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Ventilation system management - the balance between energy conservation and air quality

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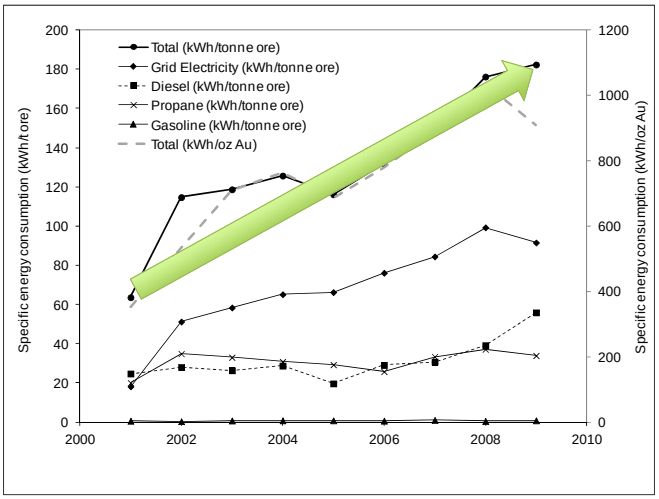
Energy consumption increases as mines get deeper



(Levesque *et al.*, 2014)

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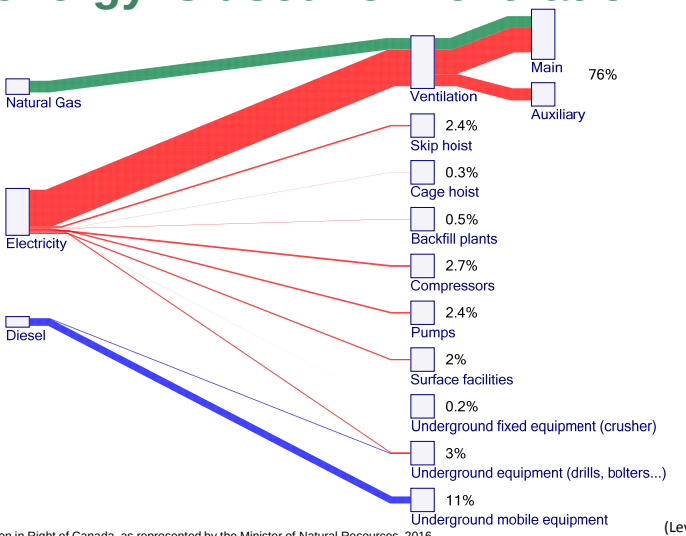
Energy audit shows that 76% of all energy is used for ventilation



(Levesque, 2015)

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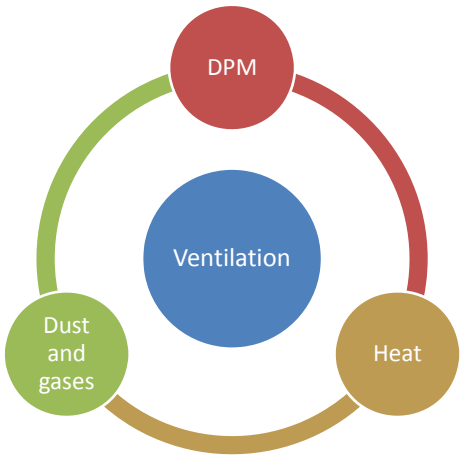
Ventilation is essential to ensure adequate air quality in mines



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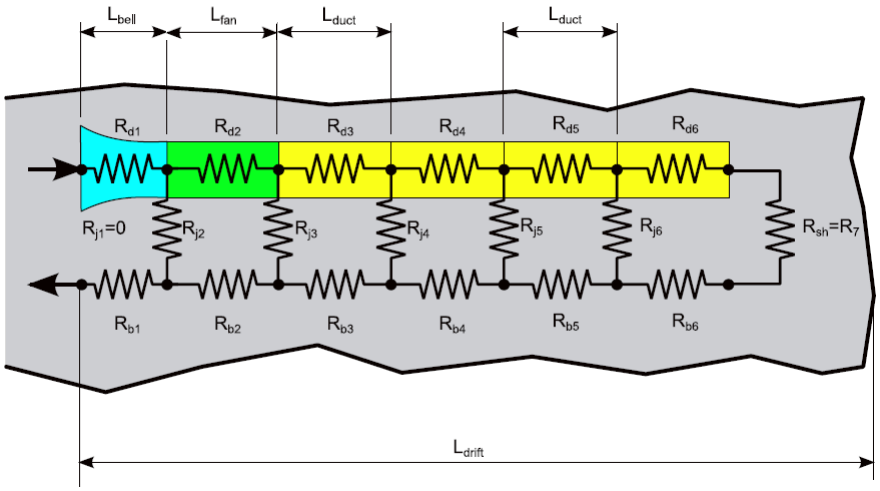
Leakage can affect air quality… but how does it impact energy?



(Levesque, 2015)

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Hypothetical cases were examined using these input values

Constants	
Duct diameter	1.2 m (48'')
Total duct length	250 m (820 ft)
Fan model	Alphair 4800—VAX-2700
Fan speed	1780 rpm fixed speed

Variables			
	Low	Medium	High
Leakage (Ns^2/m^8)	1.0 E+07	2.0 E+05	1.0 E+04
Friction factor (kg/m^3) [imperial]	0.0018 [9.7]	0.0021 [11]	0.0037 [20]

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Several output values will be used to assess system performance

Q fan (m^3/s)	Airflow through the fan
Q face (m^3/s)	Airflow at end of duct
% loss	Airflow lost between fan and end of duct
Fan power (kW)	Power consumed by fan
COV ($kW/m^3/s$)	Ratio of power to airflow at end of duct

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More air passes through the fan with low roughness and high leakage

(Millar, Levesque, and Hardcastle, 2016)

Roughness	Leakage	Low	Medium	High
Low	Q fan (m^3/s)	39.5	40.7	43.6
	Q face (m^3/s)	38.6	34.9	24.0
	% loss	2	14	45
	Fan power (kW)	114.6	113.2	106.7
	COV ($kW/m^3/s$)	3.0	3.2	4.4
Medium	Q fan (m^3/s)	38.6	39.9	43.1
	Q face (m^3/s)	37.6	34.0	23.1
	% loss	2	15	46
	Fan power (kW)	115.4	114.1	108.3
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	Q face (m^3/s)	33.2	29.9	19.7
	% loss	3	17	52
	Fan power (kW)	118.6	117.0	113.0
	COV ($kW/m^3/s$)	3.6	3.9	5.7

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More air gets to the face with low leakage and roughness

(Millar, Levesque, and Hardcastle, 2016)

Roughness	Leakage	Low	Medium	High
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Air losses in ventilation systems increase with friction and leakage

(Millar, Levesque, and Hardcastle, 2016)

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Fan power declines as leakage rises and roughness decreases

(Millar, Levesque, and Hardcastle, 2016)

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Cost of Ventilation (COV) increases with duct roughness

(Millar, Levesque, and Hardcastle, 2016)

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20% **22%** **30%**

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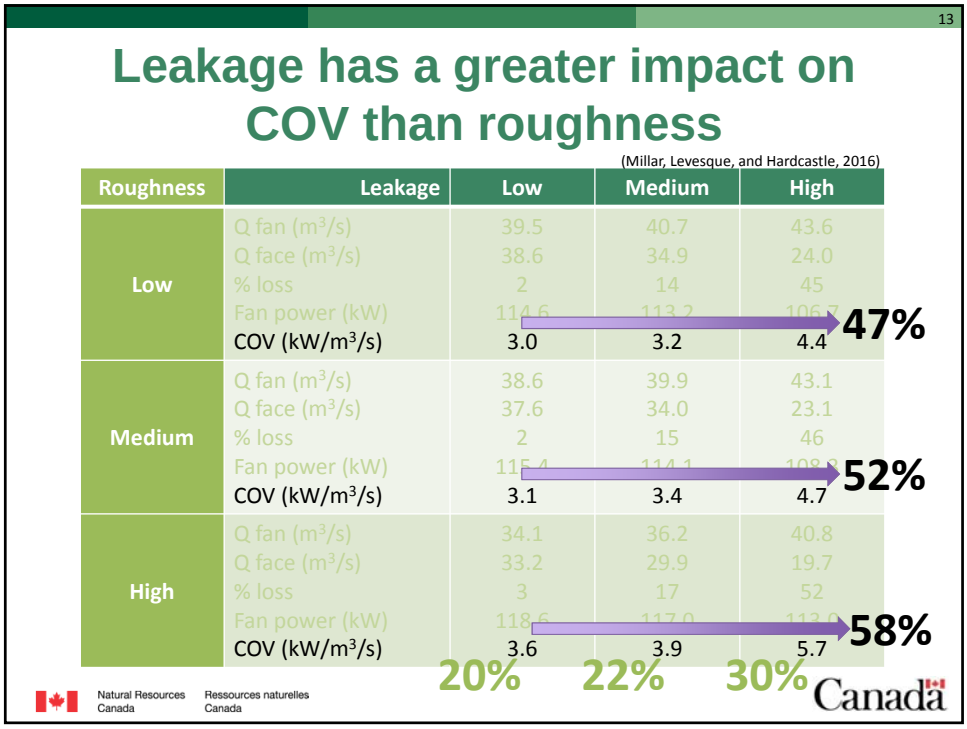
13
Leakage has a greater impact on COV than roughness
(Millar, Levesque, and Hardcastle, 2016)
Roughness | Leakage | Low | Medium | High
Low
Q fan (m³/s) 39.5 40.7 43.6
Q face (m³/s) 38.6 34.9 24.0
% loss 2 14 45
Fan power (kW) 114.6 113.2 106.7
COV (kW/m³/s) 3.0 3.2 4.4
47%
Medium
Q fan (m³/s) 38.6 39.9 43.1
Q face (m³/s) 37.6 34.0 23.1
% loss 2 15 46
Fan power (kW) 115.4 114.1 108.3
COV (kW/m³/s) 3.1 3.4 4.7
52%
High
Q fan (m³/s) 34.1 36.2 40.8
Q face (m³/s) 33.2 29.9 19.7
% loss 3 17 52
Fan power (kW) 118.6 117.0 113.0
COV (kW/m³/s) 3.6 3.9 5.7
58%
20%
22%
30%
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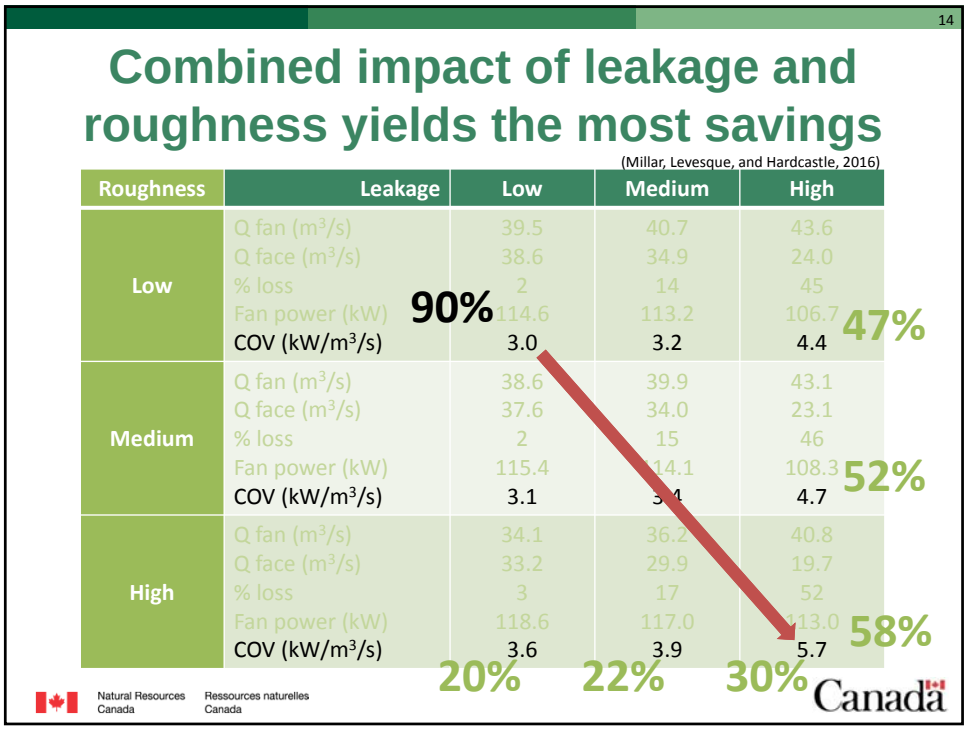
14
Combined impact of leakage and roughness yields the most savings
(Millar, Levesque, and Hardcastle, 2016)
Roughness | Leakage | Low | Medium | High
Low
Q fan (m³/s) 39.5 40.7 43.6
Q face (m³/s) 38.6 34.9 24.0
% loss 2 14 45
Fan power (kW) 114.6 113.2 106.7
COV (kW/m³/s) 3.0 3.2 4.4
90%
47%
Medium
Q fan (m³/s) 38.6 39.9 43.1
Q face (m³/s) 37.6 34.0 23.1
% loss 2 15 46
Fan power (kW) 115.4 114.1 108.3
COV (kW/m³/s) 3.1 3.4 4.7
52%
High
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58%
20%
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30%
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Managed ventilation systems: air quantity vs quality

- Better monitoring technology and improved air utilization are needed for energy efficiency and worker protection
- Improved monitoring can help maximize the benefits of automated ventilation systems (VOD)
- Project undertaken within UDMN to:
  - Assess current monitoring technology – CO, CO_2, NO, NO_2, DPM
  - Compare 100cfm/bhp vs CSA diesel engine certification quality based ventilation rates
  - Verify diesel exhaust gases and DPM are suitably diluted
  - Test local controlled recirculation to enhance dust clearance at face and air velocity for cooling in haulage drift

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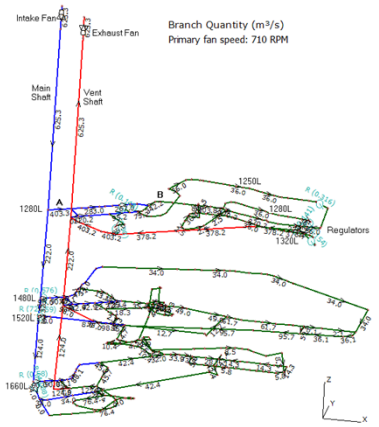
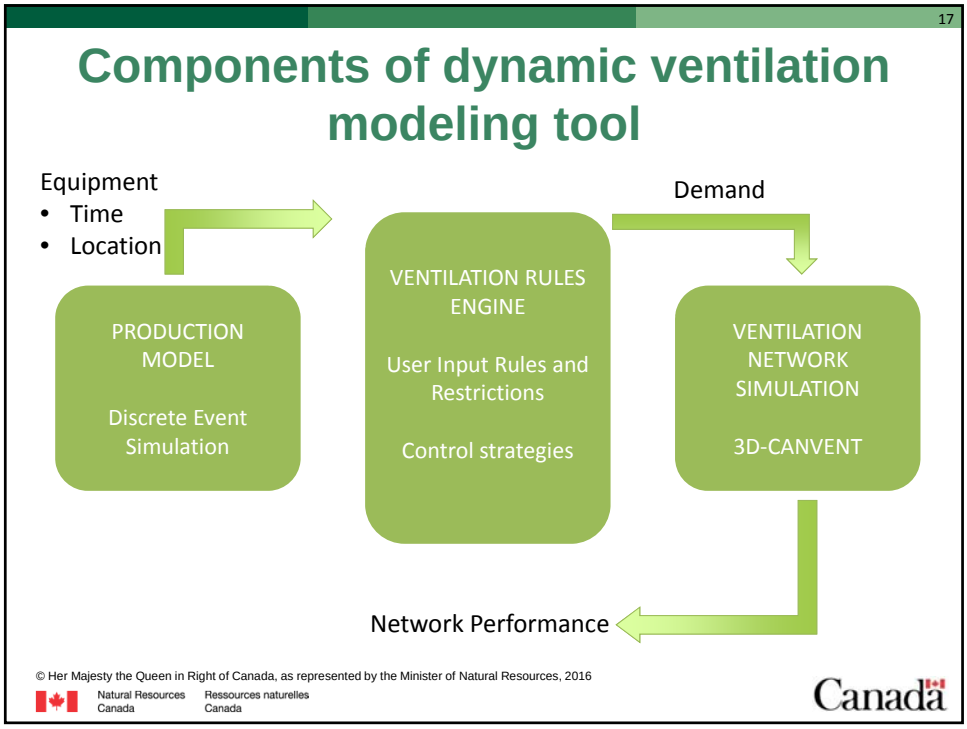
Development of a decision support tool for ventilation systems

- Assessment of impact of changes in ventilation systems is not trivial – complexity and interconnections
- A model could be used to:
  - enhance adoption of operational, technological, and regulatory options
  - evaluate cost benefit arising from changes in ventilation systems

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Components of dynamic ventilation modeling tool
Equipment
• Time
• Location
Demand
PRODUCTION MODEL
Discrete Event Simulation
VENTILATION RULES ENGINE
User Input Rules and Restrictions
Control strategies
VENTILATION NETWORK SIMULATION
3D-CANVENT
Network Performance
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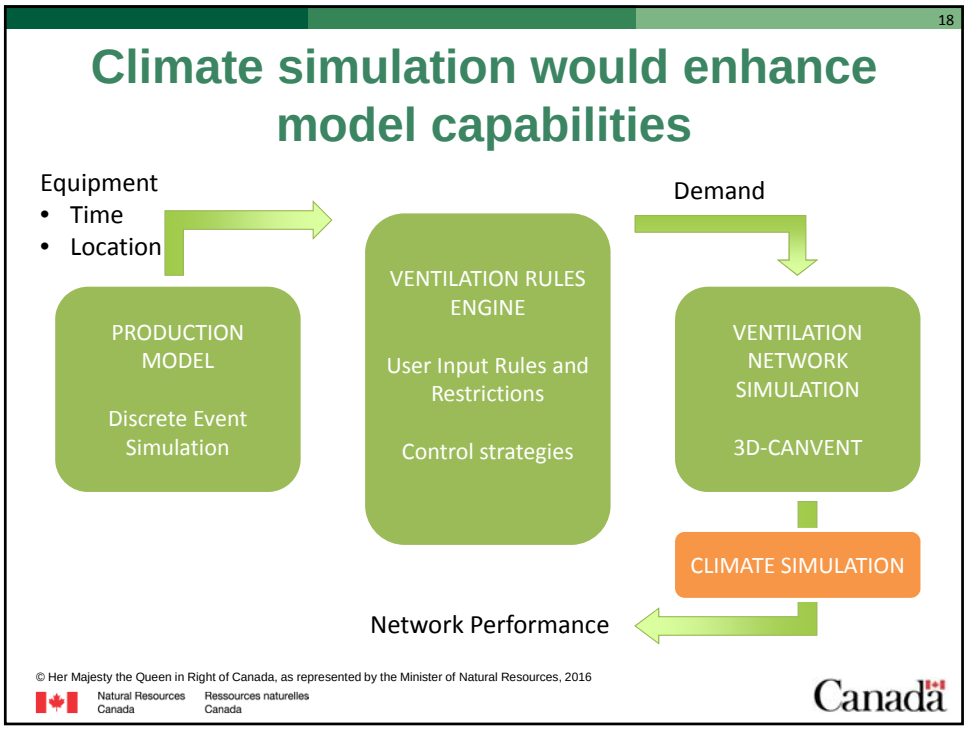
18
Climate simulation would enhance model capabilities
Equipment
• Time
• Location
Demand
PRODUCTION MODEL
Discrete Event Simulation
VENTILATION RULES ENGINE
User Input Rules and Restrictions
Control strategies
VENTILATION NETWORK SIMULATION
3D-CANVENT
CLIMATE SIMULATION
Network Performance
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There is potential for energy savings without compromising air quality

- Combined losses from leakage and roughness can be substantial
- Leakage control is the most critical element in performance
- Air quality monitoring could provide opportunity to reduce energy
- Dynamic simulation tools could enhance adoption of energy saving strategies

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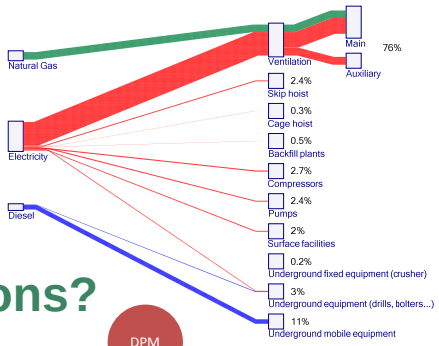
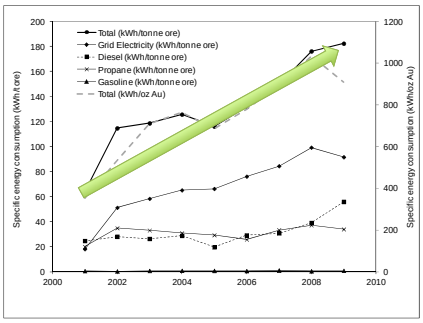
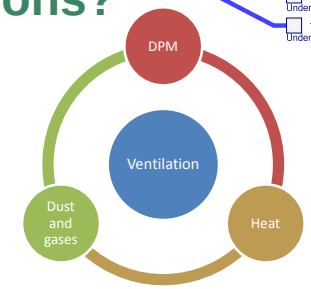


Questions?





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References

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