



## Higher-Welfare Farmed Animal Depopulation Methods: Information and Sources

METHOD <sup>a</sup>	MECHANISM OF KILLING	SOURCE	PRODUCT DESCRIPTION	OPERATIONAL CONSTRAINTS	REFERENCES
<b>Anoxia-based Methods</b>					
<b>Nitrogen gas delivered via high-expansion (&gt;300:1) foam</b>	Provided expansion ratio and bubble size are appropriate for the species, foam is a vehicle for delivering nitrogen gas (N <sub>2</sub> ) and displacing oxygen. Death occurs by anoxia without airway occlusion or drowning.	<b>Agricultural Emergency Services</b> Newark, Delaware  Gary Flory <a href="mailto:gary@agemergency.com">gary@agemergency.com</a> <a href="http://agemergency.com/">agemergency.com/</a>	Foam delivery system for use in whole barns or in dump trailers. Simple design and operation requiring minimal maintenance.  <i>For pigs and floor-reared poultry.</i>	Research on-going re: use in chickens in battery cages and multi-tiered aviaries, use in other species, and integrating a vaporizer to enable use with liquid N <sub>2</sub> .  Contracting in advancing with N <sub>2</sub> distributor recommended.	Multiple species: <sup>1-8</sup> Poultry: <sup>9-22</sup> Pigs: <sup>23-38</sup>
		<b>Livetec Systems</b> Leighton Buzzard, United Kingdom  <a href="mailto:info@livetecsystems.co.uk">info@livetecsystems.co.uk</a> <a href="http://livetecsystems.co.uk/resource_hub/nitrogen-foam-delivery-system-nfds-product-guide/">livetecsystems.co.uk/resource_hub/nitrogen-foam-delivery-system-nfds-product-guide/</a>	Foam delivery system which can be used in whole barn, corral, or other holding pen. Integration of a heated vaporizer allows this system to be used with liquid N <sub>2</sub> .  <i>For pigs and floor-reared poultry.</i>	Research on-going re: use in battery cages and multi-tiered aviaries.  Pigs: potential for increased risk of foam aspiration at temperature <15°F(-9.4°C).  Contracting in advancing with N <sub>2</sub> distributor recommended.	
		<b>HEFT International</b> Uddevalla, Sweden  Sebastian Strand <a href="mailto:sebastian.strand@heftinternational.com">sebastian.strand@heftinternational.com</a> <a href="http://heftinternational.com/c3/">heftinternational.com/c3/</a>	Foam delivery system utilizing sealed containers. After container is filled, high pressure blast of N <sub>2</sub> gas destroys bubble matrix, resulting in rapid loss of consciousness. Proprietary foam functions as non-irritating disinfectant.  <i>For pigs and poultry.</i>	Animals must be placed in containers; large-scale c3 system includes 20 ft x 8 ft container.  Careful animal handling required.  Contracting in advance with N <sub>2</sub> distributor recommended.	
<b>Nitrogen Whole House Gassing</b>	Liquid nitrogen (LIN) or gaseous nitrogen (N <sub>2</sub> ) is used to create an ambient environment of ≤ 3% oxygen; death occurs by anoxia.	<b>Livestock Welfare Strategies</b> Schuylkill Haven, Pennsylvania  Jeff Hill <a href="mailto:jeff@livestockwelfarestrategies.com">jeff@livestockwelfarestrategies.com</a> 570-640-3195	LIN version: LIN transport trailer connects to single primary hose leading to a quad distribution unit with high-density polyethylene (HDPE) pipe delivery system.  Gaseous N <sub>2</sub> version: N <sub>2</sub> pumper truck utilizes vaporizer to convert liquid N <sub>2</sub> to a gaseous state prior to introduction into the barn. Requires larger volumes of N <sub>2</sub> and air movement to ensure even distribution of gas.  <i>For chickens and turkeys.</i>	Cannot be used in excessively leaky buildings.  Proper positioning and securing of hoses are necessary to avoid inducing cold stress in animals.	7,39-47

a. The following depopulation methods may also be considered more humane if careful animal handling is implemented, but are not included here because means of accessing them are already well known: movement to federal- or state-inspected slaughterhouses for carcass production, gunshot, captive bolt, manual cervical dislocation, Koehler Euthanizing Device (KED), Turkey Euthanasia Device (TED), and intravenous pentobarbital.

<b>Nitrogen Gassing Trailers or Tunnels</b>	Rapid exposure to >97% nitrogen gas; death occurs by anoxia.	<b>Prairie Agricultural Machinery Institute (PAMI)</b> Humboldt, Saskatchewan, Canada <a href="mailto:pami@pami.ca">pami@pami.ca</a> 1-800-567-7264	Fully-automated N <sub>2</sub> gassing trailer includes N <sub>2</sub> generator, so external N <sub>2</sub> source unnecessary. Oxygen level drops to ≤2.3% within 60 seconds.  <i>Prototype made for piglets and pigs up to 60 kg, but can be custom built to accommodate various sizes/species of animals.</i>	Operation may be problematic at temperatures <14°F (-10°C).  One cycle (200–700 pigs depending on animal size) per hour.	Multiple species: <sup>7, 48, 49</sup> Pigs: <sup>28, 32, 37, 38, 50–52</sup> Poultry: <sup>10, 22, 43–45, 53, 54</sup>
		<b>Ontario Pork</b> Guelph, Ontario, Canada  Frank Wood <a href="mailto:frank.wood@ontariopork.on.ca">frank.wood@ontariopork.on.ca</a> 1-519-830-2678	Fully-automated N <sub>2</sub> gassing trailer. On-board tank is filled by commercial liquid N <sub>2</sub> (LIN) tanker. Oxygen level is dropped initially to 10%, then from 10% to ≤2% within 3 minutes. Adjustable ceiling allows use for all sizes of pigs.  <i>For pigs.</i>	Each cycle requires 15 minutes, including loading, killing, and carcass removal. Relatively slow drop in oxygen level raises concern for a period of breathlessness/air hunger. Developer describes loss of consciousness within 3 minutes.	
		<b>Oxair</b> Bellevue, Western Australia  Matthew van den Bos <a href="mailto:mattbpe.4@bigpond.com">mattbpe.4@bigpond.com</a> +61 (0) 414 537 352 <a href="http://oxair.com.au/humane-poultry-euthanasia-systems/">oxair.com.au/humane-poultry-euthanasia-systems/</a>	Anoxiatec system uses N <sub>2</sub> produced from a membrane separation system to maintain N <sub>2</sub> concentrations >98% in a tunnel through which birds are conveyed. Modules of different capacities can be custom-built, and can be made portable.  <i>For poultry.</i>	Developer describes loss of consciousness within 30 seconds and death within 3 minutes.  Air is heated during N <sub>2</sub> generation but has not been tested in extreme cold. Careful animal handling required.	
<b>Low Atmospheric Pressure Systems</b>	Gradual decompression to reduce oxygen level to <5%; death occurs by anoxia.	<b>TechnoCatch, LLC</b> Kosciusko, Mississippi  Randolph Cheek <a href="mailto:hrcheek@technocatch.com">hrcheek@technocatch.com</a> 662-289-1117 <a href="http://technocatch.com/laps">technocatch.com/laps</a>	Trailers with mounted generator, vacuum pump, hydraulic power pack, and compressed air tanks. Chamber types and size are specific to operational needs.  <i>For poultry.</i>	Correct rates of decompression must be used.  Careful bird handling required.	9, 55–62
<b>Containerized Gassing Unit</b>	Units can be used with up to 100% nitrogen or with 80% argon/20% carbon dioxide mixture; death occurs by anoxia.	<b>Livetec Systems</b> Leighton Buzzard, United Kingdom  <a href="mailto:info@livetecsystems.co.uk">info@livetecsystems.co.uk</a> <a href="http://livetecsystems.co.uk/our-solutions/on-farm-products/containerised-gassing-units/">livetecsystems.co.uk/our-solutions/on-farm-products/containerised-gassing-units/</a>	Birds in transport modules or crates are placed in the unit's chamber, which is then filled with compressed gas. Manual, automated, and bespoke options available.  <i>For poultry.</i>	3 sizes of containers available, with maximum throughput up to 22,046 lbs. (10,000 kg) per hour.  Careful bird handling required.	10, 43–45, 53, 63
<b>Electrocution-based Methods</b>					
<b>Electrocution Trailer</b>	1-step head-to-heart electrocution.	<b>University of Nebraska–Lincoln</b> Lincoln, Nebraska  Ruth Woiwode, PhD <a href="mailto:ruth.woiwode@unl.edu">ruth.woiwode@unl.edu</a> 402-472-3247 970-690-9337	V-belt restrainer mounted onto 30-ft flatbed gooseneck trailer onto which electric components and drive units are mounted.  <i>For pigs.</i>	Only suitable for pigs weighing 125–600 lbs. (57–272 kg).  Careful animal handling required.	28, 64–69
<b>H2H Chicken Euthanizer</b>	1-step head-to-heart electrocution.	<b>Top Equipment</b> Tiel, The Netherlands  <a href="mailto:info@top-equipment.nl">info@top-equipment.nl</a> +31 653776043 <a href="http://top-equipment.nl/">top-equipment.nl/</a>	The chicken (0.5 to 7.5 kg; 1.1–16.5 lbs.) is supported head down in a flexible cone for head-to-heart electrocution resulting in immediate loss of consciousness.  <i>For chickens.</i>	Because birds are killed individually, primary use is for flocks < 5,000 birds.  Careful bird handling required.	9, 70–76

## Carbon Dioxide-Based Methods<sup>b</sup>

<p><b>Carbon Dioxide Whole House or Partial House Gassing</b></p>	<p>Carbon dioxide (CO<sub>2</sub>) causes hypercapnia, leading to central nervous system depression; hypoxia may also play a role.</p>	<p><b>USDA National Veterinary Stockpile</b> contains 18 units</p> <p><b>Linde Services Canada, Inc.</b> Jolene Lylick (Western Canada) <a href="mailto:jolene.lylick@linde.com">jolene.lylick@linde.com</a> 1-780-717-6424</p> <p>Connor Donnelly (Eastern Canada) 1-519-332-0730 x223 <a href="http://lindecanada.ca/shop/en/ca/home">lindecanada.ca/shop/en/ca/home</a></p> <p><b>Linde Services, Inc. (USA)</b> Danbury, Connecticut</p> <p>Nick Bauhan <a href="mailto:nick.bauhan@linde.com">nick.bauhan@linde.com</a> 219-501-6819 <a href="http://lindeus.com/">lindeus.com/</a></p> <p><b>Air Gas/Air Liquide (USA &amp; Canada)</b> Houston, Texas</p> <p>Dr. Bill Adams <a href="mailto:bill.adams@airgas.com">bill.adams@airgas.com</a> 713-896-2386 <a href="http://airgas.com/industries/food-industry">airgas.com/industries/food-industry</a></p> <p><b>Carbox Cryogénique</b> Longueuil, Québec, Canada</p> <p>Gaétan Bélanger 1-514-953-6901 <a href="http://carboxcryo.com/">carboxcryo.com/</a></p> <p><b>Livetec Systems</b> Leighton Buzzard, United Kingdom</p> <p><a href="mailto:info@livetecsystems.co.uk">info@livetecsystems.co.uk</a> <a href="http://livetecsystems.co.uk/our-solutions/on-farm-products/whole-house-gassing/">livetecsystems.co.uk/our-solutions/on-farm-products/whole-house-gassing/</a></p>	<p>System includes distribution box, dosing manifolds, hoses, and monitoring devices to distribute CO<sub>2</sub> throughout the poultry house. CO<sub>2</sub> levels must reach a minimum of 45% for 30 minutes. The gradual rise in CO<sub>2</sub> concentration may allow birds to lose consciousness before noxious levels of CO<sub>2</sub> are reached, better protecting welfare.</p> <p><i>For poultry.</i></p>	<p>Establishing reliable sources of liquid CO<sub>2</sub> gas can improve accessibility of this method.</p> <p>Longer hold times and higher CO<sub>2</sub> levels required for waterfowl and newly hatched chicks.</p> <p>“Homemade” WHG units are not recommended due to safety, efficacy, and animal welfare concerns.</p>	<p>9, 10, 43, 87–104</p>
<p><b>Multi-stage Continuous Flow Through CO<sub>2</sub> Systems</b></p>	<p>Carbon dioxide (CO<sub>2</sub>) causes hypercapnia, leading to central nervous system depression; hypoxia may also play a role.</p>	<p><b>Petsmo Products</b> Finland</p> <p>Jürg Wülser <a href="mailto:jurg.wulser@petsmoproducts.fi">jurg.wulser@petsmoproducts.fi</a> +358 (0)207908668 +358 (0)500567007</p>	<p>The Titan Killing Unit utilizes a conveyor belt that moves birds through a gentle incline, enabling exposure to increasing concentrations of CO<sub>2</sub>. Birds are deceased when they exit system after 140 seconds. Data loggers and warning lights ensure appropriate CO<sub>2</sub> levels. System can be connected to CO<sub>2</sub> cylinders or tankers.</p> <p><i>For poultry.</i></p>	<p>Capacity is up to 5,000 hens per hour.</p> <p>Careful bird handling required.</p>	<p>53, 9, 88, 93, 94, 96–99, 22, 104</p>

b. Containerized CO<sub>2</sub> gassing for pigs has not been included due to concerns about animal welfare. If this method is utilized for pig depopulation, AWI recommends close adherence to engineering standards to ensure appropriate gas displacement rates, temperatures, etc. <sup>77–86, 28, 87</sup>

<p><b>Containerized Gassing Units with Controlled Gas Flow</b></p>	<p>Carbon dioxide (CO<sub>2</sub>) causes hypercapnia, leading to central nervous system depression; hypoxia may also play a role.</p>	<p><b>NutriQuest</b> Mason City, Iowa  Corky Feuerbach <a href="mailto:Corky@nutriquest.com">Corky@nutriquest.com</a> 515-689-0523 <a href="https://nutriquest.com/euthanex">nutriquest.com/euthanex</a></p>	<p>Euthanex gas delivery systems are incorporated into dump trailers or modified atmospheric killing (MAK) carts that are custom designed and built per customer needs. One single layer of birds depopulated per cycle. Includes heated regulator and controlled gas flow/pressure, calibrated to size of chamber.  <i>For poultry.</i></p>	<p>Maximum capacity is 2,500 birds per hour. Careful bird handling required.</p>	<p>53, 9, 88, 93, 94, 96-99, 22, 104</p>
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