Memorandum
Community Development Department, Planning Division

TO: Chair Paul Luke and Members of the Plan Commission

FROM: Johanna Nyden, AICP, Community Development Director
       Paul Reise, AICP, Planning Manager

DATE: 4/20/2023

SUBJECT: DISCUSSION AND CONSIDERATION OF DRAFT RECOMMENDATIONS OF DRIVE-THROUGH POLICY FOR PRESENTATION TO THE BOARD OF TRUSTEES

Summary:
Staff seeks discussion and consideration from the Plan Commission on six potential zoning changes and additional Village policy and development guidelines regarding the permitting and mitigation of drive-through uses. This memorandum summarizes some potential opportunities to mitigate the impact of drive-through restaurants.

Discussion:
Following the discussion of drive-through policy considerations at the March 16, 2023 Plan Commission meeting, staff has further refined the recommendations for discussion and consideration.

Recommendation 1: Modify allowed location of drive-throughs in Skokie.

- Adopt zoning changes that remove drive-through uses as an allowed use in mixed-use districts (NX, TX, and CX). Currently Sec. 118-185 of the Village’s Zoning Code allows this use but must not be visible from the street. Removing it as an allowed use could be an opportunity to further reduce this use.

- Adopt zoning changes that adopts the retail street rules for drive-throughs in all zoning districts, i.e. only drive-through facility driveways that are shared with other parking facilities are permitted, and no part of the drive-through facility shall be visible from the street.

These changes seek to manage the number of vehicles and the presence of excessive parking on site. The more vehicles on site, the more likely vehicles will be idling and potentially contributing to emissions.
**Recommendation 2:** Reduce parking requirement at drive-through establishments.

Section 188-218 requires 1 parking space for each 100 square feet of net floor area. For example, a 2,000 square foot restaurant is required to provide 20 parking spaces. Decreasing the requirement, if supported by the traffic analysis, to 1 parking spot per 150 square feet would mean smaller parking lots and more flexibility in the site plan. Ideally this space is reclaimed for green space, outdoor dining, or even convenience parking for patrons going into and out of the restaurant for items ordered ahead of time.

**Recommendation 3:** Include the following standard conditions in all approvals associated with drive-through establishments:

- Require a plan on record with village that addresses how operations are managed to reduce queuing of the line in order to better understand how the restaurant will operationally handle a long line of cars and how it will mitigate this issue.
- Prohibit deliveries during peak usage times.
- Require that mobile ordering be part of the business model of approved special uses. If customers can order ahead of time through mobile apps on phones or computers, this will reduce ordering times between the order window and the pay window at businesses. It might also discourage customers from moving through a drive-through lane and getting out of the vehicle and going into the establishment.

**Recommendation 4:** Manage emissions impact by requiring additional trees on site or a fee-in-lieu based on a formula associated with the number of cars that will be generated by the drive-through as reported by the traffic impact study. One new tree for every 100 car trips, shall be required to be planted or a fee assessed to cover planting at another location.

**Recommendation 5:** Require drive-through restaurants to offer composting and recycling in addition to waste that will go to a landfill, for both kitchen waste as well as dining area waste.

**Recommendation 6:** Develop drive-through language for Skokie zoning code in accordance to best practices to add clarity. Sample language provided for discussion purposes.

“Drive-through facility. A facility which accommodates automobiles and from which the occupants of the automobiles may make purchases or transact business, including the stacking spaces in which automobiles wait. Examples include but are not limited to drive-up windows, menu boards, order boards or boxes, drive-in restaurants, and drive-up banks and automated teller machines. Drive-through facilities shall not include the direct refueling of motor vehicles, car washes, parking spaces used for customer pick-up or loading of goods or products purchased on-site or prior to the customer's arrival, or parking and loading spaces used for the donation of secondhand goods.”

-Minneapolis MN zoning code

Attachments:
- Zoning Practice, "Making Drive-Thrus a Boon, Not a Bane,"
- Argonne National Lab, “Which Is Greener: Idle, or Stop and Restart?”

VOSDOCS-#609084-v9-Drive_Thru_Memo._-Plan_Commission_
Making Drive-Thrus a Boon, Not a Bane

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Making Drive-Thrus a Boon, Not a Bane

By Dwight Merriam, FAICP

In considering drive-through service as a planning and zoning issue, we might look back to the first zoning case to make its way to the U.S. Supreme Court, Euclid v. Ambler (1926), where the court in upholding zoning famously said: “A nuisance may be merely a right thing in the wrong place—like a pig in the parlor instead of the barnyard.” Most zoning is ultimately contextual. So too it is with drive-throughs, which are exceedingly beneficial for everyone in some locations, and utterly destructive to some objectives of planning and zoning when they are allowed in the wrong places. The challenge, sometimes a conundrum, is to decide when they are appropriate and, if so, how to best regulate them, leveraging the benefits and avoiding the burdens.

This issue of Zoning Practice explores how good planning and zoning can respond to increased demand for drive-through service since the onset of the COVID-19 pandemic. It begins with a quick look back to the days of car-hops and their effects on subsequent drive-through services. Then, recognizing how the pandemic has affected a sea change in service, it looks at how drive-through and related services have evolved and where they may go, with good planning and regulation, for the benefit of all.

A prototype Taco Bell drive-through in Brooklyn Park, Minnesota (Credit: Taco Bell Corp.)
The Drive-Through Genome Project
We most often think of inertia as uniform motion in a straight-line, but it is equally the resistance to change. Zoning is often like that, evidencing a resistance to change and reflecting irrelevancies of the past. If we could ever have a genome project in zoning, including drive-throughs, we doubtless would find that current regulations and the difficulties we have in deciding where and how they might be used can be found in the DNA of zoning from the 1950s, when carhops were the rage. They probably date to the early 1920s, the term reportedly derived from bellhop. The film, *American Graffiti* (1973), set in 1962, featured Mel’s Drive-In on South Van Ness in San Francisco, though the movie was set in Modesto, California. For a diversion from the seriousness of planning and zoning for drive-throughs, you may wish to watch *Bob’s Big Boy 1947 training film for carhop service*, including some views of parking layout and queuing that only a planner might appreciate.

Ryland Heights, Kentucky, for example, reflects that carhop history by defining a drive-in eating establishment to be inclusive of carhops: “A restaurant where consumption of food is encouraged in a vehicle on the premises, where food is provided by ‘car-hop’ or self-service, with or without incidental sit-down and carry-out facilities” ($7.0).

The Pandemic Push
Reference to carhops continues today and has had a rebirth in the response to the pandemic, as communities sought ways to increase flexibility in food service and retailing, generally, to provide social distancing and a contactless experience. Bellevue, Kentucky, is illustrative in recently adding a new reference to car hops with this change to its regulations:

DRIVE IN. An establishment offering food and beverages which are sold within the building, or to persons where the consumption is encouraged while in motor vehicles on the premises. Food is generally provided by “car-hop” or self-service, in an area designated for drive-in or drive thru service, and for consumption on or off the premises. Food and beverages are served in disposable containers. [emphasis added] (Ordinance No. 2021-06-05)

It is hard to overstate what the pandemic did to promote drive-through service. In March 2020, two months after the first case of COVID-19 in the U.S., Wendy’s reported that 90 percent of its sales were drive-through (Coley 2020). Restaurants across the country “pivot[ed] to an old-fashioned carhop model,” as one report on what a 93-year-old owner of a restaurant had to do to keep open during the pandemic in Cloquet, Minnesota (Hollingsworth 2021). The decision to go to other service models was often not voluntary. One restaurant, eight months into the pandemic, was ordered to shut down and defied the order, had its liquor license suspended, and incurred fines, only to switch to delivery service and a carhop model to escape being closed (Kurylandchick 2020).
The changes from inside service to carhops, drive-through, drive-up, and carry out was widespread, including chains like Steak ‘n Shake, Bob’s Big Boy, and White Castle. As one restaurant manager put it: “A lot of our regulars are older people who want to be safe… Even after COVID ends, we’re going to keep doing it...” (Kim 2021). It is this resurgence in service to cars, particularly from locations that had not previously offered drive-up or drive-through, that now impels the interest in determining how to provide those advantages to consumers, while preventing the nuisances that these services sometimes cause. Alan Hess, an architect who wrote Googie Redux: Ultramodern Roadside Architecture, believes we can use the drive-in experience from more than half a century ago to solve current problems:

It had a purpose, and still has a purpose. If out of this we can gain a new respect for the automobile, which in many ways has been a scapegoat for the demise of cities and communal living, we will have an “old” tool that we can use in a new way to solve problems we had no idea we were ever going to face (Kiniry 2020).

**Floating Zones and Mapped Overlays**

Walkability and drive-throughs do not mix well in many situations. Driveways in and out endanger pedestrians and cyclists and create some commercial sprawl by consuming frontage. They can coexist with careful site planning and site-specific review, review that provides the greatest discretion for the local government, the applicant, and other stakeholders (Davis 2016).

The best approach may be a floating zone just for drive-through, drive-up, and take-out service. With a floating zone, a concept plan is reviewed, and then a purely legislative, policy decision is made to allow the zone to descend and apply to the site. Courts have held that the tired “spot zoning” claim does not apply to small-area and even single-lot floating zones, in part because the standards can apply to other parcels (Vasser 2021; McCarthy 2006). The applicant’s concept site planning costs are small, making them more willing to make modifications. Courts almost always defer to legislative decisions, less so with administrative decisions like special permit or conditional uses. All around, even though it may seem complicated, which it is not, the floating zone is nearly perfect for the drive-through and related uses.

The “secret sauce,” however, that will make the floating zone a tasty addition to the regulations is found in the criteria for where the floating zone can land and what criteria are applied in making that decision. That takes a lot of hard thought. Have in mind that 1974 Burger King jingle, “hold the pickles, hold the lettuce, special orders don’t upset us.” Make each drive-through a special order, applying the locational and decisional criteria that you carefully thought out in advance. Consider testing those regulations, before you enact them, by trying to apply them to sites throughout the community. Do some role playing. It can be fun, actually, but it also will help surface problems, both procedural and substantive, with your draft regulations. Not many planning bodies do this, but it can be highly effective.

Another approach, though somewhat less desirable because it comes with less discretion, might be a fine-grained overlay zone coupled with a conditional use. With the overlay zone, the underlying zoning remains, and it enables additional regulations to be applied in subareas on top of the existing zone.
Most regulations permit drive-throughs, conditionally or otherwise, in an entire zoning district. That leaves the door open to applications for drive-throughs where they are not appropriate. It is better to take a hard look at where they can work and make that an overlay. If using the floating zone, the criteria for landing the floating zone can use an overlay to limit the areas where applications are permitted. It does not approve the floating zone in advance, but it makes a clear statement as to where they might be possible.

Two strategies might help in enabling some drive-through service along pedestrian-focused streetscapes. One is not a drive-through at all, but drive-up, where curbside service is allowed with people delivering goods to a vehicle along the curb, typically as one form of “buy online pick up in store” (BOPIS) service. Add that to your book of planners’ acronyms, and impress your friends. BOPIS, which is less expensive for retailers than drive-through service, requires short-term parking. This avoids curb cuts and is practical today with smartphone ordering. Some measure of how digital sales have increased just recently can be seen at McDonalds, where digital sales in its six biggest markets are up 60 percent in just one year, totaling over five billion dollars and 30 percent of sales (Maze 2022). The Harvard Business Review reports that, one year into the pandemic, retailers offering curbside pickup had jumped 44 percent and 40 percent of Americans want to continue curbside pickup, BOPIS, and delivery (Ketzenberg and Akturk 2021). The challenge is to provide for sufficient curbside space to meet the need and to avoid double parking during high volumes. There was widespread local experimentation during the pandemic, and much can be learned from that in fashioning local drive-up standards.

The other strategy in areas where you need to protect walkability is to plan for multiple, adjoining sites to share entrance and exit drives to reduce curb cuts. This is typically done with abutting commercial-use parking lots, as in Zebulon, North Carolina: “Parking lot connections shall join parking lots on two or more different lots... A parking lot connection shall be included on at least two sides of a lot except when conditions prevent connections ...” (§5.1.8.D). For this to work, there must be pre-planning of how separately owned properties might connect through cross-easements or some form of association.

**A Proposed Regulatory Framework**

The same issues appear across the full range of drive-through regulations. What differentiates them are the standards to be applied, which vary greatly. Here is a rough outline of what might be in a regulation, but it is by no means a model. One size does not fit all.

**Purpose**

Start with a statement about the purpose. This is visioning to a degree. Think what you want to accomplish with drive-through service. Maybe something like: Drive-through service is enabled in appropriate locations to improve service to customers, permit people with disabilities to have equal access, protect the public from contagion, and promote economic development.
Salt Lake City is more specific (§21A.40.060.A):

Purpose: The regulations of this section are intended to allow for drive-through facilities by reducing the negative impacts they may create. Of special concern are noise from idling cars and voice amplification equipment, lighting, and queued traffic interfering with on-site and off-site traffic and pedestrian flow. The specific purposes of this section are to

1. reduce noise, lighting, and visual impacts on abutting uses, particularly residential uses;
2. promote safer and more efficient on-site vehicular and pedestrian circulation; [and]
3. reduce conflicts between queued vehicles and traffic on adjacent streets.

Definitions
Much of any regulation is found in the definition of what is regulated. A typical definition of drive-through service is like this one from Brunswick, Maine (§1.7):

Any structure through which a product or service is provided directly to a customer seated in a motor vehicle including, but not limited to, take-out or pick-up windows, banking terminals, automatic teller machines and other facilities commonly referred to as drive-up, drive-through, or take-out. This definition excludes gasoline service stations, car washes, drive-in theatres, and drive-in restaurants where orders are taken and food delivered to a motor vehicle that remains in a parking space.

This definition suggests the range of drive-through uses and expressly excludes carhops. It does not acknowledge curb-side service and BOPIS. For a more holistic view of curb functions, see San Francisco’s Curb Management Strategy (2020) and guidance from the Boston Region Metropolitan Planning Organization (2019; 2022).

With nearly all zoning regulation, the definition is key as to what is in and what is out. Spend a good part of your time here defining what you mean by drive-through, drive-up, walk-up, BOPIS, carhop, and so on.

Applicability
Will your regulations include only new construction, or also rebuilding or replacement of existing drive-throughs and alterations to add new drive-through service? If there is existing drive-through service, it might be prudent to require as a condition of approval that there be a review when the floor area of the building serviced is expanded, say by 25 percent or 1,000 square feet, as that will likely increase traffic at the drive-through.

Submission Requirements
What will your regulations require applicants to submit before final approval? Important elements of the site plan are a parking and circulation plan, driveway locations, and placement of audio equipment. An on- and off-site litter cleanup plan, with a schedule and map, are worth considering. Almost always a traffic study by a qualified person, usually a professional engineer, is required. The traffic study, based on the specific identified use of the property, should describe peak hours of operations, volume of customers per hour, stacking space for anticipated volume of drive-through vehicles, turning movements, roadway capacity, and the level of service of nearby streets.

Building Design
Canopies for service windows can have a substantial visual impact. Regulating color and how many colors, where it is permitted by law, might be included, as well as prohibiting corporate colors and patterns on the canopies which are ersatz signs. Drive-through facilities, including windows and other related features, should be architecturally compatible with the building and the existing and planned streetscape.

Access
The total width of access lanes in and out should be limited, something in the order of 25 feet, unless a turning lane is required.
Typical regulations provide for access-way width, often 10 feet, and minimum turning radii of 10 feet. Sometimes it is specified that the width of curved segments of the stacking lane be 12 feet.

Specify that drive-through lanes to and from drive-through windows and order boards shall not obstruct on-site vehicular traffic flow to and from required parking and loading spaces or other driveways providing ingress and egress into and within the site. Sometimes, regulations may require entrances and exits be separated by some distance, say 25 feet, from abutting properties. That may foreclose drive-throughs at some sites. Using the floating zone approach could allow more flexibility in all the dimensional standards by offering suggested, but not mandated, design requirements.

Each entrance to, and exit from, a drive-through lane should be clearly marked to show the direction of traffic flow by signs and pavement markings or raised curbs.

To limit damage to buildings in the vicinity of drive-through facilities, a minimum of 10 feet of clear height may be required for the drive-through lane with bollards located adjacent to drive-through windows to prevent damage to the building from vehicles.

As noted in the context of drive-throughs on walkable streetscapes, where possible the design should include joint-use and cross-access connections, even where a present connection is not feasible, just as would be done with a temporary cul-de-sac and stub road. There are no obvious standards for how long that unused connection might be, but some limitation is reasonable. The accessway need not be constructed with the current development if a physical connection is impossible at the time, but the approval should require construction when joint use or cross access is feasible.

**Landscaping**

Typical regulations may require a landscaped strip between the access drive and parking and screening of the of the access drives from the roadway. It is difficult to be highly specific about landscaping because site design for drive-throughs varies greatly.
management plan addressing employee parking, not allowing truck deliveries during peak hours, a widened driveway, and a new third lane for waiting customers (Hayden 2022).

The takeaway from these bad experiences is to plan for the worst: contingency plans for traffic control at the opening of the store; required expansion of the stacking, if it proves necessary, with design built into the site plan; escalating penalties for back-ups; requiring the operator to engage off-duty police officers to direct traffic if necessary; and a clear understanding that the drive-through will be lost, or at least temporarily suspended, if there are problems with back-ups.

Required queue lengths are minimums. Extra-long required queue lengths are wasteful. The operator can make the stacking longer if they think it is necessary. If they elect to do the minimum and can defend it with the traffic report, then they must bear the burden of underestimating.

Stacking lengths are often in the range of 120–160 feet for restaurants and 80 feet, more or less, for retail and banking. Elk Grove, California, bucks the trend a bit by requiring 180 feet for drive-up windows and bank tellers, while going to 60 feet for nonfood and/or nonbeverage businesses (§23.78.030.A.2).

Requirements may provide for decreasing or increasing the recommended length based on a traffic report by a professional engineer. The decision to modify requirements for queuing, and perhaps other design requirements, should be based on written findings of fact that the alternate design, given the characteristics of the site, will be equally or more effective in protecting on- and off-site pedestrian and vehicular traffic safety and minimizing traffic congestion.

One solution to the conundrum of site- and use-specific differences might be to have a preapplication meeting with the applicant or even a two-step permitting process to establish acceptable stacking and access design based on a preliminary traffic report before the full application is prepared for the development. The scale of the development and its configuration is driven in large part by the need to handle the drive-through, and bifurcating the approval may facilitate better design and ultimate approval. It is not in anyone’s interest to have to deny a fully engineered site plan over a dispute about stacking length.

Stacking necessarily requires knowing where it starts and ends. Windows and menu/order boards should be placed as far to the rear of the building as possible to increase available stacking. The starting point measurement is often an offset of some distance, say 25 feet, from the curb line or, if there is no curb line, to the edge of the sidewalk if there is one, and otherwise to the edge of the street pavement. The end point is the pick-up window.

Walk-up windows might be encouraged, not just enabled, in the regulations or even mandated, especially in areas considered most walkable and where people are more dependent on walking and cycling.

According to David Sullivan, U.S. Manager of Traffic and Transportation Planning for SLR, operators should place the order board far enough behind the pick-up window to ensure it does not constrain service. For example, if it takes 30 seconds to place an order and two minutes to fulfill an order, the order board should be about four cars from the pick-up window.

In some settings where preservation of the streetscape is of special concern, it may be advisable to mandate that the service window be at the back of the building and that no part of the accessway be used for queuing. A graphic can help.

Importantly, the queue space should not interfere with the safe use of the required parking spaces and their required drives, interior pedestrian and other circulation, and the accessway from any public street. However, Sullivan notes that it may be okay to block employee parking or trash storage areas if access to those areas is not essential during peak drive-through usage periods.
Noise
Those loudspeakers at the order windows can be a problem. To reduce the potential nuisance, regulations may include a setback of order windows from residential properties, say 40 feet. Outside speaker use might be prohibited during certain hours, but that would effectively shut down the business during those hours. Hours of operation, of course, is an important consideration as many drive-through restaurants are now open late and even 24/7. Outdoor loudspeakers for any drive-through window might be limited to a noise level below 50 dB at the closest property line, nearest building of a separate use, or a public sidewalk off-site.

Lighting
There is nothing special about lighting with drive-throughs, but generally property owners and regulators are not doing the best job possible with lighting. It is most often too much and, more recently, too harsh with LED lighting. Guidance is available in the Outdoor Lighting collection in APA’s Research KnowledgeBase and in a PAS Memo titled “the Future of Outdoor Lighting.” In developing new drive-through regulations, it might be timely to consider revamping lighting requirements.

Walk-Up and Bike-Up Service
But what about pedestrians and cyclists? The safety issues for people on foot and on bicycles using vehicular lanes would seem to preclude joint use, but Portland, Oregon, thinks otherwise (§33.224.070):

> When a drive-through facility is open and other pedestrian-oriented customer entrances to the business are unavailable or locked, the drive-through facility must serve customers using modes other than a vehicle such as pedestrians and bicyclists.

Salt Lake City enabled joint use by cyclists in 2014, only to have the state legislature enact a law the next year prohibiting local governments from requiring a business to “allow a person other than a person in a motorized vehicle to use the drive-through service” (§10-8-44.6).
What can be done? Provide for them expressly in the zoning regulations as Madison, Wisconsin, does by authorizing a walk-up service window as a conditional use when located within 10 feet of a public right-of-way (§28.151). Many ordinances permit walk-up automated teller machines, but few allow other services.

Walk-up windows might be encouraged, not just enabled, in the regulations or even mandated, especially in areas considered most walkable and where people are more dependent on walking and cycling. Incentives might be offered, such as modest increase in lot coverage or building floor area, excluding them from setbacks, or a partial tax abatement for a few years. Waiving application fees for the addition of walk-up/bike-up windows might be a good idea.

Businesses always have the right to make their own decisions on service to walk-ups and cyclists. Reach out to them. Offer some design solutions. Honor the ones who do the right thing. Promote the advantages: they deter crime with more “eyes on the street,” they are interesting and promote walkability by making the street more pedestrian friendly, and they are a great convenience for shoppers who need not walk into a store to be served with the added benefit that they preserve the opportunity for social distancing that many continue to find is essential to their being out in public (Malouff 2012).

Conclusions
We can learn much from the long history of drive-in and drive-through service, particularly in the context of the recent pandemic experience. The public wants it in all its variations, needs it, and expects to continue to use it. The challenge is to plan for these new and evolved types of service and to find ways to make sure they work on individual sites. The effort is worth it. The public’s interest will be served, economic development and redevelopment promoted, walkability protected and enhanced, and public nuisances avoided. That is what good planning is all about.

About the Author
Dwight Merriam, FAICP, a lawyer and a land-use planner, is a Fellow in the American College of Real Estate Lawyers, Past President of the American Institute of Certified Planners, and Past Chair of the ABA Section of State and Local Government Law. He has published over 200 articles and 13 books, including co-editing the treatise Rathkopf’s the Law of Zoning and Planning. UMass BA (cum laude), UNC MRP, and Yale JD. www.dwightmerriam.com
References


Which Is Greener: Idle, or Stop and Restart?
Comparing Fuel Use and Emissions for Short Passenger-Car Stops

L. Gaines, E. Rask, and G. Keller, Argonne National Laboratory

Overview

The argument against parking and going into a business, rather than using a drive-through window, has been that the emissions and fuel use associated with restarting your car are greater than those incurred by idling for that time. Argonne National Laboratory undertook a series of measurements to determine whether this was true, by comparing actual idling fuel use and emissions with those for restarting. This work seeks to answer the question: Considering both fuel use and emissions, how long can you idle in a queue before impacts from idling are greater than they are for restarting? Fuel use and carbon dioxide emissions are always greater for idling over 10 seconds; the crossover times are found to vary by pollutant.

Background

The bulk of idling research to date has focused on the effects of heavy- and medium-duty diesel vehicle idling. Most research has ignored passenger car idling—even at schools—as a source of emissions and wasted fuel. While idling in traffic is necessary for safety, vehicles can be turned off while waiting for passengers or for freight trains to pass. Consumers can choose to park and enter a fast-food restaurant, rather than idle in a drive-through line (Figure 1). If each car in the United States idles just 6 minutes per day, about 3 billion gallons of fuel are wasted annually, costing drivers $10 billion or more. And they haven’t gotten anywhere!

The U.S. Department of Energy Clean Cities Program uses its national network of almost 100 local coalitions to reduce transportation dependence on petroleum through the use of alternative fuels and efficiency measures, including idling reduction. The program therefore funded Argonne to measure idling fuel use by and emissions from light-duty vehicles and to compare these to start-up emissions to enable data-based decision making.

Testing

Argonne National Laboratory used a 2011 Ford Fusion mid-sized sedan with a 2.5-L, 4-cylinder engine (175 HP) and 6-speed automatic transmission (Figure 2). Its EPA fuel-efficiency label shows 23 mpg city/33 mpg highway and 26 mpg combined. We equipped the vehicle to measure numerous engine parameters and temperatures, including catalyst inlet and brick temperatures and oil and coolant temperatures. We collected data in one of Argonne’s test cells at the Advanced Powertrain Research Facility (APRF), using a SemtechD emissions analyzer for emissions and a direct fuel flow meter for fuel measurement. The vehicle was prepared and run by using approximate Federal Test Procedure (FTP) standard ambient temperature testing criteria. The emissions of interest in this study include total hydrocarbons (THC), nitrogen oxides (NOx), carbon monoxide (CO), and carbon dioxide (CO2) (Tables 1 and 2).

• Criteria pollutant emissions were low for idling following catalyst activation.

Table 1. Idling Emissions and Fuel Use per Second

<table>
<thead>
<tr>
<th>Emission</th>
<th>Tier 2-Bin 5*</th>
<th>Cold Start</th>
<th>Restart</th>
<th>Idle 30sec</th>
<th>Fuel (cc)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOx (mg)</td>
<td>0.0097</td>
<td>0.266</td>
<td>0.108</td>
<td>0.588</td>
<td>0.279</td>
</tr>
<tr>
<td>THC (mg)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CO (mg)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CO2 (g)</td>
<td></td>
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</tr>
</tbody>
</table>

• Emissions from restarting were larger, but at least an order of magnitude lower than those from starting a cold engine.

• The catalyst cooled down slowly, so that restarts after times equivalent to a short transaction at a bank or restaurant are unlikely to allow the temperature to drop below light-off and incur large cold-start emissions.

Table 2. Comparison of Emissions from Cold Start, Restart, and Idling

<table>
<thead>
<tr>
<th>Emission</th>
<th>Tier 2-Bin 5*</th>
<th>Cold Start</th>
<th>Restart</th>
<th>Idle 30sec</th>
<th>Cold Start ÷ Restart</th>
</tr>
</thead>
<tbody>
<tr>
<td>THC (mg)</td>
<td>878</td>
<td>191</td>
<td>44</td>
<td>8.0</td>
<td>4.3</td>
</tr>
<tr>
<td>NOx (mg)</td>
<td>552</td>
<td>228</td>
<td>6</td>
<td>0.3</td>
<td>38</td>
</tr>
<tr>
<td>CO (mg)</td>
<td>31,290</td>
<td>2,970</td>
<td>1,253</td>
<td>3.2</td>
<td>2.4</td>
</tr>
</tbody>
</table>

*Total over 7.45-mi UDDS cycle
Testing [continued]  

Testing at 21°C ambient conditions on a late-model mid-sized American car shows that idling for more than 10 seconds uses more fuel (Figure 3) and emits more CO\textsubscript{2} (Table 1) than engine restarting.

![Figure 3](image-url)

**Figure 3.** The shaded area under the blue line (idling fuel rate) and the red line (restart) before the engine is restarted (at 10.1 s) represents the quantity of fuel that the engine would have burned if it were idling instead of being off, and the shaded area between the lines after the engine is restarted represents the excess on restart.

Conclusions

- Idling for more than 10 seconds uses more fuel (Figure 3) and emits more CO\textsubscript{2} than engine restarting.
- Idling fuel usage varies from 0.2 to 0.5 gal/h for passenger vehicles across a range of sizes, and increased with idling speed.
- The vehicle warms up faster when driving than it does when idling.
- NO\textsubscript{x} and THC emissions from restarting are larger, but at least an order of magnitude lower than those from starting a cold engine (Table 2).
- For short stops, it makes sense to turn the vehicle off in order to minimize fuel use and CO\textsubscript{2} emissions. At least for the conditions evaluated in this work, the penalty in terms of criteria pollutant emissions is very small compared to cold-start emissions.

Research Limitations

Data presented here are based on one vehicle at one temperature, with a small number of runs. Therefore, although several conclusions are suggested by this work, generalizations are unwarranted without additional work to confirm the extent to which the results apply, for the following reasons:

- Hot and cold ambient conditions are likely to affect results, as are the loads required to supply passenger comfort at those temperatures.
- Older vehicles and diesels are both likely to behave differently.
- More research is required to explain differences in THC emissions between the runs, as well as to make more generalizations regarding the emissions impacts of different restart/soak times. Additional research to fill in all these gaps would enable more conclusive statements concerning the differences in emissions between idling and restarts.

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For more information, please go to www.transportation.anl.gov/engines/idling.html