



## Introduction/Background

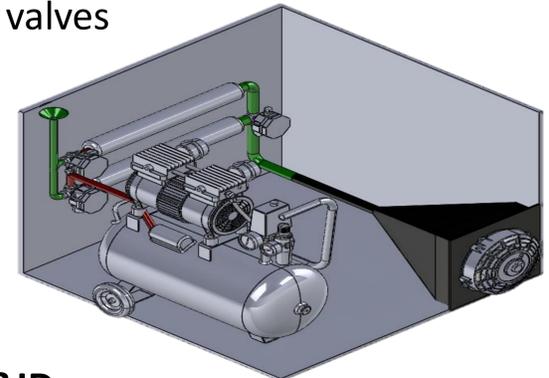
**Problem statement**  
Urban intersections see high CO<sub>2</sub> buildup from idling vehicles and fixed-timing signals, worsening pollution and delays.  
**Solutions:** Camera-based traffic sensing for dynamic signal control; Sidewalk-mounted zeolite CO<sub>2</sub> filtration unit; Smart controller triggers filtration during peak emissions.

**Constraints**  
Green light: 15–180 s  
Yellow interval: 3–6 s (SHC 601)  
Red clearance: ≥2 s for safety (SHC 601)  
The separation unit efficiency is about 50% or more

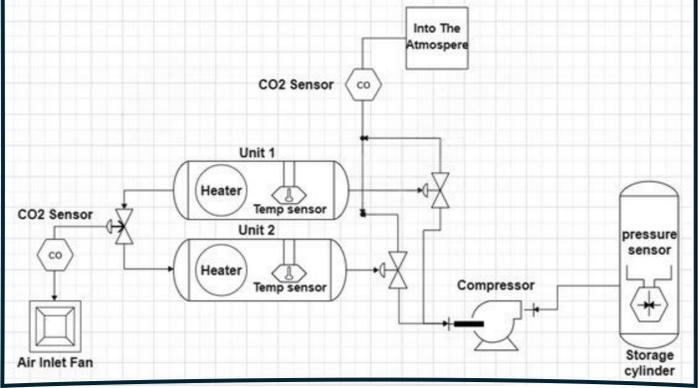
**Specifications**  
The system fits within ≤2 m<sup>3</sup>, adjusts signals in <1 s, and operates from -10° C to 60° C. It filters ≥50% CO<sub>2</sub>, pausing at 95% capacity, with ≤30% downtime. Green lights range 15–180 s. Installation takes ~2 hours, with storage ≥50 L or 30 kg. Average waiting time at a traffic signal is reduced by at least 50%

## Prototype Design

**Prototype 3D model**  
Design includes: 2 heating pipes; 1 inlet fan; 1 compressor with cylinder; 3 valves

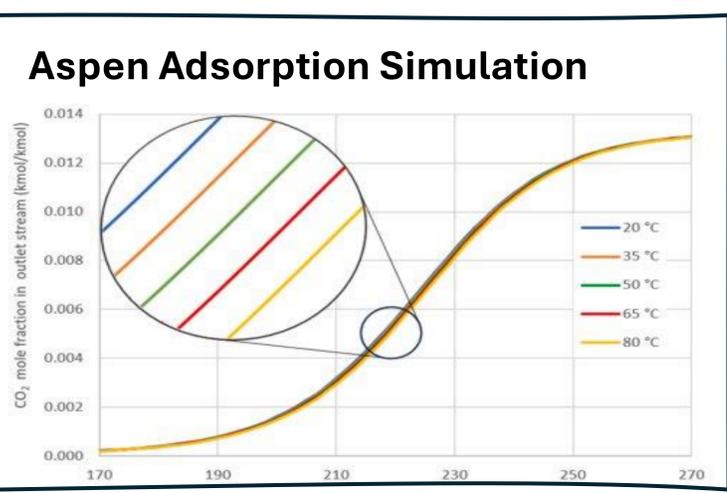


**P&ID**  
High-power fan pulls in CO<sub>2</sub>-rich air; NDIR sensor measures levels. Air flows through PPR duct to dual zeolite columns for capture/regeneration. Filtered air is vented; second sensor checks efficiency. CO<sub>2</sub> from regeneration is sent to compressor.



## Testing / Validation

- System volume confirmed ≤ 2 m<sup>3</sup>.
- ESP32-S3 responded to signals in <1 sec.
- Storage auto-stop triggered at 95% fill.
- Components validated for (-10°C ~ 60°C).
- ARENA simulation set green lights (15–180 sec) by traffic.
- Filtration achieved (70–85%) CO<sub>2</sub> removal.
- Setup time: ~2 hours.
- Downtime kept <30% via dual-column design.
- Filtration removed ≥50% of surrounding CO<sub>2</sub>.
- CO<sub>2</sub> storage ≥30 kg (50L) per cylinder.
- Simulation results shows more than 15% time reduction



## Conclusions

The Smart Traffic System integrates real-time CO<sub>2</sub> monitoring, adaptive signals, and zeolite filtration to ease congestion and cut pollution. Using ESP32 and NDIR sensors, it adjusts signals in under 1 second, reducing idling and emissions. Simulations show 15% shorter wait times. Modular, solar-powered, and cost-effective, it's easy to deploy and supports Saudi Vision 2030 goals for cleaner, smarter cities.

