 50 Pa (Typical 60 cm axial fan)

- 25 Pa = 414 watts - 23 cmh/watt
- 50 Pa = 417 watts - 14.6 cmh/watt

- An exhaust fan doesn't typically use dramatically more power when operating at a high pressure…
- but it will move significantly less air…
- Which can mean you have to operate 20-40% more fan capacity to move the same amount of air



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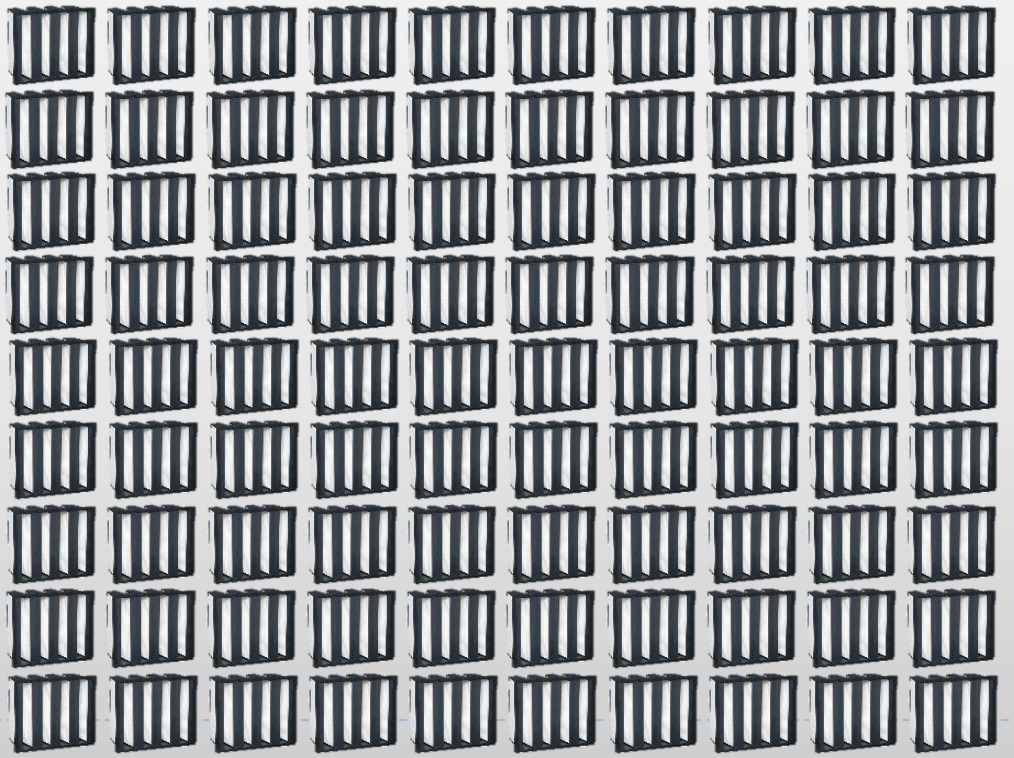
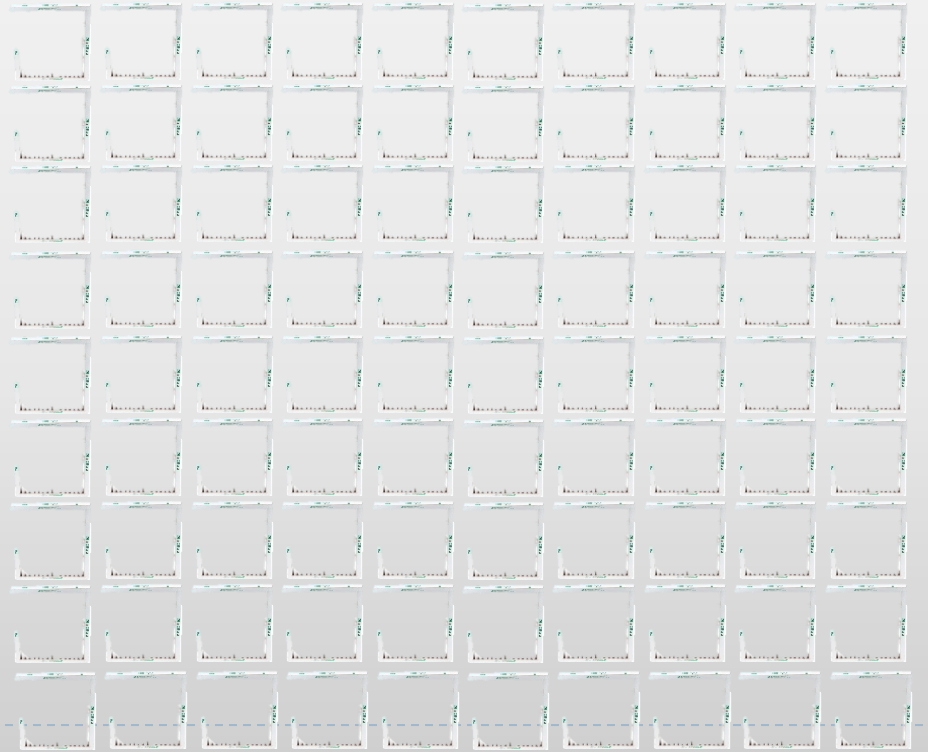
How much exhaust fan capacity should be filtered?

- Ideally all of it..
- But at a minimum a filtration system should be sized to have a capacity of at least 2.5 m^3/hr per kg to handle bird ventilation needs in the winter, early spring and fall.

15 m X 100 m house with a stocking density of 32 kg/m²…

- 32 kg/m² x 2.5 m³/hr per kg = 80 m³/hr per m²
- 15 m X 100 m X 80 m³/hr per m² = 120,000 m³/hr
- 120,000 m³/hr /2,000 m³/hr per inlet = 60 inlets with filters
- 1.5 filters per inlet X 60 inlets =





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Challenge #5: Initial cost

- The approximate cost in the U.S. of a MERV14 filter is approximately $90-$130 per 1,000 cmh.
- MERV16 filter = $130-$200 per 1,000 cmh
- This does not include:
  - filter housing
  - house modifications
  - potentially new fans and/or additional fans
  - improving house tightness
  - new doors
  - new fan shutters…

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Or back draft protection

- “Socks/caps” need to be installed on all exhaust fans

Challenge #5: Initial cost

- In the U.S. swine industry, the installation of MERV 14-16 filtration systems has been shown to increase the cost of a house's ventilation system by more than five-fold
- not including additional costs for construction/installation

Challenge #5: Initial cost



- FAPP ventilation systems are extremely expensive (roughly $2,000 per 1,000 cmh) and historically only been used in research facilities and specific pathogen free (SPF) egg production for vaccines.

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Challenge #5: Initial cost

- Specialized fans operating at 250 – 500 Pa
- Requiring very large, powerful motors…
- which use a lot of power

Challenge #6: Filter maintenance

- MERV 8 prefilters may need replacing twice a year

Challenge #6: Filter maintenance

- MERV 8 prefilters may need replacing twice a year
- MERV 16 filters should be able to go a few years without replacement
- Good news = efficiency will increase over time
- Bad news = pressure will increase over time
- Is important to keep in mind the filters must not get wet

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09/14/2009

Final points…

- Filtration systems MUST be designed by a qualified engineer in order:
  - To ensure system effectiveness at keeping viruses out of a house
  - To ensure that proper environmental conditions will be able to be maintained for the birds throughout the year

Final points…

- Filtration does not guarantee that you will not have a disease break
- Traditionally there is a higher likelihood that a virus will “walk” its way into a house than enter through a house’s inlet system

Department of Poultry Science

College of Agricultural & Environmental Sciences

UNIVERSITY OF GEORGIA

UGA Poultry Housing

Poultryventilation.com