

City Communal Aspiration System—City without Chimneys

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How to cite this paper: Kozin, Y. (2021) City Communal Aspiration System—City without Chimneys. *Open Journal of Ecology*, 11, 829-836.
<https://doi.org/10.4236/oje.2021.1112050>

Received: November 4, 2021

Accepted: December 7, 2021

Published: December 10, 2021

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Abstract

Gas emissions are produced by each economic entity individually—whether they are a large industrial enterprise, a boiler-house or a household (dwelling house). At that, in addition to visible chimneys, there are a lot of hidden (unrecorded) sources of emissions in form of ventilation branch pipes. Communal systems for removal and reprocessing of wastes of two types: liquid (municipal sewage lines) and solid (collection and removal of wastes) are operated in populated localities. For the third type of waste—gaseous—a similarly municipal structure does not exist. For the time being there is no possibility for full system control and neutralization of dust and gas wastes because there is no system in the physical form which would enable comprehensive receipt of exit gases from all the city sources for further processing thereof. It is for the first time when a principally new holistic approach to cleaning/treatment of all city dust and gas emissions (wastes) is proposed which consists in creation of a City Communal Aspiration System (Municipal Aspiration System) containing a city communal aspiration network (gas outlets) for receipt/transportation of exhaust (flue) gases and a plant for utilization of such wastes connected to such network. In other words, it is proposed to organize a “City without Chimneys”. The proposed solution permits to remove mass unsystematic and uncontrolled emissions of environmentally harmful gas wastes in cities, reduce climate risks and make the transition to a new level of organization of environmental planning and management and, therefore, eliminates or principally simplifies many ecological difficulties and restrictions in urban planning (inseparably related to ecology) in sanitary rules and standards.

Keywords

City Communal Aspiration System, City without Chimneys, Air Pollution, Carbon Dioxide Emissions, Climate Change Mitigation

1. Introduction (Problem)

The problem of dust-gas emissions into the atmosphere and air pollution turned from a local problem (urban, state) into a topical global environmental and general frontal political problem (Kyoto Protocol, WHO, UNECE, UNEP, COP-26, G7 summits etc.) which, in fact, became a neocultural and technological challenge for the society.

Public concerns about the negative consequences of intensive poorly controlled atmospheric pollution are constantly growing.

World Health Organization (WHO) declares: “The health arguments for increased climate action are very clear. For example, almost 80% of deaths caused by air pollution could be avoided if current air pollution levels were reduced to the WHO Air Quality guidelines” [1].

The United Nations Economic Commission for Europe (UNECE) also emphasizes: “Air pollution is now considered to be the world’s largest environmental health threat, accounting for 7 million deaths around the world every year. Air pollution causes and exacerbates a number of diseases, ranging from asthma to cancer, pulmonary illnesses and heart disease. Outdoor air pollution and particulate matter, one of its major components, have been classified as carcinogenic to humans by the International Agency for Research on Cancer... The main substances affecting health are nitrogen oxides (NO_x), sulphur oxides (SO_x), ozone and particulate matter with the latter—especially particulate matter below 2.5 microns (PM 2.5)—being of greatest concern, as these tiny particles penetrate deep into the lungs, affecting both the respiratory and vascular systems” [2].

Gas wastes represent a total pollutant since they poison not only the air basin but also cause harm to water reservoirs and soil while settling.

Pollutants emitted into the atmosphere from stationary sources by human activity (anthropogenic) include carbon dioxide (CO₂), sulfur oxides (SO_x), nitrogen oxides (NO_x), carbon monoxide (CO), toxic and heavy metals (lead, mercury, zinc, nickel, copper, cadmium, chromium and their compounds), particulate matter (dust), chlorofluorocarbons (Freon-12), aerosols etc.

Gas emissions are produced by each economic entity individually—whether they are a large industrial enterprise, a boiler-house or a household (dwelling house). At that, in addition to visible chimneys there are a lot of hidden (unrecorded) sources of emissions in form of ventilation branch pipes.

Communal systems for removal and reprocessing of wastes of two types: liquid (municipal sewage lines) and solid (collection and removal of wastes) are operated in populated localities. For the third type of waste—gaseous—a similarly municipal structure does not exist.

For the time being there is no possibility for full system control and neutralization of dust and gas wastes because there is no system in the physical form which would enable comprehensive receipt of exit gases from all the city sources for further processing thereof.

2. Problem Solving Strategy

It is for the first time when a principally new holistic approach to cleaning/treatment of all city dust and gas emissions (wastes) is proposed which consists in creation of a City Communal Aspiration System (CCAS, Municipal Aspiration System) containing a city communal aspiration network (gas outlets) for receipt/transportation of exhaust (flue) gases and a plant for utilization of such wastes connected to such network (**Figure 1**). In other words, it is proposed to organize a “City without Chimneys”.

The proposed solution permits to remove mass unsystematic and uncontrolled emissions of environmentally harmful gas wastes in cities, reduce climate risks and make the transition to a new level of organization of environmental planning and management and, therefore, eliminates or principally simplifies many ecological difficulties and restrictions in urban planning (inseparably related to ecology) in sanitary rules and standards.

3. Advantages and Technical Results of the Proposed Solution

For the purpose of implementation of The City Communal Aspiration System it is, in the essence, proposed to arrange system ordered controlled collection of gas emissions with further processing thereof. Such approach, in comparison with existing and often uncontrolled emissions in the air, will enable to achieve the following advantages and technical results:

1) Ecological advantage: prevention of the air basin, water reservoirs and soil against pollution by means of radical reduction or liquidation of emission of gas venting in the air.



Figure 1. The city communal aspiration system—city without chimneys.

2) Reducing climate risks (climate change mitigation) and organizing the integrated environmental planning and management process at a new level.

3) The system as an object integrating individual discrete elements is oriented towards resource saving and continuous objective control (“counters”) of gas emissions from all economic entities. Objective control will allow for maintenance of an ecological register of emissions, accurate monitoring of dynamics of issuers’ ecological parameters, forecast and ultimate high-quality management of the condition of the habitat.

4) The city planning project is facilitated. The functions of the city as a dwelling and place of work will be determined in a more cost-efficient way since restrictions on air-ecological binding of social and economic, construction, architectural and artistic, sanitary and hygienic city planning issues will be eliminated. An architectural “irritator”—a chimney (it is not shown on architectural models) will be removed; possibilities for zoning, design and esthetic solutions will be expanded.

5) The system enables to utilize physical, chemical and kinetic potential of flue gases.

6) By inclusion of a counteragent into the common aspiration structure the society will avoid the risk (temptation) of unauthorized emissions which exists in case of individual operation of this entity out of the system.

7) Risks of formation of new unexpected harmful substances in the air will be reduced. (Every enterprise issues its own set of toxins correlated to sanitary norms and established maximum permissible concentration—MPC. In the hot-house conditions of humid air and ultra-violet rays “standardized” toxins from various sources may interact with other forming new poisons the MPC whereof will be much less.) The probability of formation of acid fogs and acid precipitations will be reduced.

8) The possibility appears to resolve problems associated with ecological aggression—for example, gas emissions “gone with the wind” for large distances, i.e. associated with transboundary carrying over between regions and states. The 1979 Convention on Long-Range Transboundary Air Pollution [3].

9) There is a prospect of reducing payments for negative impact on the environment, reducing carbon tax contributions, including cross-border, and other similar compensation costs.

10) The possibilities for transfer of production facilities from one type of fuel to another will be expanded.

4. The City Communal Aspiration System—Description

Up-to-date means of dispersing exhaust gases into the atmosphere (and some reinforced concrete chimney pipes reach a height of 400 meters or more!) reduce the concentration of pollutants in the atmospheric air, but do not reduce the amount of emissions and generally do not solve the problem, affecting in large areas to varying degrees all bio-systems, all structural levels of life organization. Diffused flue gases (mainly, combustion products), in addition to air pollution,

creates a greenhouse effect. One of the probable hazardous consequences of the greenhouse effect evoking continuous concerns of the humanity is the threat of change in climate in the planet.

Chimneys significantly limit and sometimes exclude the possibility for efficient and reasonable solution of social and economic, building and technical, architectural and artistic, sanitary and hygienic problems associated with city planning since search for an optimum is conditioned by additional factors—beginning from direction and speed of the wind and ending by difficulties arising at construction of roads and communications (water, gas, electrical energy, communications, heating, sewage).

The concept “City Communal Aspiration System” or “City without Chimneys” proposes creation of a public system for removal of gas emissions (for example, like in the sewage system). Such system ensures transportation of exhaust flue gases through the aspiration system from sources of emissions to the utilization station (for subsequent processing of gas) on account of thrust power created by exhausters (vacuum fans).

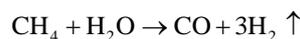
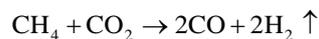
An option of gas processing at the utilization station may be presented in the following structural sequence (**Figure 1**):

- 1) Control of composition and amount of received gas wastes.
- 2) Gas treatment: removal of dust, mechanical particles—here separators, scrubbers, dust collectors, electric filters, disintegrators, top pressure system etc. are used. In this block withdrawal and utilization of heat may be effected through a heat exchanger.
- 3) Vacuum fans (exhausters).
- 4) Utilization: gas separation, filtration, neutralization, synthesis, pyrolysis and other operations may be realized with application of both well-known and future technologies (membranes, nanotechnologies, catalysis, absorption and adsorption, microbiological methods, deactivation of toxic gases by means of an electric discharge and plasma etc.).

Most of the above listed technical solutions and technologies have already been applied locally at emissions objects on the large-scale basis. This fact will materially facilitate integration of such components into the proposed system.

Significant arguments in favor of the relevance of the choice of the CCAS concept are, for example, the current implementation of technologies for managing forcibly formed mass urban air flows in the format of a “green central air conditioner”, which on an industrial scale provides centralized cooling of public premises with an area of several million square meters and covers 10 districts of the Shenzhen metropolis [4]. The District Cooling System (DCS) is capable of supplying 400,000 refrigeration tons (1.4 mil kW) of cool air to shopping centres, offices and transport stations, covering 19 million square metres. The system, under construction in the free trade and economic development area of Qianhai, can save 130 million kilowatts of electricity every year, according to the company behind the system. Three of the 10 cooling stations planned have been completed, with seven more to be built over the next few years [5].

As a popular variant (element) of utilization the so-called reaction of steam and carbon dioxide reforming of methane (CH_4 —natural gas) may be mentioned. Under the action of greenhouse gases (CO_2 and H_2O) [6] methane is converted with formation of ecologically pure fuel hydrogen [7]:



At the output from the utilization station, for example, three flows may be organized:

1) The first flow (CCS), utilization of carbon dioxide—these may be geological technologies with underground pumping of CO_2 to oil and gas deposits, unused coal deposits, permeable rock (for example, limestone), underground reservoirs of salt water etc. The technology “CCS”—“Carbon capture and storage”—has been already actively commercially used [8] [9]. It should be noted that methods of CO_2 processing being developed are plenty—from utilization of carbon dioxide using green microalgae (green algae) up to transformation thereof in a combustible: methanol, petrol or aviation fuel.

2) The second block (R)—return (recycling) to the production/consumption circulation of exhaust gases (mixtures thereof) and supply to the economic turnover of “new” gases (mixtures thereof) received in the process of utilization.

3) The third flow (P&D)—batching of gases for supply and use.

At that, ventilation gas emissions in the air fed to the utilization station may be used in the technological cycle or return to the air after treatment and deodorization.

The gas collecting network proposes the possibility of non-discriminatory connection (union) of all sources of gas emissions beginning from industrial objects (combines, plants, heat power plants, boiler-houses, waste processing enterprises etc.) and such widespread harmful production facilities with ventilation emissions as printing plants, pharmaceutical and extrusion lines, ending by industrial kitchens and ventilation chambers of dwelling houses (large tower buildings often have additional own masked chimney pipes).

The aspiration network (routes, lines and reservoirs) may, on the basis of specific conditions, include channels of both artificial origin (mines, tunnels, collectors...) and channel formations in form of natural geological formations.

The aspiration network may be conditionally divided into “internal”—for receipt of exhaust gases from production facilities, structures and buildings, and “external” (or “mainline”)—for transit of collected gases to the utilization station. Dedicated and back-up lines (gas ducts) may be provided for the network for the purpose to ensure technological stability of the system against possible sudden changes in quantity, composition and properties of exhaust gases. Moreover, various options for receipt of flue gases to the network are possible, for example, restrictions may be set for network clients as to content of water steams (water) and abrasive mechanical particles (dust) if it is easier to utilize such components locally.

The municipal aspiration network may be integrated with other structures ensuring forced transportation of wastes in form of liquids, effluent waters, pulp, slurry, solid substances etc. In other words, depending on economic and technological conditions and links, it is logical to move towards the total utilization of all types of wastes generated by production and household activities of a human.

Creation of enclosed waste-free technologies which are “rather practicable though much more difficult” was touched upon by the laureate of the Nobel Prize P. L. Kapitza already [10].

The suggested concept complies with the ideology of the “ecological city”. City without Chimneys matches the today’s tendency in city planning—construction of a “city of short ways” which means an ecological city which is compact in terms of its territory and cost-effective in operation (cost-effective in terms of resources).

Many advantages of The City Communal Aspiration System are realized even in the primitive variant of blank run (without useful load to the module of utilization)—in case of direct withdrawal of gas wastes outside the populated localities using two (depending of wind direction) points of emissions.

5. Conclusions

Thus, for the first time, it is proposed to create a progressive high-tech ecological industry—The City Communal Aspiration System is proposed incorporating a network of pipes (channels) for receipt and withdrawal of flue gases from the territory of populated localities and industrial enterprises for further use and/or neutralization thereof.

The proposed solution initiates a principally new method of system resolution of ecological problems, permits to improve human’s life, to organize “City without Chimneys” and is efficient from the ecological, social and economic point of view.

The modern scientific and technical level of development and the production and technological potential of society, necessary for the implementation of The CCAS, is completely sufficient and must be supported by the administrative and organizational component.

At this moment the pilot version of The City Communal Aspiration System is more realistic in small industrial agglomerations, during the construction of new cities, etc.

Managing the operation of the Municipal Aspiration System will be inexpensive and uncomplicated. The more expensive and complex part of the project is engineering and integration of existing gas processing technologies.

The current implementation of urban forced-air management technologies in the “green central air conditioner” format, which provides industrial-scale centralized cooling of public spaces of several million square meters and covers 10 counties in the metropolitan city of Shenzhen, is a similar systemic holistic approach.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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