# 777 fuel burn performance

## The fuel burn performance of the 777's most numerous variants with different engine selections are analysed.

The fuel burn and operating performance of four of the five passenger variants of the 777 aircraft are analysed and assessed. All three engine families powering these aircraft are represented in this analysis.

### Aircraft variants

The 777-200 has three different variants: the -200, -200ER and the -200LR. All three have analysed here, as well as the -300ER.

All three engine manufacturers are represented for the -200 and -200ER. The -200LR and -300ER are powered exclusively by the GE90-110B/-115B.

The engines selected for the analysis of the 777-200 all have a thrust rating of about 77,000lbs, making a fair comparison between the airframe-engine combinations possible. The three engine variants chosen are the GE90-76B, PW4077 and Trent 877, because they are the most popular thrust rating and variants for the -200, particularly the PW4077 engine.

The maximum take off weight (MTOW) for the aircraft is 545,000lbs.

The same basis of comparison has been used for the 777-200ER, but using four engine options. The two most common thrust ratings powering the -200ER are 90,000lbs and 94,000-95,000lbs. The lower thrust is covered by the GE90-90B and PW4090 powering aircraft with an MTOW of 656,000lbs. The higher thrust of 93,700lbs is represented by the GE90-94B and Trent 895, also powering aircraft with an MTOW of 656,000lbs.

The 777-200LR has an MTOW of 766,000lbs and is the longest-range 777 variant. It has been assessed using the only engine currently available, which is the GE90-110B with a thrust rating of 110,000lbs.

The 777-300ER is now the only -300 series variant available from Boeing and is offered with the highest-rated engine, the GE90-115B. The engine being assessed therefore has a rating of 115,000lbs thrust, and the aircraft has an MTOW of 775,000lbs.

There are many thrust and MTOW variations used by different airlines. The basic specifications, as stated by the manufacturers, have been used for these calculations.


### Flight profiles

Aircraft performance has been analysed both in-bound and out-bound for each route in order to illustrate the effects of wind speed and its direction on the actual distance flown, otherwise known as equivalent still air distance (ESAD). Average historical winds and temperatures for the month of October have been used in the flight plans produced by Jeppesen. The flight profiles in each case are based on International Flight Rules, which include standard assumptions on fuel reserves, diversion fuel, plus contingency fuel. A taxi time of 25 minutes has been factored into the fuel burns and added to the flight times to get block times. Long-range cruise (LRC) speed has been used. This is slower than other cruise speeds, but it consumes less fuel per nautical mile, thereby allowing the aircraft to fly further. Economy cruise is more likely for shorter flights. This provides an economical and operational compromise between fuel consumption and flight time. The LRC speed is different for each airframe-engine combination, as designated by the manufacturer. The speeds and the effects on the block times are shown. There are some large variations given the lengths of the routes.

The passenger airframe and engine combinations analysed have been assumed to have full three-class passenger payloads. The seat configurations used are Boeing's standard layouts of 305 seats for the 777-200 and 368 seats for the 777-300.

An alternative cabin layout on the longer-range 777-200LR and -300ER includes a crew rest area above the cabin. This reduces the passenger seat counts to 301 and 365 respectively.

For the purposes of this analysis, the passenger complement has been left the same for simplicity. The standard weight for each passenger and their luggage is assumed to be 220lbs with no additional cargo. The payload carried is therefore 61,000lbs for the 777-200s and 73,600lbs for the -300.

### Routes analysis

Most of the big airlines in each of the global areas operate 777s. The majority operate the aircraft on long-haul routes, but some operators in the Asia Pacific use

*The 777-300ER has the lowest fuel burn per seat of all 777 variants and models. This is mainly due to it having 17% more seats but burning only a little more fuel than the -200ER.*

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| City-pair variant | Aircraft | Engine model | MTOW lbs | TOW lbs | Fuel burn USG | Block time mins | Passenger payload lbs | ESAD nm | Fuel per seat | Wind speed |
|---|---|---|---|---|---|---|---|---|---|---|
| LHR-IAH | 777-200 | GE90-76B | 545,000 | 529,297 | 23,324 | 690 | 67,100 | 4,654 | 76.5 | -29 |
| | 777-200 | PW4077 | 545,000 | 528,901 | 23,183 | 718 | 67,100 | 4,642 | 76.0 | -30 |
| | 777-200 | Trent 877 | 545,000 | 534,032 | 24,174 | 680 | 65,000 | 4,649 | 79.3 | -29 |
| IAH-LHR | 777-200 | GE90-76B | 545,000 | 511,375 | 20,240 | 599 | 67,100 | 3,928 | 66.4 | 37 |
| | 777-200 | PW4077 | 545,000 | 515,483 | 20,551 | 583 | 67,100 | 3,940 | 67.4 | 37 |
| | 777-200 | Trent 877 | 545,000 | 517,870 | 21,001 | 589 | 67,100 | 3,938 | 68.9 | 37 |
| LHR-NRT | 777-200ER | GE90-90B | 656,000 | 546,619 | 25,062 | 718 | 67,100 | 5,210 | 82.2 | 15 |
| | 777-200ER | GE90-94B | 656,000 | 546,076 | 25,010 | 720 | 67,100 | 5,200 | 82.0 | 15 |
| | 777-200ER | PW4090 | 656,000 | 537,979 | 23,728 | 678 | 67,100 | 5,196 | 77.8 | 16 |
| | 777-200ER | Trent 895 | 656,000 | 550,409 | 25,517 | 716 | 67,100 | 5,202 | 83.7 | 15 |
| | 777-300ER | GE90-115B | 775,000 | 616,029 | 26,901 | 711 | 80,960 | 5,200 | 73.1 | 15 |
| NRT-LHR | 777-200ER | GE90-90B | 656,000 | 563,708 | 27,544 | 776 | 67,100 | 5,473 | 90.3 | -11 |
| | 777-200ER | GE90-94B | 656,000 | 563,155 | 27,453 | 779 | 67,100 | 5,473 | 90.0 | -11 |
| | 777-200ER | PW4090 | 656,000 | 454,054 | 25,022 | 713 | 67,100 | 5,474 | 82.0 | -12 |
| | 777-200ER | Trent 895 | 656,000 | 569,547 | 28,254 | 773 | 67,100 | 5,475 | 92.6 | -11 |
| | 777-300ER | GE90-115B | 775,000 | 633,908 | 29,468 | 766 | 80,960 | 5,471 | 80.1 | -11 |
| YYZ-HKG | 777-200LR | GE90-110B | 766,000 | 670,123 | 37,127 | 957 | 67,100 | 7,190 | 121.7 | 11 |
| HKG-YYZ | 777-200LR | GE90-110B | 766,000 | 669,322 | 36,624 | 940 | 67,100 | 6,837 | 120.1 | 32 |

Source: Jeppesen

it on high-density, short- to medium-haul routes.

The first route to be analysed is London Heathrow (LHR) to Houston (IAH) using the 777-200 and three engine options. This reflects many of the intercontinental routes on which the 777-200 is used, by airlines such as Continental and Emirates. Ellington Field Airport (EFD) is used as the alternate for IAH. London Stansted (STN) is used as the alternate on the return sector to LHR.

The first sector of LHR-IAH has block times of 680-718 minutes, and has a tracked distance of 4,349nm. This sector is hampered by a head wind of 29-30kts and an ESAD of 4,642-4,654nm. The return sector to LHR has a tracked distance of 4,269nm, and experiences a tailwind of 37kts. This results in shorter block times of 583-599 minutes and an ESAD of 3,928-3,940nm.

The second route to be analysed is London Heathrow to Tokyo Narita (NRT) for the 777-200ER and the -300ER. This is a longer route typical of those on which the -200ER and -300ER are used by large airlines such as JAL and ANA.

The alternate airport on the route to NRT is Nagoya (NGO), while STN is the alternate for the operation to LHR. The LHR-NRT sector has a tracked distance of 5,365nm, with a tail wind of 15-166kts. Block times were 678-720 minutes and the ESAD is about 5,200nm.

The return sector of NRT-LHR has a headwind of 11kts, which increases the flight time by an hour, even though the tracked distance is shorter at 5,342nm. ESAD is 5,473nm. The -300ER completes both sectors about 10 minutes faster than the -200ER.

The final route of Toronto (YYZ) to Hong Kong (HKG) is used for the 777-200LR. This city-pair is an Air Canada route. The diversion airports used here are Ottawa (YOW) on the route to YYZ, and Macau (MFM) on the route to HKG. Both sectors are similar, having block times of 940-957 minutes. The average tracked distance of 7,286nm, and the route tail winds in both directions are 11 knots to HKG, and 32 knots to YYZ.

## Fuel burn performance

The fuel burn performance of each airframe-engine combination is shown *(see table, this page)* for all routes along with the associated fuel burn per passenger and per passenger-mile.

On the first route, LHR-IAH and IAH-LHR, the GE90-76B comes out with the best fuel burn per passenger of 66.4 USG on the return sector, but it has the slowest flight time, although only by about 10 minutes. The PW4077 is close in fuel burn performance to the GE90. The Trent-877-equipped aircraft did not perform as well on fuel burn as the other two engines on this route. The seemingly fast block time on the first sector is due to the reduced payload, which is necessary in order for this combination to complete the flight.

The 777-200ER variants have burns of 77.8-83.7USG per passenger on the second route of LHR-NRT, with the PW4090 being the best performer. On the NRT-LHR route, fuel burns are 82.0-92.6USG per passenger.

The larger 777-300ER has lower burns of 73.1USG per passenger on LHR-NRT, and 80.1USG per passenger on NRT-LHR *(see table, this page)*. This is because 17% more passengers are carried, resulting in only a 5-12% higher fuel burn compared to the -200ER.

On the third route of YYZ-HKG, the 777-200LR has a burn of 121.7USG, and a block time of 957 minutes. It follows a tracked distance of 7,350nm and has an ESAD of 7,190nm. Burn per passenger is almost the same, with an ESAD of 6,837nm and block time of 940 minutes *(see table, this page)*.

If all flights had been flown at the same speeds, then the results again would have been that the PW4090 had both the fastest times and lowest fuel burn on the LHR-NRT sector.

Once fuel burn per passenger-mile is analysed then there is little variation with route length. The largest factor having an impact on burn per passenger-mile is aircraft size and seat count, which is illustrated by the -300ER's 12-14% lower burn. AC